Ministry
of Defence
Global Strategic Trends
Out to 2055
Seventh Edition

How to navigate

The **executive summary** provides an overview of all the chapters in GST 7 as well as the six **global drivers of change**.

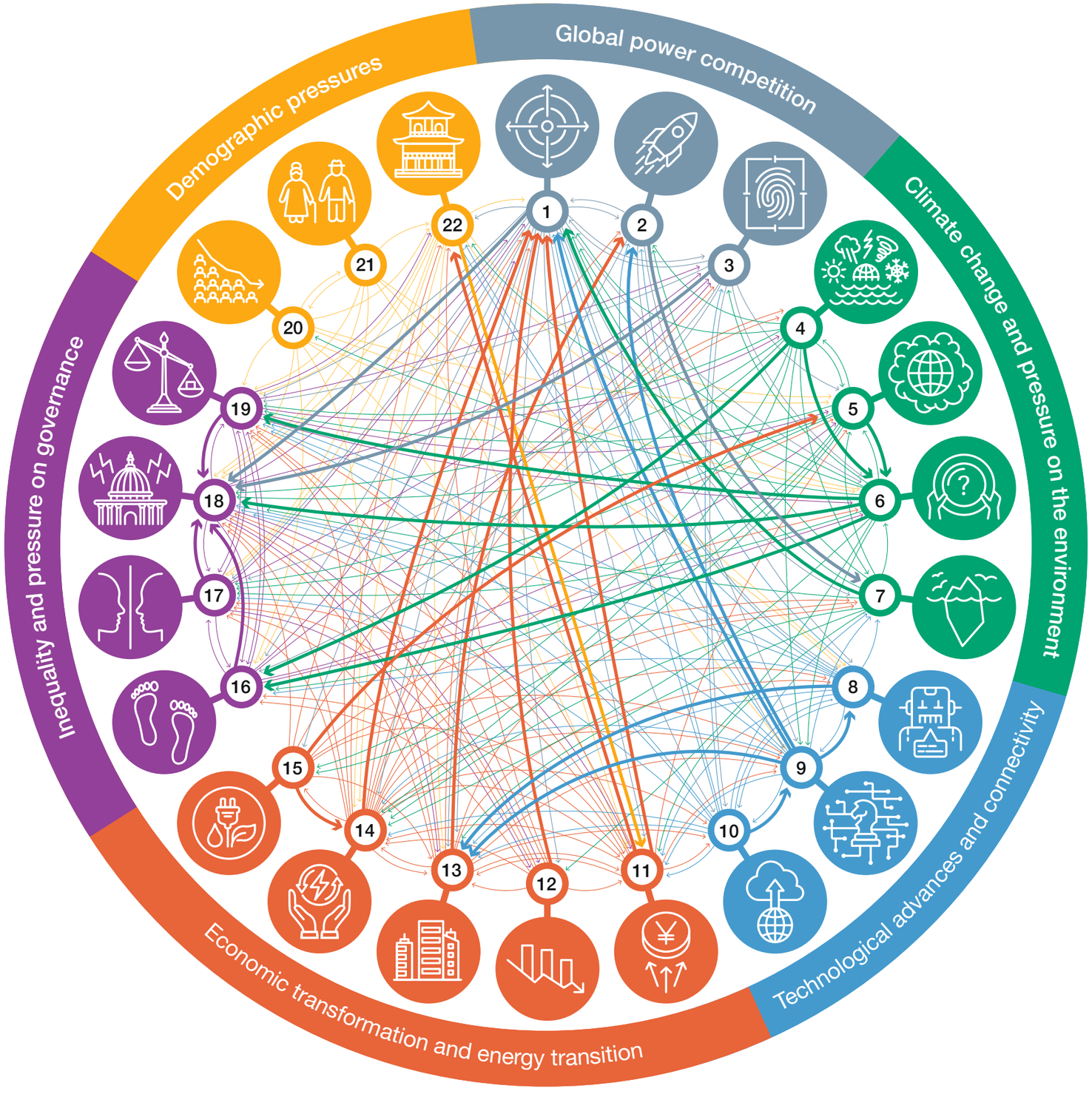
The **key drivers of change** summarise the major trends that will shape the future of that region.

Across GST 7, **pull-out boxes** offer an example of the described trends.

Using a few specific examples, the **map of interdependencies** gives a sense of how the trends in GST 7 influence global geopolitics.

Cross-impact analysis

1. Regional and global power competition will become increasingly prevalent.
2. The democratisation of space will enable commercial entities and non-state actors to become the forefront of space exploration.
3. The capability of violent extremist organisations and organised crime groups to do harm will increase.
4. Climate change will cause more extreme weather events and rising sea levels globally.
5. The pollution and degradation of the environment will increase.
6. Food and water insecurity will become increasingly prevalent.
7. Climate change and technological advances will open up access to new regions, domains and resources.
8. Societies and economies will become increasingly automated and artificial intelligence-dependent.
9. The competition for technological edge between companies as well as between states will be increasingly evident and intense.
10. Global digital connectivity will continue to increase along with the rising value of data.
11. The relative economic influence of Asia will grow.
12. Geopolitical competition will lead to a slowdown in global trade.
13. The power and influence of big corporations will continue to grow.
14. The global demand for energy and natural resources will increase.
15. The world will become less reliant on fossil fuel energy.
16. The number of migrants will increase globally.
17. Political and social polarisation will increase.
18. A growing number of parallel stress factors will increase pressure on traditional governance structures.
19. Socio-economic inequalities will increase.
20. Global population growth will slow down with some regions experiencing a decline.
21. The average age of the world population will increase.
22. The Asian middle class will continue to grow significantly.



For clarity purposes, the graphic above shows only the high and medium influence correlations.

Influence

High

Medium

Global Strategic Trends

Out to 2055

Seventh Edition

Conditions of release

Global Strategic Trends describes a strategic context for defence and security looking out to the middle of the century. It takes a comprehensive view of the future derived through research headed by the Development, Concepts and Doctrine Centre (DCDC).

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Foreword

This seventh edition of the Global Strategic Trends publication represents 20 years of strategic foresight analysis conducted by our Development, Concepts and Doctrine Centre – Defence's think tank within Strategic Command. Since the first edition was published in 2003, the Global Strategic Trends programme has sought to provide policymakers with a future strategic context to aid long-term decision-making, capability planning and strategy development. Its multidisciplinary approach involves numerous partners across defence, other government departments, academia and industry, both in the UK and internationally. By adopting a truly international approach, this analysis gathers a diverse range of insights and research.

The global future outlook indicates an abundance of opportunities for humanity. Our curiosity and creativity continue to catalyse change, redefining how we navigate and shape the world. At the same time, there is a combination of new and existing challenges that will test the ability of governments and societies to realise their ambitions. The geopolitical context has become increasingly complex, with a dynamic array of state and non-state actors competing to exert influence and power, challenging established norms, reshaping values, and disrupting the current international order. We are seeing new forms of statecraft, with shifting allegiances underscoring the complexity of the global stage, where cooperation and competition coexist in a delicate balance. The increasingly visible effects of climate change, demographic pressures, health insecurity and the widening of socio-economic disparities alongside distrust and misinformation are creating new stress factors, further complicating many of the inherent challenges that communities already face. In contrast, the promise afforded by scientific and technological innovation and new forms of multilateralism may support society and governments in tackling many of these challenges.

The need to examine the implications of these future trends in a more openly contested and volatile world, as well as the possible shocks that may emerge, has perhaps never been more important than it is now. The collective interconnected complexity of these opposing trends, and the speed at which they appear, will redefine the contours of economies, societal structures, governance and defence.

In acknowledgement of this, and of recent global strategic shocks, this edition of Global Strategic Trends describes the key drivers of change for the future, and it offers alternative pathways to different future worlds: to challenge biases, test assumptions and preconceived ideas and to shift thinking towards what **might** happen. In doing so, it calls on us to create organisations that are more alert and informed, but also open-minded, agile and proactive in the face of emerging challenges, so that we can shape as well as navigate the complexities of the future with confidence and purpose. We commend this edition of Global Strategic Trends to you.

Chief of the Defence Staff
Admiral Sir Tony Radakin
KCB ADC

Commander Strategic Command
General Sir Jim Hockenhull
KBE ADC Gen

Permanent Secretary
David Williams
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Introduction and methodology

Introduction

Today's world is hyperconnected, rapidly changing and frequently chaotic. The pace of technological and social change, against a backdrop of interconnecting shocks and crises, makes the future more uncertain. Preparing for multiple potential outcomes, with finite resources and at a time of shifting global power relationships, is proving to be increasingly difficult.

Purpose. The Global Strategic Trends (GST) programme aims to provide long-term strategic context for decision-makers in the Ministry of Defence (MOD) and wider government, as well as for the UK's allies and partners. Publications are written at the lowest level of classification to enable use by the widest possible audience. The outputs of this programme are based on the premise that predicting the future is impossible. This publication therefore offers analysis, based on a range of strategic foresight tools, to help users minimise bias and reduce the likelihood of surprise or unwanted outcomes, while building preparedness and agility to meet alternative futures.

Twenty years of Global Strategic Trends. The 1998 *Strategic Defence Review* expressed the need for a dedicated Defence function to consider the role of the Armed Forces into the future. The MOD's 2001 *Future Strategic Context of Defence* and subsequent White Papers triggered the first edition of GST, which was published in 2003. Since then, each edition has served to inform the various iterations of top-level strategic documents, including the *National Security Strategy*, the *Strategic Defence and Security Review*, the *National Risk Assessment* and the *Integrated Review*. Emerging findings from the analysis underpinning this seventh edition of GST contributed to the *Integrated Review Refresh* in 2023.

Methodology

Approach. *Global Strategic Trends: Out to 2055* (GST 7) employs a systems-based approach as the framework for analysis. This comprises three subsystems (society, economy and environment), plus a series of connecting 'ring roads', which for the purposes of this publication have been consolidated into the future world order (which includes governance, non-state actors, state actors, global power relations and uncertainties) and the thematic areas of information and technology, and conflict and security. Following a programme of regional analysis that explored the world as nine regions and five shared spaces, including cyberspace, identified trends were then examined through the lens of each of these subsystems and ring roads to provide context for developing global thematic trends. This helped to highlight areas of variation and commonality across the regions, following which the results were refined into the specific

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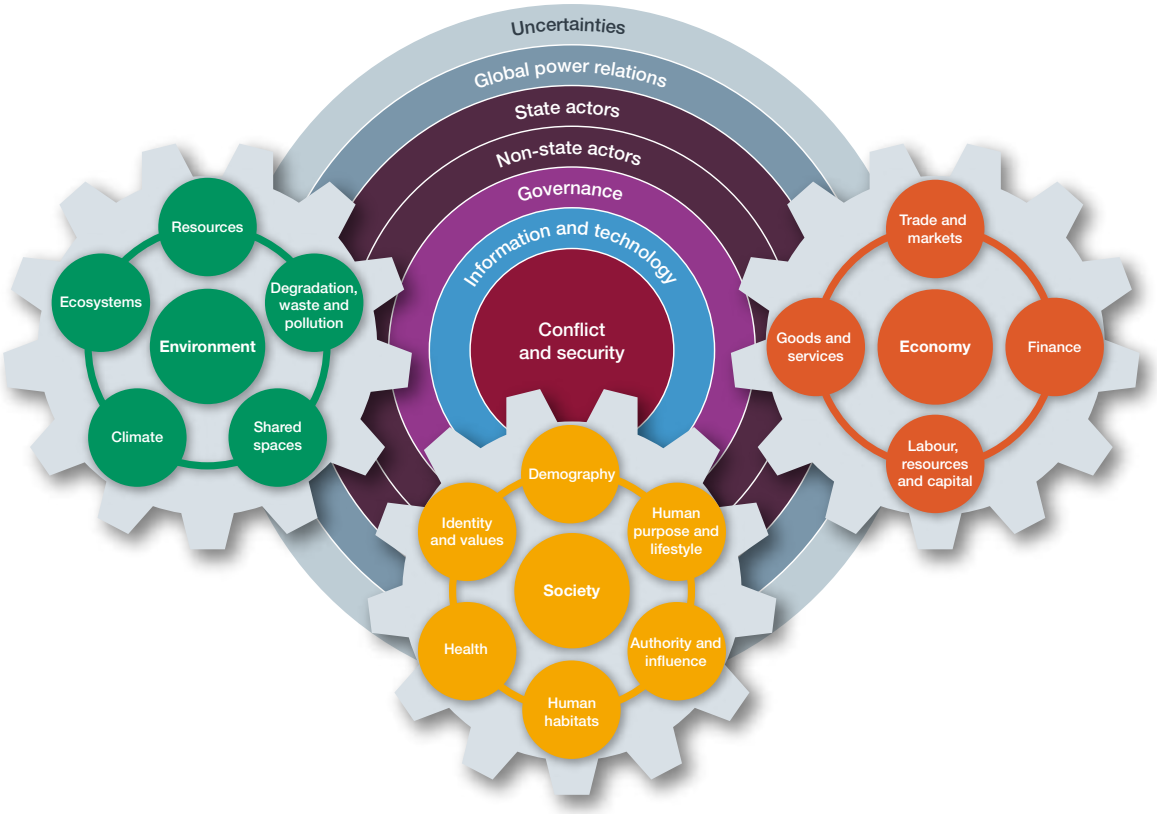
chapters contained in the publication. All findings, especially those involving emerging technology and technical scientific detail, were frequently tested for logic and quality of evidence with relevant stakeholders and subject matter experts, and then re-examined for contradictions and contraindications.



The Global Strategic Trends 7 'system'

Research. Each thematic and regional topic was researched by a designated group, all members of the Development, Concepts and Doctrine Centre's (DCDC's) Futures Team. The research phase involved collecting data points, conducting original research, and running a series of internal and external workshops to extrapolate key drivers and emerging trends. Throughout the research phase, the Futures Team employed a variety of specialist futures techniques, including statistical analysis and modelling, surveys, cross-impact and causal loop analysis, and an artificial intelligence-based literature review, to identify the second and third order consequences of these trends across all regional and thematic areas. Desk research was augmented by collecting statistical abstracts of various countries and engagement visits across most regions. Where face-to-face interviews were not possible, for example, when the COVID-19 pandemic lockdowns made international travel impossible, virtual meetings were arranged instead. Altogether, more than 60 research papers were produced to support the analysis of GST 7. In addition, DCDC was also approved to test the potential of large language models during the course of this work (although the results were always cross-checked by the Futures Team), as well as several proprietary software tools for data analytics and management.

Collaboration. GST 7 has been produced with unprecedented cross-government support and transnational collaboration. With numerous meetings and a series of engagement visits (physical and virtual) to 40 countries and seven regions, a broad network of UK and global government departments, agencies and academic institutions informed the analysis

throughout all stages of production, providing comment, advice and review. In total, 47 academic institutions were engaged throughout the process, providing background research, research papers and interviews. The Futures Team that produced GST 7 was made up not only of British military officers and civil servants, but also embedded officers and civilians from Australia, Brazil, Finland, Germany and Sweden. Finally, the Futures Team also worked widely with peer groups and foresight practitioners across the globe (in total over 10,000 individuals were engaged), including in Australia, Brazil, Canada, Chile, India, Japan, New Zealand, Singapore, South Africa and the United States, as well as with teams in the European Union, the Organisation for Economic Co-operation and Development, the North Atlantic Treaty Organization (NATO) and the Geneva Centre for Security Policy. Between them, these collaborations provided a broad range of perspectives, ensuring that the final publication is robust and 'global' in its design.

How to use this publication. This publication starts with an executive summary, together with an encapsulation of the six global drivers of change, the five core contradictions and an impact and uncertainty analysis. It is then structured into four main sections, each comprised of a number of individual chapters:

- the future world order;
- regions;
- shared spaces; and
- thematic areas.

The analysis begins by identifying trends based on discernible patterns of change that will shape the future strategic context. The purpose is to highlight changes that are likely to become threats if not dealt with in a timely manner, but which may also, if addressed promptly, provide opportunities. GST 7 articulates the trends, drivers, threats and opportunities associated with each element of the system, to provide a dynamic view of how the future might evolve if certain forces push the world along a particular path, and what the outcomes might be. Each chapter presents a set of interconnected and interdependent trends and phenomena, which are in themselves driving forces but are also influenced and shaped by one another.

To place these trends in their widest context, the analysis for GST 7 also draws on alternative pathways and future scenarios to highlight points of change between the present and the future. Inevitably, there is a huge degree of uncertainty in what is described, and some of this analysis may, at first glance, seem contradictory – simply because it illustrates possible alternative future pathways rather than a single version of the future. The publication highlights some specific areas of contradiction where evidence and prevailing opinions are in tension; this is where the impact and uncertainty analysis comes into play – to highlight the fullest range of risks and uncertainties to conflict and security.

Next steps. As with GST 6, the intention is to undertake a series of strategic implications projects over the next few years to further enhance GST 7's relevance and utility for the defence and security community. Some papers will be produced in collaboration with international partners and published, while others are likely to be classified and not publicly released.

Executive summary

Strategic context

Strategic foresight publications often begin with assessments of increasing ambiguity, complexity and volatility. Given that the story of humanity has been one of shocks and surprises as well as evolution, revolution and progress, it could be argued that there is nothing new in this. Geopolitics tends to move between cooperation, competition and confrontation; trends and disruptions in the social, economic, environmental and technological spheres, which often bring an abundance of opportunities, can also trigger change that heightens volatility and even the risk of conflict.

The geostrategic context in which previous editions of Global Strategic Trends (GST) were published illustrates this point. When the first edition was published in 2003, Russia was a partner to the North Atlantic Treaty Organization (NATO) and global terrorism was perceived to be the major security threat. Mobile phones were basic by today's standards and the world economy was expanding through globalisation. The publication of the third edition in 2010 was in the wake of a global financial crisis that would trigger waves of instability and herald shifts in geopolitical power. The sixth edition was published in 2018 in the context of shifting economic weight from West to East. Notwithstanding a growing number of conflicts across the Sahel and Southwest Asia, and that Russia had already invaded Georgia, Crimea and eastern Ukraine, geopolitical competition was viewed by many as an activity confined below the threshold of armed conflict – the global economy being considered too interdependent for states to risk war.

Five years later, the world has witnessed a series of major geostrategic shocks: a global pandemic that killed millions, accelerating misinformation and disinformation, disruption as a result of technology advances, the war in Ukraine, and a growing crisis in Southwest Asia. Geopolitical tensions have increased significantly across economic, diplomatic and security fronts; full-scale conflict with worldwide ramifications is now considered plausible. The current international order is also seeing a growth in the influence of a range of state and non-state actors and an increasing diffusion of power. The Global South and small island states are demanding a greater voice, while middle powers, city networks, corporate bodies and powerful elites, as well as violent extremist and criminal networks, are exerting increasing influence. All of this is taking place in the context of global economic transformation and energy transitions, shifts in resource demands, changing demographic structures, further advances in disruptive technologies and growing evidence on the impact of climate change.

In 30 years' time, humanity may have exploited its many strengths and opportunities to create a more equitable and sustainable future. For example, shifts in energy provision may have been achieved, today's emerging technologies may have matured in ways that bring multiple benefits to economies and societies, and further technological developments may be enabling humans to explore and understand the depths of the oceans and further into space. Conversely, the world may have become overwhelmed

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by multiple challenges, including destructive conflict. *Global Strategic Trends: Out to 2055* (GST 7) attempts to postulate pathways to these and other worlds. However, one thing seems certain: those who are prepared not only to adapt to change but also embrace it seem most likely to succeed in this uncertain future.

Global drivers of change

A study of the regional and thematic analysis underpinning GST 7 has identified six global drivers of change and a number of underlying trends that are likely to shape the coming decades. Taken together, these drivers represent a complex set of dynamics which serve to influence, counteract or accelerate each other, often in unexpected ways.

The six global drivers of change are: global power competition, demographic pressures, climate change and pressure on the environment, technological advances and connectivity, economic transformation and energy transition, and inequality and pressure on governance.

1. Global power competition. Competition will continue and the balance of power will almost certainly change. Competing actors will include major powers as well as a range of smaller state and non-state actors, which will interact with each other in different ways as they seek to advance their interests and influence.

2. Demographic pressures. The global population will continue to grow and age, although the rate of increase will be spread unevenly across the globe. Africa, South Asia and some parts of Southeast Asia and Oceania will experience rapid growth in their populations, while East Asia and Europe will see slower rates of growth and in some cases population decline. Increasing migration, including to urban areas, and the growth of the global middle class population will all have an influence on global and regional demographic structures.

3. Climate change and pressure on the environment. The effects of climate change will become increasingly evident and more extreme. Increasing demand for resources will place additional pressures on the natural world, including in the shared spaces. Efforts to mitigate and adapt to climate change will increasingly occupy societies, economies and governments across the globe.

4. Technological advances and connectivity. The exponential growth in sensors, data, storage, processing power, connectivity, advanced data analytics, automation and artificial intelligence will have an impact on virtually every area of human endeavour and lifestyle. The desire to secure technological advantage will play a central role in global power competition in future decades, influencing international relations and trade.

5. Economic transformation and energy transition. Technological advances will have a huge impact on future economic activity and energy systems. While the speed and scale of the transition will result in significant strategic advantage for some, for others it will place pressure on adaptive capacity. A failure to adapt could potentially lead to societal disruption, grievances and tensions. The resources required to enable the digital and energy transition – notably metals and critical minerals – will become of increasing geopolitical importance.

6. **Inequality and pressure on governance.** Global inequality will continue to rise. This will be driven by technological transformation and the increasing concentration of wealth, as well as slowdowns in economic growth. In addition, increasing intolerance and discrimination, and enduring corruption, insecurity and conflict in some parts of the world, will compound this issue. Growing awareness of inequities, alongside rising migration and demographic change, will put increasing pressure on state and international governance structures and capacity.

As the world continues to grapple with the impact of major strategic shocks, in addition to a number of ongoing regional conflicts and other stress factors, global volatility and risk have increased. This has caused the emergence of a series of parallel but acutely opposing trends: the five core contradictions. The world is witnessing increasing interconnectivity, resulting in part from new levels of digital connection and an increase in digital trade, but also fragmentation as a result of disruptions and shifts in global value chains and an increase in economic protectionism. Cooperation and confrontation sit side by side, with NATO enlargement and a new United Nations initiative on the protection of the high seas alongside increasing competition between states, new conflict outbreaks and a deepening divide between the developed world and the Global South. Innovation continues to revolutionise societies and economies, while the world is experiencing stagnation in the areas of poverty reduction and its ability to tackle irregular migration and refugee flows. Recent years have seen democratic declines and growing authoritarianism in some states, just as rising human empowerment is boosting the potential for public mobilisation and demand for transparency. Finally, while new technologies may lead to an increase in government capacity and strengthening roles of states, ageing populations, stretched state finances and the growing prevalence of serious and organised crime may result in an increase in state fragility and instability in some parts of the world.

The extent to which these drivers and contradictions will shape the future is likely to vary in practice, and over time. Each will also interact with other developments in different, often complex ways. As a result, a simple extrapolation of one or even a few trends will not give a comprehensive picture of the future. No matter how strong the signals are for a particular trend, there is always a degree of uncertainty about the direction it might take.

The future world order

A broad range of influential actors, including states, international organisations and non-state actors, will continue to shape global and regional developments out to 2055. The United States (US) is likely to remain one of the world's most powerful states and will still be relied on by many as the leader of a huge network of alliances and partnerships, although its relative global influence may continue to decline. In recent years, China's significant resources and its remarkable economic growth have brought it to prominence as a global power; its reach is likely to continue to extend in the future as it pursues its ambition to restore its status in a reformed global order, putting it in direct competition with the US for global hegemony and influence. How each of these powers respond to the economic, social, political and environmental pressures that they face will determine their geopolitical trajectory.

Russia's future status in the international order is likely to depend on the outcome of its war in Ukraine and its ability to manage the consequences across social, political and economic sectors, but it is likely to remain ambitious and the desire to retain or regain great power status will continue to drive its behaviour. India's influence as a global economic power may continue to grow and could be advanced further if it can capitalise on its likely demographic dividend; however, it will continue to face a range of challenges at the domestic level, and its enduring border disputes with neighbouring states are unlikely to be settled. Established middle powers such as the UK, France, Germany, Japan, South Korea, Canada and Australia will use a combination of their diplomatic outreach, economic influence and military power to influence the global balance. At the same time, emerging middle powers such as Indonesia, Pakistan, Saudi Arabia, Iran, Turkey, South Africa, Nigeria and Brazil may see their influence grow. Middle powers may also wield influence through regional economic, political and military organisations such as the European Union, NATO, the African Union, the Association of Southeast Asian Nations and the BRICS group, and some of these organisations may see their power and influence grow. In addition, a diverse range of other actors, including multinational corporations, transnational organised crime networks, increasingly powerful city governance structures and super-empowered individuals and religious leaders, will each play a role in global and regional power balances.

Taken together, these developments may see the continued diffusion of global power beyond major state actors, and possibly a blurring of the boundaries between state and non-state actors. As the international order evolves, multilateral institutions may find their effectiveness and support altered or eroded. Major powers may become increasingly selective in their engagement with global institutions, and there may be an increasing trend towards 'withdrawalism' from international treaties and frameworks in favour of smaller and more agile issue-centred coalitions and partnerships. Despite these challenges, support for multilateralism to promote mutual interests, resilience, prosperity and sustainable development seems likely to endure, making some form of enduring institutional cooperation likely.

The dynamics of relationships between states, whether cooperative or confrontational, are likely to be defined by six areas of national power and influence. The power of attraction – being a partner of choice, resting on status, standing, prestige and reliability – will be key in a world of increasing diffusion of power. Linked to this, technological leadership and advantage will remain hugely important and will depend very much on the ability to attract talent. Economic shaping power and access to resources will remain vital, but will become more complex due to growing competition and the development of new technologies. Given the magnitude of the global climate challenge, climate change mitigation, adaptation and the ability to steer the green transition will provide decisive advantage and influence. With space and cyberspace becoming increasingly central in everyday life and a key factor contributing to success in combat, influence in the shared spaces will be yet another vital area of power. Finally, military shaping power and arms control will remain the ultimate lever of power, although technology developments will see it transformed in unexpected ways and become increasingly complex.

The current escalation in global power competition, which has already resulted in a shift to a more multipolar world, is likely to continue in the near term at least. However, the precise way in which the global drivers of change will impact on each other in practice, and how actors will react to them, remains unknown, and creates uncertainties as to what the global order might look like in 30 years' time. However, what is clear is that the path which the world takes is unlikely to be linear, and may result in the emergence of a very

different world order than that anticipated, shaped by various shocks, developments and the responses of global actors. Illustrative of this are GST 7's five fictitious but plausible pathway scenarios, each of which could result in the emergence of a different world order, shaped by changes in the balance of power and the international system. The five pathway scenarios are as follows.

1. Existential threats drive a new multilateral accommodation.
2. The current system endures in a multipolar world.
3. Changing spheres of influence.
4. Competition and decoupling leads to conflict and a deglobalised world.
5. Incremental instability leads to a new networked order.

Regions

East and South Asia

The populous and industrious states of East and South Asia will remain major centres of economic, diplomatic and cultural power, although all will face pressures due to changing demographics, global economic shifts and increasing geostrategic tensions. China is likely to dominate global attention in the region as it increasingly challenges the US for global power and influence; India may also become increasingly influential. The responses of regional and external powers to this rising competition could heighten the potential for further tension in the region. Population growth will continue to vary across states. East Asia may increasingly look to automation and other technology advances to compensate for ageing and shrinking populations. In contrast, some South Asian states will continue to see high levels of population growth, potentially boosting economies but also placing pressure on state governments and education systems. With the region already highly vulnerable to the impact of natural disasters, the effects of climate change are likely to exert an increasing toll on economies and societies. While states are likely to remain dominant, rapid urbanisation and economic transformation could see some of the region's powerful cities taking on a more prominent role.

Southeast Asia and Oceania

Southeast Asia and Oceania is likely to become the focus of increasing global power competition, with multiple powers vying to secure economic, diplomatic and military advantage and access to resources. Regional states will seek to balance their economic and security interests, but may come under pressure to choose sides on a range of issues. In Southeast Asia, populations are expected to grow and become increasingly urbanised and connected; in contrast, population growth in most of Oceania will slow, and migration out of the region may increase due to the effects of climate change. The ongoing diffusion of global economic power could see Southeast Asia expand its global economic influence; countries such as Indonesia could emerge as new regional leaders, although growing inequality and other pressures could hinder progress across the region. The region will remain intensely affected by extreme weather events, as well as volcanoes and earthquakes; droughts, floods and fires will impact rural and urban areas, while the Western Pacific could become the first part of the world to experience the loss of a state due to the combined impacts of climate change.

Russia

The future of Russia remains highly uncertain, with the outcome of its war in Ukraine and the implications of this for its economic, societal and political trajectory likely to be key determinants of its future power and status. Russia could become more unpredictable in the coming decades; however, an ageing and shrinking population, alongside growing environmental challenges and governance pressures, could see it increasingly weakened and forced to turn inwards to focus on domestic priorities. By diverting its energy exports to new markets such as China and India, Russia has bolstered its economy in the short term, but this revenue may become increasingly uncertain in the long term as the green energy transition gathers pace. Russia may see increasing internal and external competition for control of its resources and strategic territories in future decades, which may be a potential source of tension with China in particular. Given that Russia is likely to retain many of its military capabilities, an increasingly weak and unstable state could become a source of considerable global risk. Conversely, a Russia that is able to strengthen and diversify its global relationships could continue to sustain its economic, political and security postures in the future.

Central Asia

Central Asia is likely to retain its geostrategic importance and remain an arena for intense power competition. While the potential growth in competition between Russia and China is the current focus, other powers such as India, Turkey and countries in the West could also emerge as significant actors in the region. The population is projected to grow, age and urbanise, although more slowly than other regions. Authoritarianism and corruption are likely to remain significant challenges for some regional states, although increased connectivity may boost awareness of injustices and poor government performance and drive calls for greater transparency. Reducing demand for fossil fuels is likely to have a major impact on some states in the region; efforts to diversify into other economic sectors may prove only partially successful. Pressures on shared water resources for both food and energy production may increase tensions in the region, and water security is likely to be a key concern for governments. However, if recent moves to establish effective dialogue on this and other issues continue, tensions may reduce and the region may see an increase in cooperation, leading to improvements in regional trade flows, prosperity and security.

Southwest Asia and the South Caucasus

Southwest Asia and the South Caucasus are likely to remain characterised by religious, cultural and political rivalry, impacting all aspects of their internal and external relations. Sitting between major seaways and home to some of the largest and most accessible global hydrocarbon deposits in the world, the region could continue to exert considerable influence over the global economy and energy markets in the coming decades. However, the regional balance of power may see multiple shifts, as states face the challenge of moving their economies away from hydrocarbons in the face of decreasing demand. Some states have already started to achieve greater economic diversification and should endure and thrive; however, in other parts of the region tensions and instability are likely to remain a concern. The rate and extent of the global green energy transition, as well as the ability to meet the expectations of its significant youth population and address the impact of climate change, will play major roles in the region's medium-term fortunes, as well as its relations with global powers.

Africa

A young and rapidly expanding population could drive the economic transformation of the region, if governments succeed in providing these young people with the education and employment opportunities they desire. However, increasing environmental stress and a continued lack of infrastructure, as well as growing inequality, weak governance and enduring political and security tensions in some parts of the region, could challenge the ability of states to capitalise on this potential. Given Africa's wealth of resources, external actors will increasingly compete for influence and access, for example, by providing investment and support to infrastructure development, which in some cases could lead to new partnerships and influences. This could see the continent becoming divided and weakened by competing alignments, leading to an increase in tensions and potentially hampering regional integration ambitions. However, an increase in African integration could boost the continent's economic power and political influence out to 2055, and could see it play an increasing role on the international stage.

Europe

Europe is likely to remain prosperous by international standards and enjoy significant cultural and scientific influence. However, while retaining significant global weight, Europe's share of the world economy may decrease. In the future, Europe may be subject to a range of potentially major shocks, including the expansion of Russian aggression, uncertainty regarding the ability to rely on US support, ongoing insecurity in Africa, Southwest Asia and the South Caucasus, and growing US–China rivalry. The region faces challenges in the form of an ageing population, shrinking workforce and increased migration, as well as the growing cost and impact of climate change. The combined impact of these pressures could result in increasing polarisation within as well as between countries, thereby weakening responses to shocks as well as resolve in the face of external threats. However, Europe may find a way to overcome these challenges, and play an increasingly influential role in the global balance of power.

Latin America and the Caribbean

Economic and social pressures, inequality, poor governance and corruption are likely to remain enduring challenges for Latin America and the Caribbean. Serious and organised crime, driven by the trade in narcotics, will continue to challenge the authority of some state governments, whilst also increasing its regional and global reach. The region's vast resource wealth, including 60% of the world's currently accessible lithium, will see an increasing range of external actors competing with established powers in the region through growing investment and infrastructure offers. Enduring tensions and growing competition between external actors could see the region increasingly divided, undermining coordinated action on climate change and environmental degradation. The coming decades are likely to see economic fortunes vary as states seek to diversify away from volatile commodity markets and the impacts of environmental change are increasingly felt. Political polarisation is likely to remain a key challenge for governments, hampering the region's social and economic development. However, new forms of innovation could see the region become a leader across the Global South on environmental protection, agrotechnology and other developments, boosting the economic performance and political influence of regional states.

Northern America

Both the US and Canada are likely to maintain their global economic and security footprints out to 2055. The US will strive to retain its economic and military lead, and both countries are likely to remain strong supporters of multilateralism and retain positions of global leadership. While strong transatlantic relationships are likely to endure, the future relationship between Northern America and Europe will be affected by both US security priorities and the strength of Europe. The US and Canada will also remain engaged in the Indo-Pacific region and Latin America, and increasingly the High North as its geography is altered by climate change. The region's wealth and institutional capacity indicate that it should be able to manage the impacts from climate change better than some others, but food and water supply, as well as internal and inward migration, are likely to present increasing challenges, alongside socio-economic inequality and demographic pressures. Technology is likely to remain a strength for the region, and regional states should continue to perform strongly across a wide range of technology sectors, with the potential to drive advances in automation and other disruptive technologies.

Shared spaces

The Arctic

The Arctic region will come under increasing pressure out to 2055. Climate change is having a more rapid and visible impact on the Arctic than anywhere else in the world. Over the next three decades, this could cause the geophysical characteristics of the region to change dramatically with major ramifications, including the alteration of ocean currents and weather systems, and impacts on biodiversity and fish stocks. Tourism, inward migration and urbanisation are also projected to increase. A growing array of states and companies will seek to exploit this emerging frontier, attracting economic migrants to a currently sparsely populated region with implications for societal dynamics. The effects of climate change and new technology advances could result in an increase in access to the region and lead to growing competition for Arctic resources, including on the part of commercial actors, as well as growing militarisation, placing increasing pressure on the Arctic Council. The willingness to collaborate on scientific research, protection of biodiversity and the rights of indigenous people could diminish.

The Antarctic

Climate change is projected to cause significant loss of ice in the Antarctic region, contributing to sea level rise and impacting global weather systems. While Antarctica's abundant hydrocarbon and critical mineral resources will remain difficult to extract in the near term, ice melt and technology advances may reveal new opportunities in the longer term, and increased global resource demand could see growing competition for Antarctic resources, heightening geopolitical tensions. Human activity in the region is already growing and could expand further due to increased fishing and tourism, placing further pressure on the Antarctic environment. States and commercial actors may increasingly position themselves for future opportunities, capitalising on scientific research to stake commercial claims or to deploy additional infrastructure, in some cases with the potential for military use in the region. The willingness of global actors to view the Antarctic as a

shared region of scientific endeavour is likely to come under increasing pressure. Future decades may see the increasing contestation of territorial claims. The 1991 Protocol on Environmental Protection will be open to review and potential modification from 2048 onwards; this could be a pivotal moment, potentially leading to an increase in extractive activity in the region.

Oceans

The world's oceans are likely to remain the dominant route for transporting goods and resources, with sea lanes and choke points remaining of geostrategic significance. However, the emergence of new economic centres of power, changing resource demands and the impact of climate and environmental change could result in altered routes and new zones of conflict and interest. Competition over maritime territories and resources is likely to increase, while a growth in offshore energy and digital infrastructure could create new pressures. Rising demand for deep ocean resources, including the abundant critical minerals which may be found on the ocean floor, may see these being increasingly contested, although the potential environmental impact of their extraction will remain poorly understood. Climate change and environmental pollution will continue to have a major impact on delicate marine ecosystems, as well as on the oceans' ability to modulate global weather patterns and atmospheric carbon. Emerging technologies could provide new options to monitor, mitigate and offset these impacts, as well as enabling access to new resources and potentially offering improved scientific understanding and expanded exploration of the deep oceans and seabeds. However, as competition in the maritime environment increases, rules and frameworks covering territorial claims and actions on the high seas may come under growing pressure, presenting challenges for maritime governance.

Space

Increasingly central to multiple aspects of modern life, space will become more congested and contested over the next three decades. As well as continuing to attract attention from the traditional space powers, space will become increasingly accessible to a wider range of state as well as non-state actors, resulting in new interests and alignments. Increasing competition in the space domain will see both state and commercial actors seeking to achieve dominance through technological breakthroughs, mindful of the potential for financial and strategic gain. The breadth of sectors supported by space will continue to expand, bringing new opportunities for environmental monitoring, agriculture and fishing, surface and sea mapping and communications, including increasingly widespread Internet access. The potential for resource extraction will also grow, including for use in off-planet activities. The dual-use character of many space-based capabilities may see the line between state, security and commercial actors becoming increasingly blurred. Competition could increasingly extend beyond Earth orbits, including to cislunar[1] space and other strategic locations. As space becomes increasingly congested and competition in the space domain grows, low Earth orbits could become unusable either due to accidental or deliberate action, potentially impacting on almost every aspect of modern life.

1 Cislunar is defined as: 'between the Earth and the Moon'. *Concise Oxford English Dictionary*, 12th Edition.

Cyberspace

While advances in processing and data storage technology will set the pace for the expansion of cyberspace, developments in advanced software incorporating features such as machine learning, artificial intelligence, quantum and other novel computing technologies will extend the possibilities for its use. As global connectivity continues to increase, this will offer opportunities for access to education, health care, entertainment and social interaction, with the potential to transform many aspects of everyday life. However, an enduring digital divide, affecting the rural poor in particular, will exacerbate other forms of inequality. The amount of time that individuals spend on activities in cyberspace is expected to increase, with digital identities and communities becoming increasingly relevant and influential, and a growing number of devices and infrastructure will be connected via the Internet, giving rise to an increasing prevalence of smart homes and smart cities. Cyberspace and cyber technologies may play an important role in mitigating and adapting to climate change, even as rising levels of cyber infrastructure contribute to its causes. Global power competition will play out in cyberspace alongside other domains, as control of data and advances in cyber technology become increasingly important tools. Cyberattacks are likely to become a growing feature of competition and conflict, with the lines between state and criminal actors becoming increasingly blurred.

Thematic areas

Society

A number of states will pass their demographic inflection points over the next three decades. In many of the world's developed countries, ageing and shrinking populations will pose challenges for economic growth models and social care. At the same time, many developing countries are projected to experience continued population growth, potentially offering new economic opportunities but also resulting in increased pressure on governments, and in some cases leading to rising levels of migration. Communities will become increasingly urbanised by 2055, but while some governments will invest in smart and sustainable city development, many people will continue to live in expanding informal housing settlements, presenting risks to health and security. Scientific and technology advances, as well as increasing access to human and societal data, are likely to see improvements in health and health care provision. However, rates of improvement will continue to vary, widening the gap between rich and poor, while non-communicable diseases, social care and mental health concerns will place an increasing burden on states. Increasing encroachment into animal habitats, as well as increasing interconnectedness and growing antimicrobial resistance, means that the risk of pandemics could grow. Middle class populations will expand across the globe, driving increased demand for resources, education and political influence; however, poverty and inequality will endure. History, culture, religion and family will remain important identity markers, but the growing use of cyberspace to generate new movements and drive or undermine social cohesion will grow significantly. This will place pressure on states and create new opportunities for manipulation by political and other elites.

Economy

Rising geopolitical tensions may lead to increasing economic volatility and uncertainty, casting doubt over previous projections for major economies whilst also resulting in the emergence of new centres of economic power. The global economy has not yet rebounded to pre-COVID-19 pandemic levels, and growth may continue to stall due to high levels of public debt in many states and growing geostrategic tensions that may potentially result in a widespread increase in protectionism. Moreover, sustainability and protection of the environment may surpass growth as a measure of success in the future. Automation and additive manufacturing (3D printing) will grow in importance. In the near term, however, traditional forms of mass production relying on extended global value chains are likely to continue to dominate manufacturing activity. The financial technology sector will continue to grow and may begin to surpass traditional financial institutions and structures, while digital goods and services are expected to gain significant economic weight. The use of cryptocurrencies may become increasingly widespread, although caution regarding their use may continue and regulation is likely to pose a challenge. The US dollar is likely to remain the world's primary reserve currency but may face increasing competition from other currencies. Approaches to economic governance may continue to diverge, potentially leading to increasingly regionalised approaches. Growing technology protectionism and an increased desire on the part of governments to de-risk critical supply chains may see states taking a more geostrategic approach to economic interdependencies, although in practice market forces will continue to dominate. The use of economic levers, including debt entrapment, de-risking activity and in more extreme cases sanctions and blockades, may increase as a tool of global power competition.

Environment

Atmospheric carbon dioxide levels, surface and ocean temperatures and sea levels are projected to rise significantly by 2055, with some regions experiencing more extreme changes. Climate change and other forms of environmental degradation will lead to shifts in rainfall patterns and a rise in the number and severity of extreme weather events. These will include droughts, floods and heatwaves, causing far-reaching and potentially permanent impacts, with some areas becoming uninhabitable. Combined with increasing urbanisation, this could lead to a 30% decrease in food yields and see 60% of the world's population suffering some degree of water stress by 2055. Expanding human activity, waste production and climate change are causing biodiversity loss at unprecedented rates, with implications for the natural environment and food chains. Demand for energy will continue to rise, but fossil fuel use is expected to peak before 2055, with other forms of energy, including nuclear, solar, wind, hydroelectric and potentially tidal and wave power, increasing their market share. A range of other technologies are also being developed that could offer additional solutions. In the near term, it is plausible that an increase in demand for the critical minerals that support the green energy and wider economic transitions could lead to new geostrategic rivalries and tensions. In the future, technologies to better monitor the environment, biodiversity and human activity, as well as re-greening strategies, carbon capture technologies and other forms of geoengineering, may offer ways to reduce the impacts of a shifting climate and changing natural world. While global power competition is likely to be a significant determinant of the rate and manner in which the world addresses climate and wider environmental challenges, the urgent need to address what many states have recognised as a climate emergency may offer a platform for cooperation.

Information and technology

Future decades could see an exponential growth in the availability of data and reliance on its use, as well as in the capacity and reach of technology. As the volume of global data generation grows and storage and processing become more efficient, data is likely to be increasingly essential for government and business decision-making. As a result, access to data is likely to be a key component of global power for both state and non-state actors. Improvements in communications technology will boost connection speeds and reliability; and as Internet coverage becomes increasingly widespread, societies and economies could be transformed, seeing significant benefits. Quantum computing has the potential to substantially accelerate problem-solving. While artificial intelligence could bring significant benefits in a wide range of socio-economic areas, regulatory frameworks may struggle to keep pace, presenting a growing risk to individuals and societies. As a result of technology advances, a range of fields, including transport and logistics, manufacturing, health care, food and energy production and communication, could all look significantly different by 2055, and governments and societies will need to remain agile to keep pace with the societal, political and economic changes which will result from this.

Conflict and security

An increasing range of security actors, including non-state, is likely to lead to a more congested and complex landscape out to 2055. Global defence spending continues to rise; this, together with investment in new technologies, has the potential to fuel instability and increase the risk of miscalculation in future. While many existing alliances are likely to endure, states may seek to diversify partnerships, in some cases through the use of proxies and clients, while retaining ties to multilateral organisations. Changing energy and resource demands and new centres of production and services could drive the emergence of new security interests in a wider array of regions and shared spaces. The impact of climate change on governments and societies, including potentially threats to the territorial integrity of some states, could lead to new and growing security challenges. In an increasingly interconnected world, social, economic, health and technological shocks could rapidly spread and prove major sources of instability. The increasing blurring of the boundaries between diplomatic, information, military and economic levers of power may undermine the global institutions and frameworks intended to prevent escalation into conflict. An expansion in the number of nuclear-armed states fielding more powerful weapons, combined with new weapons of mass effect, could create new challenges. Economic challenges, demographic changes, green energy transitions and technology advances could see states and other actors pursuing widely different forms of combat power in the future, although mass and conventional means of power projection will remain important. In an age of increasing uncertainty, the need to build resilience, agility and new forms of deterrence, while restoring trust amongst international actors, will be paramount.

Global drivers of change

One of the key purposes of this publication is to identify the drivers of change that are most likely to determine what the future might look like. Looking across regional and thematic analysis, six global drivers of change have been identified, which connect to one another, along with 22 underlying trends. Taken together, these drivers and trends represent a complex set of dynamics that may influence, counteract or accelerate each other, often in unexpected ways.

The six global drivers of change

1. Global power competition. In an increasingly multipolar world, the persistent competition between the United States (US) and Western governments with China and other non-Western powers is intensifying. In the future, however, this competition will take place in a much more crowded space, with a wide range of actors hedging their positions to secure their own interests. The influence of middle powers, new blocs and networks of non-state actors may grow, and their strategic choices may affect the global balance of power in unexpected ways. For example, as average launch costs fall significantly, space will become increasingly accessible to new actors, enabling commercial entities and non-state actors to be at the forefront of space exploration and shift traditional patterns of power. In some cases, even small states working together on specific issues will be able to exert a degree of global influence. Alongside this, violent extremist organisations and serious and organised crime groups will seek to exploit increasing political polarisation and a decline in social cohesion to advance their own agendas. Together with transnational organised crime networks, they are likely to expand their influence and pose an increasing challenge to states. The increasing sophistication and availability of digital tools and the growing dependence of most societies on cyberspace will increase the opportunities for illicit actors to do harm.

2. Demographic pressures. Population increase will continue to be unevenly spread across the globe. Most population growth will take place in Africa, South Asia and parts of Southeast Asia and Oceania, which will be faced with the challenge of providing meaningful education and employment opportunities for their young populations. In contrast, other parts of the world, such as East Asia and Europe, are already experiencing slowdowns in population growth and in some cases are already entering population decline. Looking forward, some countries will face a collapse in birth rates and much faster population decline than expected. At the same time, advances in modern medicine, combined with a better understanding of the various factors that contribute to a healthy life, mean that people around the world are likely to live longer. While this will not offset the overall slowdown in population growth, it does mean that the average age in individual countries and the world as a whole will continue to rise. The combination of these factors will have a major impact on health and welfare systems, as well as on economic models and patterns of employment.

Increasing migration will continue to influence global and regional demographics in unexpected ways and could drive economic development but also societal tensions. In parallel, the global middle class will grow, particularly in Asia, which will continue its economic rise, creating new economic opportunities and markets. Although most people will live in urban areas, human habitats will change dramatically. There will be rapid population growth in some areas alongside decline in others, and states will see the development of smart cities and city networks.

3. Climate change and pressure on the environment. Human impact on the natural environment and climate system continues to have far-reaching consequences, putting significant pressure on societies and economies and threatening the very existence of some states. Rapidly growing efforts to mitigate and adapt to its impacts are likely to become an increasing priority for governments. In some cases, governments may need to divert resources from economic and social development towards climate change response policies, especially if investment continues to be delayed. The extraction of key resources, including fossil fuels and critical minerals, will continue in a global society that demands technological progress, improved lifestyles and wider and more convenient digital access. Pollution, habitat destruction and overexploitation continue to threaten biodiversity and ecosystem services and are likely to increase.

The rapidly changing and degrading environment and the use of unsustainable agricultural practices will lead to a decrease in food and water availability in some regions. While this will affect some countries more than others, those with large, and in some cases growing, populations are likely to be most affected, thereby amplifying the impact. A combination of climate change and technological advances will increase the accessibility of previously hard-to-reach areas, opening up new reserves and making them commercially viable. The polar regions, oceans and space are likely to see increased international interest as potential locations for resource extraction.

4. Technological advances and connectivity. As technology advances, it is not only becoming more widely available but also more integrated into societies and economies. The exponential growth in sensors, data, storage, processing power and connectivity will drive improvements in virtually every area of human endeavour. This will be complemented by advanced data analytics, which will extend the use of automation and artificial intelligence in both societies and economies. Increasing technological sophistication means that the boundaries between the physical, digital and biological worlds will become increasingly blurred. Advances in biotechnology may make it possible to cure previously untreatable genetic conditions and diseases, while the augmentation of human capabilities could transform some aspects of human life. However, while technological advances will provide solutions to many of the world's problems, developments such as the weaponisation of technology will create new challenges for governments and societies across the globe.

More people will have access to the virtual world and the number of connected devices will increase. Technology advances will enable faster transmission speeds and provide new ways to connect, even in remote areas. Digitalisation will fundamentally change the way people interact at home and at work, with data and knowledge becoming key commodities. Information will play a central role in shaping perceptions and behaviours, and the ability to provide the more compelling narrative will be an essential influencing tool.

A key element of the ongoing global power competition – the race to dominate the future digital order – has already started. The increasing importance of technology to societies

and economies is driving both state and non-state actors to compete for access to, and control of, the latest technologies. In the future, this competition for technological advantage will intensify, increasingly influencing global power relations and trade.

5. Economic transformation and energy transition. Technological advances will have a huge impact on economic activity and energy systems. Artificial intelligence-driven automation and new production methods, such as additive manufacturing (3D printing), will transform economies and industries, create new resource demands, and change global value chains in far-reaching ways. The speed of the transition will put pressure on adaptive capacity, with failure to adapt potentially leading to societal disruption, grievances and tensions.

The global economy will be strongly influenced by geopolitical competition, which may lead to economic fluctuations and changes in investment patterns and trade flows. Increasing trade regionalisation, the onshoring of production and rising protectionism may even lead to some degree of deglobalisation, reversing the steady growth in international trade and development of global supply chains that the world has experienced in recent decades. Nevertheless, large multinational corporations will continue to consolidate their resources and capabilities, enabling them to expand their influence and become powerful global actors. Despite the recent slowdown in the Chinese economy, Asia's relative economic influence will continue to grow, driven by its expanding middle class, growing consumer power and production of high-value products.

Global demand for energy and resources will continue to grow and is expected to double by 2055. Although demand for fossil fuels will remain significant, major investments in renewables and alternative energy sources are likely to dramatically change global energy systems and infrastructure. Those fossil fuel exporters that fail to diversify are likely to face major socio-economic challenges. On the other hand, decentralised renewable energy systems will provide new economic and social development opportunities in many developing countries. The increasing requirement for renewable energy will lead to growing competition for access to critical minerals and clean energy technology know-how. Energy will continue to be a critical driver in global geopolitics and the uncertainty created by the rapid transition may lead to its growing securitisation.

6. Inequality and pressure on governance. While the world has witnessed significant progress in extending access to education, health and information, global inequality continues to rise. This is driven by factors such as the technology-driven transformation of economies and increasing concentration of wealth, but also slowdowns in global economic growth, increasing intolerance and discriminatory politics in some societies, corruption, insecurity and conflict, all of which exacerbate existing socio-economic imbalances. At the same time, there is a growing awareness of inequities which, alongside recent setbacks in poverty reduction, could lead to internal unrest if not addressed.

The demand for access to economic opportunities, personal freedom and better public services, together with the impact of climate change, will in some cases drive people to seek a better life elsewhere. Most countries will be affected by population displacement in some way, either through emigration and the resulting brain drain or through inward migration. A growing middle class will also place increasing demand on public services and government performance. Overall, citizens with greater mobilising power will place a strain on political leadership, whether authoritarian or democratic, and challenge the legitimacy of governments, potentially leading to growing divisions and social and political polarisation.

The five core contradictions

Taken together, the six global drivers of change will redefine societies, economies, governance, security and defence, as well as the natural world itself. However, sitting alongside the six drivers are five core, interacting and dynamic contradictions, as illustrated in Figure 1.

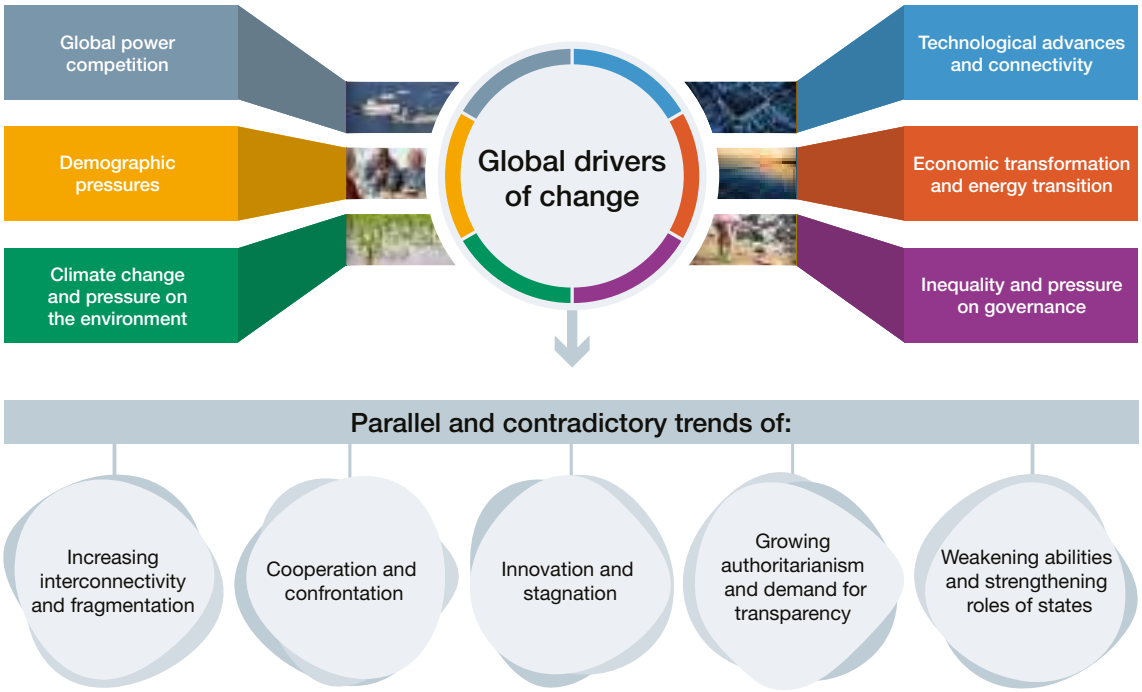


Figure 1 – Six global drivers of change and five core contradictions are shaping the future

1. Increasing interconnectivity and fragmentation. The interconnectedness and interdependency of global economies has been brought into sharp focus in the past few years. The world is more connected than ever before. New levels of digital connectivity have changed lifestyles, working and consumption patterns. Digital trade and levels of e-commerce have surpassed the value of traditional commerce and accelerated the reach of some multinational corporations, as well as that of organised criminals.

However, the global impact of the COVID-19 pandemic has seen the emergence of enduring economic pressures, some of which have been compounded by the war in Ukraine. Governments' attempts to secure global supply chains and address critical dependencies have resulted in an increase in protectionism and economic fragmentation. The widespread imposition of sanctions against Russia has resulted in economic decoupling and energy trade shifts by some states. Despite recent record levels of trade, the ongoing tensions between the US and China and their competition for technological dominance add to continued global economic disruption. Instability and conflict continue to endure, with drivers of stress beyond the immediate effects of the pandemic causing high levels of state fragility and tensions in many parts of the world, including Africa and Southwest Asia.

2. Cooperation and confrontation. As states and societies continue to recover from the COVID-19 pandemic, competition between the US and its allies and partners on the one hand and China, Russia and other authoritarian states on the other has accelerated and sharpened. Flashpoints in the Indo-Pacific region, including North Korea and Taiwan, have again come into focus, while the 2022 Russian invasion of Ukraine constitutes the highest level of aggression seen in Europe since the Second World War. The attack on Israel and subsequent events have demonstrated the continued fragility of peace in Southwest Asia, despite attempts in recent years to build a regional rapprochement. Climate geopolitics remain fraught, and the divide between the developed world and the Global South is increasing. In a world where positions are hardening and the willingness to compromise appears to be declining, global institutions are struggling to retain their relevance.

In contrast, the Russian invasion of Ukraine has seen the West pulling together in its efforts to sanction Russia and increase its ability to defend itself against aggressive authoritarian states. The North Atlantic Treaty Organization (NATO) has been revitalised and enlarged. Germany has made a historic change to its national foreign and security posture. Although international institutions remain under pressure, some significant progress has been achieved. For example, United Nations (UN) member states recently adopted the world's first international treaty to protect the high seas and its remote ecosystems. International institutions continue to be engaged around the world in conflict and humanitarian response emergencies, and on environmental issues. Overall, the UN remains an important arena for global diplomacy. Regional cooperation continues to expand and is becoming more effective. The 'global middle ground' has risen in prominence and influence on the international stage, and out to 2055 may influence new patterns of cooperation.

3. Innovation and stagnation. Recent years have seen significant setbacks in human development. Only 12% of the UN's Sustainable Development Goal targets currently remain on track, while there has been a decline in performance on 30% of them.[1] Reversals of previously positive trends in gender equality and poverty are particularly concerning. Irregular migration and refugee flows have increased, and emerging economies face a bleaker future, including the risk of debt distress.

In parallel, though, the world is also seeing some positive developments. Exceptionally rapid efforts on a global scale to develop vaccines against COVID-19 have changed the blueprint for dealing with illness and disease, including the potential eradication of malaria. The war in Ukraine has presented opportunities to decouple economies and energy security from fossil fuels and accelerate the transition to renewables in Europe and elsewhere. In 2022, the US introduced the biggest national climate package ever seen through its Inflation Reduction Act. The development of green technologies has taken new steps forward and is already helping to reduce emissions, while bioengineering may give rise to significant opportunities in a range of areas, from health to food security and beyond.

1 Independent Group of Scientists appointed by the Secretary-General, United Nations (2023), *Global Sustainable Development Report 2023: Times of crisis, times of change: Science for accelerating transformations to sustainable development*.

4. Growing authoritarianism and demand for transparency. The number of states considered to be fully democratic has declined in recent years. Institutions that provide checks and balances, one of the building blocks of a healthy democracy, are under pressure and are becoming increasingly politicised in many countries. Presidential term limits continue to be challenged in some parts of the world. Some apparently democratic states have seen increasing levels of ethnic, religious and gender-based discrimination, while others have in practice turned into electoral autocracies. Many existing authoritarian states, such as China and Russia, have become more authoritarian, with expanding levels of state control over the last decade.

In contrast to this, a trend of rising human empowerment, driven by increasing access to information, education and other services, is boosting the potential for public mobilisation. Mass protests against discrimination and the erosion of democratic principles have been seen in many countries. Corrupt governments that fail to deliver equitable and sustainable economic development are increasingly under pressure. Internal public outrage and protests against the harsh methods used by the Chinese government to control the COVID-19 pandemic illustrate that even the strongest authoritarian states are likely to be challenged when events and actions lead to societal tipping points. Open societies continue to be more attractive to talented and skilled individuals than closed ones with limited personal freedoms.

5. Weakening abilities and strengthening roles of states. In many respects the COVID-19 pandemic saw the return of the strong state, with democratic as well as authoritarian governments imposing contingency laws and measures to protect public health and lessen the impact on employment and economic growth. Whether or not this trend endures, there are a number of technologies at the disposal of governments that could make state governance more efficient in the future, while at the same time extending their ability to monitor and control their populations. Digital technology may increasingly act as an enabler for state governments, enhancing state capacity. Governments will increasingly exploit technology to prepare, avoid and respond to crises, leveraging data to inform decision-making and using digital communication methods to communicate messages quickly and effectively to a large audience. In developing countries, technological innovations are resulting in development 'leapfrogs' whereby governments are able to shortcut slow and costly stages of infrastructure development and move directly to more advanced (and often remote) forms of service delivery.

At the same time, the pandemic and the war in Ukraine have significantly increased state fragility and inequality in large parts of the world, and today the number of countries facing high levels of instability is significantly higher than it was at the end of the last decade.[2] Ageing populations in many of the world's developed states are leading to increased pressure on state health, welfare and pension budgets, at the same time as decreasing working age populations are leading to a decline in tax revenues. The cost of living crisis is driving social fragmentation in both developed and developing countries. The increasing pervasiveness of social media appears to have provided a platform for toxic politics and hatred, fuelling division. Single issue protest groups have seen their profile rising across the globe. Corruption still constitutes one of the greatest threats to legitimacy in a number of states, as well as exacerbating inequalities. Serious and organised crime is constantly expanding at the expense of state governments.

2 The Fund for Peace (2023), *Fragile States Index Annual Report 2023*.

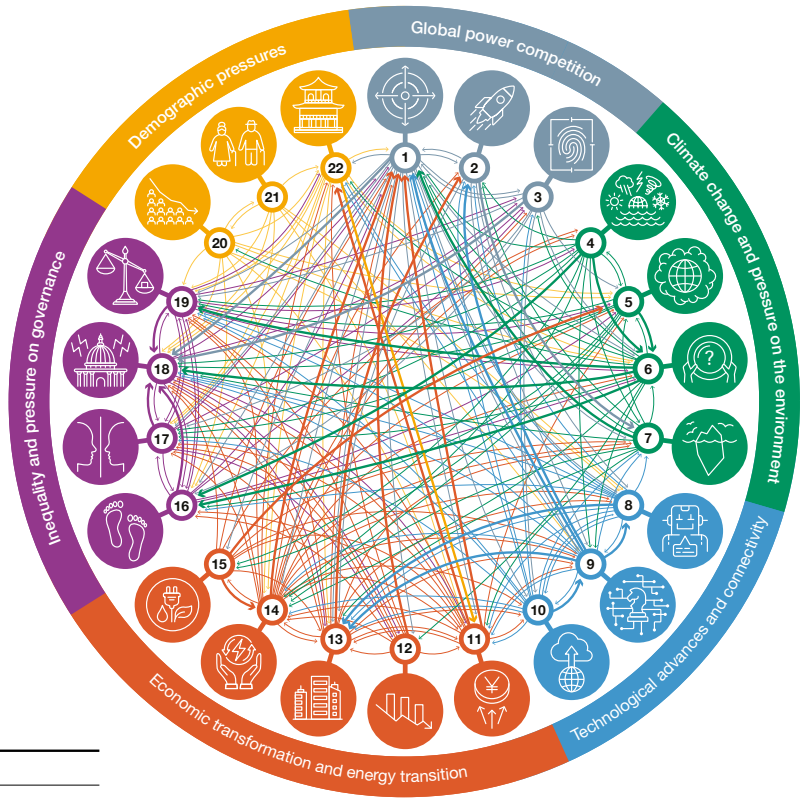
Impact, uncertainty and the ‘big questions’

Impact and uncertainty. The extent to which the six key drivers and their associated contradictions shape the future will be determined by how they play out in practice. A driver’s influence will vary over time, and interact with other developments in different, often complex ways. The contradictions will shape and re-shape the underlying context of the drivers of change, and a number of associated trends within the drivers will influence their speed and direction and the possible disruption they cause. As a result, a simple extrapolation of one or even a few indicators of change will not give a comprehensive picture of the future. No matter how strong the signals are, there will always be a degree of uncertainty about the direction change will take, particularly over a long period of time.

Figure 2 represents some of this complexity. It presents perceived uncertainty about the actual manifestation of trends and how they relate to the impact they might have in the future. The outliers with a higher or lower element of (subjective) uncertainty and impact may require particular attention.

Figure 2 – Impact and uncertainty assessment, based on in-depth analysis of the regional and thematic areas, and engagement with the Development, Concepts and Doctrine Centre’s global network of strategy and foresight practitioners

However, the drivers and trends do not exist in isolation to one another and they may vary in relevance depending on the thematic or regional perspective. As such, the extent to which they influence each other is another factor to consider when setting strategic priorities with limited resources. It is therefore not only necessary to monitor trends with major impact and high uncertainty, but also to consider the interaction of these trends. Some are likely to have a greater effect on others, thereby indirectly amplifying their impact.



Influence

High ——————

Medium ——————

1. Regional and global power competition will become increasingly prevalent.
2. The democratisation of space will enable commercial entities and non-state actors to become the forefront of space exploration.
3. The capability of violent extremist organisations and organised crime groups to do harm will increase.
4. Climate change will cause more extreme weather events and rising sea levels globally.
5. The pollution and degradation of the environment will increase.
6. Food and water insecurity will become increasingly prevalent.
7. Climate change and technological advances will open up access to new regions, domains and resources.
8. Societies and economies will become increasingly automated and artificial intelligence-dependent.
9. The competition for technological edge between companies as well as between states will be increasingly evident and intense.
10. Global digital connectivity will continue to increase along with the rising value of data.
11. The relative economic influence of Asia will grow.
12. Geopolitical competition will lead to a slowdown in global trade.
13. The power and influence of big corporations will continue to grow.
14. The global demand for energy and natural resources will increase.
15. The world will become less reliant on fossil fuel energy.
16. The number of migrants will increase globally.
17. Political and social polarisation will increase.
18. A growing number of parallel stress factors will increase pressure on traditional governance structures.
19. Socio-economic inequalities will increase.
20. Global population growth will slow down with some regions experiencing a decline.
21. The average age of the world population will increase.
22. The Asian middle class will continue to grow significantly.

Figure 3 – Cross-impact analysis, showing the links between different trends[3]

3 Note: analysis clearly shows that almost all underlying trends are connected in some way and influence each other to varying degrees. This visualisation only shows the 'medium influence' and 'high influence' links (thinner and thicker lines).

The 'big questions'. From this analysis it can be argued that there is an overarching set of global themes of uncertainty, which prompts a series of big questions.

The pace of research and development in the technology sector always creates a degree of uncertainty when trying to anticipate technological progress. Will Moore's Law[4] be relevant into the future? To what extent will the physical and virtual worlds blur? However, it is not only the technical aspects of new science and technology developments that are uncertain. Perhaps more important is how people, societies and states will adapt to developments, and whether the way humans think and behave fundamentally changes in response.

Over the past two decades, the need to adapt to and mitigate the effects of climate change has become widely accepted. The question is how states will balance the desire for economic prosperity and social stability with the need to address the climate crisis. There are now energy transition policies in place in most developed and developing countries. However, while there is a drive to reduce the use of fossil fuels, there is not yet a full understanding of what their remaining share of the overall energy mix will be by 2055. What will be the critical natural resources over which states and corporate actors compete? How will this impact global and regional trade dynamics? Will there be a significant deglobalisation and decoupling of the world's economies as competition increases and international trade appears to be slowing down? Will the climate crisis be magnified as governments come under increasing pressure on a range of other issues, including, for some, the need to adapt to a peaking and ageing population? Or, will governments embrace the opportunity to drive a low carbon economic transition?

It has become increasingly clear that a vast number of uncertainties surround the future landscape of global governance. Central to this is the question of how great power competition will influence international relations and thereby alter the course of events. What will be the impact of global power competition on middle powers? Is the likelihood of regional conflicts rising amid escalating global competition? Will China emerge as the world's leading power, possibly surpassing the US? What is the future global influence of the US; what is the political evolution of Russia; the fate of multilateral institutions such as the UN; and what are the underlying factors that could lead to greater cooperation between states? Finally, increasing pressure on state governments leads to the pressing question, for Western countries in particular, of the future of democracy as a form of governance.

4 Moore's Law states that the number of transistors on a microchip doubles about every two years, though the cost of computers is halved.

NORWEGIAN SEA
ICELAND
Reykjavik
Mt. Hekla
4,747
Faroe Is.
(DENMARK)
Shetland Is.
(U.K.)
Orkney Is.
Cape Wrath
Rockall
(U.K.)
Hebrides
SCOTLAND
Aberdeen
Edinburgh
Glasgow
UNITED
KINGDOM
NORTHERN IRELAND
Belfast
IRELAND
Liverpool
Dublin
WALES
Cork
Cape Clear
Birmingham
London
Portsmouth
Plymouth
Land's End
English Channel
Brest
Lorient
Nantes
Bordeaux
Bay of
La Coruña
Cape Finisterre
Vigo
Oporto
PORTUGAL
Trondheim
Bergen
Stavanger
NORTH
SEA
DENMARK
Copenhagen
Hamburg
NETH.
Amsterdam
GERMA
BELGIUM
Le Havre
Paris
Orleans
FRANCE

The future world order

Global actors

A broad range of influential actors, including states, international organisations and non-state actors, will continue to shape global and regional developments out to 2055. Although the United States (US) and China are by far the most powerful states at present, and are likely to remain highly influential in the long-term future, both face considerable domestic challenges, which may disrupt their standing. While today's middle powers are likely to retain a certain degree of influence, emerging powers, new blocs of states and non-state actor networks may expand their outreach, and their strategic choices may influence the global power balance in unexpected ways. In some cases, even small states working collectively on a specific issue may exert a degree of global influence. However, although it remains uncertain which actors will carry the most influence by 2055, there is a clear trend towards power diffusion and a more crowded stage. Whether states will even be the predominant actors in the long-term future is becoming increasingly uncertain.

State actors

United States. Over the next three decades, the increasing competition between the US and China will be a key driver for the former's behaviour as a global actor. The US will not easily give up its status to China, and out to 2055 geopolitics will be heavily characterised by the contest for global influence between these two giants. How this competition will play out remains one of the key uncertainties of this century.

The US has lost its status as global hegemon in a unipolar world in recent years and, going forward, it is likely to see a further reduction in its relative global influence. Even so, it is likely to remain one of the most powerful (and attractive) states in the world for the foreseeable future, and will still be relied on by many as the leader of a huge network of alliances and partnerships stretching across the globe. The US will continue to benefit from its deep underlying strengths, including its huge geographical size, population and natural resources, as well as the scale and outreach of its economy and financial markets, its expertise in scientific research and technology, its military power and its attractiveness to talent. While the US has traditionally relied on the skill, technological edge and sheer size of its armed forces to sustain its global outreach and military supremacy, it remains uncertain whether the country will succeed in sustaining its advantage in the future, with China catching up in key technologies and even bypassing the US to some extent in critical mass.

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The United States has great fundamental strengths, but the extent of its global power in 2055, and willingness to exert it, is uncertain

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Over the next three decades, the greatest challenge to the global position of the US will potentially come from the growing internal pressures that the country faces. These include rising inequality, an expanding health care crisis, the increasing impact of climate change and profound levels of distrust in state institutions, all of which could drive further political polarisation and weaken US democracy. However, as seen throughout its history, the US has repeatedly faced and overcome significant challenges and crises, particularly when faced with major external threats. A skills and learning environment that is able to exploit and benefit from technology-driven economic and social transformation, without driving further divisions within society, will be key in determining whether the US will succeed in maximising on its huge potential going forward.

Out to 2055, the consistent engagement and leadership that the world has come to expect from the US may not continue. The country's role as a global actor will be more unpredictable, and the question of whether it will continue to intervene actively in global affairs or retreat into isolationism remains uncertain. While its huge corporations and technology giants could contribute to its national strength, there is also the chance that their power could rise to such an extent that they could rival state governance structures. Whatever the outcome, how others perceive the US' status in the international system will be a key influence on global strategy and policy direction in the future.

China. After three decades of spectacular levels of economic performance, China has now established itself as a global power. There is already a degree of Chinese presence in every region of the world and almost every aspect of human endeavour, and China's reach is likely to continue to extend in the future. It is this rise as a global power that constitutes a central element of today's intensifying global power competition. While China's challenge to US dominance makes it a direct competitor to the US, several other states and organisations are increasingly wary of China's growing influence and ambitions.

Out to 2055, China will actively seek to restore its status in a reformed global order, encouraging the development of a new version of multilateralism centred around the coexistence of major powers operating within their own spheres of interest. While China is likely to continue to support the existence of international institutions and rules, it will wish to see these increasingly brought under strong Chinese influence and economic control. However, whether the People's Republic of China will achieve this great rejuvenation by the time it celebrates its centenary in 2049 is far from certain. Continued progress towards prosperity and economic development – on which the legitimacy of the Chinese Communist Party rests – is becoming increasingly difficult due to a range of complex challenges such as climate change, water scarcity, an ageing population, slowing economic growth and growing debt, and extensive inequality. The recent Chinese economic slowdown means that the question of whether or not it will surpass the US economy is now more uncertain, and one plausible outcome is that the US and Chinese economies will be of similar size for a significant period of time. However, China's biggest challenge is perhaps the pressure from an ever more demanding urban middle class, at the same time as a more authoritarian and assertive leadership is increasing the risk of military confrontation.

China's global strategy is likely to be centred around a desire to limit the outreach of its competitors while itself being strong enough to prevent hostile containment. Its economic weight, together with its self-promotion as an alternative development partner for the Global South, will be key tools in this. China will continue to use economic interdependencies, underpinned by military strength, as core means to achieve its objectives. Grand economic investment and trade initiatives, such as the Belt and Road Initiative and Global Development Initiative (and new versions in the future), will be used to boost economic integration between China and the rest of the world and expand Chinese influence both economically and militarily. China is also likely to exploit its technology development capabilities to play a leading role in standard setting and technology regulation, as well as seeking to expand its influence through its hugely influential gaming and film industries.

China's armed forces have undergone a rapid modernisation in recent years, with sustained efforts to improve the People's Liberation Army's (PLA's) position as a leading military force. Despite the current economic slowdown, the PLA will remain an essential instrument in asserting China's status as the leading regional and potentially a major world military power. Investment in mass, space exploration and technologies providing asymmetric advantage will be important elements of this. China is also likely to seek to expand its system of military bases to protect its economic investments and access to global trade routes.

China will refuse to compromise on its core security interests, including its position on Taiwan. The potential use of economic warfare, including sanctions and the decoupling of trade, by the West in response to any heavy-handed action will drive China to review its own critical value chains and strategic resilience, which may strengthen it in the long term. The war in Ukraine will continue to be a concern for China as the long-term implications remain highly uncertain. However, even a weaker Russia may play a useful role in helping China to achieve its global ambitions, by maintaining pressure on Europe – giving China more freedom of action – and potentially as part of a Chinese-dominated Eurasian bloc.

Russia. While Russia lost a significant degree of power following the collapse of the Soviet Union, its strategic posture and significant resources mean that it still retains global influence. However, its enduring domestic challenges – including an ageing and declining population, the impact of climate change on its agricultural production and infrastructure, poor economic performance and overdependence on fossil fuel exports, and high levels of corruption and serious and organised crime – will continue to influence its long-term outlook. The war in Ukraine is compounding these challenges, with Russia seeing the departure of around a million skilled young people and a major decoupling from Western economies. The war has also seriously weakened and damaged the reputation of the Russian armed forces. Taken together, these factors have the potential to drive internal instability and separatist movements, which will in turn add to Russian perceptions of vulnerability to destabilisation by external forces and powers. As a result, the trajectory that Russia will take over the next decade remains highly uncertain.

The desire to retain or regain status as a 'great power' will remain a key driver for Russian behaviour. Russia will continue to view the world order as a multipolar one dominated by hard competition – over resources, values, influence and markets – and it is likely to continue to regard the US and its Western allies as hostile powers aiming to deliberately weaken it and reduce its influence. The 'Russian Nation' – a conceptual view of a Russian world bound together by a shared understanding of history, values, culture, traditions and supremacy, but not necessarily ethnicity – will continue to form an integral part of Russian thinking and influence its perception of its geographical scope as extending beyond the Russian Federation. Due to its long history of invasion, Russia's near abroad and maritime access – including access to the Arctic, which is once again becoming important for Russia – will continue to be a key consideration in Russian strategy.

Despite its many challenges, Russia could remain a power with global outreach and influence. It is the largest country in the world (double the size of the US), resource rich, a permanent member of the United Nations (UN) Security Council and a nuclear arms power; it has strong bonds with many states in the Global South and makes use of proxies and non-state actors to reinforce its reach. Faced with demographic decline and limited economic resources, the military instrument of power – particularly its nuclear capabilities – will continue to be key to Russia's status as a global power.

Regardless of whether the current regime survives or not, future Russian leaders are likely to make every effort to recover Russia's strength and position in the international system. However, to recover, Russia is likely to become increasingly dependent on support from China and other countries such as India and Iran; as a result, Russia's position in the international system may look very different in the future. Russia's long-term trajectory may see the country recover and continue to play an independent role in the future world order; alternatively, it may be subsumed into the Chinese sphere of influence, collapse completely, or suffer from enduring internal instability, thereby constituting a major challenge to global stability. An outlying possibility, though not implausible in the long term, is that Russia could constructively engage with Europe again.

India. Already a regional power, India has the potential to exert increasing weight in the global political order. Its geographic position, together with its status as the world's most populous country, largest democracy and one of the top economic powers, means that it will have a significant influence on the world's trajectory over the next three decades, shaping regional and global power dynamics.

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India faces several challenges in the coming decades but has the potential to be a global power

However, India will continue to face a range of challenges out to 2055. It will remain highly vulnerable to the impact of climate change and natural disasters, its massive population will demand greater employment and wealth creation opportunities, and its enduring border disputes with China and Pakistan are unlikely to be resolved and may result in further conflict. However, along with these challenges comes the chance for great reward. India may succeed in capitalising on its demographic dividend over the next few decades, boosting economic growth and social development. Its commercial sector has the potential for rapid domestic and international growth, and science and technology development may provide opportunities for an expansion in connectivity, digital trade and space exploration. An increasingly outward-looking approach to world affairs may enable it to establish bilateral agreements with a range of states with varying geopolitical views, giving it significant influence over global and regional power relations. If India succeeds in realising its economic and demographic potential and can expand its global economic, diplomatic and military outreach, it may well join China and the US as another global power by 2055.

A key question for the future global power balance will be whether India shifts its policy of non-alignment, and either builds its own power bloc (possibly with aspirations to become the leader of the Global South) or joins forces with another bloc or actor. It has a close and long-standing relationship with Russia (and formerly with the Soviet Union), particularly in the areas of arms procurement (where Russia is India's leading arms supplier) and purchasing Russian energy supplies. However, in recent years, India has increased its cooperation with other actors such as the US, France, Australia and Japan, and has extended its strategic outreach through bilateral agreements with states in the Indian Ocean, Africa and Southeast Asia. Out to 2055, a weakened Russia, under heavy influence from China, may see a deterioration in Russia–India relations. Alternatively, a more unpredictable and isolationist US, alongside a more influential China, may see China succeed in building a closer relationship with India, capitalising on its status as India's second biggest trading partner, and providing a boost to organisations such as the Shanghai Cooperation Organisation and regional trade agreements. However, a more likely scenario is that the competition for influence between China and India will escalate significantly.

Middle powers will play an increasingly important role in the future

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Middle powers. Today's two superpowers, China and the US, tend to be the primary focus in any discussions about global power competition. However, out to 2055, a number of less prominent but still powerful states (often referred to as 'middle powers') will have the capacity to influence the global power balance based on a combination of their diplomatic outreach, economic influence and military power. In addition, some states will be considered as middle powers because of their role in the international system and its institutions rather than as a result of their economic or military capabilities. Over the next three decades, if middle powers begin to build blocs and closer cooperation amongst themselves, they could become increasingly influential and may even challenge the global economic and political dominance of the existing superpowers. Alternatively, future years may see increasing competition between middle powers, creating a more complex global dynamic.

The range of states currently regarded as middle powers represents a diverse range of perspectives and interests, and going forward all will have their own distinct approaches to international engagement. Global legal and normative frameworks bring clear benefits to states through the principle of reciprocity by which countries will abide by their international legal obligations in good faith. For middle powers, this may enable them to use their influence to best effect and potentially act as a restraint on the most powerful states in the system, although the way in which these states regard the current international system will differ. Some, particularly those who see themselves as rising and future great powers, may be inclined to favour change, including reform of the UN Security Council to increase the role and influence of middle powers within the organisation.

The UK and France are likely to retain their considerable global outreach over the next 30 years. Although they have seen their relative influence decline in recent years, they continue to wield significant economic and military power. Both are nuclear arms powers with permanent seats on the UN Security Council and both are regarded as desirable and capable partners, as well as being highly attractive to global youth through their language training and other forms of education provision. Its dominant role in

the European Union (EU) provides a powerful lever of influence for France, while the UK benefits from its links to the US and its relationships through the Commonwealth. In addition, given its geographical location, shared security challenges and the huge extent of existing trade relations, the UK is likely to maintain its close cooperation with European partners and the EU in the future. Out to 2055, both powers can be expected to maintain a degree of global influence through the pragmatic use of these various levers of power, and by taking a leading role in addressing global issues such as climate change, corruption and the regulation of artificial intelligence. However, domestic factors such as economic constraints, socio-economic tensions and separatist movements may constitute major challenges.

Germany and Japan currently wield power chiefly through their economic weight, but in the future, this may change: in Japan, through further changes to its constitution, and in Germany, as changes to its security and foreign policy profile lead to a new strategic culture being developed. Japan and South Korea, another middle power, have the clear potential to build partnerships with other powerful Asian states, including India, which could see the emergence of new and highly influential blocs in the Indo-Pacific region. At the same time, both Japan and South Korea are likely to retain their alliances with the US, and an alternative outcome, depending on the US' long-term posture, could see them becoming part of a stronger US-led alliance in the Indo-Pacific region. Elsewhere, Canada and Australia have economic influence and are regarded as respected, attractive partners, and they are likely to retain their status as important middle powers due to their global posture and outlook.

Emerging middle powers, including Indonesia and other Southeast Asian states, Pakistan, Saudi Arabia, Iran, Turkey, South Africa, Nigeria and Brazil, may become increasingly influential over the coming decades. In Southwest Asia, the wealthy Gulf states have some potential to exert influence through regional cooperation initiatives, particularly if they succeed in diversifying their economies, but how this plays out in practice will depend on the long-term relations between Saudi Arabia, Iran and Turkey. In general, however, over the next three decades the desire to gain influence over these emerging middle powers will be a high priority for the world's leading global and regional powers. Organisations such as the BRICS group, as well as new blocs that may emerge in the future, may bring growing weight to bear and out to 2055 may increasingly compete with the Group of Seven (G7) for power and influence. However, all of these emerging middle powers face considerable domestic challenges of one kind or another, which out to 2055 will affect their strategic choices as well as their influence.

Turkey has the potential to be a major actor but will face economic and demographic challenges that may undermine its capacity to act. How its relationships with other powers will evolve remains uncertain; while Turkey's economic interests suggest that cooperation with Europe will remain important, its political aspirations for regional and global influence could generate friction and make maintaining relationships with Europe, the US and the North Atlantic Treaty Organization (NATO) more difficult. Despite its aspirations, Turkey may struggle to maintain its status as a regional power, and the potential for competition with Saudi Arabia and perhaps Egypt over influence in its neighbourhood cannot be ignored. Notwithstanding this, Turkey is likely to continue to promote itself as a global power by building new partnerships and seeking to deepen existing ones; the next 30 years may see it expand its outreach in Africa and Central and Southwest Asia.

While multilateralism is likely to endure, what it will look like in 30 years' time is uncertain

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Multilateral organisations and frameworks

The United Nations and the international system. The current international system has evolved significantly since its evolution in the aftermath of the Second World War. Today, its core institutions, in particular those of the UN, the International Monetary Fund and the World Bank, are comprised of a huge family of functional organisations with extensive global reach. However, an escalation in global power competition will have an impact on the effectiveness of, and support for, the institutions that make up the international system. Major powers may become increasingly selective in their engagement with global institutions, deliberately distancing themselves from those that they regard to be working against their interests, and there may be an increasing trend towards 'withdrawalism' from treaties and resistance to meaningful reform. States may increasingly reject authoritative and legally binding treaties in favour of informal non-binding arrangements, further limiting the potential for cooperation. Increasing global power competition may see growing resort to selective single-issue political alliances or 'mini-lateral' approaches over the next 30 years, giving rise to a proliferation of smaller, more agile issue-centric coalitions.

While the current state-centric nature of global cooperation means that at present the interests of the stronger and more influential member states still continue to dominate, it is likely that out to 2055 emerging powers and developing countries will demand more influence. This may result in increasing calls for reform of the current system, so that the interests of these new powers may be better accommodated. A more decentralised system may provide opportunities for financial and technical cooperation, which could benefit less powerful states. However, the ability to secure widespread agreement on the precise nature of any reform remains uncertain.

Despite these challenges, support for multilateralism as a vehicle to promote mutual interests, resilience, prosperity and sustainable development seems likely to endure, meaning that some form of cooperation through international institutions and frameworks will continue to take place out to 2055. However, what multilateralism will look like in

30 years' time remains uncertain. Escalating power competition could, as it often has in the past, lead to a major conflict where the current system collapses. Alternatively, the impact of creeping polycrises could lead to extensive state failures and a fundamentally new kind of networked multilateralism, where states work alongside non-state actors. On the other hand, a series of existential crises and threats may unify and lead to new accommodations, and may see the current system evolve and adapt to tackle global challenges more effectively. Rising actors may outcompete current powers, changing global and regional patterns of influence and leading to a new international system being established in its entirety. Whatever form it takes, the character of the international system will have huge influence on how global drivers of change manifest themselves in the long term.

European Union. In 2055 it will be over a century since the European Coal and Steel Community was created with the purpose of preventing new wars in Europe. Since then, the EU has evolved significantly and now constitutes a major economic power bloc, with unprecedented levels of integration in Europe.

The ability to deal with multiple destabilising factors, while maintaining social cohesion within and between member states, will be key to determining the EU's future trajectory. In particular, how EU member states manage to exploit technological advances and interconnectivity, and adapt to the economic transformation and energy transition, could be decisive in determining the role that the EU will play as a global actor in the future. However, adapting to external pressures in its surrounding neighbourhood, as well as wider escalating global power competition, climate change imperatives and global economic fluctuations, will remain core challenges. Although the EU is still likely to exist in 2055, this may be due to the continued existence of external pressures rather than to any ideological commitment on the part of member states to the idea of a unified Europe.

In addition to its primary focus on the stability of its own neighbourhood, including support to the reconstruction and integrity of Ukraine, the EU as a global actor is likely to make every effort to support the current international order and a multilateral approach to global politics. However, the realities of an increasingly multipolar world, and the competition between the US and China in particular, will shape future geopolitics and global trade, forcing the EU to make difficult balancing choices. If member states feel that their global position is better secured through bilateral relations than under the EU umbrella, there is a significant risk that the EU will be weakened. On the other hand, an EU that actively uses its economic power and attractiveness to build global networks and partnerships, based on common values and norms, may drive the resurgence of multilateralism in a multipolar world. In some cases, the EU may also engage transactionally on particular issues, influencing the overall power balance. For example, tackling global climate change is an area where the EU has great potential to demonstrate leadership and extend its global influence, acting as an alternative partner to China on green technology solutions and climate change mitigation and adaptation initiatives.

North Atlantic Treaty Organization. The Russian invasion of Ukraine in 2022 has strengthened Northern American and European commitment to NATO and has resulted in the admittance of two new member states to the Alliance. NATO is also increasingly recognising the challenge posed to Europe by China, indicating a potential widening of its scope in future years. Most European member states are unlikely to allow NATO's focus to be diverted from Europe as long as the threat from Russia persists. In the future, this may become a growing source of friction not only between the US and European

members, if the US begins to demand support from the Alliance in countering Chinese expansion in the Indo-Pacific region, but also between European members with differing security priorities. However, concerns over an increasing US focus on the Indo-Pacific region may drive increased investment in European and Canadian military capabilities, which in the end may provide Europe with more choices.

The long-term outlook of NATO is likely to be decided by levels of US investment and commitment, threat perceptions and the cohesion of its member states. Aside from the US, the UK and Germany are likely to play key roles in the organisation. Looking forward, a major question will be whether the Alliance is ready to accept new members aside from Sweden and Finland – most importantly Ukraine. This would be a watershed moment that would fundamentally change the character of the Alliance. NATO may also deepen and expand its partnerships with non-member states over the next 30 years, particularly with states in the Indo-Pacific region, increasing its global outreach further. However, the challenge of diverging threat perceptions and priorities within the Alliance is likely to remain. This could result in member states increasingly resorting to bilateral security arrangements and coalitions alongside the Alliance. Nevertheless, during the coming three decades NATO is likely to take major steps forward in its role and presence in space, cyberspace and the Arctic, with climate change impacts and other major environmental challenges also potentially becoming a major focus. Its member states include six of the G7 members as well as most EU member states, giving considerable potential for the use of economic instruments of power in addition to the military and political ones. A reassertion of global commitment to multilateralism could see NATO become a major tool for global stability in the future.

Regional and functional organisations. A large network of regional organisations (for example, the African Union, Association of Southeast Asian Nations, Gulf Cooperation Council and Shanghai Cooperation Organisation) and global forums and intergovernmental organisations (such as the G7, Group of Twenty (G20), World Economic Forum, BRICS group, Organisation for Economic Co-operation and Development, and the Asian Infrastructure and Investment Bank) will increasingly complement, but could also potentially undermine, the UN and the current core international institutions. In a multipolar world with increasing global power competition, the influence of some of these organisations is likely to grow further, and regional- and functional-based cooperation may increase as global collaboration becomes more difficult. In addition, states and new power blocs may work to develop new competing or parallel institutions if the established system fails to help them achieve their desired objectives – and as part of wider competition over influence.

There are already a number of non-geographical-based functional organisations built around specific interests, such as the Organization of the Petroleum Exporting Countries. Looking forward, new powerful alliance and partnership systems are likely to emerge. As an increasing number of human and economic activities take place in the virtual space, digitally based alliances and interest organisations, including powerful non-state actors, could become even more influential than traditionally geographically based ones. Functional partnerships will increase in importance in areas such as space exploration, cooperation around disruptive technologies and critical minerals and metals cooperation.

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Non-state actor networks may become more powerful than many states

Non-state actors

Corporations with global outreach. Multinational corporations (MNCs) form an integral part of modern capitalism and out to 2055 are likely to play a central role in shaping the global economy. They will also exert significant influence over global geopolitics, and in a more networked world may increasingly replace traditional state-based governance in some aspects of citizens' everyday lives. Although it is unlikely that new formal company sovereigns of the type epitomised by the British and Dutch East India Companies will emerge, it is plausible that the future could see some corporations become sufficiently integrated into the delivery of state functions that they effectively fulfil a similar role. Alternatively, it may be that technology firms find ways to operate distributed or 'virtual' company towns, perhaps through franchising services or arrangements with partner 'host' cities.

Despite the proliferation and growth of MNCs, one of the most notable features of recent years has been the increasing concentration of wealth, with a growing proportion of the proceeds of economic growth now held by an increasingly small group of powerful MNCs and individuals. Many of today's 20 biggest companies have market capitalisation equivalent to G20-size economies.[1] Although different corporations will head these lists in the future, trends suggest that technology firms will be increasingly dominant. However, looking forward, it will not just be the largest or most profitable MNCs that will have the ability to wield influence in the future. Some may represent a critical component of a country's domestic economy (such as the banking sector, the potential collapse of which was viewed by many countries as a systemic risk in 2008) or carry disproportionate influence due to investment in critical sectors or as major employers.

While there is often a symbiotic relationship between MNCs and the state based on mutual economic interests, this relationship could increasingly come under challenge as MNCs gain in power. The ability to force states to compete against each other – for example, by providing tax breaks to influence decisions over where MNCs locate their headquarters – may be of growing significance. MNCs may increasingly challenge states through legal frameworks in multinational trade organisations, and in some cases may also be able to use economic and financial levers more effectively than states in future years. However, it

1 *Forbes*, Statista (8 June 2023), 'The 100 largest companies in the world by market capitalization in 2023 (in billion U.S. dollars)'.

is possible that greater transparency and access to information may mean that societal pressure on MNCs and other businesses to behave responsibly and uphold certain social, ethical and environmental standards may increase.

MNCs have been a strong driving force in globalisation over recent decades, and the transition to an increasingly multipolar world, with a rise in protectionism, trade wars and the decoupling of value chains, is likely to constrain their operations and force them to adapt. However, new opportunities, enabled by the commercial exploitation of technological advances, may see them extending their operations into the shared spaces such as space, the oceans and cyberspace, while digital trade will continue to grow. The bioeconomy, including health care, food and water solutions, carbon capture and energy, may open up significant new opportunities, and see new value chains emerge. While this could spur high levels of economic growth, there is the potential for it to result in growing inequality and unrest. This may see new socio-economic movements gain broader support, as well as the use of private security by MNCs to deal with economic protests or striking workers. Private military and security companies are likely to continue to expand further and may even replace traditional defence and law enforcement entities in some states.

Super-empowered individuals. Over the next 30 years, a number of super-empowered individuals will seek to use the power that they hold as a result of their wealth, ownership of major MNCs or some other special status within society to campaign and lobby governments on issues that they consider important. Although this is not a new phenomenon, the ability of these individuals to achieve real change and influence domestic, regional and global political developments is likely to be amplified significantly through their access to both social and traditional media, which will increasingly provide them with a platform from which to promote their aims. While business leaders have always lobbied governments, the next three decades will see influential individuals changing their approach and expanding their reach not only to lawmakers and policymakers but also to the wider public. The importance of the virtual space means that ownership of social media platforms is likely to become an increasingly important enabler for political and social influence. While this has the potential to be a force for good, with some individuals choosing to campaign on environmental and social issues, for example, it could also be used by wealthy individuals to try to shield their business interests from public or state interference – and even, in some cases, to undermine state governments. How this trend evolves will depend on the character and interests of the individuals in question, and it is impossible to predict with any certainty what the outcome will be.

Serious and organised crime. Recent decades have witnessed an explosion in interconnectivity, connecting both licit and illicit economies around the world. Taken together with the technological advances seen over the same time frame, this has created huge opportunities for criminals and armed non-state actors to grow and participate in transnational markets, with disparate groups often connected via trafficking and smuggling routes across multiple regions. In this respect, serious and organised crime is driving its own 'globalisation', with European crime networks based in Latin America controlling drugs manufacturing and illicit value chains stretching over Africa into Europe and other regions.[2] While criminal networks are already in de facto control over states and vast territories in some parts of the world, they are also rapidly expanding into the virtual space, further expanding their global reach and influence.

2 Andrade, C., et al., *Americas Quarterly* (12 April 2023), 'Ecuador's Crime Wave and Its Albanian Connection'; den Held, D., InSight Crime (November 2022), *Cocaine Brokers: The 'Ndrangheta in South America*.

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Serious and organised crime is likely to continue to expand and challenge governance in both strong and weak states

Serious and organised crime is constantly increasing its economic power: the global cost of cybercrime is expected to reach US $10.5 trillion in 2025,[3] while the UN estimates the total funds involved in global money laundering to be between 2% and 5% of global gross domestic product (GDP),[4] although the full cost of corruption will remain unknown. Often more adaptable than state governments, serious and organised crime has the potential to expand its global outreach significantly through agile networks, not only becoming a powerful global actor but also a serious challenge to local, national and international governance.

Out to 2055, the pervasive presence of illicit actors across fragile regions will continue to weaken state structures, prevent the resolution of armed conflicts and hinder post-conflict institution-building. With access to funds and other resources flowing beyond the reach of states, organised criminal and armed groups will be well placed to extend their ability to act in conflicts and in the shared spaces whilst more easily avoiding legitimate economic enforcement measures such as sanctions. By infiltrating vital state institutions such as health care, banking systems, tax authorities, judiciaries and law enforcement agencies, serious and organised crime groups may increasingly challenge the state as the principal provider of security and basic services. This already allows these groups to command far more authority than state institutions in some parts of the world, while also stripping the state of important sources of income and legitimacy. In the long term, by exploiting multiple vulnerabilities, new technologies and the acceleration of global power competition, serious and organised crime is likely to continue to expand, with the potential that it may increasingly pose a challenge to governance in both strong and weak states.

3 Cybersecurity Ventures (2023), *2023 Official Cybercrime Report*.
4 European Union Agency for Law Enforcement Cooperation (2022), 'Money Laundering'.

Will globally connected cities be able to turn wealth into political power in the future?

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City networks. In future decades, technological and scientific advances may make it increasingly difficult to define the limits and reach of cities. Increasing levels of urbanisation and interconnectivity are likely to see high-tech city networks increasing their power and influence, becoming platforms for global financial transactions and political engagement. The increasing devolution of political power from the state to city level may also see sub-national diplomacy evolving to surpass the influence of the state. While in some cases city networks may cooperate for mutual benefit, in other cases, in particular in an era of rising global power competition, they may use economic, political and legislative tools, and potentially even criminal activities such as cyberattacks, to achieve their aims. Rising levels of inequality and the demands of densely packed populations will give rise to significant stress, and potentially unrest, at the local level, thereby increasing pressure on local as well as state governance structures.

New ideologies and religion. Throughout the history of humanity, new ideologies and religions have played a crucial role in the evolution of politics and society. For example, the Industrial Age saw the rise of socialism and Marxism, ideologies with huge global attraction across cultural borders. In the Information Age, with new and much more powerful mobilising tools available through social media and other platforms, the potential for new ideologies to spread much more quickly could see the rise of new global political movements. With population growth driving an increase in the number of adherents to some faiths over the next 30 years, there is the potential for religious groups to gain in power, and the world may see the emergence of new religious leaders with huge global outreach. In addition, new religious faiths or new variants of existing religions could develop into globally influential movements.

Global power relations

Global influence and power will never be static and will constantly evolve. As the world transitions from the Industrial Age to the Information Age, propelled by sensors, data, processing power and increasing global interconnectivity, so too the world order is evolving into one of increasing global power competition driven by a diffusion of power, where emerging powers challenge established ones. Global volatility and risk have increased in recent years. Despite this, cooperation of some sort will continue to be an enduring feature of the international system, and the need to work together to tackle current and future challenges has never been greater.

There are six areas of competition and cooperation that are likely to determine the dynamics of global power relations over the coming decades:

- the power of attraction;
- technological leadership and advantage;
- economic shaping power and access to resources;
- climate change mitigation, adaptation and the green transition;
- influence in the shared spaces; and
- military shaping power and arms control.

The power of attraction. Status, standing and prestige in the international system are key elements that determine a state's influence and shaping power, with significant ramifications for both prosperity and security. In a more crowded geopolitical space, potentially characterised by major shifts in economic and military power, being seen as a partner of choice for strategic cooperation and winning the battle of the narrative will be critical. While the US is currently the only power with full global military outreach, resting on its attraction as a partner of choice heading up an unparalleled system of alliances and partnerships, China is likely to continue to expand its global military presence through bilateral arrangements. Whether future years will see Chinese-led alliances comparable with those led by the US remains highly uncertain. Going forward, however, the attractiveness of both states as strategic partners will depend on their actions at the global level, and the way in which they manage their own domestic challenges.

Out to 2055, the US and China are likely to lose relative influence to other emerging powers, which will be guided by their own strategic choices. New blocs and alliances involving (and in some cases led by) the world's middle powers, together with groupings of smaller states with shared interests or similar mindset, are likely to form an increasingly important part of future hedging strategies. Future strategic partnerships are likely to go beyond existing cultural and historical relationships, and could potentially be more pragmatic and less dependent on shared values and ideals. While the long-term role and influence of Russia remains uncertain, India and the EU have considerable shaping and network-building potential. Out to 2055, multilateral frameworks and institutions will inevitably play a part in this as forums through which to gain support and shape global agendas.

The power of attraction, in an increasingly interconnected world, is something that extends beyond relations between state governments. For example, cultural influence, such as that achieved through the arts and sport, plays a crucial role in boosting a state's attractiveness at the popular level. In the Information Age, rather than being measured in terms of military capability, economic weight and diplomatic outreach, power will

be much more dependent on data, knowledge and skills, which provide actors with a competitive edge and enable them to adapt, operate and shape developments more efficiently than others. Being the state and society that is seen to provide opportunities for those skilled in areas such as applying and exploiting disruptive technologies will be key as the competition over these individuals intensifies. Brain drain will be one of the greatest challenges for any actor, and the future is likely to see concerted action between competing economies to recruit people with the skills they require. Today, open societies in liberal and safe states with a high degree of welfare and sustainable living conditions are all on the global top list of attractive countries. Australia, Sweden, Norway and Canada currently have the lowest level of brain drain in the world,[5] illustrating that the power of attraction extends beyond the superpowers.

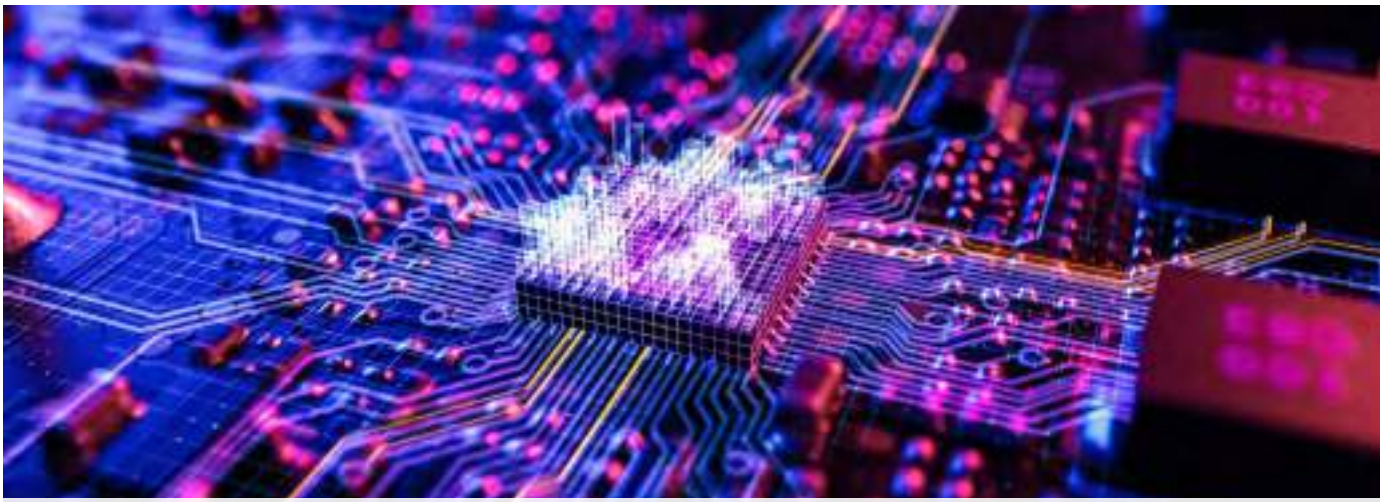
Technological leadership and advantage. Technological advantage will remain a central part of global power relations. The ability to exploit, scale, commercialise and protect technological innovation forms an integral part of this, as does a mutually reinforcing skills ecosystem and enabling infrastructure. At present, examples of areas at the forefront of the race for technological leadership include artificial intelligence, automation and robotics, quantum computing and bioengineering. While the US has a long tradition of groundbreaking technological innovation, a number of European and Asian states are expanding their strength in this area. In addition, MNCs, particularly those in high-tech areas, will play a key role in enabling states to gain or retain technological advantage.

Going forward, the US' position will be increasingly challenged by a China supported by massive research and development investment, as well as a learning and skills development system that promises to deliver an estimated 300% increase in tertiary graduates by 2030.[6] The number of Chinese patent applications is already higher than that of Japan, Germany, South Korea and the US and continues to increase; while still more an indicator of quantity rather than quality, the standard is likely to improve in the long-term future. If China were to become the world's technological leader, the US' diplomatic and military power is unlikely to be enough to enable it to retain its dominance either in Asia or globally.

Russia is likely to decline as a technology power due to the massive exodus of young and well-educated people as a result of the war in Ukraine; in addition, far-reaching sanctions are depriving it of access to Western technology. This may have a negative impact on Russia's influence in the Global South, including its relations with India and Iran, which may provide China with an opportunity to expand its influence still further.

In general, however, the ability of states to set the agenda will be increasingly limited. Commercial enterprises will continue to lead on the development of disruptive technologies, giving them an advantage over most states and potentially an increasing ability to shape and set the rules for their future use. Serious and organised crime groups will not only exploit existing innovations to gain advantage over law enforcement agencies but may, as their wealth increases, develop their own technologies. Espionage and cyber theft to gain access to key technologies is likely to be an increasing security threat.

5 World Population Review (2024), 'Brain Drain Countries 2024'.
6 Swanstrom, N. and Engman, M., Institute for Security and Development Policy (2021), *China Out to 2050: Key Trends* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).



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The ability to establish a lead in technological innovation could form a major advantage for states

Economic shaping power and access to resources. The use of economic levers of power to achieve strategic objectives will remain an integral part of global power relations. States will continue to have domestic priorities, including the need to provide employment and generate public finance revenues for economic growth and prosperity. They will also continue to assess those goals in terms of their wider security and geopolitical power objectives, including the desire to secure access to vital resources.

Economic statecraft – including leveraging trade relations and dependencies, foreign aid and investment in overseas infrastructure projects, and the use of sanctions and blockades – will be heavily influenced by the technology-driven transformation of economies. With the increasing fusion of the physical, digital and biological worlds, control over key data and access to information will be vital influence tools. Protectionism and trade restrictions will be integral tools in the competition for technological advantage. However, such efforts are also likely to strengthen domestic research capabilities and create new partnerships among those targeted, potentially leading to improvements in economic performance as a result.

The desire to secure access to strategic resources such as water, food, energy and critical minerals will also continue to shape global trade patterns and the battle for influence. This may include using the military instrument of power, whether directly or indirectly, to gain economic advantage and protect or obtain access to critical resources. Out to 2055, technology advances will play a hugely important part in providing alternatives to strategic resources that are difficult to secure or that are controlled by competing powers.

Over the coming decades, growing competition between the US and China, as well as other major powers and economic blocs, will have a profound impact on global trade. Although there will continue to be extensive global interdependencies, including those between the US and China, there is a growing trend of economic disentangling, with increasing contestation of supply chains. China is likely to look to expand its trade relations in the growing consumer markets of Southeast Asia, Southwest Asia, Africa and Latin America. While both China and the US will seek to exert pressure on third party states to pick sides, most will try to hedge to secure their prosperity. More widely, recent trade disruptions have led to many state governments seeking to boost resilience by identifying alternative supply chains to secure critical dependencies.

Climate change mitigation, adaptation and the green transition. As the impact of climate change continues to rise, investments in resilience, mitigation and adaptation projects and disaster relief will be an increasingly important tool that actors will seek to exploit for strategic influence. The ongoing transition to more sustainable energy sources and forms of economic production will also play a key part in this. China's current lead in green technology and access to the resources required for a green energy transition place it in a strong position to achieve global influence in this field. In addition to major state powers, however, influential non-state actors such as MNCs are likely to play an increasingly significant role in these activities.

The impact of the war in Ukraine on energy supplies means that the EU may achieve net-zero targets before the rest of the world. Together with the US, the EU may be in a position to offer alternative support to countries in the Global South, including through technology-sharing. Africa is an interesting region in this respect due to its significant share of the global population alongside its shortfall in energy distribution; energising Africa in a sustainable manner could lead to new levels of economic growth on the continent. Africa could also see vast improvements in its food and water security by introducing better water management and farming techniques and using drought-resistant crops. However, in a world of increasing global power competition and technological protectionism, developing countries are likely to be the losers; leading technology powers may be less inclined to share knowledge and advances in technology.

Influence in the shared spaces. The desire to control strategic resources accessible through new extraction technologies, and secure access to platforms delivering essential societal and military functions, will be a key driver for actors' behaviour over coming decades. Governance of the shared spaces – including the polar regions, oceans, space and cyberspace – is likely to be a highly contentious issue, as the presence of an increasing number of actors leads to a more congested and contested environment.

The polar regions will become more congested and contested as non-state actors compete with states to exert greater influence and control. Sea ice melt and an escalation in power competition mean that both the economic and military importance of the Arctic will grow; as the security paradigm changes in the region, there is likely to be an increase in militarisation. The geopolitical dynamics of the Antarctic are also becoming increasingly complex as a broader range of actors seek to establish a footprint and garner influence. The 1991 Protocol on Environmental Protection (Madrid Protocol) will be eligible for review in 2048, opening the continent to the possibility of resource extraction. Military activity is likely to increase in parallel with a growing human presence and a heightened state of competition.

The oceans will continue to be vital conduits for international trade and power projection, and freedom of navigation will continue to be a driver for global power behaviour. As technologies for deep-sea resource extraction become more sophisticated, allowing access to vast deposits of minerals and precious metals, the competition over rights to these resources may increase. A growing number of pipelines and cables across the seabed, as well as increasing offshore infrastructure such as rigs and wind farms, will lead to new vulnerabilities.

While there are a number of established space powers today, the increasing ability of both state and non-state actors to access space will make the picture far more complex in future decades. New relationships are likely to form; for example, US and European space actors may develop global partnerships with an increasing number of

countries, as might India and China, who will seek to portray themselves as alternatives to Western partners. Emerging space powers may become increasingly coordinated and form new partnerships, especially against forms of regulation that might limit their ambitions. While space governance remains an obvious area for cooperation, the weaponisation of space could result in a space-based arms race and lead to new types of conflict. Some states may seek to increase their strategic resilience by developing alternatives to space-based functions.

The ability to control cyberspace and the data contained within it will be key to protecting economic wealth, vital societal functions and business activity. It will also provide actors with the means to extend their coercive power and strategic reach, giving rise to new forms of asymmetric advantage. Finding ways to reach people more effectively, with more convincing messages than those of competitors, will be decisive. At the same time, the security challenges arising from an unregulated cyberspace may also be a strong driver for cooperation between states, and between state and non-state actors.

Military shaping power and arms control. In a global environment characterised by persistent competition, the military instrument of power is likely to be an increasingly important component of the overall battle for influence. Military levers will continue to form a fundamental part of power projection and deterrence, as well as potentially being used to secure critical value chains and in some cases to gain access to critical resources.

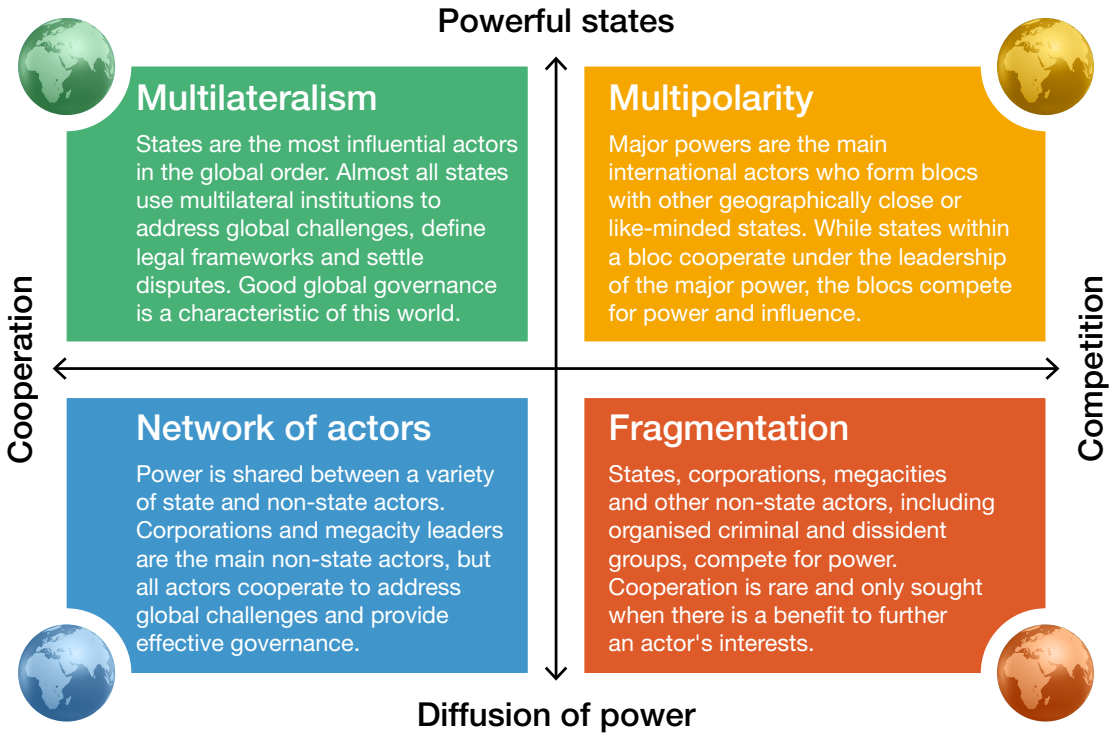
However, technological developments will transform the military instrument of power in unexpected ways, and the proliferation of disruptive technologies will continue to see a reduction in Western technological and competitive advantage. Increasing Chinese military capability – particularly in areas where the US is behind, such as missile technology – will drive the US and other powers to invest in counter capabilities. The commercialisation and potential weaponisation of technologies will provide non-state actors with asymmetric means to attack far stronger opponents. Technology will provide opportunities to create mass through automated systems and other means. However, conventional mass and capabilities will still matter for both power projection and deterrence, and will remain a key component of the increasing competition between major powers.

The proliferation of weapons of mass effect will remain a cause for regional and global concern. Continued investment in nuclear weapons arsenals by a number of states could increase the probability of use, or trigger other states to pursue nuclear programmes of their own.[7] However, in a world where every technology can be weaponised, weapons of mass effect development goes beyond nuclear capabilities. For example, the weaponisation of biotechnology, in combination with other technologies such as artificial intelligence, will provide novel opportunities to cause immense destruction, as well as high-precision personalised targeting. Space-based high-energy weapons and long-range hypersonic missiles, in combination with artificial intelligence-supported cyberattacks, may make it possible to attack anyone anywhere in the world. These developments come at a time when the current arms control regime is under pressure from competing interests and cooperation is becoming harder to achieve. However, given the demands and risks involved, new efforts and initiatives to agree arms control treaties to re-emphasise adherence to international humanitarian law and the regulation of weapons of mass effect may well be seen in the future.

7 Aylward, M., et al., Atlantic Council (2024), 'Welcome to 2034: What the world could look like in ten years, according to nearly 300 experts'.

Alternative future world orders

The current escalation in global power competition, which has already resulted in a shift to a more multipolar world, is likely to continue in the near term at least. However, the precise way in which the global drivers of change and contradicting trends will impact on each other in practice, and how actors will react to them, remains unknown, and creates major uncertainties as to what the global order might look like in 30 years' time. To better understand how alternative developments may play out is therefore critically important as the future is not likely to be linear.



The four future worlds are characterising the pathways to the future

The 'four future worlds' is a scenario model used to facilitate discussions about the future of global order and geopolitics. Developed for *Global Strategic Trends 6*, it uses two variables – distribution of power, and relations between actors – to define four future worlds. The 'distribution of power' axis ranges from centralised power, where states are the predominant actors, to diffused power, where state power has eroded, leading to an increase in the influence of non-state actors. The 'relations between actors' axis ranges from high levels of cooperation at one end of the spectrum to intense competition at the other.

This 'two by two' format creates four different worlds: multilateralism, multipolarity, network of actors and fragmentation. This provides a framework for assessments about the possible impact of different trends and geopolitical developments, and how the choices that are made today may drive the planet's future trajectory. The model is value neutral and can be used to develop global as well as regional scenarios. However, the reality will always be a combination of the four worlds and this can shift over time – and there could be many different versions of multipolarity, for example. Hence the development of the future global pathways.

Global pathways scenarios

To better reflect how various shocks and developments might influence global actors and drive future trajectories, five hypothetical pathways have been developed. Each pathway results in the emergence of a different world order, shaped by changes in the balance of power and the international system. Each pathway consists of a brief scenario, a set of watchpoints and indicators, and analysis and implications.

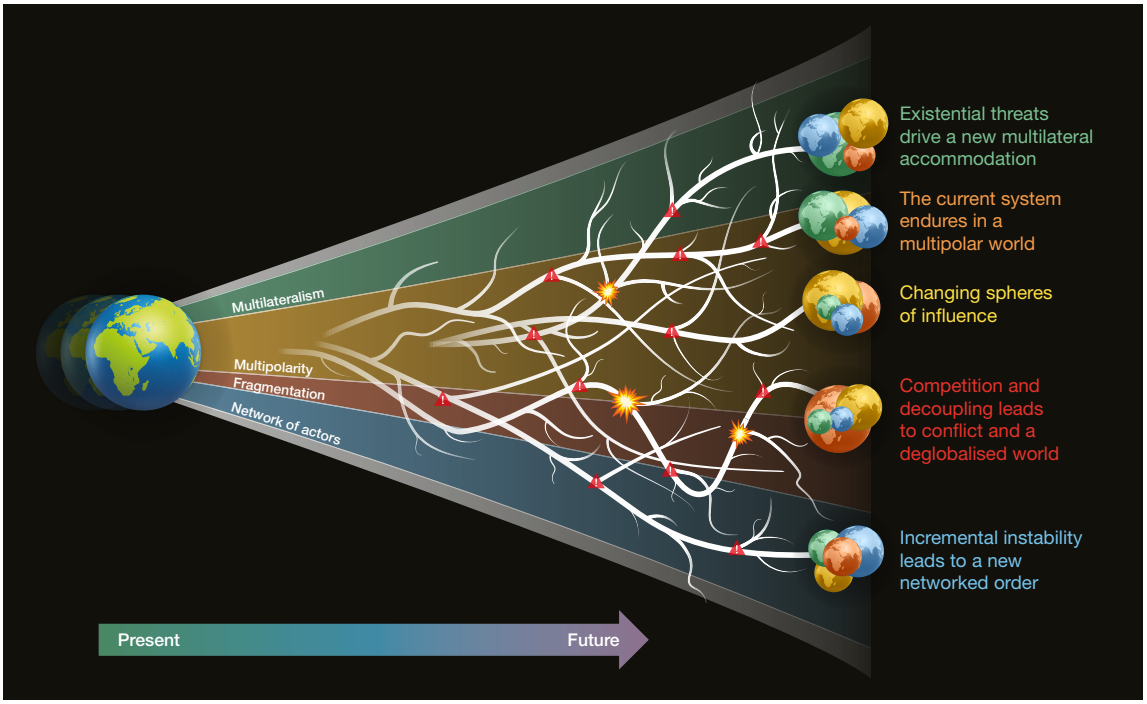
1. **Existential threats drive a new multilateral accommodation:** designed to enable an assessment of the factors that could bring the world together, resulting in a new version of multilateralism better suited to meet the needs of the planet and its inhabitants.

2. **The current system endures in a multipolar world:** intended to enable an analysis of the factors that may foster continued cooperation between democratic and open societies, enable them to remain attractive partners, and retain their considerable shaping power within the framework of the existing international system.

3. **Changing spheres of influence:** depicting circumstances that enable China to expand its global outreach in an increasingly multipolar world, and take a lead in developing and establishing an alternative international order operating under strong Chinese influence.

4. **Competition and decoupling leads to conflict and a deglobalised world:** highlighting the risk that increasing competition in a multipolar world could escalate into a major conflict with global ramifications.

5. **Incremental instability leads to a new networked order:** portraying a radically different approach to global governance, in which over time a series of factors cause extensive state failure and result in non-state actors playing an increasing role in state, regional and global governance.



Pathway 1 – Existential threats drive a new multilateral accommodation

Scenario

Global competition over geopolitical influence, resources and values accelerates. The US and China dominate, but other powers and groupings of states avoid picking sides. The impact of climate change causes unprecedented social and economic disruption, which leads to a new wave of global activism, placing further pressure on states. The expansion of serious and organised crime, proliferation of weapons of mass effect, a new lethal pandemic and severe disruptions of space-based functions add to the incentives for states to work together. A new multilateral accommodation emerges that is better suited to the needs of the planet and all its occupants.

Watchpoints and indicators

- Increasing levels and outreach of global activist movements.
- A more powerful African Union gives African countries a unified voice and drives the development of a climate change agenda.
- Emerging and middle powers demand more influence over global issues.
- Reform of the UN Security Council provides a better balance of influence.
- Global agreement on technology regulation and knowledge-sharing.
- Multilateral institutions deliver successful interventions for financial stability, confidence-building measures, tackling serious and organised crime and sustainability.
- US–EU–India–China initiative for global cooperation on space governance.
- New series of arms control talks among major powers.
- China invests in global security and internationalism.

Analysis and implications

This scenario sees the opening of a new cooperative space, permitting the generation of global and inclusive solutions to the creeping crises and existential threats that the world faces. The assumption is that cooperation will be driven by common global challenges, such as climate change, threats to the global financial system from transnational serious and organised crime, the onset of new and potentially more lethal pandemics, the proliferation of weapons of mass effect, and concerns over possible disruption to space-based systems. It is also assumed under this scenario that high levels of interconnectivity are allowing non-state actors and interest groups to develop influential networks to extend their reach. A new multilateral order built out of novel accommodations will inevitably look different from the one in place today – and will need to balance the interests of the West, China, and the Global South in particular.

Pathway 2 – The current system endures in a multipolar world

Scenario

Despite the ambitions of some states to reshape the world order, leading powers, led by a resurgent US, redouble their diplomatic, economic and military efforts to preserve the existing international order. Democracies and open societies are seen as increasingly attractive. Geostrategic competition remains a driving factor, impacting economics, trade and responses to common challenges; however, a major conflict is avoided.

Watchpoints and indicators

- The EU continues to integrate and attract new members.
- New member states are admitted to NATO.
- The US invests heavily in the UN and multilateral institutions.
- The US remains the biggest economy with the US dollar being the leading global currency.
- A US-led coalition takes the initiative in tackling global issues and governance of shared spaces.
- Compromises allow for reform of current global institutions.
- Increasing numbers of students attend educational institutions in democratic countries.
- Authoritarian states continue to develop parallel institutions, but these fail to attract new membership applications from non-aligned states.

Analysis and implications

This scenario sees the US retaining its active role on the global stage, and open and democratic societies maintaining their cohesion. It takes its starting point in a situation where Ukraine is able to prevail as a free state, strongly supported by a unified West. A global coalition re-doubles efforts to tackle global challenges and preserve the current institutions, frameworks and rule of law. A major factor behind this is the continued ‘power of attraction’ exercised by open and democratic societies, as well as global desires for free market access, technology-sharing and the free flow of information. A pragmatic approach and a willingness to compromise will be key to winning over neutral and hedging actors, as well as allowing for flexible cooperation with opposing powers where appropriate. Nevertheless, the ability to counter military threats and address security challenges remains important, and helps to deter major conflict.

Pathway 3 – Changing spheres of influence

Scenario

Western democracies struggle under multiple pressures while China manages its internal challenges successfully and increases its soft power. A Eurasian bloc under China's leadership evolves into an embryonic new global order. Other states and coalitions are drawn in through economic coercion and dependencies.

Watchpoints and indicators

- Russia wins the war in Ukraine.
- China becomes the biggest economy and the renminbi becomes the leading global currency.
- Emerging middle powers cooperate more closely with China.
- There is an expansion and deepening of Chinese-led trade agreements.
- The US retreats from international institutions and its global presence declines.
- China takes the lead in tackling global issues, including technology standard setting and governance of the shared spaces.
- A new China–Russia–India space initiative is developed.
- The Shanghai Cooperation Organisation develops into a military alliance.

Analysis and implications

This scenario envisages a China that has managed to deal with its many domestic challenges and has seen its economy start to grow again, at the same time as Western democracies are struggling to maintain prosperity and social cohesion. In this scenario, China gains influence over a weakened Russia, and succeeds in building a Eurasian bloc, involving a number of emerging powers, which then evolves into a new world order operating under strong Chinese influence. A Russian victory in Ukraine is not a prerequisite for this scenario; however, it would suggest Western weakness, and allow China to rally the Global South behind a concept of a more equitable world order where their interests are better accommodated. Although China's influence would be strong under this scenario, it is important to note that other powers will still act in their own interests. This is likely to be a value-neutral, transaction-oriented world divided into different spheres of influence. In such a scenario, China achieves its ambition to reunify with Taiwan.

Pathway 4 – Competition and decoupling leads to conflict and a deglobalised world

Scenario

A series of crises and conflicts in Europe, the Indo-Pacific region and elsewhere accelerates competition over resources, influence and values. Protectionism and resource nationalism become the norm, leading to regionalised and fragmented trade and energy markets. The US' role is more unpredictable, while China, India and other Asian powers expand their outreach. Rising multipolarity sees the proliferation of new weapons of mass effect. Following intensified competition over influence in the Global South, tensions escalate into a devastating regional conflict with global ramifications. Unable to agree on a common global approach after the conflict, the world retreats into deglobalisation.

Watchpoints and indicators

- Attempts to de-escalate tensions and arms control talks fail.
- The world sees escalating trade wars and substantial decoupling of value chains.
- There is an increase in the weaponisation of space.
- Freedom of navigation is reduced and challenged in several regions.
- There is extensive proliferation of weapons of mass effect and the emergence of new nuclear powers.
- There is a rise in the number of enduring conflicts and military incidents.
- The current international order collapses.
- Increasing competition undermines the US dollar's position as the leading global currency.
- A number of states abandon their policies of non-alignment.

Analysis and implications

In this scenario, rising global power competition leads to increased tensions, a decline in trust and the decoupling of global value chains, eventually spiralling into a major regional conflict with global ramifications. It is a scenario that the world has witnessed in the past to some extent. However, with the increasing diffusion of power and the proliferation of novel weapons and weapons of mass effect, the question is whether nuclear arms will continue to act as the ultimate deterrent. The scenario also demonstrates that the current competition between the US and China should not be allowed to overshadow developments at a regional level. A question connected to the scenario is whether and how islands of stability could develop in a fragmented world.

Pathway 5 – Incremental instability leads to a new networked order

Scenario

A range of creeping crises leads to rising discontent with state governments and increasing instability. In a world dominated by persistent competition, state governments and international organisations are unable to address the challenges that the world faces. Serious and organised crime groups and violent extremist organisations expand their outreach. Alliances and partnerships unravel, treaties and trade agreements become unworkable, and multilateral institutions are dysfunctional and ineffective. Impatient with these failings in state capacity, new actors, including networked commercial bodies, powerful cities, belief networks and serious and organised crime groups, fill the void.

Watchpoints and indicators

- An increasing number of states downscale their ambitions on climate change.
- Decreasing state finances mean that governments are unable to deal with the impact of financial crises and climate change.
- There is an increasing number of non-state actors in the shared spaces.
- More powerful private military and security companies take over state functions.
- A network of commercial actors takes the lead on technology regulation.
- Non-state actors and MNCs become increasingly active in discussions on climate change.
- Regional organisations become increasingly ineffective and in some cases collapse.

Analysis and implications

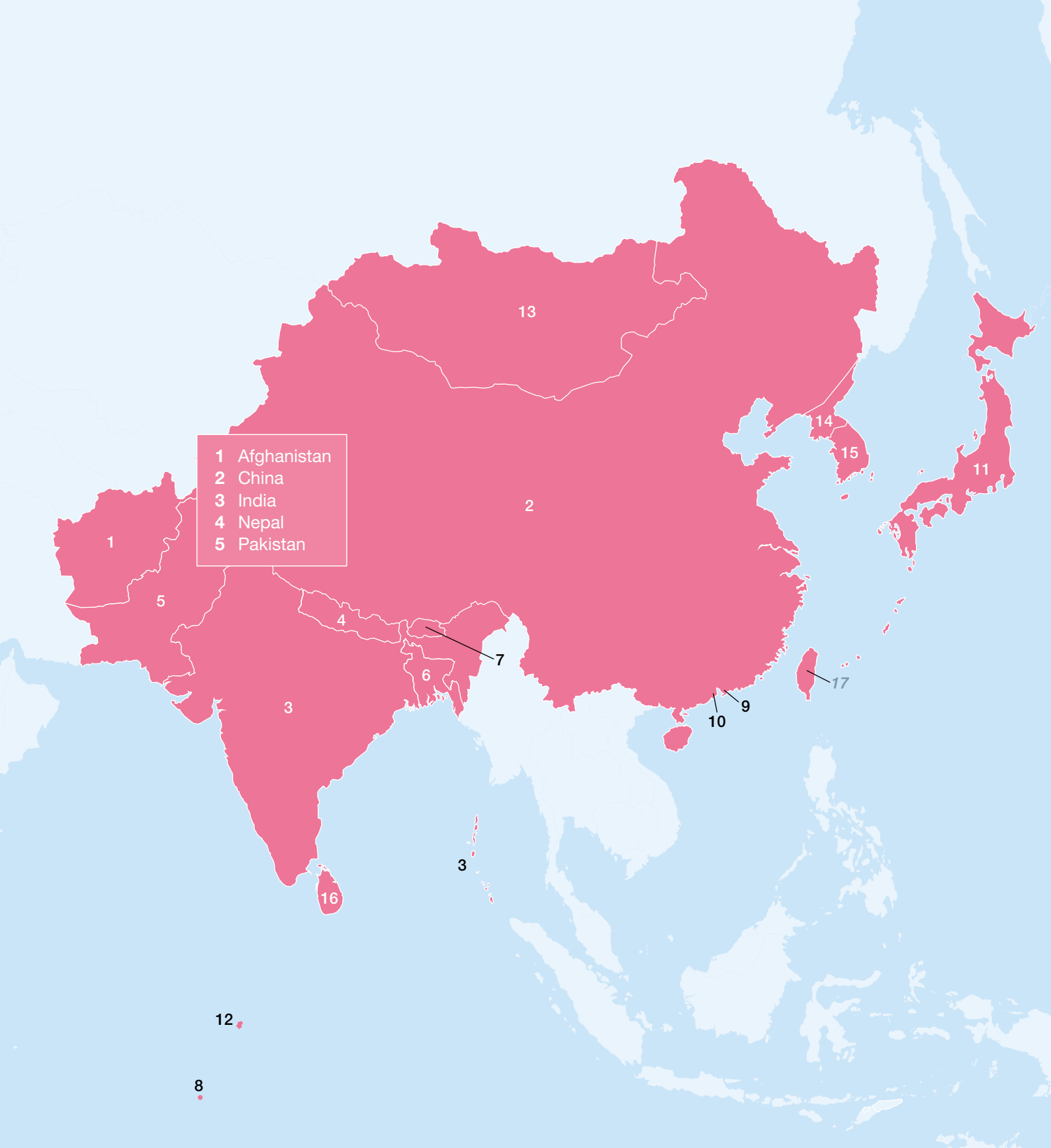
This scenario sees a series of small shocks and crises driving a gradual increase in instability, until ultimately this reaches a point where states lose control and begin to fail. A constant focus on short-term priorities inhibits cooperation and leads to a chaotic, fragmented world, at immense cost to economies and societies. Networks of non-state actors emerge to provide a viable alternative to the old model of states and institutions, proving themselves to be more agile and innovative than less adaptable state structures. Indeed, there are significant parts of the world where this scenario is already occurring to some degree, with informal structures delivering services that the state is unable to provide.

Final thoughts…

Out to 2055, states will face an array of challenges that will place a strain on government capacity and finances. How states deal with these pressures and, perhaps more importantly, how they are perceived to deal with them by others, will be key. Those states that benefit from high levels of trust, stable economies and effective and capable institutions should weather the storm, but other less effective states may struggle to cope with the burden of challenges facing them, resulting in an increase in instability and state fragility in many parts of the world.

As a result of these multiple challenges, even strong and effective states are likely to be faced with a shortfall between what is being demanded of them and what they can realistically achieve given limited finances and capacity. Governments alone will not be able to meet the needs of their citizens, and will increasingly be required to work with other actors to provide basic services and to address the challenges that societies are facing. The next three decades will see state governments increasingly competing for power and influence against a wide range of other actors, including local power structures, city governance structures, individual citizens and networks of actors. While this will present a challenge for state governments, it may result in a more resilient and responsive approach to governance, which is more able to deal with the broadening range of polycrises that the world may face.

Regions



6 Bangladesh
7 Bhutan
8 British Indian Ocean Territory (UK Overseas Territory)
9 China, Hong Kong Special Administrative Region
10 China, Macao Special Administrative Region
11 Japan
12 Maldives
13 Mongolia
14 North Korea
15 South Korea
16 Sri Lanka
17 *Taiwan*

East and South Asia

Current strategic context

For most of modern history, East and South Asia have been the population centres of the world. The region accounts for nearly 45% of the global population;[1] China and India together are 80% of this figure, home to over 1.4 billion people each. Other countries in the region such as Pakistan (236 million), Bangladesh (171 million) and Japan (124 million) are among the most densely populated in the world.[2] The region has a varied geography and while it is the location for some of the globe's most densely populated areas and is home to seven of the world's top ten megacities,[3] it also contains tropical rainforests, the highest mountains on Earth, vast deserts and rich farmland. Although population growth has started to slow or even decline in much of East Asia over the past two decades (notably in Japan, South Korea and more recently China), many South Asian states such as Afghanistan and Pakistan maintain youthful populations, which continue to grow in size. Because of the region's vast population, even minority cultural or religious groups are huge by global standards. For example, while approximately 15% of Indians are adherents to Islam, this relatively small percentage represents more than 200 million people and the second largest Muslim community in the world.[4]

As well as dominating global population statistics, the region is also increasingly viewed as the economic powerhouse of the world. China's economy has grown significantly in recent decades and today it has the world's second highest level of gross domestic product (GDP) behind the United States (US), at around 20% of the global total,[5] although this growth has moderated recently. Japan is third in the global rankings, although its economy has seen little growth over the past two decades; in addition, South Korea has consolidated its explosive economic gains in recent years, and India has achieved moderate expansion. Many economies in the region have strong and increasingly innovative manufacturing bases, with China, Japan, India, South Korea and Bangladesh being some of the primary producers of global goods; China in particular dominates global manufacturing, with 35% of the world's total output in 2023.[6] South Korea, Japan and Taiwan are dominant in the manufacture of semiconductors. Trade by sea is particularly important for the large export markets many of these countries have, meaning politics over the ocean is often of particular importance to the governments there.

1 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
2 Ibid.
3 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.
4 Pew Research Center (21 December 2022), 'Religious Composition by Country, 2010-2050'.
5 Central Intelligence Agency (2022), 'The World Factbook'.
6 Norton, B., Geopolitical Economy (31 January 2024), 'China is 'world's sole manufacturing superpower', with 35% of global output'.

Over the past few decades, due in part to its vast population, the growth of its middle class and its increasing economic wealth, the region has grown significantly in global importance, and it is likely that the Indo-Pacific region will continue to dominate global attention in the coming decades. In particular, China's significant economic weight and assertive diplomatic and military posture will continue to be regarded by some in the West as presenting a challenge to the current international order and its activities and relations with other regional and global powers will be closely monitored. While Western governments have sought to develop Indo-Pacific strategies and partnerships to shape their preferred outcome, some regional states may continue to favour a non-aligned approach. It is always possible that the future may see the emergence of an anti-Western bloc in the region, something which will generate concern in Western capitals.

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Key drivers of change

Great power competition. The next few decades are likely to see East and South Asia becoming an increasing focus for competition between the major global powers, notably the US and China, which will place increasing pressure on regional states to line up behind one side or the other. There should be no assumption that regional powers will continue to favour current alignments, and how they choose to align, or not align, will have a profound impact on power relations at both the regional and the global level.

An ageing, urban population. East Asia is at the forefront of global population ageing. Many regional countries have already reached or will reach points of peak population and decline, and how these states meet the challenge will be of interest to the rest of the world in learning how to deal with an ageing population. Out to 2055, the region will also lead on global urbanisation trends. As cities begin to act as centres of power in their own right and are increasingly able to act independently of state governments in international affairs, this may create tensions within domestic political systems.

Climate change and natural disasters. The region is one of the most vulnerable in the world to the impacts of natural disasters. Whilst any state could see itself severely impacted by a natural disaster, the region's less developed countries will be at most risk from large-scale loss of life, climate-driven migrations and the longer-term effects of water and food shortages and disease. At the same time, given its vast population and continuing economic development, the region will have a fundamental impact on global environmental trends and its actions will dictate the degree of effectiveness of the global response to climate change.

Demand for resources. The region's increasing demand for resources will be driven by a combination of factors, including a rising population (particularly in South Asia), a growing middle class across the whole region, and national imperatives to achieve economic trade advantage and secure domestic supply chains. As resource demand grows, this will lead to an increase in competition between regional actors, which over time is likely to spill out further into the shared spaces of the polar regions, the oceans, space and cyberspace.

A growing middle class. As states move into the middle-income bracket and China into high-income status, the region is likely to see a significant growth in its middle class population. As large numbers of people gain the financial ability to spend more freely on discretionary products or services, this will result in increases and shifts in consumption patterns and will further drive demand for and pressure on resources. The collective influence of the middle class is likely to grow, placing new demands on the region's governments, which in some cases may lead to political change.

Future key trends

Global power competition

Over the next three decades, East and South Asia will continue to be a theatre for global power competition. Previously non-aligned actors may look to one another to counter global power giants in their region. Elsewhere, large corporations, especially those in the technology sectors, and some cities could possibly become more powerful than their state governments and shape regional dynamics. In addition, corruption, serious and organised crime and the presence of violent extremist organisations will also influence regional power dynamics in East and South Asia.

China's assertive military posture, both in the Indo-Pacific region and beyond, is likely to continue. Its rapid investment in military capability development has polarised the international community, with some viewing China as a useful partner in times of need and others as an increasing threat. China's relationship with Russia remains possibly its strongest international link, although seemingly driven by necessity due to both states' ideological differences with the West. Looking forward, Russia's willingness to accept a stronger China, China's tolerance of Russia's aggressive foreign policy, and in the short term the repercussions of Russia's actions in Ukraine will determine the durability of this bond. A successful outcome for Russia in Ukraine, for example, could see a bolstered Russia cooperating more closely with China on global matters, potentially leading to the emergence of a Chinese-led Eurasian bloc. A weakened Russia, conversely, poses a risk to China, although this could also offer opportunities in terms of influence, concessions on resources and access to strategic territories in eastern Russia and Central Asia.

Chinese economic investment and cooperation has generally been welcomed in Central Asia, parts of South Asia, Southwest Asia, Russia, Latin America and some parts of Africa as a much-needed source of capital. The longer-term Belt and Road Initiative and Global Development Initiative objective has, however, been met with varying degrees of caution by recipient states. This caution may increasingly prompt them to limit their economic exposure to China. Over time, this may drive greater cooperation between other regional powers, which may increasingly act collectively to protect their interests.

In response to China's growing influence, the US has taken steps to reinforce its focus on the region, a trend which shows no signs of abating in the future. Recent years have seen the US reinforce its efforts at military and economic cooperation with the region, as well as moving to insulate its soft-power advantage in education and research. Over the next three decades, as great power competition in the region increases, regional states may find themselves increasingly pressured to align with one power or the other.

The US' growing focus on regional engagement, along with a deepening Chinese–Russian partnership, may see India's traditional approach of non-alignment and bilateral cooperation with a broad range of states shift. India has recently shown increasing willingness to be involved in multilateral arrangements such as the Quad[7] and the Combined Maritime Forces;[8] however, it also continues to have strong ties with Russia.

7 The Quad is a diplomatic partnership between Australia, India, Japan and the US.
8 The Combined Maritime Forces is a 43-state multinational maritime partnership that exists to uphold international order by countering illicit non-state actors on the high seas.

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East and South Asia will be at the forefront of global power competition

While bilateral tensions with China may drive India towards the West in the short term, a long-term improvement in its global power position or its relationship with China (currently its second biggest trading partner after the US[9]) is also possible. India may in the future shift its policy of non-alignment and build an Indian-led power bloc, possibly focusing on the wider Indian Ocean and including states in Africa and Southwest Asia; this could have a profound effect on regional and global power relations. India could also choose to align with another bloc or actor, which again would heavily influence the global power balance. However, with the exception of Pakistan, which is likely to retain close links to China, other neighbouring states are likely to take a pragmatic approach and seek to balance Chinese and Indian interests.

Both China and India have domestic challenges that may limit their influence on the global stage. While China's growth has been rapid and consistent for several decades, the recent economic slowdown has cast doubt on whether it will be able to transition into a position of global dominance. In addition, China risks being dominated by local issues and governance challenges. Although China considers these to be domestic challenges, any heavy-handed action on China's part would be likely to result in an international response, which could prejudice the country's international standing as well as its economic fortunes.

As the world's most populous country, India's economic potential is vast, but it will face significant challenges in realising this, including those resulting from the growing impact of climate change and the need to provide the educational opportunities and meaningful employment that its young workforce desires. These challenges may see India focusing more on domestic than international issues, limiting its potential for global influence.

While global power competition in East and South Asia mainly centres on the actions of China, India and the US, the region is also host to other influential powers such as Japan, South Korea and Pakistan, all of which have the potential to significantly alter regional power dynamics. Japan and South Korea's relationships with the West (the US

9 Rahim, F., *Forbes India* (29 December 2023), 'India's foreign trade in 2023: Its top trading partners and most traded commodities'.

and Five Eyes partners in particular) will continue. The two countries may also overcome past difficulties in their own relationship and cooperate more actively with each other to balance Chinese influence, which may have a profound impact on regional power relations. Both Japan and South Korea also have close relationships to many important states in Southeast Asia. Pakistan may reinforce its geostrategic posture by developing closer links to the Gulf states and other Islamic countries.

The dispute on the Korean peninsula is unlikely to be resolved and will remain a potential flashpoint; while North Korea is likely to see a change of leader at some point over the next few decades, there are no indications that this will result in any substantive change in the country's politics. North Korea will continue to influence both regional and global geopolitics with its access to weapons of mass effect and military actions. While a Korean unification cannot be excluded, China is unlikely to allow this to happen unless it favours its strategic interests, perhaps as a neutral state with strong Chinese influence.

Pakistan is likely to continue to strengthen its relations with China; its primary security concerns will be its border disputes with India, terrorist threats and the possibility of large-scale migration from Afghanistan due to enduring insecurity in that country. However, despite its many domestic challenges, in the future it may potentially play a more independent role as a middle power. The strong relationship between China and Pakistan, and Chinese attempts to gain influence in other neighbouring countries to India, including Sri Lanka, will be a hugely important influencing factor for the geopolitics of South Asia and the Indian Ocean.

Mongolia, now a full democracy, partner to the North Atlantic Treaty Organization (NATO) and strong supporter of multilateralism and the United Nations, will continue to balance Russian and Chinese interests and maintain relationships with other countries, both within and outside the region. How this strategy will play out in the long term will very much depend on where the key shaping power lies in the future world order.

Looking forward there should be no assumption that middle powers in the region will continue to favour current alignments. A military crisis in the region could rapidly lead to shifts in the balance of power. Non-aligned states, particularly those in South Asia and neighbouring Southeast Asia, may become an important stabilising influence as they seek to reclaim sovereignty and refuse to choose sides. India and Indonesia's growing economic weight give them the greatest potential to take on this role.

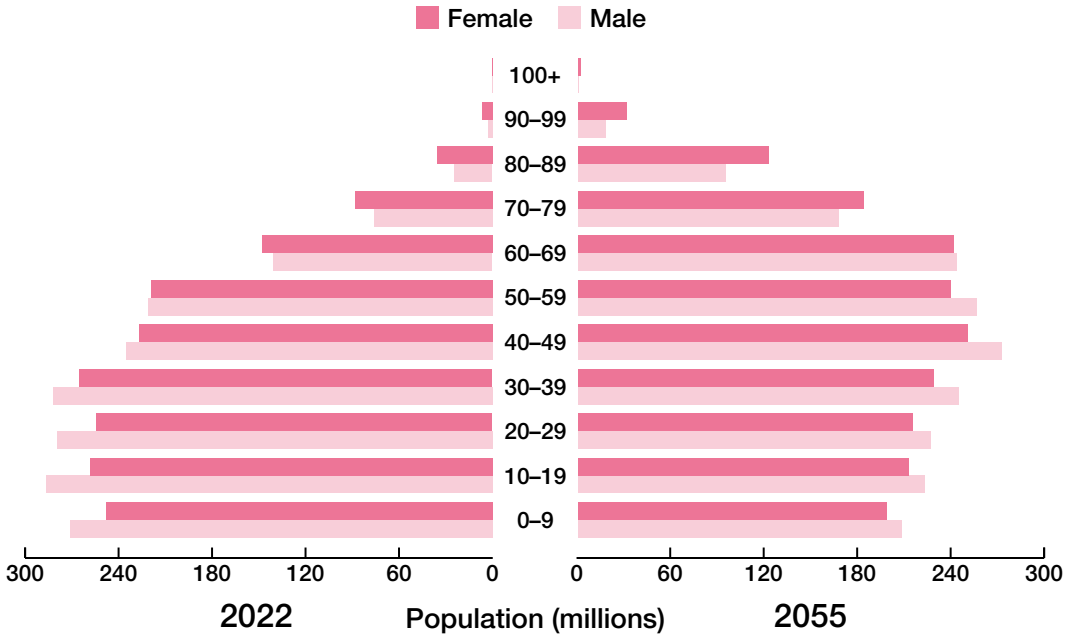
Due to conflicting interests among its members, the Shanghai Cooperation Organisation may struggle to fulfil its potential ability to influence. Whether this organisation will come to play a more important role in the future will depend on the relationship between China, India and Russia, its three biggest member states, and China and India's status in the future world order.

Increasing demand for resources by both regional and external actors means that global trade through the region's oceans and choke points will remain critical. Alongside trade routes, the growth in fossil fuel extraction, fisheries, undersea cables, offshore renewables and the emerging seabed mining industry will create a highly contested maritime environment. This will intensify as China and other regional actors seek to increase their presence, including base access, to secure resources and other scientific and military benefits.

Society

Population growth in East Asia will slow, and in some cases reverse, resulting in ageing populations. Societies in Japan, South Korea and the city of Hong Kong are among the oldest in the world and have already reached points of peak population; Japan is expected to see an almost 20% reduction in population between 2020 and 2055, and South Korea's population is expected to shrink by 16% in the same time frame.[10] Affluent Asian countries, such as Japan, will seek to mitigate the impact of a diminishing workforce through technology, particularly automation. China may seek similar solutions to address the projected decline of its working age population by as many as 280 million people over the same period.[11] However, despite its huge overall GDP, China maintains a relatively low GDP per capita and adopting new technologies such as automation may exacerbate inequality as the poor and uneducated find themselves disproportionately affected.

In contrast, South Asia will continue to see high levels of population growth. India is already the world's most populous state, having overtaken China in 2023, and is projected to peak at 1.69 billion people around 2055.[12] Afghanistan will show the highest level of population growth, with the number of people expected to more than double by 2055 and not peak until late in that decade, although climate impacts may moderate this trajectory.[13] Bangladesh will remain one of the world's most densely populated countries. While this will place these countries in a demographic window of opportunity where the ratio of working age people to dependants could serve to boost economic growth, uncertainty remains as to how far individual South Asian countries will succeed in maximising on these opportunities.



Source: United Nations Population Division (2022)

Population statistics projection for East and South Asia by age range

10 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
11 Ibid.
12 Ibid.
13 Ibid.

It is estimated that 88% of the next billion people to attain middle class status will reside in Asia, with the majority being in China and India.[14] The growth in the urban middle class will result in an increase and shifts in consumption as large numbers of people gain the financial security to spend more freely on discretionary products and services. The collective influence of the middle class will grow, resulting in increasing pressure on governments, and in some cases demands for political change.

The region will see the continued expansion of its education sector with a massive growth in the number of students attaining tertiary qualifications. The share of Chinese and Indian 25–34 year old tertiary graduates is projected to increase from 31% of the global pool in 2013 to 50% by 2030; the US share almost halves in the same period.[15] Due to sheer numbers, the region will dominate global education outputs, particularly in science, technology, engineering and mathematics (STEM); by 2030, 60% of global STEM graduates will be the product of China and India's education systems, with the US and Europe graduating only 4% and 8% respectively.[16] While China has drawn ahead of India in the tertiary rankings, there are signs that this trend might be moderated in the future as Western states increasingly seek to compete against China in the education arena;[17] if this does transpire, India may ultimately be the net beneficiary.

Inequalities in the ability to access education will continue to persist both within and between regional societies. In those countries where education levels remain low, growing youth populations may be frustrated by the lack of education and employment opportunities, which could drive instability. Even where improvements do occur, certain sectors of society in some countries may remain left behind. The region's enduring gender divide provides one example of this, most strikingly in Afghanistan, where the Taliban government has imposed fresh restrictions on female access to education. Although China, conscious of looming workforce issues, has been approaching gender equality for secondary and bachelor-level education for some time now, gender disparities still persist in India, which could see a significant rise in general educational attainment levels if progress can be made in this area.[18]

Most people in East and South Asia live in cities and the trend to move from rural to urban areas will continue, with approximately a quarter of global urban population growth out to 2055 predicted to occur in this region. Global megacities will continue to be concentrated in this region, remaining steady at around 50% of the world's total based on current projections to 2035.[19] Many countries will see urban environments evolve into high-tech digitalised cities, where systems are interconnected and there is a high reliance on data in civic management and decision-making. However, while urbanisation will result in a steady improvement in living conditions for many, the benefits will not be shared evenly, and others will continue to reside in poorly serviced informal housing within an increasingly modern metropolis. This proximity of uneven living conditions could lead to a growing awareness of inequality, potentially resulting in urban unrest.

14 Kharas, H., The Brookings Institution, Global Economy and Development Working Paper 100 (28 February 2017), *The Unprecedented Expansion of the Global Middle Class: An Update*.
15 Organisation for Economic Co-operation and Development, Education Indicators in Focus, Number 31 (April 2015), *How is the global talent pool changing (2013, 2030)?*
16 Schleicher, A., BBC News (16 March 2016), 'China opens a new university each week'.
17 Ellis, R., Times Higher Education (12 October 2022), *World University Rankings 2023: US Stagnating, Oceania Rising and a weak point for China*.
18 World Bank (2022), 'Educational Attainment Dataset'.
19 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.

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While urbanisation will result in a steady improvement in living conditions for many, the benefits will not be shared evenly

As levels of urbanisation increase, it is likely that the region's cities will become more active on the international stage through diplomatic initiatives at the sub-national level. This may create tensions within domestic political systems as cities begin to act as centres of power in their own right and are increasingly able to act independently of state governments in international affairs. City-based trade agreements, information-sharing and investment decisions are just some of the activities that may increasingly occur outside direct state-level control. In some cases, cities could find themselves in direct competition with state government objectives, leading to an increase in political and social unrest.

The increase in urban migration could be exacerbated by a growth in other forms of migration, particularly due to climate change and natural disasters, which over the next few decades are likely to cause large-scale movements of people both within and between countries. If emission levels remain high, it is estimated that South Asia could see 35.7 million climate migrants, equivalent to 1.6% of the population, by the middle of the century;[20] however, other studies suggest the number could be as high as 63 million.[21] Bangladesh's population density and vulnerability to climate impacts makes it most liable to see large-scale external migration, most likely into neighbouring India and Southeast Asian countries. The ability of South Asian governments to control these movements will be limited and there is a risk that existing ethnic tensions will be exacerbated. In East Asia, migration is more likely to remain within state borders, presenting a domestic challenge for governments.

Religion and culture will continue to play a significant role in regional politics, particularly in South Asia. Inter-group inequalities and discriminatory policies towards minority groups are likely to endure in some countries, most evidently in terms of religious divides where a

20 Zandt, F., Statista: World Bank (4 November 2021), 'Climate Change, the Great Displacer'.
21 Singh, H., et al., ActionAid (18 December 2020), *Costs of climate inaction: displacement and distress migration*.

dominant religious group may carry disproportionate influence in state politics. Aside from religion, cultural and historical factors also inhibit diversification; for example, Japan and China remain reluctant to encourage inward migration, although ageing populations may cause both countries to re-examine this in future years.

The rapid adoption of new technologies will create profound societal shifts in the region. Although the precise character and impact of these changes remain uncertain, access to a wider range of information sources may lead to a readjustment in cultural attitudes as family, religion and educational institutions become less dominant in shaping the information that young people receive. Changes in the way in which citizens consume information will spur some states to establish increasingly strict controls over information systems, potentially driving increases in nationalism and political polarisation between states.

The next 30 years are likely to see a number of regional actors expand their global cultural influence. The Chinese gaming industry, now the biggest in the world, is constantly expanding, and in the future may contribute to a significant increase in China's soft power. Chinese blockbuster films with patriotic themes are reaching an increasing number of viewers, including many outside China. However, in terms of output, the Indian film industry continues to be by far the biggest in the world, with a huge global audience. South Korean K-pop and Japanese manga are other examples of globally popular phenomena that provide these countries with extensive soft power; over time the increasing popularity of these and other emerging artistic genres may see the region's cultural influence rise further.

Global K-pop success

South Korean pop culture, often referred to as K-pop or Hallyu (Korean Wave), has gained a worldwide following in recent years. This success is built on decades of South Korean government investment in the arts, but there are indications that it is no longer purely a one-way export. The global fanbase is now generating its own Hallyu-inspired music, dance and even 'Webtoons', a form of digital comic popular in South Korea.[22] This deeper reciprocal flow of Hallyu art could gradually increase popular awareness of South Korean culture, making it an effective long-term soft power tool, particularly within Asia.[23]

Economy

East and South Asia are likely to dominate global economic growth rankings out to 2055. Most of the region will step into the middle-income bracket and China, despite its recent economic slowdown, will move into the high-income bracket over the next few decades, forcing a change in geopolitics as countries shift from developing status to being key players in the global economy. Large multinational corporations, including those operating in the advanced manufacturing and technology sectors, will continue to emerge from the region and will increasingly compete with Western companies for dominance.

22 Choi, H., *Sociétés*, Volume 161, Issue 3 (July 2023), 'The Korean Wave: From Global Consumption to Global Creation', pages 137–145.
23 Space Oddity, Statista (12 August 2019), 'Distribution of K-pop view on YouTube worldwide as of June 2019, by country'.

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Competitive advantage in high-tech manufacturing will be increasingly central to the region's economic prospects, and may help counter demographic decline

The development of the region's technology sector will provide significant trade opportunities, which out to 2055 should further boost its share of the global economy. Technology will increasingly be seen as the key to continued economic prosperity, particularly for East Asian states experiencing population declines. The traditional regional technology centres of Japan, South Korea and Taiwan will continue to be important, although their relative advantage may erode. China, and increasingly India, will seek to expand their global technological influence and compete with more established players for a greater share of the global market. North Korea and Afghanistan are likely to remain among the lowest ranking countries for technology development, and they may see themselves fall further behind.

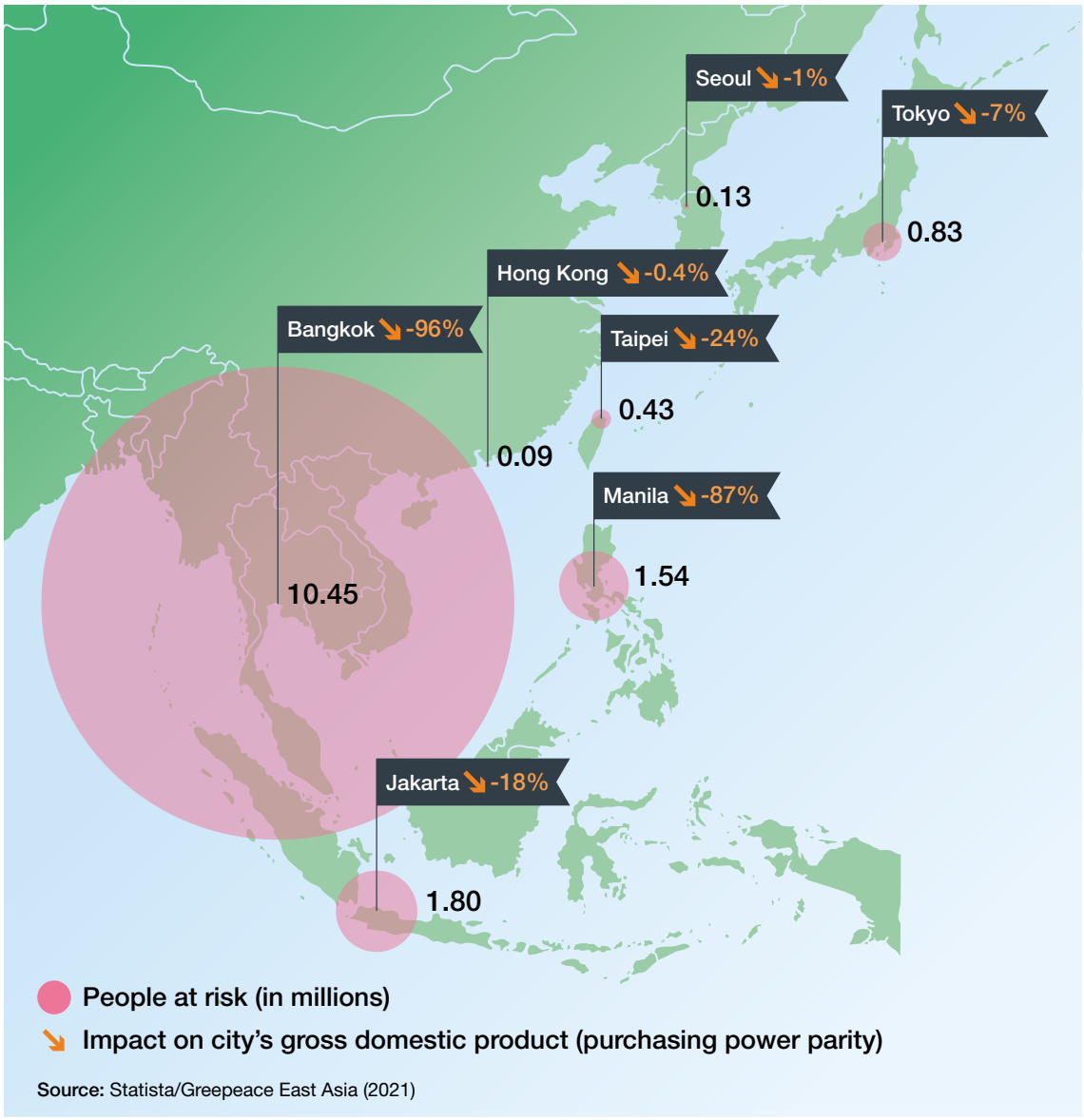
Increasing regional and global dependence on critical minerals will result in growing demand and high levels of competition between states. China currently has 37% of global reserves of rare earth elements and was home to over 80% of the global processing capacity in 2021;[24] it already uses its market dominance as a tool for geopolitical influence, and it is likely to continue to do so in future. China's role as the primary global processor of critical minerals makes it a significant importer of ores and concentrates, and out to 2055 it will look to protect supplies by investing in critical mineral mines through the Belt and Road Initiative and other forms of foreign investment.

East and South Asia are likely to see increasing demand for resources, driven by a combination of factors, including an expanding population in some parts of the region (particularly in South Asia), a growing middle class across the whole region, and national desires to achieve economic advantage in trade and to secure domestic supply chains. Reliance on the oceans as a provider of food will grow and overfishing, already a recognised issue in many places, may present an increasing problem. Increased competition for fish is likely to result in a growth of illegal fishing by both commercial and state actors in the exclusive economic zones of other countries, thereby increasing tensions in the maritime environment. At some point the region may experience a sudden and unexpected collapse in fish stocks, with significant economic and social implications for many states.

24 Institute for Energy Research (23 February 2021), *China and the Rare Earth Supply Chain Policy Brief*.

Ocean trade routes will continue to be important in the region, although China will look to reduce its reliance on maritime choke points through land-based Belt and Road Initiative projects, such as the land corridor in Pakistan. In the long term, however, such initiatives may have relatively little impact in comparison to broader developments such as the possible opening of Arctic routes due to climate change, or the reconfiguration of global trade patterns by additive manufacturing (3D printing) technology.

The impact of natural disasters and climate change will take an increasing toll on the region's economies over the next 30 years. Rainfall patterns in China have altered drastically in the last few decades, causing large increases in flooding; the resulting economic damage is currently estimated at US $25.3 billion a year, with projections that it could reach US $389 billion a year in the next two decades.[25] Several of the region's major financial centres, including Hong Kong, Tokyo, Seoul and Taipei, are at risk from sea level rise.[26]



Risk to Asian cities due to rising sea levels and flooding[27] by 2030

25 World Bank (2021), 'Capture fisheries production (metric tons)'.
26 Brooks, C., et al., *Nature*, Volume 558 (13 June 2018), 'Watch over Antarctic waters', pages 177–180.
27 In the event of a ten-year flood (1:10 chance of occurring in any given year).

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Low levels of freshwater availability in states such as Pakistan are already causing challenges

The density of populations and proximity of countries in the region create good conditions for economic advancement, but also a need for infrastructure development. Economic growth will depend on external investment, improvements in the region's education sector, a growth in Internet connectivity and the development of digitised systems. However, these improvements are likely to occur as a result of broader global trends and technology diffusion, potentially creating a virtuous circle of economic and social development. As regional wealth grows, many countries are likely to move to a more services-based economy; at the global level, the region may shift from being the traditional supplier to a dominant user of goods. In the longer term, traditional manufacturing may begin to migrate from the region to developing parts of Africa.

Environment

The region will experience increased pressure on resources over the next three decades, not only due to the impact of climate change and environmental degradation on food and water supplies but also as a result of population growth. For the densely populated areas of Macau, Hong Kong, Japan and South Korea, food, water and energy security will be of increasing importance, but difficult to achieve due to the tense geopolitical environment and limited domestic capacity. Elsewhere, high levels of population growth will place South Asian countries under increasing food and water stress.

Water security will remain a critical issue for the region, which is likely to suffer from increasing levels of water stress. Low levels of freshwater availability in Pakistan, India, South Korea and Afghanistan already create challenges for those countries; at the extreme end, the Maldives are almost totally dependent on non-renewable sources or converting non-potable water sources.[28]

28 Central Intelligence Agency (2022), 'The World Factbook'.

Water is already a geopolitical issue in the region because the Tibetan Plateau is a source of fresh water for many countries and the Mekong River, which originates in China, supplies water to much of Southeast Asia. As populations grow and environmental degradation increases, these sources are likely to come under increasing pressure, adding to tension and competition between states. As water becomes increasingly scarce, there will be a growing reliance on technological solutions that go beyond rainwater collection and include water recycling, fog collection and desalination.

Atmospheric water harvesting

Atmospheric water harvesting technologies provide a method to access the increasing amount of atmospheric moisture in a warming atmosphere as traditional water sources such as rivers and groundwater become exhausted or unreliable. Electrically powered active atmospheric water harvesting systems are a mature technology, using water-absorbing materials to extract up to 10,000 litres of water a day, but are costly to install and run.[29] Passive systems are more suitable in rural or developing regions, and by using advanced materials they are generating respectable yields at higher relative humidity levels.[30] However, although a warming atmosphere will hold more water, climate change may see atmospheric water harvesting confined to coastal regions and higher latitudes, while higher relative land temperatures in equatorial inland areas could see relative humidity decline.[31] This may make passive atmospheric water harvesting more challenging in the areas where it is perhaps needed most.

Changing weather patterns and a greater incidence of extreme weather events could cause short- and long-term changes to crop production. The effect on rice crops, which may be increasingly at risk from low rainfall and saltwater intrusion, is a particular concern. As a staple food both regionally and globally, this could not only cause economic loss and periods of food stress at the local level but could also impact global food supply chains and prices.

Already highly vulnerable to the impact of natural disasters, the region is likely to be increasingly affected out to 2055 as the effects of climate change increase the intensity and occurrence of extreme weather events. Beyond the growing risk of floods and droughts, a large-scale earthquake in the Himalayan region, along the Pacific Ring of Fire (the location of 75% of all active volcanoes and 90% of all earthquakes) or in the Indian Ocean is a further ever-present threat that could cause catastrophic damage, particularly in densely populated areas. While any state could be severely affected by a natural disaster, the region's poorly developed countries will be most vulnerable to large-scale loss of life, climate-driven migrations and the longer-term effects of disease and water and food shortages.

29 Eisenstein, M., *Nature* (14 December 2023), 'Fresh water from thin air'.
30 Zhu, W., et al., Nature, *Communications Engineering* (9 June 2023), 'Radiative cooling sorbent towards all weather ambient water harvesting'.
31 Willett, Dr K., World Economic Forum (7 December 2020), 'Investigating climate change's 'humidity paradox''.

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Many of the world's most polluted cities are found in this region

East and South Asia may be increasingly vulnerable to hazards resulting from their extremely high levels of pollution. In some parts of the region air and water quality are among the worst in the world, and even Japan (which arguably has the best air quality in the region) is still considered to have moderately unhealthy levels of pollution. This was highlighted during the COVID-19 pandemic when national lockdowns resulted in an immediate improvement in air quality. This has fostered a greater public awareness of the effects of pollution and is beginning to spur societal demand for improvements in air and water quality. Meeting these demands will be difficult, particularly in South Asia where states are experiencing high levels of population growth, urbanisation and industrial development, all major contributors to pollution.

The increased demand for energy in the region over the next few decades will be significant. India will overwhelmingly dominate this growth, with energy consumption set to almost double, driven by population increase (including a growing middle class) and industrial development.[32] In the short term at least, fossil fuels will continue to play a significant role in meeting the region's energy requirements. China has 332 coal power plants currently planned or under construction and elsewhere, India is already planning or building an additional 26 coal power plants, Pakistan eight and Bangladesh eight.[33]

The region is also likely to see significant development of its renewable energy sector over the next 30 years. China is currently the market leader in solar power production and supply, but India has demonstrated its capabilities by producing the world's cheapest solar energy and, along with the European Union, may grow as a competitor to China. Smaller states in the region also have the potential to expand into renewable production and in so doing improve their energy security. For example, Bhutan and Nepal have significant potential to expand their hydroelectric production and export this to neighbouring states such as India and Bangladesh. As economic factors continue to be a major consideration in the switch to green energy, a continued decline in costs may encourage a growing shift away from fossil fuels to alternative sources.

32 International Energy Agency (October 2022), *World Energy Outlook 2022*.
33 Global Energy Monitor (January 2024), 'Coal-fired Power Stations by Country'.

China and India are establishing themselves as global research powers, with their capabilities illustrated in increasingly ambitious space programmes

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East and South Asia will dictate the degree of effectiveness of the global response to climate change over the next few decades. The size of the region's population and its projected growth in energy demand will not only place a significant strain on global resources but will also mean that countries' actions, for good or ill, will have a profound influence on global rates of climate change. The region currently demonstrates mixed trends on climate action, making the outcome uncertain. Both China and India rank poorly on environmental performance, carbon dioxide emissions and pollution, and have among the latest carbon neutral goal dates in the world (2060 and 2070 respectively).[34] Both are likely to see continued growth in fossil fuel use, while at the same time leading on technology development and the supply of green energy. East Asia has the capacity to act independently on climate change, supported by strong domestic markets and economies; however, some South Asian countries are likely to be economically and technologically limited in the actions they can take and will look to the international community for support.

Technology, infrastructure and communications

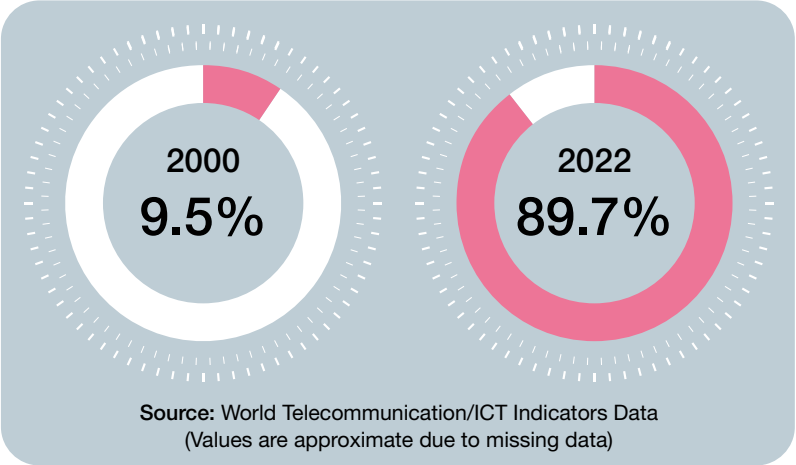
Out to 2055, the region's traditional leaders in technology development, notably Japan and South Korea, will face increasing competition from others, particularly from India and China, which have made rapid progress in the global technology race. The rise of these new technology powers will occur in conjunction with a rapidly growing education sector in both countries, and both will make increasing efforts to invest in high-end technology, manufacturing and automation capabilities, with the result that they may soon be global leaders in the fields of science and technology.

A key area for future focus will be whether China and/or India will grow to dominate the global research and development sector. Recent trends of industrial modernisation and research in China are often cited as evidence of its impending dominance; however, this rapid rise has been enabled primarily by technology transfer rather than through domestic innovation. The success of current initiatives to transition these competencies into true indigenous innovation will be a critical factor for future growth.[35] The recent US focus on

34 Central Intelligence Agency (2022), 'The World Factbook'.
35 Zhao, J., *Monthly Review* (1 July 2021), 'The Political Economy of the U.S.-China Technology War'.

restricting technology transfer may slow down the growth of China's technology sector in the coming decade. India's more favourable relations with the US and Europe and its high levels of proficiency in the English language could potentially give it an advantage here. India, as an emerging technology power, may become an essential provider of less costly technology solutions in major parts of the world.

Out to 2055, new technology developments may allow the region's developing countries (a number of South Asian states in particular) to experience rapid technology leapfrogs, which could give rise to significant economic and social development opportunities. This will be enabled by the expected increase in digital connectivity in the region. China currently has the greatest number of Internet users in the world,[36] and the number of Indian Internet users is projected to reach one billion by 2024.[37] However, levels of digital connectivity in other states remain significantly lower, with under 23% of the population having access to the Internet in Afghanistan and 17.1% in Pakistan, resulting in a sharp digital divide between states.[38] Even within countries, levels of connectivity remain uneven, with approximately 72% of the Chinese urban population having access compared with 28% in rural areas.[39] Over time, as digital communication becomes increasingly part of everyday lives, this could result in further increases in societal inequality, with women and the rural poor seeing themselves increasingly isolated from access to information and services.



Source: World Telecommunication/ICT Indicators Data
(Values are approximate due to missing data)

Average percentage of the population using the Internet in East and South Asia

Over the next 30 years, China, and possibly India, have the potential to challenge US dominance in the information sector. In recent years, regional Internet and social media use has grown immensely so that its pervasiveness now surpasses that seen in the West; Chinese-developed applications such as WeChat and Weibo compete with US applications such as Facebook and YouTube for customer allegiance. However, while China may increasingly come to challenge the US for market dominance within the region, geopolitical pressures may limit its ability to expand its influence outside the region and across the globe. China is likely to face continued challenges to the expansion of its technological influence in parts of the world as the West seeks to highlight security

36 Wan, L., *Global Times* (28 April 2020), 'China's internet users reach 900 million, livestreaming ecommerce boosting consumption'.
37 Bansal, R., et al., Carnegie India (21 September 2020), *Recovery, Resilience and Adaptation: India from 2020 to 2030*.
38 Central Intelligence Agency (2022), 'The World Factbook'.
39 Wan, L., *Global Times* (28 April 2020), 'China's internet users reach 900 million, livestreaming ecommerce boosting consumption'.

concerns over adopting Chinese technology, and the US coordinates technology restrictions against it. This could lead to growing international divergence as states find themselves forced to choose between US- or Chinese-developed software and social media platforms.

Enabled by its high levels of economic growth in recent years, China has invested heavily in space-access capabilities, which has made it less dependent on Russia in this field. China's satellite network has grown from an Asia–Pacific to a global coverage navigational and communication system, and its value is projected to grow to be approximately US $156 billion by 2025, exporting services to more than 100 million users across 120 countries.[40] China will continue to view space as a source of power and prestige and will pursue parity with the US in the 2030s.[41] China's long-term ambition is to build presence in the cislunar space and beyond and potentially displace the US as the leading space power. In addition to China, Japan and India are also established space powers and recent technology developments have seen a major expansion of space programmes in these and other regional states. While these programmes are largely dictated by national considerations (and are primarily of a military nature), their programmes, policies and objectives naturally differ. North Korea is rapidly advancing its rocket launch capabilities, while India is making progress in sensor and engine technology ambitions, and Pakistan could expand its space programme in the coming years.

Conflict and security

Defence spending in the region has historically been high and has increased over the last decade, driven in particular by China's efforts to modernise its military capability. Of the top ten global military powers, five – China, India, South Korea, Japan and Pakistan – are in East and South Asia.[42]

The region has numerous historical tensions, including a number of territorial disputes. On land, the border between North and South Korea, the overlapping claims of China, Pakistan and India, and Japan's sovereignty of the Senkaku Islands (contested by China and Taiwan) and the Kuril Islands (contested with Russia) are just some of the points of tension. In the maritime environment, there are numerous competing claims in the South China Sea, East China Sea and Bay of Bengal that involve many of the states in the region as well as some further afield, notably in Southeast Asia. In addition, the future of Taiwan remains a key uncertainty and how this develops over the coming years may have global ramifications.

These disputes are merely symptoms of the underlying drivers of nationalism and resource competition that out to 2055 are forecast to increase further in the region. As a result, regional tensions will persist and over time may worsen, carrying the risk of state-on-state war. Given the size of state military forces and the presence of nuclear weapons in the region, the implications of any such escalation could be significant, potentially drawing in China, Russia, the US and other members of the Five Eyes partnership. The involvement of these actors may result in the crisis spreading to the Euro-Atlantic region, with global implications.

40 Sewall, S., et al., Belfer Center for Science and International Affairs (February 2023), *China's BeiDou: New Dimensions of Great Power Competition*.
41 U.S. Department of Defense (2023), *Military and Security Developments Involving the People's Republic of China: Annual Report to Congress*.
42 Global Firepower (2024), '2024 Military Strength Ranking'.

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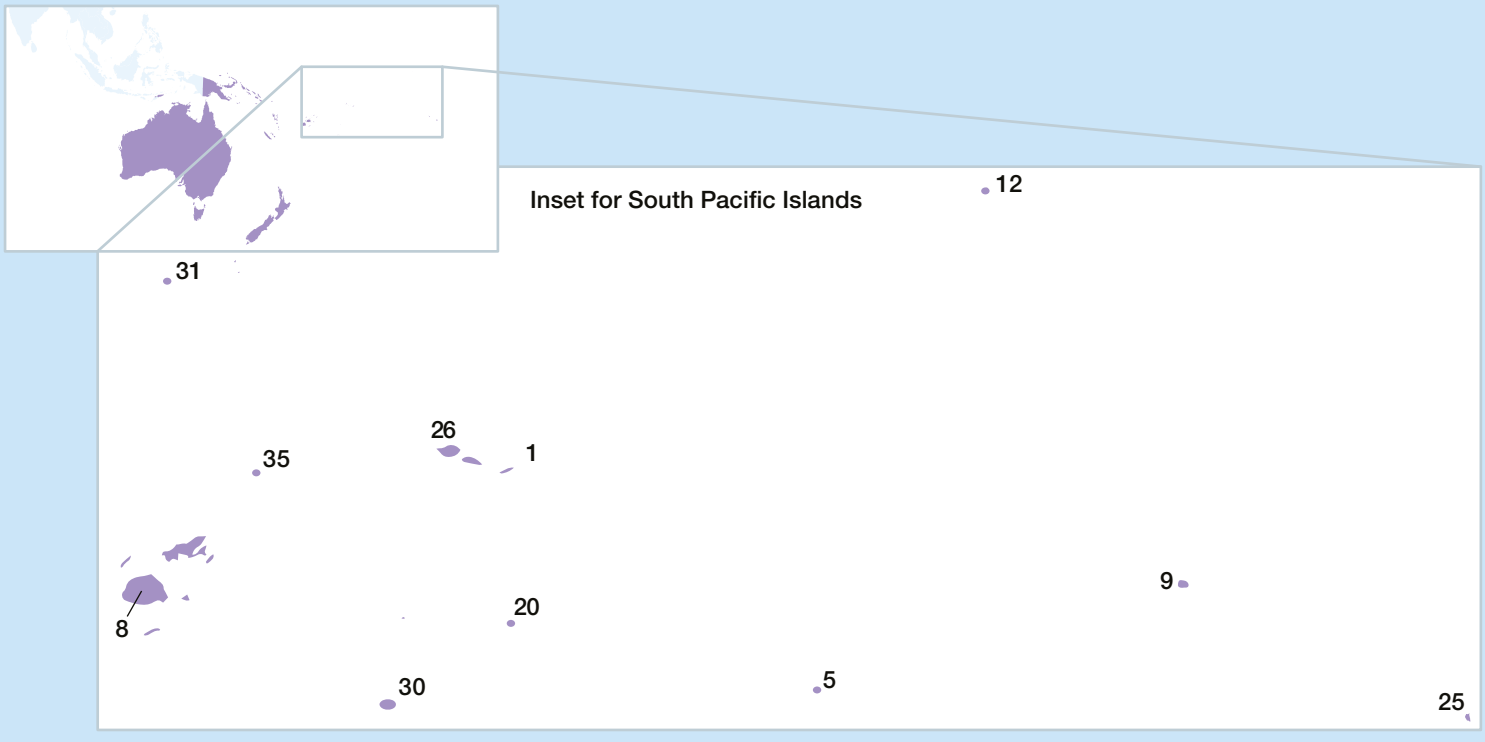
Regional tensions are likely to encourage states to invest in diverse defence partnerships

Whilst international tensions dominate today's headlines, internal security could be a growing issue for regional states. A growing middle class, rising inequality and climate-driven resource scarcity are the most likely drivers of domestic unrest. In tandem with this increase in internal instability, terrorism will continue to challenge some states, most notably Sri Lanka and Afghanistan, but also other states in the region.

The frequency and severity of natural disasters, combined with dense populations and inadequate infrastructure in some areas, makes the region highly vulnerable to large-scale humanitarian disasters, including the emergence of new pandemics. Out to 2055, the requirement for humanitarian assistance and disaster relief operations in the region may grow, leading to increased calls for support from the international community. In an era of enhanced global power competition, states will increasingly target their assistance activities in favour of allies and partners in the region, or to win new support.

1 American Samoa[i]
2 Australia
3 Brunei
4 Cambodia
5 Cook Islands[ii]
6 East Timor
7 Federated States of Micronesia
8 Fiji
9 French Polynesia[iii]
10 Guam[i]
11 Indonesia
12 Kiribati
13 Laos
14 Malaysia
15 Marshall Islands
16 Myanmar (Burma)
17 Nauru
18 New Caledonia[iii]
19 New Zealand
20 Niue[ii]
21 Northern Mariana Islands[iv]
22 Palau
23 Papua New Guinea
24 Philippines
25 Pitcairn, Henderson, Ducie and Oeno Islands[v]
26 Samoa
27 Singapore
28 Solomon Islands
29 Thailand
30 Tonga
31 Tuvalu
32 United States (US) Minor Outlying Islands[i]
33 Vanuatu
34 Vietnam
35 Wallis and Futuna Islands[iii]

[i] Unincorporated unorganised territory of the US.
[ii] Self-governing entity in free association with New Zealand.
[iii] Overseas collectivity of France.
[iv] Commonwealth in political union with the US.
[v] UK Overseas Territory.



Southeast Asia and Oceania

Current strategic context

Extending into both the Indian and Pacific Oceans, the region of Southeast Asia and Oceania is intimately intertwined with the wider Indo-Pacific region. Although Australia dominates in terms of size, and several states are part of the Eurasian land mass, the region largely comprises a collection of islands, from archipelago states like Indonesia, with the fourth largest population in the world, to the city state of Singapore. A third of regional states are small, dispersed islands with populations under 150,000 and only a third of states have a population over 1 million, making them some of the smallest countries in the world.[1]

Despite the exceptionally small population and land mass of many states, almost all lay claim to large maritime exclusive economic zones as a result of the dispersed island geography of the region. This significantly increases their relative size and, taken together with their geographic location, is giving them significant influence in global affairs as the importance of ocean-based resources increases.

Economically, the region remains one of extremes. At one end, many of its smaller states have commensurately low economic power, whilst, in contrast, Australia and Indonesia are ranked in the top 20 global performers on gross domestic product (GDP) ratings and Singapore has one of the highest levels of per capita GDP in the world. In Southeast Asia, economic growth has been consistently high for the last two decades.

Environmentally, the region is one of the lowest direct contributors to climate change but is highly vulnerable to its impacts. Natural disasters and extreme weather events are common and, when combined with the effects of climate change, they present an existential risk for some states.

The region's geographic location and its growing economic weight, together with intensifying interest in its ocean-based resources and seaways, means it is attracting increasing interest from global actors. Despite some fluctuations in relations, the posture and guarantees of the United States (US) have largely underpinned regional security since 1945; however, other powers, such as China, are now vying for influence and trying to secure footholds from which to leverage the region's potential. Although regional powers such as Australia and New Zealand are broadly Western-oriented in their strategic outlook, the region's history has in general fostered a desire to avoid being caught up in the growing competition between the great powers. A number of states, including Indonesia, have long-standing traditions of non-alignment and in the future may become crucial to determining the strategic approach of the region overall.

1 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.

The region's complex history has left an array of overlapping security, economic and diplomatic relationships, many of which are bilateral or mini-lateral in nature. In terms of the region's multilateral bodies, the Association of Southeast Asian Nations (ASEAN) and the Pacific Islands Forum (PIF) currently dominate, and going forward are likely to remain its most influential organisations, although competing priorities sometimes limit cooperation in practice. Whether these organisations succeed in strengthening and broadening their remits, as some members wish them to do, will be a key influence on the region's future trajectory.

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Key drivers of change

Great power competition. Southeast Asia and Oceania's location and resources will give it critical importance over the next 30 years. The growing opportunities for wealth creation in the region will drive increasing global interest in its resources and markets and will see external powers vying for footholds from which to project their influence. Shifts in geopolitical alignment could occur in many states in the region. At the same time, rising regional powers such as Indonesia could act as a counterweight to external influences and encourage the development of a strong regional voice, helping the region to mitigate the effects of increasing global power competition on its own trajectory.

Inequality of wealth and power. Many regional states will see improvements in their economic performance, driven by growing populations, increases in consumption, technology development and access to the growing consumer markets of China and India. In contrast, Oceania's small island states will continue to face significant economic challenges and are likely to remain reliant on external actors for investment and support. This increasing divergence in economic performance will result in growing inequality between regional states, potentially leading to shifts in the balance of power.

Climate change and natural disasters. Despite its relatively small contribution to total global emissions, Southeast Asia and Oceania will be highly vulnerable to its impacts. Aside from the risks posed to populations, infrastructure and economies by natural disasters and extreme weather events, rising sea levels will pose an existential threat to the region's coastal cities and small islands, and some of these may become uninhabitable. Dependence on external actors for disaster relief will grow, potentially becoming an increasing source of competition and rivalry.

Access to shared spaces. Southeast Asia and Oceania's maritime routes will remain important both to regional states and the world. The region's vast natural resource holdings will come under increasing pressure in future decades due to a growth in regional and global demand; access to fishing grounds and fossil fuel deposits are likely to remain potential flashpoints, particularly in disputed areas. The region's size and isolation mean that access to space-based technology will be critical, and may facilitate the monitoring of its vast maritime zones.

A growing middle class. Many of the region's small and medium powers will see an increase in the size of their domestic consumer markets over the next few decades, which will drive improvements in levels of economic and social development. While this should result in an increase in overall standards of living, social and economic inequality will remain significant in many regional states, and the gap between the poor, the middle class and the elite population will continue to grow.

Future key trends

Global power competition

Southeast Asia and Oceania's geographical position between the US and China, and adjacent to the growing powers of India and Japan, will give it critical importance in an era of increasing global power competition. With access to both the Pacific and the Indian Oceans, the region is the gateway for maritime trade to the largest consumer markets and population centres in the world. This growing opportunity for wealth creation will drive growing global attention to the region, and it is here that world powers will increasingly seek to influence out to 2055.

Historical linkages will be increasingly tested over the next 30 years by new economic opportunities arising from increased investment on the part of global powers, for example, China, through its Belt and Road Initiative, and Japan. Shifts in geopolitical alignment are likely to occur in many states in the region. While Australia and New Zealand will continue to partner closely with each other, as well as with Northern American and European states, long-standing positions of non-alignment may come under increasing pressure as a result of rising geopolitical tensions. Economic or security pragmatism may encourage non-aligned states to turn away from Western influence to secure Chinese investment, although any indications of such a move may encourage the intensification of Japanese and Western investment initiatives.

Within the region, however, middle powers will become increasingly influential in balancing these external influences. Historically, Australia has been one of the most active regional states through its trading links, diplomacy and provision of overseas development assistance, enabled by its high levels of wealth. Given Australia's deepening ties with the US, Japan and India, this seems set to grow. However, Australia's influence on regional matters may be limited due to its close relationship with the US, and its soft power potential will be closely coupled to US fortunes in the region. In contrast, New Zealand's strong economic, cultural and people links to many of the smaller island states in the Pacific Ocean result in a high emphasis on positive and enduring relationships with these countries. This may provide New Zealand with more durable diplomatic influence in Oceania, especially on matters related to climate change. As interest in the Antarctic region increases further, the 'gateway cities' of Hobart (Australia) and Christchurch (New Zealand) may see their geostrategic importance rise, and they could attract growing attention from external actors looking to gain access to Antarctic resources.

In the future, Indonesia's huge demographic dominance may give it greater influence in the region, particularly around trade and international diplomacy. The potential future admission of Indonesia to the BRICS group could see it strengthen its links with powers based outside the region. The evolution of Indonesia's relationship with China, particularly around South China Sea maritime disputes, remains a key uncertainty. Indonesia has a competing claim with China in this area, and states with similar disputes are likely to follow Indonesia's actions closely. Indonesia may leverage its considerable influence within ASEAN to promote its claim, creating another possible seed of regional cooperation.

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The region will increasingly be the subject of global competition for influence

The role of other external powers may also change in the coming decades. India is likely to use its increasing voice in the region, albeit balancing this role against its other interests. Some European powers have maintained important historic links with the region and have increased their military, diplomatic and economic interests; however, there is growing pressure in some quarters to sever colonial-era ties, which might lead to the loss of overseas territories over the next few decades. Russia is also seeking to build economic relationships in the region. However, its posture is likely to remain focused on security, as indicated by its regional relationship with China, its participation in military exercises and other activity, and its defence sales and provision of other support to authoritarian states such as Myanmar.[2]

Over the next three decades, competition is likely to resurface in the Indian Ocean. Myanmar will increasingly face competition for resources from other regional actors such as Indonesia, Malaysia and Thailand, all of which have direct access to the Bay of Bengal. Over time there is the potential for these countries to increase their activities in the Indian Ocean to avoid competition with China and others in the South China Sea. The presence of a growing number of actors in the Indian Ocean will increase competition with India, Sri Lanka and Bangladesh in particular, bringing new points of tension.

Although small by demographic and economic standards, the Pacific Ocean's island states will increasingly command the attention of global powers due to their geostrategic location. While some have maintained historical links to the US, France, Australia, New Zealand, the UK and the Commonwealth, these allegiances may increasingly be called into question, particularly as China expands its regional influence. In the longer term, other actors may be drawn into the competition, including India, ASEAN as a collective bloc, and potentially multinational corporations through large-scale investment. While island states may continue to act independently, there are increasing indications of the PIF developing into an effective collective forum, enabling them to protect their interests against pressure from global powers. However, economic factors may drive island states to prefer bilateral agreements, creating a possible driver for fragmentation of the PIF.

2 Ganesan, N., East Asia Forum (5 November 2022), 'Russian arms and influence in Myanmar'.

Can regional forums such as the Association of Southeast Asian Nations and the Pacific Islands Forum collectively resolve regional issues and balance the influence of global powers?

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Dependence on external actors to provide disaster relief will continue to grow, while also becoming an increasing source of competition and rivalry for those providing it. Investment in dual-use infrastructure (such as ports and airfields) that challenge existing US and other bases is also likely to continue or increase and heighten tensions. While such investments are currently evident in the Pacific islands, there are indications that in the future they may also extend into the Antarctic region as interests grow in polar space monitoring and potentially resource access.[3] Australia and New Zealand are particularly vulnerable to a reordering of the regional security architecture should this happen due to their proximity to these areas.

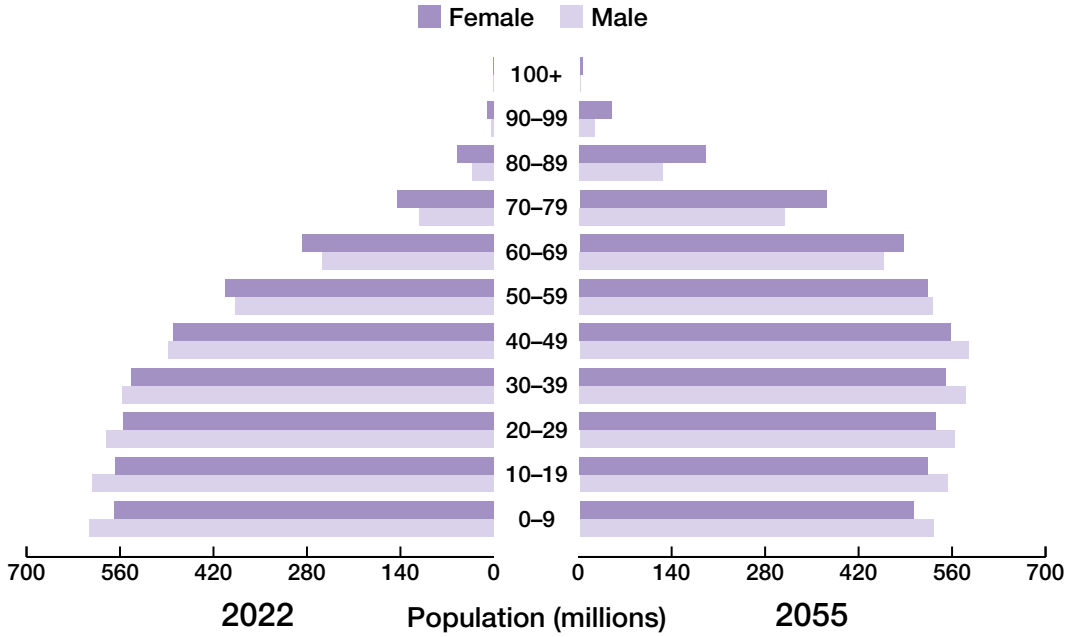
Key regional security bodies such as ASEAN and the PIF could increasingly fulfil their intent to manage regional security, economic and other challenges collectively and independent of outside influence. However, the level of agreement between members on key regional security issues remains an uncertainty, and both bodies (plus their individual members) may come under increasing pressure from external actors, potentially undermining organisational unity. Historic distrust and overlapping maritime claims could also prove an ongoing limitation to cooperation. Ultimately, the possibility of fragmentation due to differing levels of commitment on the part of member states should not be ruled out. Over time, this may see one or both of these forums superseded by sub-groupings, potentially aligned to China or the US. It is also plausible that a third 'non-aligned' bloc may emerge under Indian stewardship.

Society

Over the next 30 years, the demographic trajectory of the region's states will differ widely. Most Southeast Asian states – including Indonesia, Vietnam, Thailand, Malaysia and the Philippines – will experience a demographic dividend over the next two decades,[4] where

3 Runde, D. and Ziemer, H., Center for Strategic and International Studies (16 February 2023), 'Great Power Competition Comes for the South Pole'.
4 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.

the ratio of working age people to dependants may drive regional (and potentially global) economic growth. Conversely, many of Oceania's island states, including Nauru, Niue and Tokelau, are at risk of significant population collapse (and at worst, potentially, total depopulation) due to emigration, threats to food supply and the cumulative impacts of climate change. Papua New Guinea, the population of which is expected to double in size over the next 30 years,[5] stands out among the island states as an exception to this trend.



Source: United Nations Population Division (2022)

Population statistics projection for Southeast Asia and Oceania by age range

The ability to educate the region's young people will be a key requirement out to 2055 if they are to obtain high-quality employment opportunities. Australia, Singapore and New Zealand are likely to retain their position as leading higher education centres. Within the region, only these three states have universities ranked in the global top 100 universities, and they have more than double the number of top 1,000 ranked universities than the rest of the region combined.[6] However, while this high-quality education will remain in demand, it comes with high tuition costs. A degree from the nearby growing education superpowers of India and China or rapidly improving Malaysia is a fraction of the cost. These cheaper yet reputable destinations will increasingly be the destination for students aiming to gain skills to equip them for advanced technical roles in the future economy. Citizens who lack the necessary education may find their options increasingly limited to employment in low-skilled service roles, including casual work in the informal labour market.

Over the next 30 years, the region, and particularly Southeast Asia, will see a continued growth in its urban population. While this will provide opportunities for many, including employment and access to services, not all will benefit. For some, the pace of urbanisation will create significant challenges. Papua New Guinea's urban population is projected to increase by over 70% alongside a general population boom, with Cambodia and Myanmar facing similar challenges.[7] Even in regions with more moderate urbanisation,

5 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
6 Times Higher Education (2024), 'World University Rankings 2024'.
7 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.

those who remain in rural areas or who end up in informal urban housing settlements will find themselves increasingly left behind. While overall standards of living will increase in the region, inequality will remain a significant factor for many regional states, and the gap between the poor, the middle class and the elite population will continue to grow.

Some of Oceania's states will experience increasing internal migration challenges as outlying and remote islands become uninhabitable due to a complex combination of environmental, economic and social pressures. This could potentially lead to increased tensions between different ethnic groups and between traditional versus more modern communities, creating security challenges that may see an increase in intervention by outside powers.

Foreign direct investment

The economies of Pacific Ocean island states are highly dependent on foreign direct investment.[8] While large Chinese investments have attracted attention in recent years, Australia remains the highest aid donor in the region.[9] Such support will become increasingly important as Pacific Ocean island states grapple with climate adaptation, and in future years their needs will extend beyond financial aid and investment. The proposed 'Falepili Union', where Australia would accept Tuvaluan climate migrants in return for security cooperation, may signal a shift to broader and more meaningful models of cooperation.[10]

Out to 2055, the region's Muslim population is likely to grow due to high birth rates in Indonesia and to a lesser extent Malaysia and Brunei.[11] Stricter interpretations of Sharia Law are already gaining traction in the region, including in countries that were founded on multicultural principles at the time of independence, and over the next few decades may become increasingly widespread. Other states will face the challenge of a rise in radical Islam, potentially threatening social cohesion and resulting in a growing security challenge. Christianity and Buddhism will also remain significant in some regional states.

Levels of democratic development vary widely in the region. Freedom House categorises ten states as 'Free', five as 'Not Free' and eight as 'Partially Free', with Thailand moving up to 'Partially Free' in 2024.[12] However, out to 2055, there remains a risk of democratic backsliding in the region. In most cases, any such changes will be gradual and minor, with little noticeable impact on everyday lives, but in some countries, such as Papua New Guinea or the Solomon Islands, these shifts may lead to an increase in instability and unrest. Myanmar is also likely to remain highly volatile following the 2021 coup; the continued use of violence against pro-democracy campaigners is likely to continue and potentially increase, in some cases supported by external powers.

8 World Bank (2021), 'Net official development assistance and official aid received (current US$) – Pacific island small states'.
9 Dayant, A. and Duke, R., Lowy Institute, 'The Pacific Aid Map'.
10 Huckstep, S. and Dempster, H., Center for Global Development (4 December 2023), *The Australia–Tuvalu Climate and Migration Agreement: Takeaways and Next Steps*.
11 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
12 Freedom House (February 2024), *Freedom in the World 2024: The Mounting Damage of Flawed Elections and Armed Conflict*.

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For states experiencing a demographic dividend, the quality of the educational opportunities that they are able to provide for their young populations may dictate their future economic success

Economy

Many of the region's countries, particularly Southeast Asian states, will see significant opportunities for economic growth out to 2055, driven by growing populations, wealth, technology development, and access to Chinese and Indian markets. Increases in the size of the domestic consumer class will be significant in the small and medium powers of the region, driving economic and social development. At the other end of the scale, the smallest of Oceania's island states will continue to face significant economic challenges due to their small and highly dispersed populations, weak education systems, and limited land mass and capacity to capitalise on ocean-based resources. As a result, they are likely to exhibit limited growth potential and will remain reliant on external support. However, despite wide variation in regional levels of economic growth, many countries will see improvements in their economic performance. Malaysia is likely to reach high-income status by the end of the decade,[13] and Indonesia and Thailand will also see rapid growth in their income levels in the next 30 years.[14]

Some Southeast Asian states stand out as having significant potential to achieve economic development as a result of their growing working age populations. Indonesia and the Philippines are most likely to realise benefits, while Vietnam, Thailand and Malaysia may also see progress but may potentially be limited by a larger number of retiring workers.[15] However, some states may be unable to meet the demands of their growing youth populations for high-quality education and employment opportunities, leading to frustration and potentially instability. In cases where a government chooses to maintain a labour-intensive workforce to meet population demands, it may lose out on international competitiveness to rival states that have adopted automation into their processes. In contrast, Oceania's small island states, with their small and highly dispersed populations, have the potential to benefit most from automation and new technologies, although

13 World Bank (16 March 2021), 'Malaysia to Achieve High Income Status Between 2024 and 2028, but Needs to Improve the Quality, Inclusiveness, and Sustainability of Economic Growth to Remain Competitive'.
14 Asian Development Bank (August 2011), *Asia 2050: Realizing the Asian Century: Executive Summary*.
15 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.

they will need external support to do so. The willingness of corporations and foreign governments to invest in such ventures remains uncertain and so, for the medium term, most of these states will continue to be heavily reliant on remittances and foreign aid.[16]

The exploitation of resources, notably minerals and food, has always been important for the region's economy and will continue to be so. What is more, competition for these resources will intensify in the next few decades as a growth in regional and global demand drives their extraction. Illegal, unreported and unregulated fishing will remain a significant challenge across the region as markets seek to meet the growing Asian demand for food. Larger states, including China with its significant fishing fleet, will extend their activities further into the Western Pacific and Southern Oceans as fish stocks migrate to cooler waters. For the Pacific Ocean's island states this will have an impact not only on their ability to capitalise on this abundant resource but may also lead to the collapse of a key food source, potentially leading to population displacement.

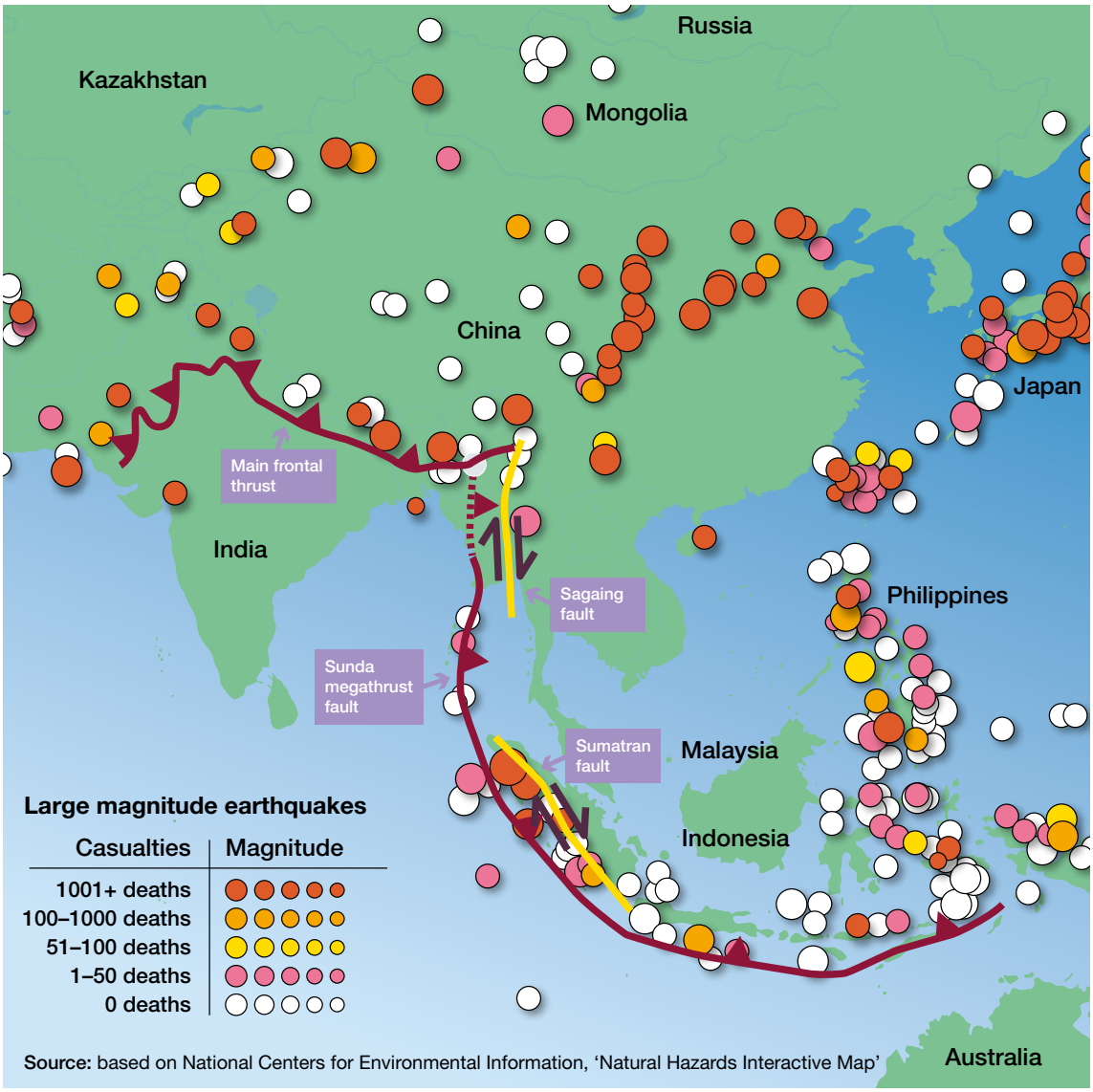
The region will continue to be a major supplier of the global demand for coal, gas, iron and uranium out to 2055. There is also significant potential for Australia and Vietnam in particular to increase mine production of a number of critical materials that may be required for the green energy transition. In the context of supply chain risks, these states are actively moving into processing and refining these materials as well, in some cases funded directly by other global powers.[17]

Given the high volumes of global trade that pass through them every day, regional maritime routes will remain of major importance to both regional states and the rest of the world. Out to 2055, the region's choke points, including the Malacca Strait which runs between Singapore, Malaysia, Thailand and Indonesia, are likely to remain and potentially become increasingly important. China's Belt and Road Initiative investments into alternative land routes connecting China to Europe and the Indian Ocean, as well as a proposed canal across Thailand to bypass the South China Sea, could change the region's maritime dynamic if they are ever completed. However, at present this remains an uncertainty given the difficulties that have been encountered so far with these projects. In the long term, Arctic sea ice loss may also create new routes with even greater implications for global trade patterns, although at the present time the precise impact remains uncertain.

Environment

Southeast Asia and Oceania will be increasingly impacted by climate change and environmental degradation over the next three decades. Extreme weather events, such as flooding, fires, drought and storms, are already widespread and are likely to be increasingly frequent and severe over the coming decades. Already highly affected by natural disasters, including from seismic and volcanic activity along the Pacific Ring of Fire (the location of 75% of all active volcanoes and 90% of all earthquakes[18]), the region is likely to see the incidence and severity of these events increase further.

16 Reuters (30 October 2023), 'Pacific Islands is world's most aid-reliant region – report'.
17 The White House (20 May 2023), 'Australia-United States Climate, Critical Minerals and Clean Energy Transformation Compact'.
18 National Geographic, 'The Ring of Fire'.



Areas at most risk of earthquakes in the region

Rising sea levels pose an existential threat to the region's coastal cities and small islands, and over the next three decades some of these may become uninhabitable. The total collapse of a Pacific Ocean island state, through a combination of climate, economic, demographic and security pressures, cannot be ruled out and would trigger widespread global attention. Responding to such an extreme situation would require an extreme response, for example, creating self-sustaining floating habitats, which in that time frame could be a technically feasible option. Where an island is no longer viable for habitation, it is possible that states may look to floating cities as potential solutions so that citizens can retain a sense of culture, identity and home. Some countries are also considering the creation of virtual space avatars as a means to preserve their heritage in the case of a loss of physical territory.[19]

19 Kelly, N. and Foth, M., The Conversation (16 November 2022), 'An entire Pacific country will upload itself to the metaverse. It's a desperate plan – with a hidden message'.

Preserving Tuvalu's heritage

In 2022, the Tuvalu government declared its intentions to become the world's 'First Digital Nation', recreating itself in the digital world. This digital reconstruction will allow the Tuvaluan government and people to retain their identify by capturing their history and culture, despite losing their physical territory. In addition, all government functions will be moved into the digital world, allowing the country to continue to function as a state. Tuvalu has also become the first state in the world to amend its constitution in a way that future-proofs its existence, despite the very real risk of land mass losses through climate and other environmental changes. Tuvalu's revised definition of statehood 'declares that the Tuvaluan state, within its historical, cultural and legal framework, shall remain in perpetuity in the future'.[20] In so doing, 'Tuvalu aims to maintain a sense of durable sovereignty and cultural preservation'.[21] This digital sovereignty has already been legally recognised by 25 countries.

Out to 2055, climate change, extractive industries and pollution are likely to pose an increasing threat to regional biodiversity and ecosystems, including the coral reefs on Australia's east coast and the rainforests of Indonesia. While the longer-term impacts of these losses remain unclear, they are likely to be significant due to the relative importance and size of these two ecosystems at the global level. A breakdown of either of these ecosystems, or a localised fish stock collapse somewhere in the region, may have cascading global impacts.

Access to water is likely to become a growing challenge due to population pressures, climate impacts and environmental degradation. The Mekong River is likely to become an increasing source of friction between China, Myanmar, Laos, Thailand, Cambodia and Vietnam. Use of the river for agriculture, freshwater supply and power generation is highly likely to increase over the next few decades, with the potential to cause international disputes over water rights and access.

Glacial melt from the Tibetan Plateau will continue to feed the Mekong River for the next couple of decades, and climate change is likely to increase the water supply for this period. However, in the long term, human activities, including constructing dams to improve domestic water security and as a source of hydroelectric power, will alter the flow of the river, with implications for downstream states. In the long term, beyond 2055, the cumulative effect of climate change on glaciers and rainfall, together with poor management of water resources, may undermine the viability of rivers such as the Mekong, affecting Southeast Asian food production.

20 Tuvalu website (2024), 'Tuvalu Government's Ministry of Justice'.
21 Hegde, A., *International Journal of Communication*, Volume 18 (2024), 'Digital Nations and the Future of the Climate Crisis'.

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In a region that is highly exposed to climate risks but home to fossil fuel-reliant economies, the politics of energy transition will be keenly felt

Southeast Asia and Oceania states are at present relatively small contributors to total global carbon emissions. However, by the middle of the century, it is projected that Southeast Asia's energy demand will have increased by 38–78%; based on stated policy, fossil fuel use is projected to continue to grow at least out to 2030, increasing Southeast Asia's relative contribution to global warming.[22] This sits in contrast to the low carbon emissions of Oceania's island states, whose vulnerability to sea level rises and extreme weather will make them highly sensitive to the climate policies and actions of their more carbon-intensive neighbours. Australia is a notable exception in Oceania, as a very high per capita emitter and a major exporter of fossil fuels, and which notably has lagged behind in implementing effective climate change policies.

The failure of regional leaders to match climate rhetoric with action will sit increasingly uneasily with the region's high exposure to climate risk. Given increasing frustration amongst regional states regarding the delivery of green pledges, Australia's ability to transition its economic model and enact climate-friendly policies could well determine its future effectiveness as a regional leader. Although there are recent positive indications, it remains to be seen if this momentum can be sustained in the long term. Out to 2055, a return to inaction on climate change may be to Australia's detriment and as a result it could see its diplomatic standing and economic power diminish. Indonesia will face similar challenges as it seeks to maximise on the potential of its growing working age population. While its bountiful fossil fuel reserves provide cheap energy, the continued exploitation of these may come at significant diplomatic cost.

In the immediate term, the increasing frequency and severity of natural disasters are almost certain to impact most regional states, placing an increasing financial burden on the region. In parts of this region, choices will be necessary to mitigate environmental degradation, as exemplified by Indonesia's decision to move its capital from Jakarta to the newly built Nusantara. Elsewhere, investment will be necessary to replace or protect climate-exposed infrastructure. Out to 2055, the combined burden of such responses may see some regional states coming under increasing economic strain.

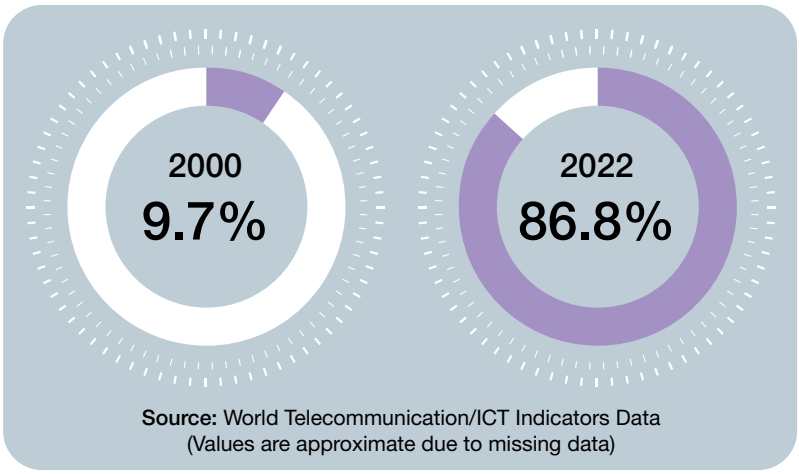
22 International Energy Agency (2022), 'Southeast Asia Energy Outlook 2022: Key findings'.

While natural disasters could lead to an increase in international cooperation, the next few decades may also see states expanding their domestic response capabilities as a source of national prestige. For a state to become a leader in the region, it will require an effective natural disaster response capability that can respond rapidly to a variety of circumstances; as a result, many of the middle powers in the region, such as Vietnam, Malaysia, Thailand and the Philippines, may look to expand their humanitarian assistance activities as their economies grow. At the same time, powers outside the region may seek to offer disaster relief support as a tool for influence in the region.

Despite the challenges that the region faces, climate change adaptation and mitigation measures may bring opportunities, and this could drive climate positive action in the region. Most of the region's island states rely on imported fossil fuels for energy supplies, representing a significant cost to national budgets; moving energy supply onshore through renewable technology would provide significant economic advantage in the medium term as renewables start to reduce in cost. In addition, Singapore is looking to diversify its energy supply chains by building solar farms in Australia and Indonesia;[23] if similar measures could be adopted by the island states of the Pacific Ocean, this could provide a significant boost to energy independence.

Technology, infrastructure and communications

Parts of the region will see a significant growth in Internet use over the next few decades as its expanding middle class populations seek and gain access to new forms of communication. The number of Internet users in Southeast Asia is expected to rise from 392 million in 2018 to 662 million by 2029.[24] Beyond driving economic growth, the ability to access information from a growing range of sources is likely to have an impact on youthful populations, whose attitudes and beliefs will be increasingly shaped by other influences rather than just the traditional ones of family, religion and education. This, together with the spread of disinformation by malevolent actors, will present an increasing challenge for regional governments over future decades. While states will differ in their responses, some, including liberal democracies, will increasingly look to control the flow of information to their populations to maintain stability.



Average percentage of the population using the Internet in Southeast Asia and Oceania

23 Reuters (8 September 2023), 'Singapore approves import of 2 GW low carbon power from Indonesia – minister'.
24 Statista (25 July 2023), 'Number of internet users in Southeast Asia from 2014 to 2029 (in millions)'.

A growth in digital connectivity will be particularly important to the smaller island states in the Pacific Ocean as their economies grow increasingly reliant on cyberspace to overcome their physical isolation. In some cases, increased connectivity could enable members of a state's diaspora population to return home as remote workers. However, increased connectivity will present new risks to states, including those presented by cybercriminals and terrorists who will seek to exploit technology to expand beyond physical boundaries. Security and espionage risks could also increase as major powers compete to dominate regional Internet and undersea cable provision.[25] Smaller states will remain reliant on external actors for support in areas such as cybersecurity and the policing of cybercrime activities.

Automation and other technologies may help some regional states to increase productivity and offset labour shortages over the next 30 years. Although the use of automation and artificial intelligence is already rising, the region lags behind East Asian states such as South Korea, China and Japan in this area; Singapore is the exception, as a regional and global leader in new technology. However, some states, including Indonesia and Cambodia, may face a dilemma as new technologies such as additive manufacturing (3D printing) and robotics threaten their labour-intensive industries, which are of high economic and social importance.

Out to 2055, technology developments could offer potential solutions to some of the environmental pressures facing the region. Sustainable farming methods and advances in water collection, use and recycling could all help to improve living standards, particularly in states with a limited land mass. Elsewhere, other technologies are being developed to remove plastic and other waste from the Pacific Ocean's garbage patches.[26]

Marine clean-up technologies

Technologies to clean up garbage patches in the Pacific Ocean have attracted much attention. Most rely on fixed or towed nets channelling the waste into extraction systems, with artificial intelligence guiding their deployment. The latest research suggests focusing these efforts on sensitive coastal ecosystems with high pollution inflows where more microplastics enter the food chain than in the open ocean.[27] However, whilst marine clean-up technologies are innovative and useful, they only treat the symptom and not the cause. To make a lasting difference, a change towards a circular economy, better waste management and abandoning single use plastics is of the utmost importance to reducing plastic pollution in the region's oceans.[28]

Regional states will increasingly seek to increase their access to space-based capabilities, either through domestic programmes or commercial arrangements with external actors. The region's geographic expanse and isolation means that access to space-based technology will be critical. Space-based capabilities, alongside remote sensing and automation technologies, may facilitate the monitoring of vast maritime zones. In the

25 Kotsonis, S. and Chakrabarti, M., wbur (22 May 2023), 'A new rivalry between the U.S. and China over the world's undersea cables'.
26 Cho, R., Columbia Climate School (13 October 2022), 'How Do We Clean Up All That Ocean Plastic?'.
27 Rochman, C., IOP Science, *Environmental Research Letters*, Volume 11, Number 4 (23 March 2016), 'Strategies for reducing ocean plastic debris should be diverse and guided by science'.
28 Colasanti, A. and Trotta, E., Mondo Internazionale (30 July 2022), 'Ocean plastic removal: technology as a development and sustainability driver'.

Antarctic and surrounding waters, for example, this will offer improved means to assess the effectiveness of environmental protection measures, as well as supporting efforts against illegal, unreported and unregulated fishing.

Technology developments could bring significant benefits for the region, offering unprecedented opportunities for economic growth and connectivity as well as new ways to manage the significant challenges presented by climate change and ecosystem losses. However, any such initiatives are likely to require external financial support and knowledge-sharing, which external states and corporate actors may exploit as a tool for influence. Competition between global powers to be the partner of choice for these many technological opportunities is likely to increase out to 2055 and may play a significant part in the region's evolving security outlook.

Conflict and security

Out to 2055, Southeast Asia and Oceania will continue to be characterised by multiple territorial disputes, driving tension and limiting cooperation between states. Political instability and ongoing ethnic tensions will continue to plague some countries, including Myanmar and Thailand. Cambodia, Malaysia, Indonesia, the Philippines, the Solomon Islands and Papua New Guinea also face a complex mix of internal challenges. Violent extremist organisations and serious and organised crime are also likely to present a continuing source of instability and, going forward, this could impact future investment decisions by outside powers. Although some partnerships have been developed, ongoing regional mistrust is likely to continue to limit the region's ability to develop multilateral responses to issues of this sort.

As well as the land-based border disputes such as those between Thailand and Cambodia, and Myanmar and Bangladesh, the region's many overlapping maritime claims will continue to contribute to tensions in the region. While the South China Sea is often regarded as the main focus, there are disputed zones across the region's seas, often involving multiple claimants. Access to resources, for example, fishing grounds and mineral deposits, are likely to remain flashpoints out to 2055, and a driver for increasing investment in coastguards, naval capabilities and further militarisation of reefs and other features. While tensions have so far been managed by the various states involved and diplomatic solutions may still be found, the possibility that these could lead to crises and even conflict, potentially drawing in other global powers, cannot be ruled out.

Rising sea levels, loss of territory and in some cases potentially the creation of self-sustaining floating habitats may also create uncertainty over the extent and sovereignty of island states' maritime zones, leading to new areas of competition in the Western Pacific region. The continued relevance of legal mechanisms, such as the 1982 United Nations Convention on the Law of the Sea, and the ability to rely on these to adapt and manage these challenges, will be important to prevent such disputes escalating into a major conflict.

Illicit activities, including illegal fishing in exclusive economic zones, will increase in frequency, particularly where states lack the ability to monitor or police their maritime claims effectively. Some states may resort to technology, big data and partnerships with external actors, including states and private military and security companies, to support them where their own domestic monitoring capabilities are lacking.

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Illegal fishing may grow as existing fisheries fail, driving tension in a region with many boundary disputes

Until recently, defence spending in the region has been moderate and is generally tied to levels of economic growth. However, recent tensions have led to a significant spike in investment in defence capabilities, especially in Southeast Asia, Australia and New Zealand, and may lead to further increases in spending in future. In contrast, the smaller island states of Oceania have minimal (if any) spending on defence, and instead will continue to rely on international agreements to provide military, and in some cases policing, support. Over the last few decades, Australia has been the region's dominant influence in providing international policing, military and humanitarian assistance support to other regional states, but China is now seeking to compete in many of these areas. This in turn has seen an increase in activities on the part of more distant actors such as France, the UK and the US. This growing competition for influence may see a further escalation of tensions in the region.

The region also faces an increasing risk of being drawn into conflict in neighbouring regions such as East Asia. The US has a number of territories (some of which include military facilities) in the region, as well as basing and access arrangements with several states. In the event of major conflict between global powers, these locations could become targets for attack, resulting in global economic effects. The potential impact of a crisis in the Indo-Pacific region on trade flows, commerce and other dynamics would have major implications for the region and the rest of the world. If other global states were drawn in, this could risk significant widening of any conflict.

1 Russia

Russia

Current strategic context

With a land mass of 16,376,870 square kilometres and spanning 11 time zones, Russia is the world's largest country and enjoys an abundance of natural resources. Its vast oil and gas reserves ensure virtual energy independence and it also holds significant deposits of major industrial raw materials. With rich agricultural regions in the south, Russia is also a major wheat exporter, giving it significant influence over global food security.

The flat geography of the Great European Plain has historically made Russia vulnerable to invasion. The past 500 years have seen Russia embroiled in frequent conflicts with its European neighbours, shaping its geostrategic outlook. Russia has also fought China and Japan many times and remains in dispute with Japan over the Kuril Islands. Although its vast northern coastline offers strategic advantage, most ports there are ice-locked in winter. Arctic sea ice melt may change this in the future, but access to warm-water ports in the Black Sea, Mediterranean Sea and Indo-Pacific region is likely to remain a critical requirement in the medium term.

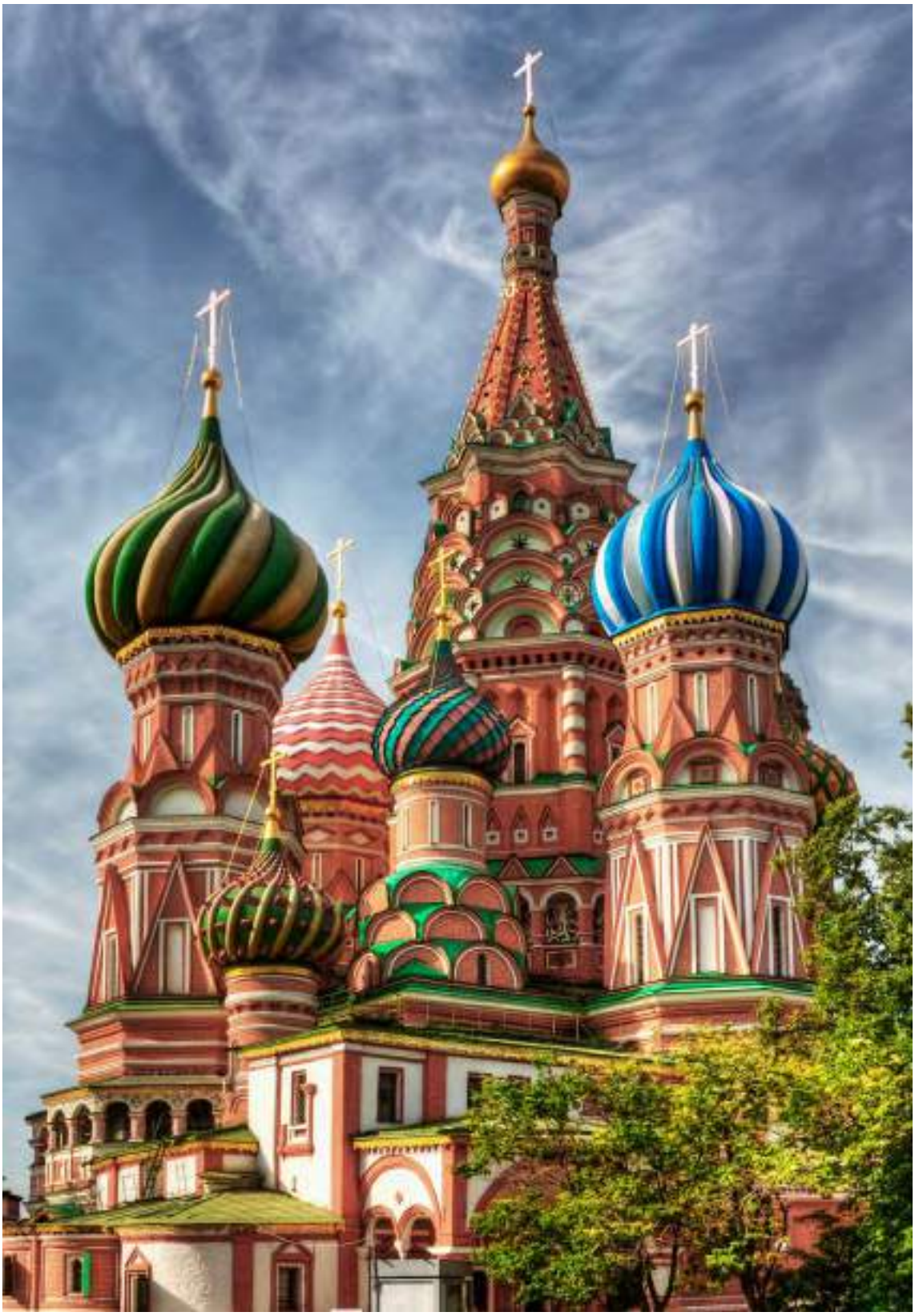
Russia is currently grappling with a demographic crisis sparked by rapid population decline, caused by falling birth rates and low life expectancy relative to other developed countries.[1] The country is seeking to address this issue through increased migration, particularly from Central Asia. Most citizens live in western Russia; the east of the country is particularly underpopulated compared with adjacent Chinese territories.

Life satisfaction in Russia is generally low,[2] with a culture of passive despondency and distrust in traditional authority structures. Although Russia's invasion of Ukraine rallied popular support in 2014 and again in 2022, as the war drags on and sanctions mount there is increasing political alienation among the intelligentsia and growing dissatisfaction within wider society. Political repression, corruption and a lack of state accountability have seen an increase in riots and protests,[3] which in turn have led to government crackdowns and an upturn in political repression. This dissatisfaction could see some regions seek greater autonomy in the future, increasing pressure on the Russian Federation.

Russia's 2022 invasion of Ukraine has severely strained relations with the West, impacting its economy and bringing relations back to Cold War levels of animosity. Despite this, Russia remains intent on reinvigorating and consolidating its status as a great power and has established itself as an important player in the Eastern Mediterranean, Southwest Asia and parts of Africa, Latin American and the Caribbean. The country has strengthened its relationships in the Indo-Pacific region, notably with China, currently its most important partner, although this relationship could become increasingly imbalanced in the future.

1 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
2 Organisation for Economic Co-operation and Development, Better Life Index, 'Russian Federation'.
3 Greene, A. and Robertson, G. (11 June 2019), *Putin vs. the People*, pages 7–13.

Together with China, Russia seeks to challenge and shape the current international order, which it perceives as Western-dominated. Russia sponsors a range of parallel institutions in its near neighbourhood and globally, including the Eurasian Economic Union, the Collective Security Treaty Organization and the BRICS group. Through these it seeks to shore up security and trade links, while at the same time influencing the geopolitical orientation of neighbouring countries and those further afield.



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Key drivers of change

Russia's great power status. While the outcome of the war in Ukraine will be a key determinant of its ability to act on the global stage, Russia's key focus will be to maintain and build on its status as a great power. Russia will continue to adapt to the imposition of Western sanctions through trading partnerships with Asia, Africa and Latin America, and in particular with its fellow BRICS countries. It may also seek to extend membership of this grouping to close partner states to enhance its global influence. Russia will also continue to act assertively in the Indo-Pacific region, coordinating its actions with China while seeking to limit its own vulnerabilities to its more powerful partner.

Regional power dynamics. Security in its near neighbourhood will remain a prime concern for Russia, and it will seek to strengthen and expand its relationships in its European and Central Asian border regions to shore up support in what it still considers to be its main sphere of influence. Russia will seek to take advantage of an increasingly accessible Arctic, while also seeking to ensure it protects itself from encroachment and encirclement.

Resource competition and environmental change. The changing natural environment will have far-reaching implications for Russia, as both a major agricultural producer and global energy exporter. Climate change will potentially result in reduced productivity in Russia's southern wheat 'bread basket' regions; any significant reduction in overall production will impact domestic, regional and global food markets, as well as food security. A global transition towards sustainable energy sources presents a dual landscape of opportunities and challenges for Russia. Chinese and Indian demand for Russian fossil fuels, for example, offers alternatives to declining demand from Europe. In the medium to longer term, this may lead to tensions with other hydrocarbon-exporting countries, particularly in Southwest Asia, as they vie for a share of a dwindling market in an evolving energy landscape.

Population stagnation and migration. Russia will continue to experience a range of demographic challenges, including an ageing population, declining birth rates and a shrinking workforce. This may be exacerbated should the outward migration of certain parts of society in response to the Ukraine war become permanent, or at least semi-permanent. Global attitudes toward Russia and its outward postures may also impact longer-term inward migration. Russia's ability to adapt to enduring and more recent population changes will be key to determining its future social, economic and political trajectory.

Societal change and its impact on attitudes, authority and regime stability. Russia will experience significant changes in its societal structure and demographic profile over the next few decades, potentially resulting in an increase in social and political divisions in the country. The ability to maintain political stability will remain a primary concern for the current Russian regime; however, tensions appear to be building and the pressure for political reform might be intensifying. Increasing internal instability in the country cannot be ruled out, and in the ultimate scenario, regime replacement or disintegration of the Federation should not be discounted.

Future key trends

Global power competition

Out to 2055, one of Russia's imperatives will be its status as a great power in what it perceives to be a changing international order, and how best to maintain this given the wide range of economic, social and political challenges that it currently faces. The 2022 Russian invasion of Ukraine has inevitably damaged Russia's political and diplomatic relations with the West as well as economic activity between Russia and Western countries. While the European Union was previously Russia's largest single trading partner, in the short term at least, Western sanctions will remain a constraint on the Russian economy, negatively impacting trade and investment and restricting access to critical technologies and markets.

In the long term, Russia will continue to adapt to Western sanctions by expanding its trading partnerships, especially those with its fellow BRICS countries. China is currently Russia's largest import and export trade partner, with significant increases in trade in the energy and technology sectors in recent years.[4] However, this partnership carries risks for both sides. For Russia, it could lead to China gaining more influence and exerting leverage over resources and strategic territories. For China, it could exacerbate tensions with other Indo-Pacific countries, as well as with the United States (US) and Europe, which remain vital trading partners. Out to 2055, Russia may increasingly rely on its already significant trade links with India, in particular in the energy sector,[5] although this could become a vulnerability as India's economic power increases. India's exports to Russia are in decline, despite record levels of trade (US $44.4 billion) in the 2022–23 financial year, indicating the imbalance in the trade power dynamic.[6]

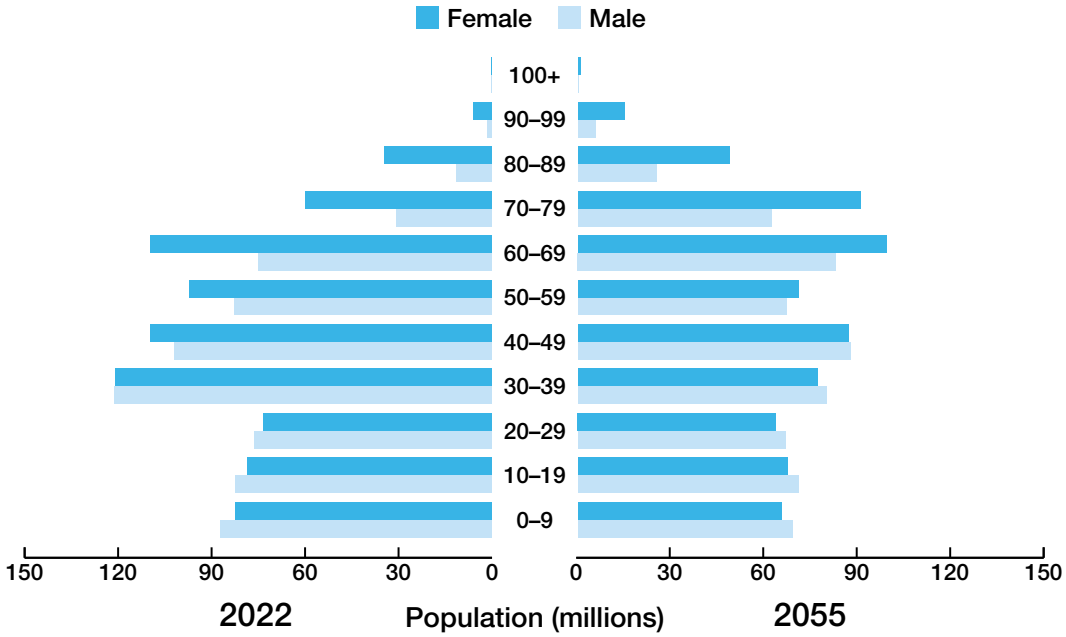
Russia's use of trade and investment deals to advance its foreign policy interests may remain limited outside China and India.[7] The levers of economic power available to Russia are fewer than during the Soviet period,[8] although it has gained some influence through its market-oriented global corporations, especially in the energy, information and technology sectors. While natural gas revenues may continue to play a significant role in the Russian economy, its reliance on oil as a major income source may reduce Russia's long-term influence. Russia's global economic levers are also dwarfed by those of China and may decline further if its economic situation continues to deteriorate. To secure political and security leverage Russia has, in part, looked to using private military and security companies in Africa and elsewhere, particularly amongst states with fragile or failed democracies. The continued ability to depend on private military and security companies in the future, however, remains uncertain.

4 Hillman, J., Center for Strategic and International Studies (15 July 2020), *China and Russia: Economic Unequals*.
5 Business Standard (17 January 2023), 'Russia becomes India's fourth-largest trading partner, imports jump 5-fold'.
6 Observatory of Economic Complexity (January 2022), 'Russia / India'.
7 Sakwa, R., University of Kent (2022), *Russia and Twenty-First Century Challenges*, (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
8 German, T. and Kuhrt, N., King's College London (21 February 2023), 'Will Russia's global influence continue to decline?'.

Relations with ex-Soviet border states will remain important to Russia from a security standpoint. The evolution and enlargement of the North Atlantic Treaty Organization (NATO), and particularly the possibility of further border states being admitted to membership, will significantly shape Russia's strategic interests and its relations with the West in the future. Its relationship with China will remain an essential counterweight to this for Russia, particularly if China's global economic influence continues to expand. Over time, the relationship between the two may evolve into a security-focused alliance, albeit more as a 'marriage of convenience' against the West than a genuine friendship.

Society

Russia is expected to witness a decline in its population from 140 million in 2023 to 130 million in 2055, with some predicting an even steeper fall to 125 million.[9] This declining population will have profound implications for the Russian economy, which will suffer from a shrinking labour pool as the working age population declines. Russia's working age population in 2020 was 86.4 million; according to United Nations estimates this could fall to 79.7 million by 2040.[10] Russia's workforce challenges have also been exacerbated in the short term as fighting-age males have left the country to escape the war draft. While some have now returned, this has the potential to remain an enduring issue.



Source: United Nations Population Division (2022)

Population statistics projection for Russia by age range

Out to 2055, the ability to attract inward migration from the Central Asia region will be an essential goal of the Russian government's domestic policy to mitigate the continuing fall in its own domestic working age population. Before Russia's 2022 invasion of Ukraine, it was second only to the US in its ability to attract migrants. However, current numbers indicate a strong decrease in migration and current levels are far from high enough to offset Russia's population decrease. According to Russian statistics the number of

9 Aris, B., Intellinews (15 July 2021), 'Demographic disaster in Russia, but a catastrophe in Ukraine'.
10 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.

migrants dropped from 430,000 in 2021 to 61,900 in 2022.[11] Furthermore, with the continuation of Western sanctions and a deteriorating economy, the incentives for migration to Russia may not return in the near future.[12] While migrants may be welcomed as an economic asset in Russia's leading economic hubs, Russian citizens in other parts of the country may be more hostile, particularly in the North Caucasus where the unemployment rate is rising, and in the Russian Far East if there are future increases in migration from China. In addition, the fact that the Russian power elite remains predominantly ethnic Russian could potentially exacerbate tensions if migration returns in large numbers.[13]

Although the overall urban population in Russia has seen only a slight increase in recent years, urban lifestyles are gaining in popularity and rural to urban migration may increase further in future. However, the rural population will remain stable in Russia and the rate of urbanisation should not be overstated; urbanisation increased by only 1.2% between 2011 and 2021.[14] Where Russians do seek to move out of rural areas, this will generally be to provincial towns and cities or regional capitals, rather than to the country's major urban centres.[15]

The quality of education and health care in Russia is likely to continue to vary across regions, exacerbating current levels of inequality within the country. In general, rural populations continue to experience poorer health outcomes than those in urban areas.[16] Educational attainment is lower in some regions, reflecting social disparities within the country. Although the issues of health and social care and education are moving to the top of the political agenda, improvements in these areas might be hindered by the increasing allocation of resources to the military and defence sector.

In the absence of any meaningful political reform, the continued subordination of the Russian state to the ruling regime will continue to weaken the rule of law and the functionality of state institutions in the country.[17] Upholding stability will remain a primary concern for the current regime. Maintaining an authoritative posture that evokes traditional Slavic customs and the Eastern Orthodox faith forms part of this approach. However, there is a growing tension between state repression and citizen resistance, and the pressure for political reform might be intensifying. Should this trend persist, it is possible that internal instability could increase in the country. Metropolitan populations, driven by increasing access to information and opposition to state surveillance, could influence Russia's future political direction, while external influences, such as social media, may provide avenues for dissent beyond the state's control. Socio-economic divisions are also being exacerbated. Russia's regions are becoming increasingly dissatisfied with Moscow's leadership, which could lead to increased calls for greater autonomy within the Russian Federation, whilst also fuelling domestic unrest and terrorist threats from separatist movements.

11 *The Moscow Times* (13 April 2023), 'Unprecedented Migration May Be Only Chance to Beat Russia's Population Decline'.
12 Schnek, C., Migration Policy Institute (7 February 2023), 'Post-Soviet Labor Migrants in Russia Face New Questions amid War in Ukraine'.
13 Zakharov, A. and Napalkova, A., BBC News (1 November 2019), 'Why Chinese farmers have crossed border into Russia's Far East'.
14 O'Neill, A., Statista (8 February 2024), 'Russia: Degree of urbanization from 2012 to 2022'.
15 Ibid.
16 Russian Federal State Statistics Service, Statista (19 June 2023), 'Mortality rate per 1,000 population in Russia from 1990 to 2022, by type of area'.
17 Gill, G., (Ed.) (2022), *Routledge Handbook of Russian Politics and Society*, 2nd Edition.

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The Russian state's ability to manage societal challenges will be a key determinant of its future stability

In the long term, Russia's ability to adapt to and manage these societal challenges will play a crucial role in shaping its future political trajectory. As the country experiences generational shifts and demographic changes, the government will need to address the concerns and aspirations of its diverse population to ensure increased stability. At present, the future of Russia's political development remains highly uncertain and the route that the country takes will have profound implications for its future economic and social development, as well as its relations at the regional and global level.

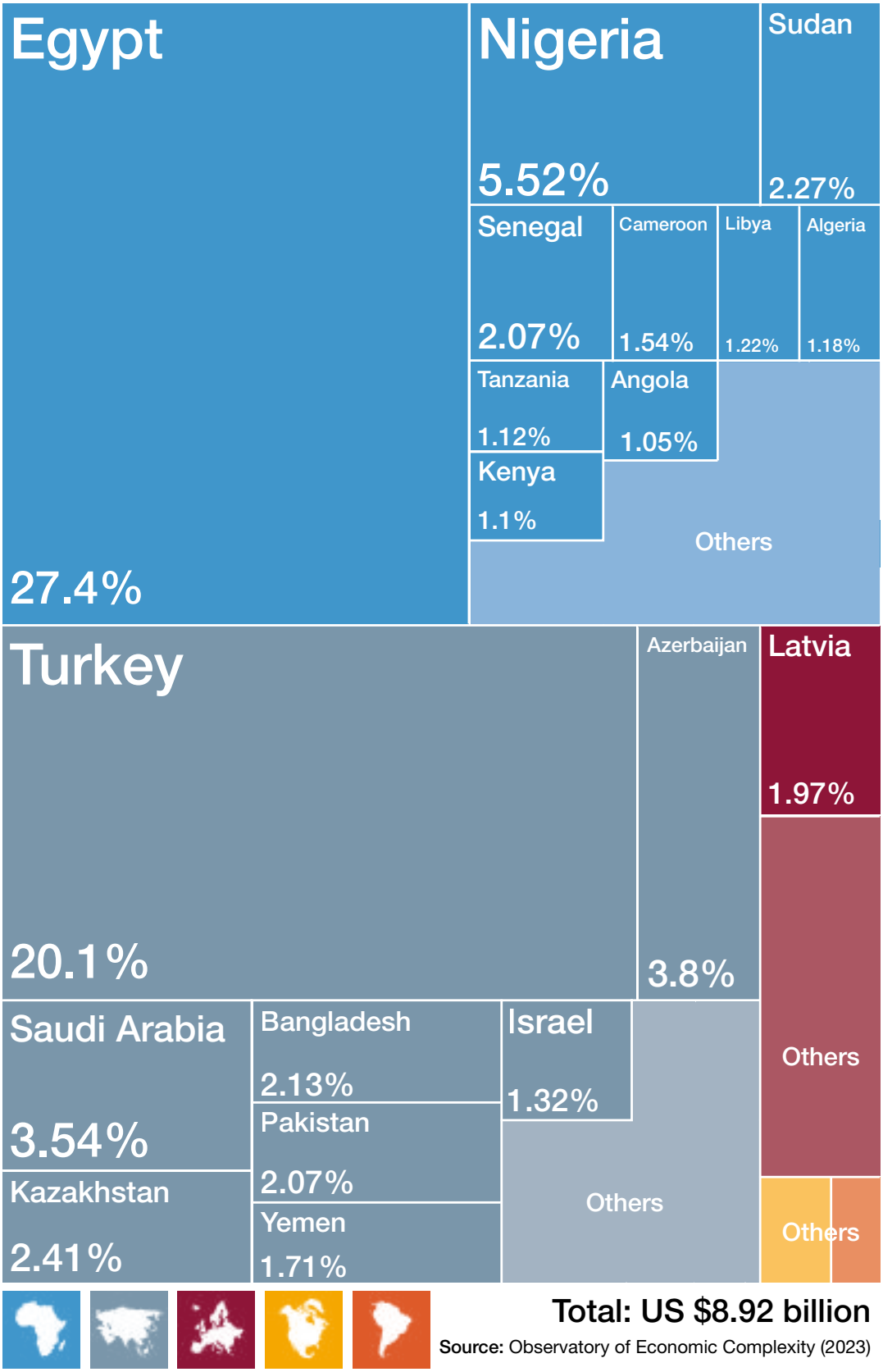
Economy

Over the next few decades, Russia is likely to face significant economic challenges. In particular, its declining workforce, low labour productivity and chronically low levels of investment could result in the continued suppression of economic growth. While Russia's gross domestic product (GDP) increased by 4.7% in 2021,[18] it declined considerably in 2022, due to the impact of the conflict in Ukraine, sanctions, changing foreign direct investment patterns and the wider global economic slowdown.

Russia's ability to realise further levels of economic diversification will be crucial if it is to succeed in achieving sustained economic growth. Over the past few decades, Russia has witnessed significant changes in the structure of its economy, with the service sector now comprising 54% of GDP[19] and employing 68% of the workforce.[20] In addition, the drive for self-sufficiency in pharmaceuticals since 2013 has boosted domestic manufacturing and supply; by 2017, over 80% of drugs sold in the country were domestically produced,[21] with a sharp decrease in dependence on imports. However, Russia's success in diversifying its exports has been limited; even prior to 2022, exports were largely constrained to raw materials such as petroleum products, minerals and wheat,

18 World Bank (2022), 'GDP growth (annual %) – Russian Federation'.
19 World Bank (2022), 'Services, value added (% of GDP) – Russian Federation'.
20 World Bank (2022), 'Employment in services (% of total employment) (modeled ILO estimate) – Russian Federation'.
21 Sundries (3 February 2023), 'The Russian car market decreased by another 47 percent in January'.

partly due to the quality of its manufactured goods and a distrust in its data services. Russia continues to depend heavily on imports of manufactured goods, including semiconductors, cars, vehicle parts, broadcasting equipment and other key components.



Russia's wheat exports provide a source of global leverage

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The dependence of the Russian economy on fossil fuel exports may create vulnerabilities in the context of the global energy transition

Russia's role as an exporter of fossil fuels to Europe is expected to decline by 2055, as demand falls and Europe seeks to reduce its dependence on Russian energy imports.[22] While this will encourage Russia to seek new ways in which to diversify its economy, China and India's continuing demand for fossil fuels will provide alternative opportunities for Russia, which despite a potential fall in overall global demand in the long term is likely to remain active as a commodity exporter.

As warming temperatures and melting sea ice results in the Russian Arctic becoming more accessible, this region may begin to offer some degree of potential for economic diversification. However, the current lack of infrastructure, as well as Russia's limited ability to attract investment to the region, may restrict the opportunities here. By contrast, Russia's eastern regions are of increasing interest to foreign investors who have been encouraged by the 'Pivot to the East' policy since the third term of Vladimir Putin's presidency.[23] Almost a third of foreign direct investment flows into the districts in the Russian Far East.[24] While this is offering Russia opportunities to develop this region, in the longer term it also risks creating dependencies and vulnerabilities.[25]

Out to 2055, corruption will present an enduring challenge for Russia. It is estimated that 45% of current Russian economic activity has ties to the black and grey economies, which has a negative impact on investment.[26] Russian citizens and businesses, as well as Western companies and investors, find the Russian financial system unreliable, and the use of foreign currency accounts is high. In particular, the Russian economy fails to provide sufficient incentives for the growth of private businesses. The under-development of the

22 Lawson, A., *The Guardian* (23 February 2023), ''Energy battle' between Europe and Russia not over, says global watchdog'.
23 Lee, H. S. and Yu, W., *Eastern European Economics*, Volume 60, Issue 6 (25 August 2022), 'The Effects of FDI and Exports on Economic Growth of Russia and its Far Eastern District', pages 479–497.
24 Russia & CIS Business and Financial Newswire, Gale OneFile: News (25 June 2021), 'Far East receives a third of Russia's foreign direct investment – Trutnev'.
25 Humpert, M., *High North News* (6 February 2023), 'Russian Mining Company Partners With China to Develop Massive Titanium Deposit in Arctic'.
26 Putniņš, T. and Sauka, A., Stockholm School of Economics (January 2020), *Shadow Economy Index for Russia 2017-2018: comparison with the size of the shadow economies in Ukraine, Kyrgyzstan, Kosovo, Moldova, Romania, Latvia, Lithuania, Estonia and Poland.*

small and medium enterprise sector, which accounts for just 22% of GDP[27] and is declining (compared with 53% in the US and 50–60% in most European Union countries),[28] hampers economic growth and diversification. Corruption, embezzlement and a lack of access to credit compound the challenges that the small and medium enterprise sector faces.

The long-term economic outlook for Russia remains profoundly uncertain. Political reform in Russia opens the likelihood for re-established relations with the West, which in the medium term at least could boost investor confidence and economic stability. However, the current geostrategic barriers to any rapprochement are significant and Russia may instead become increasingly dependent on commodities exports to China, India and other emerging markets. While these relationships could provide a substitute for the role previously played by Western commerce in Russia's economy, this would possibly result in these new partners facing sanctions, which few seem willing to risk at the moment. This could change in the future, although that would seem most likely to happen due to a wider regionalisation of the global economy – potentially along ideological lines – under conditions of prolonged and heightened tensions.

The hidden impact of the war in Ukraine on the Russian economy

International scepticism towards official Kremlin economic data has led to the use of alternative analysis methods, such as satellite data from the European Space Agency, to assess Russia's economic situation. Satellite data is able to track nitrogen dioxide levels and this has revealed increased urban pollution in Moscow and Saint Petersburg but decreased pollution in industrial regions. This contrasts with Russia's official data, which reported increased industrial production. This suggests that the war in Ukraine and Western sanctions may have a greater impact on Russia's economy in the future than is currently being assumed.[29]

Environment

The effects of climate change will have significant and far-reaching implications for Russia. The frequency and intensity of extreme weather events such as floods, heatwaves, wildfires and severe droughts[30] are already rising, and out to 2055 are likely to increase further. In addition, temperature rises and changing rainfall patterns will affect agricultural production and food supply. While northern Russia may experience a longer growing season as a result of these shifting weather patterns, droughts are already affecting wheat yields in more southerly regions such as Stavropol, and in the future wheat harvests are likely to remain highly vulnerable to climatic variations.[31] Reduced agricultural production in the country as a whole could lead to social instability and increased migration, as well as impacting global food supplies.

27 Organisation for Economic Co-operation and Development (22 April 2020), *Financing SMEs and Entrepreneurs 2020: An OECD Scoreboard*.
28 Ibid.
29 Zhang, C., et al., *Science of The Total Environment*, Volume 869 (15 April 2023), 'Satellite spectroscopy reveals the atmospheric consequences of the 2022 Russia-Ukraine war'.
30 Conley, H. and Newlin, C., Center for Strategic and International Studies (13 January 2021), 'Climate Change Will Reshape Russia'.
31 CEIC Data, 'Crops Production: Wheat: NC: Stavropol Territory'.

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As a key contributor to the global food market, the impact of climate change on Russia's agricultural output will be felt globally

Climate change will also have a profound effect on Russia's forest resources. While some parts of the region may see an increase in forest cover in the near future due to improved growing conditions, wildfires, plant diseases and pests are likely to surge in the long term, posing challenges for the Russian timber industry.

The Russian Arctic is currently experiencing rates of warming at double or even triple the global average, leading to extreme weather effects, permafrost melt and the emergence of giant sinkholes.[32] Over the next few decades the effects of this are likely to increase and result in further damage to infrastructure and housing in Yakutia and other areas. The release of pathogens and gases such as methane from melting permafrost will be another cause for concern.

Out to 2055, an increase in Arctic sea ice melt may place Russia in a good position to exploit the opening of the Northern Sea Route, creating opportunities for trade but also increasing concerns about environmental disasters and the degradation of ageing infrastructure.[33] The Northern Sea Route is already becoming navigable for longer periods of the year, intensifying disputes over the status of the Arctic Ocean and the rights of littoral states. The total traffic volume on the Northern Sea Route has been steadily growing; in 2022, it reached an estimated 34,034 million tonnes, in comparison with 20,180 million tonnes in 2018.[34]

32 Conley, H. and Newlin, C., Center for Strategic and International Studies (13 January 2021), 'Climate Change Will Reshape Russia'.
33 *The Moscow Times* (7 September 2021), 'Rapid Arctic Warming is Accelerating Permafrost Collapse in Siberia, New Report Warns', drawing on data from a International Climate Advisory Group report'.
34 Center for High North Logistics (9 June 2023), 'Shipping traffic at the NSR in 2022'.

Russia's capability as the sole proprietor of nuclear icebreakers will provide it with opportunities as Arctic sea traffic grows

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As one of the world's major energy exporters, Russia's economy and politics remain closely tied to fossil fuel production, with little focus on climate action. Russia's recent approach to climate diplomacy has tended to emphasise sovereign choice while protecting its export interests.[35] However, global energy dynamics are rapidly changing and over the next three decades Russia is likely to face increasing pressure to join the green energy transition. While environmental concerns have tended to take a back seat to economic and national influence, the impact of climate change on the Russian economy, society and security may drive more significant policy changes in the long term.

The shift away from a carbon-intensive economy will be a major challenge for Russia. The exploitation of hydrogen and critical minerals, along with more sustainable forms of energy generation such as nuclear and hydropower, could play a role in meeting Russia's future energy requirements. However, large-scale decarbonisation is unlikely to occur in Russia over the next 30 years, and exports of fossil fuels are likely to continue to play an important role in the Russian economy. As global demand for hydrocarbons decreases, this may cause tensions with other hydrocarbon-exporting countries, particularly those in Southwest Asia.

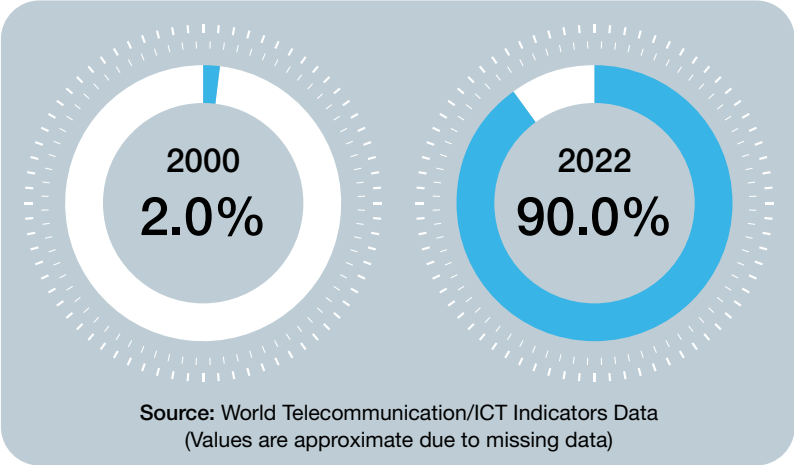
Technology, infrastructure and communications

Out to 2055, the technology sector may present significant economic opportunities for Russia. The country already has a well-developed information technology industry, aircraft and shipbuilding capabilities, and a significant presence in the nuclear sector. It ranks 14th in the world in terms of steam power turbine production and is a key player in the global nuclear industry, controlling 40% of the world's uranium conversion infrastructure.[36] Furthermore, Russia stands as the exclusive proprietor of nuclear-powered icebreakers, due to its pioneering efforts in the Arctic region. If Russia is able to secure the necessary financial investment to build on these successes, over the next few decades this may significantly boost levels of economic diversification and growth.

35 Davydova, A., *The Moscow Times* (20 January 2023), 'How Russia's War is Impacting the Global Environmental Agenda'.

36 Clifford, C., CBNC (23 May 2022), 'Russia dominates nuclear power supply chains – and the West needs to prepare now to be independent in the future'.

Within the digital realm, Russia hosts some prominent e-commerce giants, including TCS Holding Group, which operates Tinkoff, the world's sixth largest digital bank, and Yandex, a multifaceted technology company providing cloud services, artificial intelligence solutions, self-driving cars, search engines, mapping services and more. These enterprises have made substantial contributions to Russia's technological landscape and global influence in recent years. However, concerns over global supply chain vulnerabilities and the imposition of Western sanctions are posing significant challenges for these operators. Many sectors, including the information technology industry, are reliant on imports for essential components, and securing a stable supply of silicon chips has been particularly complex, often involving multiple moves via intermediary states. If it continues over time, this dependency on imports could present vulnerabilities for Russia's technology sector, restricting technology development and the growth of the Russian economy. In addition, while Internet penetration in Russia is high, the Kremlin is working on a 'sovereign Internet' and there have been recent tests to isolate the country and severely limit access to global Internet services.[37]



Average percentage of the population using the Internet in Russia

With its long history of activities in the space environment, Russia remains one of the world's leading spacefaring states; however, several middle space powers are catching up.[38] Together with Canada, the European Space Agency, Japan and the US, Russia has been instrumental in the construction and maintenance of the International Space Station. This partnership is expected to end in 2028, which will be the end of decades of collaboration in the space domain between the West and Russia.

Unlike Europe and the US, Russia's private space industry is non-existent and Roscosmos, the Russian State Corporation for Space Activities, together with the Russian Space Forces, are responsible for launching and operating Russian satellites. As the global number of actors in the space environment has increased, the Russian space and launch industry has faced growing competition, from public and private entities. Public space agencies from other countries, such as the National Aeronautics and Space Administration (NASA) and the European Space Agency, are investing heavily in new space technologies, and private companies, such as SpaceX, Rocket Lab and Blue Origin, have developed new launch vehicles and spacecraft. This, in addition to sanctions imposed on Russia by the West, has severely challenged Roscosmos' space launch market.[39] Over the next few decades, the

37 Broderick, T., *Scientific American* (12 July 2023), 'Russia Is Trying to Leave the Internet and Build Its Own'.
38 Hallgren, K., et al., Swedish Defence Research Agency (FOI) (December 2022), *Russia in the space domain: From Sputnik to sanctions – a defence and security perspective*.
39 Ibid.

Russian space industry will need a major overhaul to stay relevant in this new competitive landscape. Given Russia's historic space achievements, which are viewed as a reason for national pride and a base for Russia's claim to global power, it is likely that efforts will be made to keep Russia's standing as a major space power.

Russia's space sector and China

Before the conflict in Ukraine, Russia and China unveiled plans for a joint lunar base, the International Lunar Research Station, targeted for completion by 2035. The ambitious project includes developing an automated nuclear reactor to power the base and collaborating on identifying the optimal location for the lunar base. However, the future of Russia's space ambitions remains uncertain, and factors such as its relationship with China, the overall direction of its space sector and economic instability stemming from Russia's invasion of Ukraine could significantly influence the future direction of this project.[40]

Over the next 30 years, ageing and degraded infrastructure will continue to present a challenge for Russia. In particular, the impact of permafrost melt on Russia's Arctic infrastructure is already significant; in 2016, a section of the Kolyma Highway in Siberia collapsed, cutting off a major transportation route, and in 2020 a section of the Yamal–Europe natural gas pipeline sank into the ground, causing a temporary disruption to gas supplies. Over the next few decades, the impact of permafrost melt on Russia's infrastructure is likely to worsen. As the climate continues to warm, permafrost is expected to melt at an even faster rate. This could lead to widespread damage over a shorter period, with significant economic and social consequences for Russia's northern territories.

Conflict and security

Russia is likely to face a range of stability and security challenges out to 2055, including domestically, in its wider neighbourhood, through increasingly strained relations with the West, and due to transactional and uncertain partnerships with other global powers. While the outcome of the Ukraine war will be critical in determining that trajectory, it is not the only factor at play in an increasingly complex dynamic.

Tensions with the West, and in particular NATO, are likely to persist following the 2022 invasion of Ukraine and will significantly influence Russian defence policy and capability development in the long term. In response to NATO enlargement and the war in Ukraine, the Kremlin has ordered a 170,000 increase in military personnel to bring it to an estimated total of 1.32 million,[41] and it has re-established the Moscow and Leningrad military districts. NATO's combined forces currently outweigh Russian conventional forces by a substantial margin, with the US alone spending around US $800 billion on its military compared with Russia's US $61 billion budget in 2021.[42] Although Russia doubled its defence budget in 2023 and is set to increase planned military spending to 10.78 trillion roubles in 2024 – a third of all public expenditure – economic realities may still act as a limiting factor.[43]

40 Xiaoci, D., *Global Times* (22 March 2023), 'Scientist reveals key objectives for lunar station project co-proposed by China, Russia'.
41 Reuters (1 December 2023), 'Russia increases maximum size of armed forces by 170,000 servicemen'.
42 World Bank (2022), 'Military expenditure (% of GDP)'.
43 Bloomberg UK (22 September 2023), 'Russia Plans Huge Defense Spending Hike in 2024 as War Drags'.

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Russia's future military reputation will depend on how it emerges from its near-term challenges in Ukraine

Given this resource overmatch, Russian military attention is likely to remain focused on Ukraine in the short term as Moscow seeks to extract a 'sellable' outcome from its invasion. Even if Russia faces a significant setback, an expansion of its front remains possible given that it retains considerable air, maritime and nuclear capabilities. The third most capable cyber state after the US and China (at state level and through its 'patriotic hackers'), Russia could also expand its assault through this domain as well as in space.

A significant concern for Russia over the next three decades will be establishing stability and security in post-Soviet Eurasia and its wider neighbourhood, including Central Asia, Afghanistan and Syria. The NATO withdrawal from Afghanistan in August 2021 resulted in the Russia-led Collective Security Treaty Organization playing a revitalised role in the region.[44] However, political division caused by the war in Ukraine and the conflict between Armenia and Azerbaijan has since weakened it, leading some to question its long-term viability. Security guarantees to former Soviet states in Central Asia are also an important source of influence in a region of critical importance to Russia, but which may be increasingly contested by other powers out to 2055.

Serious and organised crime in Russia has a long and complex history, becoming particularly prominent in the years following the collapse of the Soviet Union in 1991. Members of organised crime groups were able to exploit the resulting chaos and corruption to became closely intertwined with Russia's politicians, judiciary, law enforcement authorities and emerging business elites. Without a significant change in the way that crime is tackled in Russia, the nexus between serious and organised crime and political power is likely to persist in the future.

Terrorism remains a significant concern within Russia, although its dynamic changes as various groups move closer to or further from the Kremlin, and domestic counterterrorism legislation has proved a useful lever to suppress internal dissent. New sources of terrorism may potentially emerge as a result of Russia's 2022 invasion of Ukraine.

44 Schulz, D., Caspian Policy Center (16 September 2021), 'Crisis in Afghanistan Gives New Purpose to CSTO'.

Russia may struggle to maintain leverage in its strategic partnerships with China and India

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Russia has been actively engaging in large-scale military exercises with China in recent years, notably an increasingly ambitious Vostok programme, as well as joint air and maritime operations in the Indo-Pacific region and with other BRICS partners. While the future scale of these exercises remains to be seen, Russia seems likely to continue to showcase its military capabilities and project its influence on the global stage. A Russia that is either emboldened or weakened by the ongoing Ukraine war could also increasingly seek to strengthen its military partnerships with states such as China, Iran and North Korea. However, Russia's security also risks being weakened by this development, particularly if China presses for access to military and other key infrastructure in exchange for any economic support.

As the Arctic region begins to open up and gain in strategic importance, Russia's investment in military infrastructure in the region is likely to increase, reflecting its determination to assert and defend its Arctic territory and interests in the future. Recent years have seen Russia focus on building and enhancing military bases in the Arctic, including the Nagurskoye military complex on Franz Josef Land; future decades could see an increase in activities of this kind. Russia is also investing in capabilities, including uncrewed systems to improve monitoring of the Northern Sea Route and the Northwest Passage,[45] and is planning to develop search and rescue drones that could play into a wider video surveillance and security agenda. However, climate change and environmental degradation will continue to place a strain on Arctic infrastructure, including military assets and supply routes.

Historically, Russia has been the world's second largest arms exporter after the US, accounting for 20% of global arms sales between 2016 and 2020.[46] Historically, Russia has used arms sales to cement its global relationships, in particular its relationship

45 Nilsen, T., *The Barents Observer* (12 July 2016), 'This is Russia's new unique underwater drone for Arctic waters'.
46 Wezeman, P., et al., Stockholm International Peace Research Institute (March 2021), 'Trends in International Arms Transfers, 2020'.

with India, and establish new dependencies, as seen with Turkey's purchase of the S-400 Triumf surface-to-air missile system. However, concerns about the effectiveness of Russian military hardware following its performance in Ukraine may challenge its credibility and lead to a decline in arms sales in the future. Exposure of Russia's battlefield tactics has also dented its reputation, although the ultimate outcome of the Ukraine war could lead to further re-evaluations.

Given Russia's considerable internal challenges, some form of collapse – either triggered by the war or due to an accumulation of growing domestic pressures – cannot be discounted. That could in turn give rise to new challenges, resulting in mounting concerns over nuclear weapon security, terrorism, expanded criminality on the part of its already powerful mafia, and other forms of insecurity.

1 Kazakhstan
2 Kyrgyzstan
3 Tajikistan
4 Turkmenistan
5 Uzbekistan

Central Asia

Current strategic context

Central Asia stretches from the Caspian Sea in the west to China and Mongolia in the east, and from Afghanistan and Iran in the south to Russia in the north. The region has always had huge geostrategic importance, not only because of its resources but also due to its location at the crossroads between major world civilisations, allowing it to act as a trade link and a buffer between competing empires. Conquered by Russia at the end of the 19th Century, the region was divided during Soviet times into separate republics with artificial borders across ethnic fault lines, something that continues to drive tensions today. While the Soviet legacy left a significant footprint on the region, its young countries have a strong desire to strengthen their national identities and protect their sovereignty as they navigate their paths towards economic development, political stability and regional cooperation.

The landscape is characterised by vast steppes, deserts and mountains, and a scarcity of water. Central Asia depends on its two major rivers, the Amu Darya and the Syr Darya, for approximately 90% of its fresh water.[1] However, the flow of these rivers is being impacted by climate change, making water security one of the most critical issues facing Central Asia at present. In the future, the management of these shared water resources could drive either cooperation or tensions between regional states.

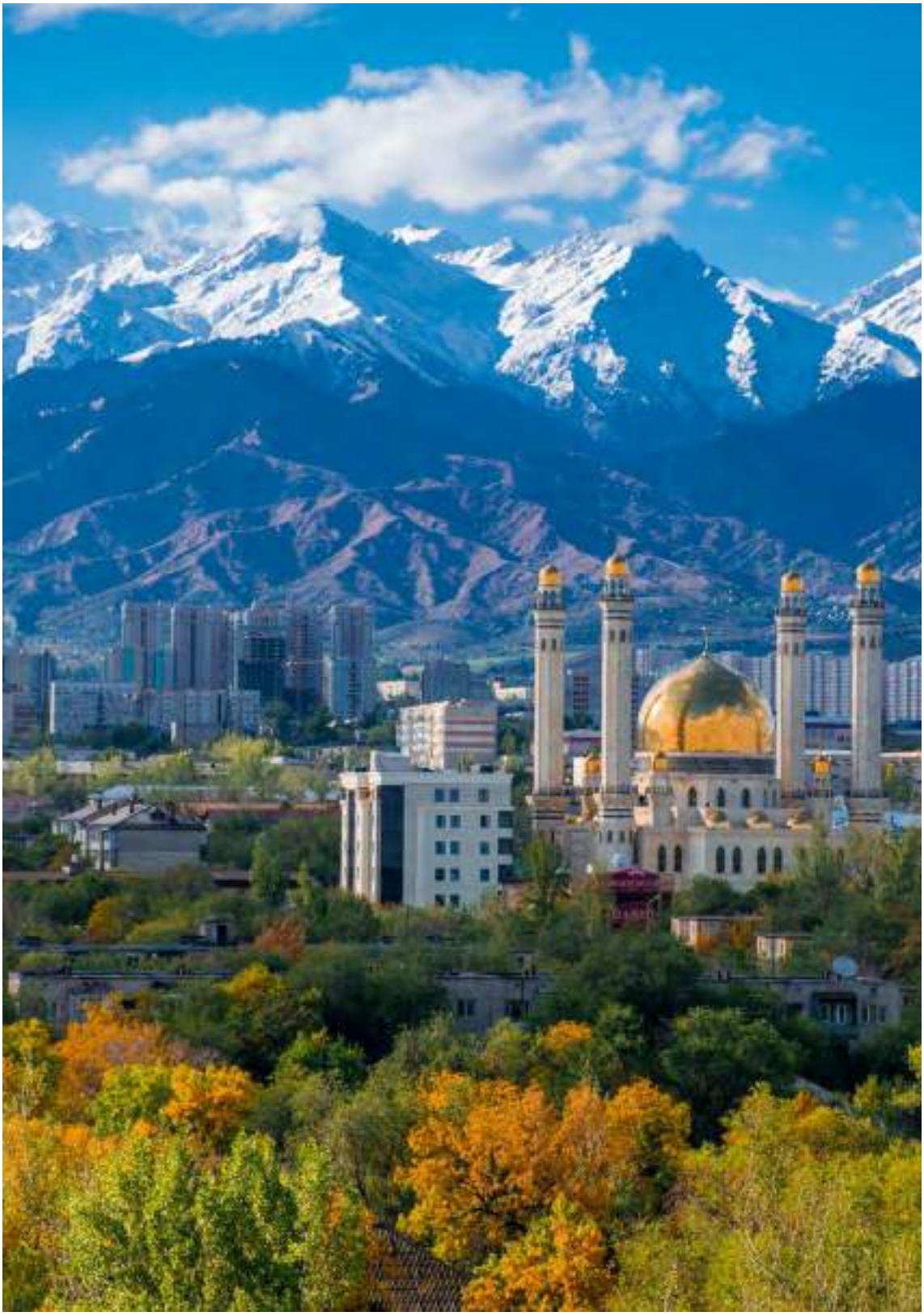
Most people live along the fertile banks of the rivers and in the Fergana Valley, close to the region's biggest city, Tashkent, capital of Uzbekistan. The region is home to a wide array of ethnic groups, each with its own distinct customs, languages and folklore. Historically and culturally, Afghanistan, northern Pakistan, Iran and western China are closely linked to the region. The influence of Persian, Turkic and Russian culture is evident in art, literature and daily life.

Central Asia faces a host of social and political issues, including corruption, ethnic tensions, weak governance, inadequate service provision and human rights violations in some countries. The political landscape remains influenced by authoritarianism, although pressure for reform is growing.

Central Asian economies are closely tied to the region's significant natural resources, including oil, gas and minerals. Being largely landlocked, states are heavily dependent on pipelines, roads and other infrastructure that pass through neighbouring countries, which presents a key economic and strategic vulnerability. The energy-producing states of Kazakhstan and Turkmenistan have experienced significant growth in recent years, while others such as Tajikistan and Kyrgyzstan continue to grapple with economic challenges. Trade and foreign investment, as well as economic diversification, will be central to the region's future development.

1 Russell, M., European Parliamentary Research Service (September 2018), *Water in Central Asia: An increasingly scarce resource*.

China's influence in the region has grown significantly since the collapse of the Soviet Union, and Russia and China are likely to remain the two key external powers in regional security and trade. However, in times of increasing global power competition, and as demand for natural resources grows, Central Asia is attracting increasing attention from a wider range of actors. How Central Asian countries balance external interests will have a significant influence on their future trajectory.



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Key drivers of change

Balancing international interests. China's influence in Central Asia is highly likely to increase, although societal resistance could potentially hinder its ambitions in the region. While Russia is expected to tolerate China's growing economic influence, future developments may lead to an increase in tensions between these two powers. At the same time other external actors will seek to boost their presence in Central Asia, leading to increased competition for regional influence. Whether Central Asian governments succeed in balancing these actors against each other will be key to the region's future trajectory.

Regional cooperation. Improvements in cooperation between regional states will be a key determinant of Central Asia's future direction. In the past, national and ethnic differences, border disputes, and concerns over sovereignty, water security and resource distribution have often hindered meaningful collaboration. However, recent trends are more promising, with increased dialogue leading to breakthroughs on border demarcation, infrastructure development and security.

Water and food security. Water security will remain a key concern for Central Asian governments, potentially leading to reduced agricultural production and food shortages. Rising pressure on shared water resources will continue to pose a challenge for regional cooperation, potentially leading to tensions between communities in border regions and between upstream and downstream states. However, Central Asian countries have demonstrated progress in recent years through the successful negotiation of bilateral and multilateral water- and energy-sharing agreements, giving some cause for optimism.

Economic diversification and trade. Economic diversification and the successful integration of Central Asian economies will be pivotal to the region's future economic development. Intraregional trade remains low and relies primarily on bilateral agreements between states, with regional tensions hampering consistent interstate cooperation. However, international investment through mechanisms such as the Chinese Belt and Road Initiative presents opportunities, potentially boosting regional infrastructure and generating employment opportunities for the region's young workforce.

Changing social identity and values. Digital media is emerging as a powerful driver of change in Central Asian civil society and calls for greater political transparency and openness are likely to increase. However, this will lead to some state governments seeking to control access to the Internet, which may result in rising levels of popular discontent and potentially to tensions and uprisings.

Future key trends

Global power competition

It is likely that Central Asia will retain its geostrategic importance and remain an arena for intense power competition out to 2055. While Russia and China will continue to be the key external actors, and may increasingly compete for influence, the presence of a wide range of other players, including the European Union, Turkey, the United States (US), India, Iran and Pakistan, is increasing. This, taken together with the impact of the war in Ukraine on Russia and Chinese long-term ambitions, makes the character and outcome of this competition highly uncertain.

Regardless of who is in power in the Kremlin, Central Asia is likely to remain a key consideration in Russian strategic thinking, economically, as a buffer to threats from the south, and as part of Russia's desire for great power status (due in part to its significant ethnic Russian population and shared cultural and historical ties). Out to 2055, Russia will continue to make use of its language and media outreach and its cultural and historic affiliations with these former Soviet states to deepen relationships. It will also seek to capitalise on its ability to provide security guarantees to regional governments, as well as using its military power to shape and retain influence on political developments.

China's influence in Central Asia is likely to continue to increase, with the region remaining an important trade link between China and states to its west. So far, Russia has accepted China's growing economic influence, which has been boosted by decades of investment, trade and infrastructure projects under its Belt and Road Initiative and now the Global Development Initiative.[2] In turn, China has carefully avoided challenging Russia's political influence and its status as the region's dominant security partner. However, this may change in the future if the war in Ukraine results in a weakened Russia which is more dependent on China and other actors for its recovery. This may not only encourage Central Asian states to seek alternatives to Russian security guarantees, but may also allow China to take the lead in regional defence cooperation. However, China's growing presence has sparked local concerns and a backlash in some regional states, which may constrain its future ambitions. Russia is not likely to give up its influence freely, and the future may see increasing competition between Russia and China in the region. Nevertheless, in response to wider global power competition, there is the possibility that China and Russia could increase their cooperation in the region to form a cohesive bloc, with an influence that would be difficult to match for other powers.

Central Asian states will continue to pursue a multi-vector foreign policy approach, courting investment and engagement from a range of states and international organisations to balance the influence of Russia and China.[3] In particular, the region will seek to diversify the customer base for its energy supplies and establish new energy transit routes, potentially through projects such as the Trans-Anatolian Natural Gas Pipeline, aimed at transporting natural gas from the Caspian Sea to Turkey and Europe. In addition, the desire to access the Indian Ocean via Afghanistan, Pakistan and Iran is likely to drive bilateral relations between landlocked Central Asian countries and these states.

2 Jie, Y. and Wallace, J., Chatham House (13 September 2021), 'What is China's Belt and Road Initiative (BRI)?'.
3 Sitenko, A., IPS (28 September 2023), 'The Central Asian states are stepping up their game'.

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The region's significant natural resources make it an attractive partner for other states

Turkey's engagement in Central Asia has increased significantly in recent years, driven by economic, political and security considerations.[4] In the increasingly unstable geopolitical landscape resulting from Russia's invasion of Ukraine, Turkey has sought to carve out an enhanced diplomatic and military role for itself, extending into Central Asia. The Organization of Turkic States could potentially constitute a powerful geoeconomic tool in this respect. Resting on its loose cultural links and its high dependence on Central Asian energy supplies, Turkey is likely to seek to enhance its trade and investment ties with Central Asian states, aiming to benefit from the region's vast natural resources and its emerging markets.

India, an emerging power in Central Asia's wider neighbourhood with close historical and cultural links, may look to act as a bridge between the Central and South Asian regions, and may take a more prominent role in the region in future.[5] In recent years, India has established strong political and strategic ties with regional states, in particular through the International North–South Transport Corridor and its membership of the Shanghai Cooperation Organisation, and views Central Asia as key to the stability of its own neighbourhood. Out to 2055, India will also look increasingly to the region for access to resources such as uranium. Due to their good relations, Russia is likely to support an Indian presence in the region. However, India's ability to influence commercial relations is likely to be constrained by China's geoeconomic dominance, as well as the lack of a secure land connection with Central Asia due to its enduring tensions with Pakistan and continuing instability in Afghanistan. In this respect, Iran may become a more important link between India and Central Asia.

Iran's location and close historical and cultural ties mean that it may also seek an active role in Central Asia and has the potential to benefit from regional infrastructure projects. Its strong relations with Russia, China and India mean that it should find support for its regional ambitions. For China and Russia, Central Asia provides a vital link to Iran and the Indian Ocean.

4 Donnellon-May, G., *The Diplomat* (13 October 2022), 'Turkey's Growing Influence in Central Asia'.
5 Afzal, A., Institute of Strategic Studies Islamabad, *Strategic Studies*, Volume 23, Number 3 (Autumn 2003), 'India's growing influence in Central Asia: implications for Pakistan', pages 155–167.

Water security is one issue that causes tensions between states in the region

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South Korea and Japan are two Asian countries with a considerable economic footprint in the region that are capable of competing with Chinese exports across a wide range of sectors.[6] South Korea, Japan and India may potentially cooperate more closely with each other to boost their weight in the competition with China. In the future, South Korea, and potentially Japan in the longer term, may join forces with the US to become more involved in security cooperation in the region.

European engagement with the region will continue to be driven primarily by energy security concerns, economic interests and the desire to promote stability and democratic governance in the wider neighbourhood.[7] Overseas development assistance provided by the European Union, combined with assistance provided by European Union member states individually, makes the European Union the number one aid donor in the region.[8] In addition, European countries remain highly attractive to young Central Asians, who place a high value on European education provision and English language learning. Over the coming decades, as Europe seeks to diversify its energy supplies and reduce dependence on Russian gas, Central Asia's energy reserves may be an attractive alternative to boost European energy resilience. Although this is likely to reduce in the long term as Europe seeks to transition to green energy alternatives, natural gas will remain a key element of European energy supply for the foreseeable future.

The US will continue to have a strong interest in preserving the national integrity of Central Asian states to prevent the development of a Chinese/Russian-led Eurasian bloc. It has supported this with extensive economic assistance, and since the 2022 Russian invasion

6 Murashkin, N. and Varpahovskis, E., *Journal of Eurasian Studies*, Volume 13, Issue 2 (29 August 2022), 'The role of development models in Japan's and Korea's relations with Central Asia: Discourses and practices', pages 180–199.
7 Komilov, A., *The Diplomat* (22 November 2022), 'What Explains Growing European Engagement in Central Asia?'.
8 European Union External Action (16 March 2022), 'The EU Development Priorities in Central Asia'.

of Ukraine it has increased its efforts to influence politics in the region. However, to what extent the US may seek a security role in the region remains uncertain. Although the North Atlantic Treaty Organization (NATO) and US withdrawal from Afghanistan damaged US credibility as a regional security provider, there remains the possibility that the US may in future succeed in re-establishing its military presence in the region. Whether or not it will succeed will depend on whether it can provide credible and sufficient security guarantees to any host country in competition with China and Russia.[9]

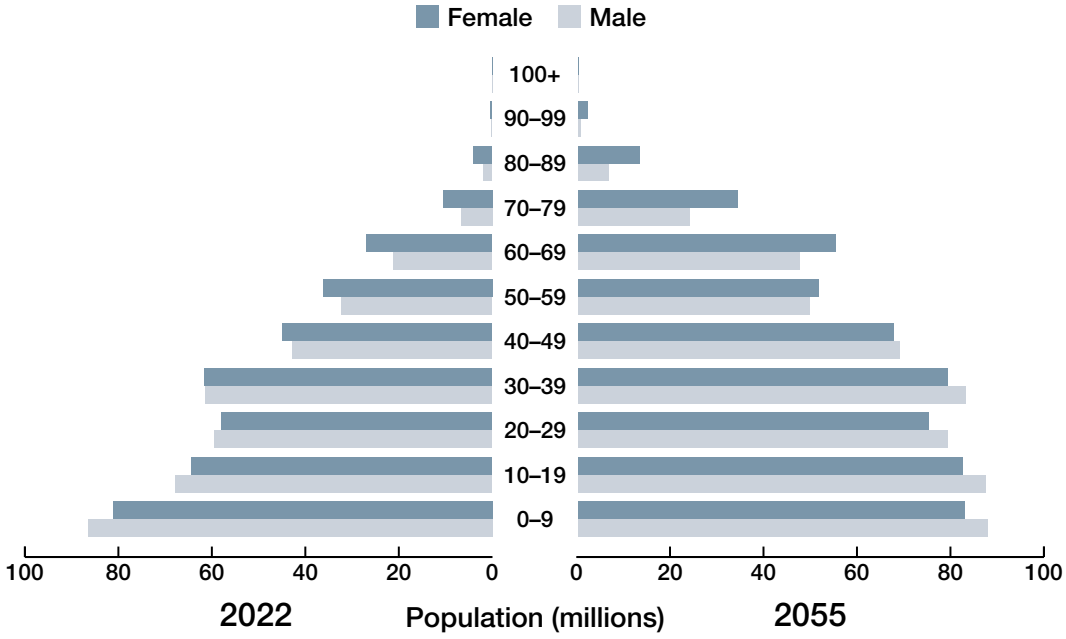
Above all, the question of whether Central Asian states can work together to address common challenges may be the crucial factor in determining the region's future. While countries share common historical roots and cultural heritage, regional cooperation remains a challenge. Nationalist tendencies on the part of some leaders, as well as ethnic tensions, border disputes and concerns over sovereignty, water security and resource distribution, have at times hindered meaningful collaboration between regional governments. However, recent trends are more promising, with a growth in dialogue leading to breakthroughs on border demarcation, infrastructure development and security, and out to 2055 it is possible that the region will see cooperation extending into other areas. The United Nations agencies, the World Bank and the International Monetary Fund are actively supporting Central Asian states to develop an institutional framework and instigate reforms to facilitate a more structured approach to regional cooperation. In the future, this may see fresh initiatives in areas such as preventative diplomacy, water management, economic integration, counterterrorism and countering serious and organised crime.

In terms of wider regional cooperation, organisations such as the Shanghai Cooperation Organisation and the Collective Security Treaty Organization may become increasingly important not only to regional governments but also to Russia as it realigns itself away from the West following the war in Ukraine. The Shanghai Cooperation Organisation also provides a potential mechanism for the expansion of Chinese influence in the region. Shanghai Cooperation Organisation members account for around one third of global gross domestic product (GDP) and about 40% of the world's population, and an accommodation between China and India, both members of the organisation, could potentially make it a major player in future global power dynamics.[10]

Society

Although Central Asia will continue to experience a general trend of ageing, with an expected increase in the median age to around 32 by 2055 (up from 26.5 in 2023), its population will remain young in comparison with most other global regions.[11] The total population is expected to grow from 81 million in 2022 to around 108 million in 2055, with Uzbekistan being the region's most populous country.[12] Given the relatively high levels of education in most regional states, it is likely that Central Asia will benefit from a young and productive working age population over the coming decades.

9 Temnycky, M., *New Atlanticist* (6 September 2023), 'The United States must strengthen its engagement with Central Asia'.
10 Shanghai Cooperation Organisation Secretariat (2022), 'English Translation of Remarks by Prime Minister, Shri Narendra Modi at the SCO Summit'.
11 database.earth (2023), 'Median Age of Central Asia'.
12 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.



Source: United Nations Population Division (2022)

Population statistics projection for Central Asia by age range

Urbanisation levels remain relatively low but they are increasing. The dynamics have started to change over the last decade, with permanent moves to cities replacing traditional seasonal migration patterns. By the middle of the century, it is estimated that 60.5% of the population will be living in urban areas, compared with 48.3% in 2020.[13] While this will place a strain on urban development and it is likely to lead to further depopulation of rural areas, increasing proximity and connectivity could act as a spur to economic growth and boost levels of economic and social development. Over the next few decades urban centres are likely to assume increasing economic and political influence in Central Asia, further boosting their attractiveness to the region's young population.

Migration both within and out of the region is expected to increase further.[14] Environmental challenges, including pressure on food and water supplies, will lead to a growth in intraregional migration, potentially resulting in an increase in ethnic tensions in some areas. In other cases, the search for employment opportunities will lead to migration out of the region. Russia has traditionally been the key destination, due to its declining population and its cultural and historical links to Central Asia. However, while the full impact remains uncertain, the long-term impact of the war in Ukraine may lessen the attractiveness of Russia as a migrant destination. In addition, there are indications of significant numbers of young Russians moving to the region in search of new opportunities, and depending on the region's future economic trajectory it is possible that Central Asians will also start to return home in future. Moreover, future decades may see the development of new outward migration patterns – potentially to China, which will suffer an increasing shortage of workers due to its ageing population, but also to other Asian countries and Europe.

13 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.
14 Khashimov, S., et al., The Oxus Society for Central Asian Affairs (11 May 2022), 'Introducing the Central Asia Migration Tracker'.

Poverty rates have fallen consistently since the 1990s and are expected to continue to decline, albeit at a decreasing pace. Today, by one measure, close to a fifth of Tajikistan's and a third of Kyrgyzstan's populations live in poverty for at least some portion of the year. In contrast, poverty rates in Uzbekistan and Kazakhstan are much lower (a sixth and a twentieth of their populations respectively).[15] However, global economic volatility, rising prices and pressure on remittances may undermine attempts to reduce poverty. Going forward, poverty rates are likely to remain uneven, which could exacerbate inequalities within and between states.

Islam is likely to remain an important influence on Central Asian politics and society. Anti-secularist pressures are growing in parts of the region and conservative attitudes continue to persist in some quarters, impacting women's rights in particular. While religious extremism attracts little support in the region, how various governments position themselves on religious affairs in the future is likely to vary, from aggressive secularism to using religion for electoral politics.

Digital media is already emerging as a powerful driver of change in Central Asian societies, and increasing access to information may result in a greater demand for transparency and social and political change in the region's states in the future. This is already encouraging attempts by some state governments to control access to the Internet, a trend which may increase over the next few decades. At the same time, individual citizens will explore new ways to bypass government restrictions, and they will generally demand more openness and transparency in politics.

The Digital Silk Road

Under the Digital Silk Road initiative, Central Asian countries are cooperating with Chinese information and communications technology firms to develop 'Safe City Projects', such as the one launched in Astana, Kazakhstan's capital, in 2018. In collaboration with Huawei, this project employs facial recognition cameras and data management systems to bolster public safety, traffic management and urban planning. Although these initiatives strive to enhance domestic governance, future concerns include increased state surveillance, long-term dependence on Chinese technology and the potential loss of data sovereignty.[16]

The future character of state governance in the region remains a key uncertainty. Overall, democracy in Central Asia is in decline; the *Freedom in the World 2024* report classifies all five regional states as 'Not Free' (based on Freedom House scorings for political rights and civil liberties), with Kyrgyzstan having dropped from 'Partly Free' in the last few years.[17] Out to 2055, political instability may continue to endure in some states. In other states, personalist political systems, which have proved relatively durable even through transition periods, may continue to dominate, and will have strong external support from Russia and

15 World Bank (2022), 'Poverty headcount ratio at national poverty lines (% of population) – Kyrgyz Republic, Tajikistan, Uzbekistan, Kazakhstan'.
16 Kassenova, N. and Duprey, B., Davis Center for Russian and Eurasian Studies (June 2021), *Digital Silk Road in Central Asia: Present and Future*.
17 Freedom House (February 2024), *Freedom in the World 2024: The Mounting Damage of Flawed Elections and Armed Conflict*.

China if they align with their geopolitical interests. However, generational change, stronger institutions and citizen pressure could see political reform occurring in the future, leading to more open, transparent and democratic governance in some countries.

Corruption remains pervasive in Central Asia, hindering efforts to police criminal activity and contributing to the consolidation of wealth in the hands of the elite.[18] This plays into the hands of serious and organised crime networks and the drugs trade, which use illicit payments as a tool for influence. Without far-reaching political reform, corruption is likely to remain a significant challenge for the region and hinder social and economic development.

Economy

Out to 2055, economic growth will be paramount for the region's development and will require a focus on diversification, market access, intraregional trade and integration, and improvements in infrastructure and connectivity. Strategic partnerships with external players will remain vital to achieving this goal, but Central Asian economies will need to strike a delicate balance between attracting necessary investment to the region and limiting foreign ownership and control.

With the exception of the COVID-19 pandemic period, levels of economic growth in the region have proved resilient over the past few decades.[19] Most regional economies have benefited from the Russian invasion of Ukraine, with Central Asia seen as an alternative source of energy supplies for Western governments, as well as being an attractive destination for educated young Russians looking to avoid conscription. However, average manufacturing productivity in the region has declined since 2010, due in part to some states overlooking this sector in favour of a heavy reliance on raw material exports.[20] Continued dependence on commodity exports has led to a failure to diversify and has resulted in persistent income inequalities within and between states. Remittances from migrant workers based in Russia remain an important source of external financing for many Central Asian states, particularly for families in poor rural areas, where they help to support households and boost economic activity.[21]

Agriculture, constituting between 10 and 45% of countries' GDP and up to 50% of the workforce in 2019,[22] remains important in many Central Asian states, but will face increasing challenges due to the effects of climate change, water scarcity and competition from imported food. In the past, overuse of water for cotton production contributed to the collapse of the Aral Sea ecosystem, although large-scale restoration efforts have done much to improve the situation in the North Aral Sea in recent years. Looking forward, the introduction of new technologies for improved water management and more drought-resistant crops may alleviate some of the environmental challenges facing the region.

18 Transparency International (31 January 2023), 'CPI 2022 for Eastern Europe & Central Asia: Growing security risks and authoritarianism threaten progress against corruption'.
19 World Bank (5 October 2023), 'Economic Activity in Europe and Central Asia Improves but Growth Lags Pre-Pandemic Levels'.
20 Yormirzoev, M., *Comparative Economic Studies*, Volume 64, Issue 3 (September 2022), 'Economic Growth and Productivity Performance in Central Asia', pages 520–539.
21 Poghosyan, T., International Monetary Fund (17 July 2020), *IMF Working Paper: Remittances in Russia and Caucasus and Central Asia: The Gravity Model*.
22 Khitakhunov, A., Eurasian Research Institute (2020), 'Agricultural Potential of Central Asian Countries'.

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Regional states that rely on agriculture will be impacted by climate change

Central Asia's currently small manufacturing sector is increasing and out to 2055 has strong potential to boost economic growth in the region.[23] While this will depend on further investment and developing a skilled workforce, Central Asia's young working age population is a clear advantage in this regard. In addition, the establishment of special economic zones that are attracting high-skilled young Russians moving their businesses out of Russia has created a new economic dynamic, which in the future may also attract businesses from other regions.[24]

In the next 30 years, a failure to diversify may see some Central Asian economies remaining heavily reliant on commodity exports for their income. As a result, expanding the customer base for commodity exports will be essential to build resilience. However, geopolitical tensions and regional instabilities will continue to pose challenges. The development of north–south energy and gas transit infrastructure will help to provide new markets for Central Asian energy exports, including projects such as the Central Asia–South Asia Electricity Transmission and Trade Project (CASA-1000), the Turkmenistan–Afghanistan–Pakistan–India (TAPI) gas pipeline, and the Turkmenistan–Uzbekistan–Tajikistan–Afghanistan–Pakistan (TUTAP) electricity transmission line. However, all of these projects depend on a stable, cooperative Afghanistan. Russian initiatives to control Central Asian gas exports present another geopolitical challenge for gas-exporting states, impacting the region's bargaining power with Europe and China.

23 Taguchi, H. and Abdukodirov, A., *Asia-Pacific Journal of Accounting & Economics*, Volume 30, Issue 3 (2023), 'Manufacturing exports and institutional qualities in Central Asian countries', pages 769–779.

24 Eglitis, A., Bloomberg UK (16 May 2023), 'Putin's War Boosts Central Asian Economies as Russians Relocate'.

Electricity and trade

The Central Asia–South Asia Electricity Transmission and Trade Project (CASA-1000), a 1,227 kilometre cross-border transmission line currently under construction, aims to connect Central Asia with South Asia. This initiative seeks to facilitate electricity trade by transferring surplus hydropower from Central Asian states to energy-importing countries in South Asia. Under the project, excess electricity from Kyrgyzstan and Tajikistan will be exported to Afghanistan and Pakistan. Although the project experienced a temporary suspension due to leadership changes in Afghanistan, the World Bank has recently reinstated it. With a 15-year timeline, CASA-1000 promises to bolster regional energy cooperation and foster economic development among participating countries.[25]

Although trade dynamics in 2020 were affected by the COVID-19 pandemic, with China reducing gas imports from Central Asia by 20–25% in March of that year, China remains a significant customer for the region's primary commodities.[26] China is likely to remain the dominant trading partner and investor for Central Asian economies in the long-term future, although Russian businesses are likely to retain significant economic influence as well. A continued reliance on exports means that the region will remain vulnerable to commodity price fluctuations and import policies on the part of customer states.

Central Asian countries' willingness and ability to integrate their economies will play a crucial role in their attempts to achieve economic diversification and growth over the next few decades. At present, intraregional trade remains extremely low and is mostly conducted through bilateral deals, with regional tensions hindering long-term cooperation between states. Chinese Belt and Road Initiative investment could facilitate trade within the region by providing infrastructure upgrades and employment opportunities, potentially boosting local manufacturing capabilities and shifting Central Asian economies up the value chain. The Eurasian Economic Union, which has become more useful for Russia following the invasion of Ukraine, may also see its potential increase in future.

Environment

The Central Asian region will face increasing vulnerabilities due to the effects of climate change as warmer temperatures and more volatile weather patterns disrupt ecosystems and increase the frequency of droughts, floods, heatwaves and forest fires. Above all, effective water management stands out as one of the most significant challenges facing Central Asian states today. Approximately 50% of river water in the region originates from glacial melt,[27] but rising temperatures have accelerated melting in mountainous areas, leading to erratic water flow patterns and periods of scarcity. Deforestation worsens the consequences, increasing the risk of mudslides, while changing rainfall patterns intensify droughts and flooding. The Amu Darya's water availability is projected to decline by 40% over the next three decades, potentially reducing crop yields by 30% and exacerbating

25 World Bank, 'Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000)'.
26 McGraw Olive, M., Central Asia Program (9 September 2020), *Post-COVID-19: Can Central Asia be Central to Eurasian Integration?*
27 Miles, E., et al., *Nature Communications* (17 May 2021), 'Health and sustainability of glaciers in High Mountain Asia'.

food security issues.[28] Southwestern parts of the region, such as Turkmenistan, Uzbekistan and western Kazakhstan, are particularly vulnerable to water stress due to environmental conditions. These areas experienced severe droughts in 2021, leading to the premature death of thousands of cattle and affecting crop yields and soil structure due to increased salinity.

Agriculture and water supply in Central Asia

Initiatives to improve water management in the region give some cause for optimism. For example, Kazakhstan has used World Bank funds to slow the decline of the North Aral Sea, while farmers in some parts of Kyrgyzstan have transitioned to more water-efficient crops. Uzbekistan offers subsidies for farmers using efficient irrigation systems and is supporting improvements to Turkmenistan's water infrastructure. World Bank investments in water-level monitoring aim to balance water usage against availability. Looking ahead to 2055, advances in technology, such as solar-powered desalination, offer other potential solutions. Although it will require significant political will and financial investment for these to be realised, addressing the region's water management failures could yield substantial economic benefits, which the Swiss Agency for Development and Cooperation estimates have a potential worth of US $4.5 billion.[29]

28 World Bank (2021), *Climate Risk Country Profile: Uzbekistan*.
29 Assaniyaz, A., *The Astana Times* (24 July 2023), 'Swiss Initiative Promotes Water Cooperation in Central Asia'.

Technology to the rescue: Caspian Sea desalination

Despite being landlocked, Kazakhstan's southwest region borders the Caspian Sea. As Kazakhstan grapples with deteriorating and underfunded water infrastructure, the country is exploring desalination of the Caspian Sea as a potential solution. A memorandum of understanding between Veolia Water Solutions & Technologies and Kazyna Capital Management aims to use private sector participation to deliver 125,000 cubic metres of fresh water per day. The proposed desalination plant in Aktau will supply water to industries and the populations of Aktau and Zhanaozen, the two main cities in the oil-rich Manghystau province.[30]

Central Asia is currently almost totally dependent on fossil fuels for its energy supply. However, given the region's high and still largely untapped potential to produce renewable energy, in particular wind, solar and hydropower, a transition to net zero by 2050 is feasible.[31] While Kyrgyzstan and Tajikistan lack the hydrocarbon reserves found in neighbouring states, both possess significant hydropower potential, which could result in improvements in energy security and electricity access, as well as providing a significant boost to their economies. However, the exploitation of this will require substantial external investment; major projects such as Tajikistan's Rogun Dam could cost half of each country's GDP. The ability to provide support to Central Asian countries through investment in sustainable energy solutions may become a key lever of influence for external powers such as China, the European Union and Japan.

Out to 2055, increasing pressure on shared water resources for food and energy production may strain regional cooperation and potentially lead to humanitarian crises and a rise in insecurity. Tensions between communities in border regions and between upstream and downstream states may escalate. However, governments have entered into bilateral and multilateral agreements in the years since independence to address energy provision and water access. Regional cooperation has shown signs of improvement in recent years, with agreements on electricity- and water-sharing between Uzbekistan and Kyrgyzstan and Kazakhstan and Tajikistan respectively. By collaborating and implementing sustainable solutions in future years, Central Asian states may succeed in tackling the water management challenge and achieve lasting economic growth. However, international support is still likely to be required in the short term at least to support climate change adaptation, boost water and food security and promote agricultural production in the region.

Technology, infrastructure and communications

In the future, adopting genetically modified crops may increase resilience to water stress in the region and provide a boost to food security. Genetically modified cotton (known as Bt cotton) also has the potential to mitigate the impact of climate change on the region's cotton industry. However, aside from the uncertainties and controversies that continue to surround developments of this sort, their use in the region will also depend on governments being able to dedicate the necessary financial investment to fund such projects.[32]

30 Water Online (10 November 2015), 'Veolia And Kazyna Capital Management Signed A Memorandum Of Understanding For A New Seawater Desalination Plant In Kazakhstan'.
31 UN Economic Commission for Europe (20 April 2023), 'Central Asia would need a massive shift rather than a massive increase in investment to reach net zero by 2050, according to the UN'.
32 Ibid.

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Baikonur Cosmodrome will remain a strategic asset for Kazakhstan

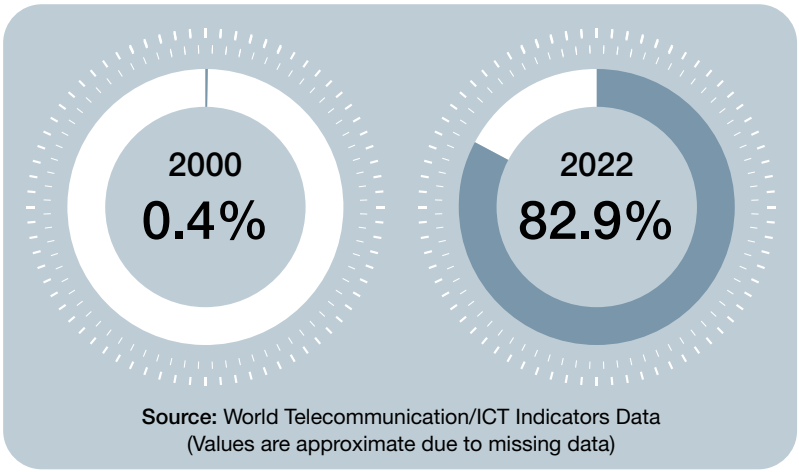
Central Asia has made inroads into the cryptocurrency sector in recent years, driven by relatively cheap energy prices in the region and China's anti-Bitcoin mining policies, and it has emerged as a key player in cryptocurrency mining. However, the rapid growth of this industry has started to place a strain on the region's energy infrastructure, in response to which Kazakhstan and Uzbekistan have implemented new regulations to tackle illegal cryptocurrency mining, manage energy usage and generate income through leveraging new taxes on the sector. Out to 2055, the ability of Central Asian states to keep energy prices down and cope with the increased energy demands generated by the cryptocurrency industry, as well as the future of cryptocurrencies themselves, remains highly uncertain.

Central Asian countries, particularly Kazakhstan, have been actively involved in the space sector since the Soviet period, and they are likely to continue to explore opportunities for space exploration, satellite launches and space-related activities. However, although the Central Asian space industry has significant potential to develop further over the next few decades, it also faces a number of challenges and uncertainties. Developing and maintaining space infrastructure, such as launch facilities and satellite ground stations, requires significant investment, and ensuring sufficient funding and technical capabilities may pose a challenge for some countries. Baikonur Cosmodrome in Kazakhstan remains a vital space launch site due to its strategic location, and Kazakhstan signed a 56-year lease with Russia in 1994 to grant it control and maintenance of the spaceport until 2050.[33] However, the future of this lease will depend significantly on the future of Russia's space industry, as well as the ability of Kazakhstan to maintain its space infrastructure. In response to these uncertainties, it is increasingly likely that Kazakhstan will explore opportunities for regional space cooperation to pool resources, share expertise and jointly pursue space-related projects. Examples of future collaboration might include joint satellite missions, space research and establishing regional space agencies or institutions.

In recent decades, following the collapse of the Soviet Union, Central Asian states have done much to extend their transport network – both roads and railways – to drive economic growth and boost exports to neighbouring regions. Reliance on road and rail infrastructure will continue to increase, and over the next few decades initiatives to

33 Bekus, N., *Central Asian Survey*, Volume 41, Issue 2 (2022), 'Outer space technopolitics and postcolonial modernity in Kazakhstan', pages 347–367.

increase the capacity and speed of this transport network is likely to remain a focus of the region's landlocked states. Currently, nearly half the population of Central Asia is not digitally connected.[34] Achieving improvements in digital connectivity will also remain a priority for the region, and out to 2055 should provide a significant boost to levels of economic, social and potentially political development.



Source: World Telecommunication/ICT Indicators Data
(Values are approximate due to missing data)

Average percentage of the population using the Internet in Central Asia

Conflict and security

Central Asian states will face complex challenges in navigating their security landscape over the next 30 years. The region sits in close proximity to a number of conflict-prone areas, including Afghanistan, Southwest Asia and the South Caucasus, and the potential impact of terrorism, violent extremism and serious and organised crime will remain a pressing challenge for regional governments, societies and the international community.

Although levels of terrorism have reduced since 2013,[35] the potential for a further rise in violent extremist organisations and terrorist attacks remains a concern for Central Asian governments. Future risks are hard to predict, but heavy-handed counter-extremism measures, such as restrictions on the right to assembly and crackdowns on protests, may inadvertently provoke further unrest rather than de-escalate tensions. Historically, terrorism in Central Asia has been cross-border and focused on local power structures. However, in the future the region may see increasing infiltration from international Islamist networks, not least as some Central Asians who joined extremist groups in Syria, Iraq and Afghanistan have since returned as refugees. The resurgence of the Taliban in Afghanistan is a particular concern, which could fuel radical forms of Islam among the Central Asian population.

Ethnic tensions pose an additional challenge in the region and they can lead to occasional violent clashes. In February 2020, southern Kazakhstan witnessed fatalities and injuries in fighting between ethnic Kazakhs and Dungans.[36] Such incidents may persist in the future, and further violence in areas such as Badakhshan and the Fergana Valley will remain a distinct possibility. In some cases, state security forces' involvement in such conflicts may aggravate tensions and escalate hostilities between populations.

34 Burunciuc, L., World Bank Blogs (21 June 2021), 'How Central Asia can ensure it doesn't miss out on a digital future'.
35 Institute for Economics & Peace (February 2024), *Global Terrorism Index 2024: Measuring the Impact of Terrorism*.
36 BBC News (9 February 2020), 'Kazakhstan: Ethnic clashes kill 10, injure dozens'.

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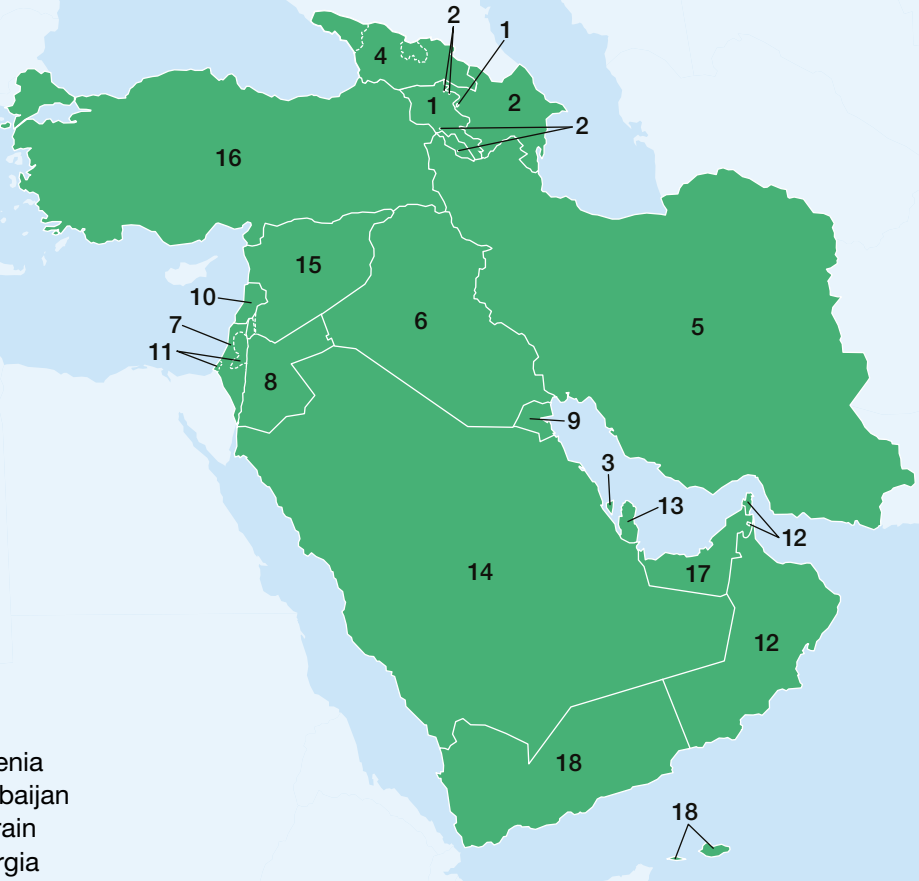
Russia is likely to maintain its presence in the region, but the war in Ukraine has dented confidence in Russia's role as security guarantor

Defence cooperation initiatives will play a significant role in Central Asian security and geopolitics out to 2055. Russia maintains bilateral and supranational avenues of military cooperation with the region, including bases in three states, and is a major supplier of arms and military training and education to Central Asian countries. The Russian-led Collective Security Treaty Organization has lost status and importance in recent years, and Russia's credibility as a security guarantor has been called into question following its forces' initially poor battlefield performance in Ukraine. Nevertheless, Russia retains significant levels of military capability and is expected to retain a military presence in the region, including conducting exercises there.

China's military presence is also increasing in the region, evidenced by its conduct of joint exercises with regional states.[37] While counterterrorism and border security may currently remain the major motivations for Chinese presence, if Russia were to become seriously weakened by the war in Ukraine, China may become more directly involved in future regional security arrangements, and in the long term potentially replace Russia as the main security guarantor. Another possible outcome of a weakened Russia could be increased Indian security engagement with the region, potentially in competition with China. On the other hand, China and Russia may increasingly act collectively in the region, placing pressure on Central Asian states to become part of a Eurasian bloc. Although less likely, an accommodation between China and India could see the Shanghai Cooperation Organisation transforming into a military alliance, possibly becoming part of a broader military coalition under a joint Chinese–Russian–Indian lead.

37 Shin, W., CNA (5 February 2024), 'China held a record number of military exercises with ASEAN states in 2023. What's fuelling the spike?'.



1 Armenia
2 Azerbaijan
3 Bahrain
4 Georgia
5 Iran
6 Iraq
7 Israel
8 Jordan
9 Kuwait
10 Lebanon
11 Occupied Palestinian Territories (Gaza and West Bank)
12 Oman
13 Qatar
14 Saudi Arabia
15 Syria
16 Turkey
17 United Arab Emirates
18 Yemen

Southwest Asia and the South Caucasus

Current strategic context

Southwest Asia and the South Caucasus cover less than 5% of the Earth's land surface, an area smaller than that encompassed by several individual countries such as Russia, Canada, China, the United States (US), Brazil and Australia. The natural environment is diverse: the Caucasus and Talysh mountains dominate Azerbaijan; the sparsely populated Rub' al-Khali desert spans Oman, Saudi Arabia, the United Arab Emirates (UAE) and Yemen; whilst the Euphrates and Tigris rivers feed the historically extensive Mesopotamian Marshes of southern Iraq and Iran. At the crossroads between Europe, eastern Africa and Asia, the region has produced many empires and hosts the holy sites of all Abrahamic religions. It is a region of immense diversity, albeit with pockets of homogeneity (for example, Armenia, the population of which was over 98% ethnic Armenian in 2022). While Arabs form the largest ethnic group, Persians, Kurds and Turks also constitute a significant share of the population,[1] and there are also sizeable migrant worker populations from Western countries, Africa, and South and Southeast Asia. In 2024, for example, expatriates accounted for 88.5% of the UAE's population.[2] Religious affiliation in the region is predominantly Islam at 92.2% of the population, followed by Christianity (4.3%) and Judaism (1.8%).[3]

As the site of a large proportion of the world's proven oil and gas reserves, as well as several key maritime choke points that are critical to the global economy, regional stability remains a high priority for major powers. However, tensions and rivalries within and between states – between the region's Sunni and Shia communities, for example, as well as between Israel and some of its neighbours – have historically plagued the region, resulting in enduring tensions and frequent conflict. As the 2023 attack on Israel and subsequent aftermath have demonstrated, such events can be sudden, unexpected and have widespread regional and global implications. In addition, three of Southwest Asia's most populous countries (Iraq, Yemen and Syria) have experienced civil wars in the last 20 years, while the recent border conflict between Armenia and Azerbaijan has its roots in long-standing historical tensions between these two countries.

The ongoing tension between pragmatic cooperation in response to global drivers such as energy transition and climate change, set against long-standing disputes over religion, territory and regional power balances, remains a key uncertainty. Despite the existence of several multilateral organisations aimed at increasing prosperity and stability throughout

1 Central Intelligence Agency (2021), 'The World Factbook: Field Listing – Ethnic groups'.
2 Globalmediainsight.com (3 April 2024), 'United Arab Emirates Population Statistics 2024'.
3 Pew Research Centre (21 December 2022), 'Religious Composition by Country, 2010–2050'.

the region, cooperation remains a challenge, with continuing conflicts and tensions undermining the ability of countries to work together to achieve common objectives.

In recent decades, the US and its European and Asian partners have led on global engagement in the region. However, with Indian and Chinese fossil fuel consumption increasing, the US becoming increasingly self-sufficient, and the green energy transition potentially diminishing the overall importance of oil by the middle of the century, the nature and balance of geostrategic interests across the region may undergo significant changes. Russia's military intervention in Syria and growing relationship with Iran, as well as China's recent brokering of a Saudi–Iranian rapprochement, are indicative of this trend, although China has not yet surpassed the US as the major power-broker. Similarly, the war in Nagorno-Karabakh has changed the geopolitical landscape of the South Caucasus making it a more congested space, reinforcing the influence of Russia and Turkey through their respective military presences.

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Key drivers of change

Increasing regional and global competition. Regional and global powers will increasingly compete for resources and influence, with major implications for stability and the long-term trajectory of Southwest Asia and the South Caucasus. Chinese, Russian and Indian influence may increase at the expense of US, European and other East Asian partners. Within the region, the future of Iran and its relationships with other regional and global powers will have profound implications for stability here and in the wider neighbourhood.

Growing societal demands and divisions. While some citizens may continue to accept authoritarian governance structures (including state surveillance) in return for stability and prosperity, this could increasingly lead to unrest and tensions in some parts of the region. Serious and organised crime and violent extremist organisations will present a persistent threat to peace and stability throughout much of the region. Conflict and instability will continue to stifle economic development and regional cooperation, and over the next three decades could contribute to the failure of some of the region's states.

Accelerating energy and resource transition. The global green energy transition and the ability to respond through economic diversification will increasingly shape the region's future. Those states that are able to diversify, set aside differences and establish new economic partnerships are likely to continue to prosper. However, not all will succeed in this, potentially leading to new winners and losers in the region. Regional hydrocarbon exporters are also likely to seek to exercise influence over the rate and extent of the green energy transition to protect their own interests, influencing their partnerships and alignments with other global powers.

Increasing environmental stress. Climate change and other environmental impacts will place increasing stress on states, societies and economies. Some states will seek to adopt new technologies to mitigate these impacts and support economic diversification, but implementation is likely to be uneven. This could exacerbate existing tensions and inequalities, fostering instability.

Adoption of new technology. Technological change will present opportunities for the region to address its environmental and economic challenges and will be a key enabler for economic development and the green energy transition. However, authoritarian regimes might take advantage of technology to control their populations, and violent extremist organisations and serious and organised crime actors may seek to exploit new technological developments to further their own ambitions.

Future key trends

Global power competition

Southwest Asia and the South Caucasus are likely to remain home to numerous competing and overlapping interests. These include: competition between global powers in the South Caucasus, where Azerbaijan is in the forefront of Russian, Turkish and Iranian competition; long-standing rivalry between Saudi Arabia and Iran; the ongoing proxy conflict between Israel and Iran; and continuing tensions between Israel and some of its neighbours (acknowledging that it is unclear when or if Arab–Israeli cooperation following the 2020 Abraham Accords might resume after the events of October 2023). The situation will continue to be complicated by the involvement of a wide range of external actors, including the US, European countries and India, but also increasingly others such as Russia and China.

The Western interventions of the early 21st Century, the awakening of Southwest Asia's significant youth population through the events commonly known as the Arab Spring in 2011, and the growing need for economic diversification have seen many countries expand and realign their regional and global partnerships in recent years, and future decades are likely to see relationships evolve further. While Southwest Asia's many unresolved ideological and religious conflicts could remain a block to further regional integration at the formal level, the changing dynamic means that new and unexpected rapprochements and alliances could develop between regional powers, including pragmatic or transactional partnerships and accommodations based on common interests in a particular field.

Within this dynamic, the individual trajectories of the region's countries will play a central role. The relative scale of states' demographic and environmental challenges, their ability to diversify their economic models and their willingness to adapt governance mechanisms to meet popular demands will all determine which countries succeed and which fall behind in the coming decades. Some Gulf states, for example, seem well placed to have the resources and political will required to shape cohesive societies adapted to new regional realities. The future of Iran and Turkey will also have major implications for the region. While it appears that previous attempts at liberalisation are now being reversed, with these two countries becoming increasingly conservative and nationalistic in recent years, such trends could be subject to sudden and unexpected shocks and reversals over the next few decades.

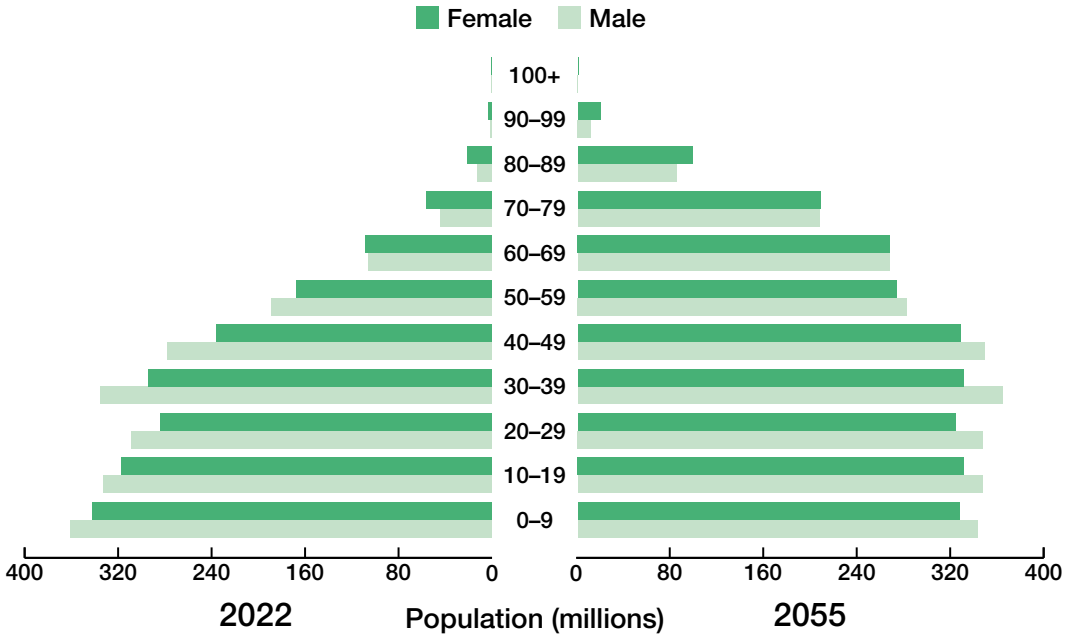
By 2055, the region's global economic significance may have declined as the world seeks to transition away from fossil fuels. However, China and India's expanding economies will continue to require increasing amounts of oil and gas, and hence these two powers may see their regional influence grow as Southwest Asian and Azerbaijan's economies increasingly come to rely on these markets for income. China is already creating economic partnerships and influence through its infrastructure and other investments in the region. In 2018, China pledged US $20 billion in loans to countries across Southwest Asia and North Africa to facilitate economic and industrial reconstruction,[4] while its recent brokering of a rapprochement between Saudi Arabia and Iran has also increased its regional reach.[5]

4 van Genugten, S. and Quilliam, N. (2020), chapter in Gervais, V. and van Genugten, S., (Eds), *Stabilising the Contemporary Middle East and North Africa: Regional Actors and New Approaches*, 'Economic Stabilisation of the MENA Region: 'Old' vs. 'New' Actors', pages 185–204.
5 Campbell, C., *Time* (15 March 2023), 'China Just Brokered a Historic Truce Between Saudi Arabia and Iran. Can It Do Ukraine Next?'.

Given the region's geostrategic importance and the security challenges that it will face out to 2055, Western interest in regional security is highly likely to endure. This could include Western involvement in negotiations to persuade Iran to halt its nuclear weapons programme, de-escalate tensions with Saudi Arabia and reduce support to proxy groups. Georgia and Armenia have expressed a strong desire to be part of European security structures and economic integration. The increasing number of external actors that are active in the region may offer some regional states the opportunity to extract benefits from multiple partners, building relationships of convenience, which in some cases will see governments prioritising economic interests over values.

Society

The region was home to over 386 million people in 2022, and this number is forecast to rise to approximately 535 million by 2055.[6] The regional population is currently growing at approximately 1.29% per year, but it is set to slow to 0.65% by 2055.[7] However, population growth will be uneven, and while some states will continue to experience a steady population increase, others such as Georgia, Armenia, Qatar, Kuwait and Lebanon are already shrinking. Syria, Iraq and Yemen, conversely, are expected to grow by more than 50% by 2055[8] and Iraq's population is predicted to overtake that of Iran in 2071.[9]



Source: United Nations Population Division (2022)

Population statistics projection for Southwest Asia and the South Caucasus by age range

6 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
7 Ibid.
8 Ibid.
9 PopulationPyramid.net (2023), 'Population Pyramids of the World from 1950 to 2100'.

Competition for technical as well as manual labour may challenge traditional approaches to employing and hosting foreign workers

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Some of the Gulf states will continue to rely on expatriate and migrant populations to meet their workforce needs, which in numbers often significantly outmatch indigenous populations. Many regional powers have traditionally sought to reduce the impact of large migrant populations on their societal norms by not affording full rights to economic workers. As global workforce markets change due to ageing and shrinking populations in developed economies, competition between regional states and with other global powers for human capital could intensify.

The South Caucasian states have seen a major influx of Russian migrants after the escalation of the war in Ukraine. Southwest Asia also faces internal displacements due to its ongoing conflicts. For example, over 12 million Syrians remain forcibly displaced in the region, including almost 6.8 million within Syria itself and 5.4 million living as refugees in neighbouring countries such as Iraq, Lebanon, Jordan and Egypt.[10]

By 2055, if population growth is employed effectively, it may provide a significant boost to some regional economies. However, it is likely that not all citizens will benefit from this, and inequality will endure both within and between countries. There are significant disparities between the region's elites and the general population, as well as between indigenous populations and migrant workers. The region's ongoing conflicts contribute to its enduring poverty; in Yemen, for example, 20% of the population live below the poverty line. If enduring peace settlements can be established over the coming decades, this may have a significant impact on regional poverty reduction.[11]

The number of urban inhabitants has exceeded the region's rural population since the 1970s,[12] and by 2055 it is predicted that almost 90% of the region's population growth will take place in cities.[13] However, this masks significant disparities in levels of urbanisation.

10 World Vision (16 February 2024), 'Syrian refugee crisis: Facts, FAQs, and how to help'; UN Refugee Agency (UNHCR), Global Focus (2024), 'Syria situation'.
11 World Bank (2023), 'Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population)'.
12 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.
13 UN Development Programme (1 January 2016), *Arab Human Development Report 2016: Youth and the Prospects for Human Development in a Changing Reality*.

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The region's conflicts are impacting on standards of education provision

In Kuwait, for instance, an estimated 99% of the population already live in urban areas,[14] whereas in Yemen the urban population represents only 39% of the country's total.[15] Vast areas of Southwest Asia will remain uninhabited or uninhabitable. While the region's growing cities could be engines for economic growth, they are also exacerbating environmental degradation and risk becoming centres for instability, particularly if urban infrastructure is inadequate or if large influxes of people result in growing competition over jobs and housing and an increase in crime.

In 2020, there were approximately 15 million out-of-school children in Southwest Asia and North Africa, a figure that is projected to rise to 20 million by 2030.[16] Iraq, Syria and Yemen are thought to account for nearly two thirds of this figure, illustrating the impact of the region's conflicts on access to education.[17] Although consistent reporting is lacking across the region, published figures suggest that girls are more likely to be denied access to schooling. Despite this, they are more likely to remain in education if they are given the opportunity to attend and female university graduates outnumber men in many of the region's countries.[18] Looking forward, it is likely that cultural and religious influences will continue to act as a barrier to female education, limiting the ability of some regional states to maximise on their potential workforce. Conversely, gender equality in other states may enable them to harness more of their workforce's capacity and potential and exploit the cognitive diversity which this brings.

Southwest Asia has seen significant improvements in health in recent decades, with life expectancy rising, maternal and infant mortality rates declining and access to health care improving. While the burden of communicable diseases is decreasing, however, non-communicable diseases accounted for 74% of all deaths in the region in 2018,[19]

14 Bogan, J. and Feeney, A., UK Defence Science and Technology Laboratory (17 February 2020), *Future Cities: Trends and Implications*.
15 World Bank (2024), 'Urban population (% of total population)'.
16 UN Educational, Scientific and Cultural Organisation (27 January 2020), 'Millions of children in Middle East and North Africa are missing out on education, UNESCO and WFP say'.
17 UN Children's Fund (December 2018), *Regional Fact Sheet on Out-of-School Children in MENA*.
18 Development, Concepts and Doctrine Centre (DCDC) (2018), *Global Strategic Trends – The Future Starts Today*.
19 McNatt, Z., *Conflict and Health* (18 February 2020), 'Addressing noncommunicable diseases among urban refugees in the Middle East and North Africa – a scoping review'.

although this differs by country.[20] Out to 2055, as population growth slows in some countries and reverses in others, and as lifestyles and eating habits change, it is likely that non-communicable diseases will place an increasing burden on regional health systems.

Israel is the only Southwest Asian country labelled as 'Free' (based on Freedom House scorings) in the 2023 Freedom House Global Freedom Index and only Armenia, Georgia, Kuwait, and Lebanon are labelled 'Partly Free'.[21] However, polling suggests that citizens in the Arab world, including those in the region's more socially conservative countries, retain a strong preference for democracy,[22] and in the future it is possible that representative approaches may be adopted alongside traditional structures and Sharia Law. This is by no means certain, however, and the region's economic, social and environmental challenges could encourage further authoritarianism as governments seek to retain their hold on power, in some cases making use of new surveillance technologies, which may allow them to exercise increased control over their populations. Continuing instability in some parts of the region, together with the influence of external actors on systems of governance, may also support the further development of authoritarian regimes.

According to the latest Arab Barometer survey, the majority of citizens have extremely low levels of trust in their governments and are resigned to corruption.[23] Corruption has reportedly worsened since the events commonly known as the Arab Spring of 2011, despite this being a key driver for the protests.[24] Attempts to reduce corruption in the public sector, including Bahrain's investment in governmental digitalisation, have not necessarily translated into improved perceptions.[25]

Looking forward, Israel's willingness to embrace innovation and new technological developments may see it increase its economic significance. However, regional perceptions over the Israel–Palestine conflict and the plight of Palestinians are likely to influence the country's political trajectory, making its future role even more uncertain.

Economy

There is likely to be continued variation in economic performance between states in the region over the next 30 years. Levels of economic development vary widely across the region, from high income countries such as Bahrain, Israel, Kuwait, Oman, Qatar and the UAE to Yemen, which ranks as one of the world's least developed countries.[26] Average gross domestic product (GDP) per capita in 2019 was US $26,764; however, this masks significant differences between countries, with Qatar (US $94,028) and the UAE (US $70,089), for example, contrasting starkly with Yemen (US $3,689).[27]

20 Sustaining Health Outcomes through the Private Sector Project and Health Financing and Governance Project (July 2018), *Health Trends in the Middle East and North Africa: A Regional Overview of Health Financing and the Private Health Sector*.
21 Freedom House (2023), 'Countries and Territories – Global Freedom Scores'.
22 Arab Barometer (2021), 'Data Analysis Tool'.
23 Ibid.
24 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.
25 Fakir, I. and Yerkes, S., Carnegie Endowment for International Peace (2018), 'Arab Horizons: Governance and the future of the Arab World'.
26 UN Conference on Trade and Development, 'UN list of least developed countries'.
27 World Bank (2021), Interactive data tool for 'GDP per capita, PPP (current international $)'. All years 2019 except Yemen (2013); no data for Syria.

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Stark contrasts in wealth are increasingly evident both within and between regional states

The region possesses approximately 55% of the world's proven crude oil resources[28] and approaching half of its gas reserves, of which Iran holds around 26% and Qatar 18% of the world's total.[29] This uneven distribution of resources contributes to persistent inequalities between states. Regional instability also has a major impact on economic performance, with Syria and Yemen seeing almost total collapses in oil production as a result of their protracted conflicts.[30]

Southwest Asia and the South Caucasus accounted for just over 6% of global GDP in 2021.[31] The UAE and Saudi Arabia feature among the world's leading exporters, largely due to their significant fossil fuel holdings, accounting for 2% and 1.2% respectively of global exports in 2017.[32] While over 60% of the region's trade is currently with the European Union (EU),[33] China and increasingly India are likely to play a growing role in future decades. Although current levels are relatively low, trade across the wider region is expected to increase, with Turkey in particular showing signs of a reorientation towards its immediate neighbours.[34] Currently, eight Southwest Asian countries participate in the Greater Arab Free Trade Area, with Armenia, Azerbaijan and Georgia being members of the Commonwealth of Independent States Free Trade Area and Turkey having some bilateral arrangements with the EU Customs Union. All of the region's states have some involvement in the Chinese Belt and Road Initiative.

28 Organization of the Petroleum Exporting Countries (2023), 'OPEC Share of World Crude Oil Reserves, 2022'.
29 Eni (2023), *World Energy Review 2023: Natural Gas – Supply and Demand*.
30 Woertz, E., European University Institute, *Revisiting Natural Resources in the Middle East and North Africa* (2020), 'The Geopolitics of Renewable Energy Transitions in the MENA', pages 1–8.
31 World Bank (2021), Interactive data tool for 'GDP, PPP (current international $)'. All years 2021 except Yemen (2013) and Kuwait (2020); no data for Syria.
32 Saidi, N. and Prasad, A., Organisation for Economic Co-operation and Development (27–28 November 2018), *Background Note: Trends in trade and investment policies in the MENA region: MENA-OECD Working Group on Investment and Trade*.
33 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.
34 DCDC (2018), *Global Strategic Trends – The Future Starts Today*.

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The recent growth in tourism in Southwest Asia is expected to continue

The region will remain highly susceptible to fluctuations in international energy prices and market shocks, such as those which followed the US shale boom. Over the next three decades, while Southwest Asia and Azerbaijan will remain key suppliers of hydrocarbons during the early stages of the green energy transition, if the global transition to renewables gathers pace and demand for hydrocarbons decreases, revenues could begin to decline sharply. Over time, this may see a reduction in global influence and at the domestic level may impact on levels of government spending. This may lead to a decline in popular support for ruling regimes, given that in the majority of the region's countries the social contract between state and citizen is based on popular acquiescence funded through subsidies, public sector jobs and services.

Given the potential impact of the global green energy transition on hydrocarbon usage, the next few decades are likely to see states forced to consider new ways in which to achieve economic diversification. Some may draw on sovereign wealth funds to invest in new industries, such as green technologies, to substitute for falling hydrocarbon revenues. However, it is likely that not all regional countries will succeed in diversifying their economies and keep pace with global technological and environmental change. Out to 2055, varying levels of diversification could drive changes in the regional power balance and become a new source of tension between countries.

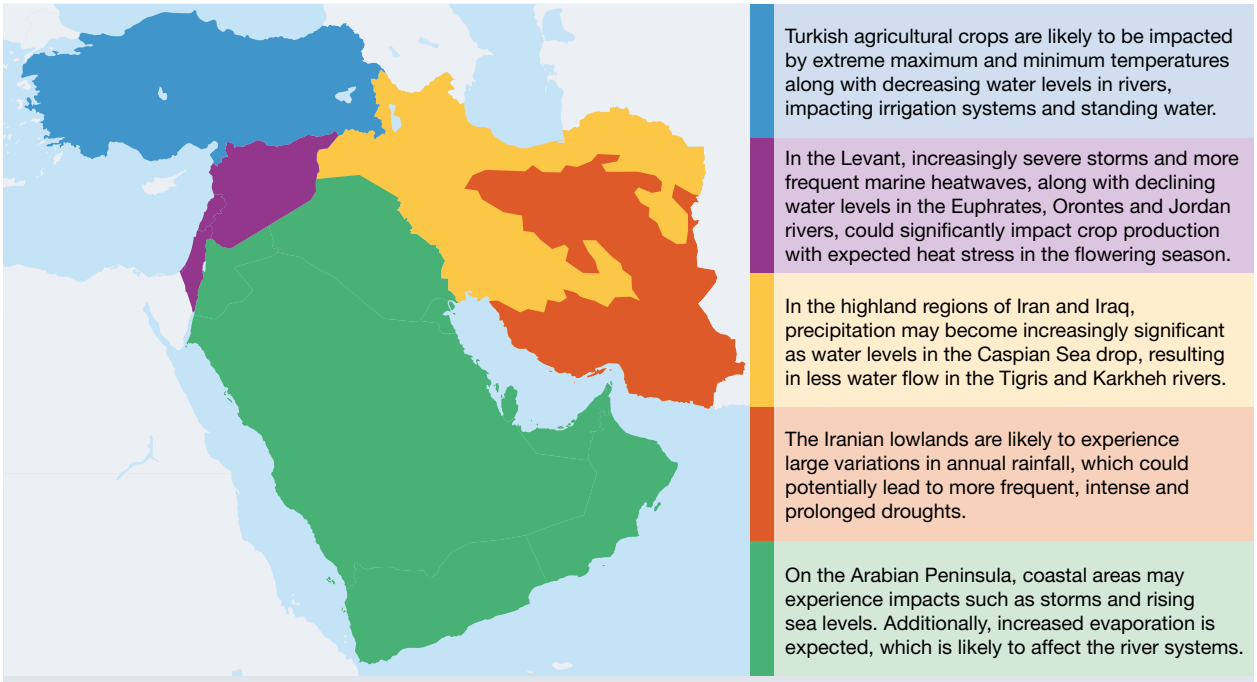
According to the United Nations World Tourism Organization, before the COVID-19 pandemic, tourism in Southwest Asia and North Africa was growing at a faster rate than in any other region.[35] This trend is projected to continue, driven by a favourable economic environment and strong demand from global tourist markets such as Russia, the US, France, Australia and South Korea. Oil-exporting countries are seeking to diversify their economies by integrating tourism into their development strategies, creating more business opportunities and boosting investment in infrastructure and transport. Many countries are putting tourism at the core of their strategic long-term vision, for example, Saudi Arabia's Vision 2030 and Oman's Vision 2040. Saudi Arabia aims to attract 100 million tourists by 2030, increasing the contribution of tourism to overall GDP from 3% to 10%.[36]

35 UN World Tourism Organization (March 2019), *Tourism in the MENA Region*.
36 Abdallah, K., et al., Strategy& PwC (2020), 'Five key stages for developing the tourism sector across the Middle East'.

A skilled and educated workforce will be an essential requirement for economic development and diversification out to 2055. The region has historically suffered from high levels of unemployment and significant levels of informal employment, contributing to low competitiveness in some states. High levels of public sector employment, inflated subsidy systems and low female participation in the workforce all add to these challenges. Looking forward, high levels of population growth, increasing immigration and jobs being replaced by automation could see stresses in some states' labour markets increase, leading to pressure on regional governments. Public sector employment is also falling with a general slowdown in hiring across the region, leading to increasing unemployment among educated young people, particularly women.[37]

Environment

Southwest Asia is already one of the regions most affected by climate change and over the next three decades the impact will become increasingly severe, with profound implications for governments and populations. Rising temperatures and sea levels, and increased variability in rainfall, will lead to higher levels of drought, flash flooding in coastal and mountainous regions, the depletion of already limited arable land and an acceleration in desertification, all of which could make new areas of the region uninhabitable.[38] The South Caucasus region shows comparable trends.[39]



Source: The Met Office study on climate risks for the Middle East and Northern Africa (2021)

The climate of Southwest Asia will become hotter and drier on average, with days exceeding 35° Celsius becoming more frequent

37 Assaad, R. and Barsoum, G., IZA World of Labor (August 2019), 'Public employment in the Middle East and North Africa'.
38 Abumoghli, I. and Goncalves, A., UN Environment Programme Faith for Earth Initiative (2020), *Environmental Challenges in the MENA Region*.
39 Environment and Security Initiative (25 July 2017), *Climate Change and Security in the South Caucasus*.

Agrotechnology will be a critical enabler to address the challenges of food and water scarcity

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Food and water insecurity is likely to increase, disproportionally affecting the region's poorer areas and populations. At present, eight of the top ten most water-stressed countries in the world are located in the region;[40] over the next few decades, further water shortages could exacerbate inequalities and societal tensions and lead to increased migration to overburdened cities. Reliance on food imports, which are already significant (the majority of countries currently import more than 50% of their cereals, for example[41]), will increase dependencies on external actors and global markets. Looking forward, however, technological advances may offer options to reduce the impact of water scarcity, through increased efficiency of water use, biomimicry, fog-harvesting, vertical farming and desalination.

Vertical farming in Dubai

The world's largest vertical farm is due to be operational in Dubai, UAE by 2026. At 87,000 square metres, it is expected to produce up to 3,000 tonnes of produce per year. Capable of sustaining two billion plants each year, the 'gigafarm' consists of hundreds of 12 metre growth towers with an organic food waste recycling system. It is estimated to be 98% more water efficient than traditional agricultural methods and aims to replace 1% of the country's fresh produce imports. More than 250 varieties of plants, seedlings and saplings, from salads, herbs and leafy greens to vegetables, can be grown on the vertical farm. Renewable energy will be used to power the farm, thereby contributing to the UAE's efforts to decarbonise. However, current systems are very power intensive, so energy prices will remain an important factor.

40 World Resources Institute, 'Aqueduct Country Rankings'.
41 UN Data, Food and Agriculture Organization (2023), 'Cereal import dependency ratio (percent) (3-year average)'.

Beyond the impact of climate change, the region also faces a number of other environmental challenges, including oil spills as a result of poorly maintained or damaged infrastructure, and waste and toxic chemicals emitted from the increasing number of desalination plants across the region. While Israel, Turkey and some Gulf states appear well prepared to address these impacts, most regional states have little capacity to respond effectively and adapt to the increase in environmental stress. However, if increased regional cooperation can be achieved out to 2055, this could lead to collective solutions and knowledge-sharing between states. Some of the better prepared states, for example, have been leading on innovations in desalination, water conservation in agriculture and other measures that could have wider regional benefit.[42]

While the vast majority of the region's domestic energy supply continues to come from fossil fuels, concerns over environmental issues and depletion of reserves have encouraged attempts at energy diversification. For example, the UAE plans to spend US $160 billion on renewables by 2030 with the ambition of generating two-thirds of its electricity from carbon-free sources by the middle of century,[43] and Dubai aims to be the first 'net-zero city' by 2050. In practice, however, the price of hydrocarbons compared with renewables will determine the extent to which energy diversification can be achieved by 2055, not just within this region but worldwide. Some regional states are also pursuing dualistic strategies to manage the green energy transition domestically while continuing to promote hydrocarbon use overseas through diplomatic, economic and other levers of power. This dynamic could also impact regional alignments with other global fossil fuel exporting and consuming states.

Technology, infrastructure and communications

The adoption of emerging technologies will be vital in addressing some of the region's key challenges out to 2055. Technological innovation may provide a route to economic diversification for some states, which may increasingly seek to present themselves as world-leading innovation hubs to attract global interest and investment. Dubai, alongside its net-zero efforts, aims to become a global leader in science and technology, particularly in artificial intelligence and the robotics sector, and is seeking to become the first country in the world to employ flying taxis, via a series of 'vertiports', which are intended to be operational by 2026. Dubai also hopes to be the first truly smart city by 2050, not only acting as a test bed for new technologies but also being the first to employ them practically. Israel has become a hub for technology start-ups such as Eco Wave Power, which aims to deliver renewable clean energy through the use of wave power.

While some states are already well placed to exploit and expand their innovation base out to 2055, it is uncertain whether all will become developers of technology or simply consumers. Over the next few decades, diverging levels of access to and adoption of technology might exacerbate existing inequalities between states and potentially create new ones. In addition, some governments may be reluctant to adopt certain new technologies and invest in human capital for technology exploitation, fearing that such developments may constitute a threat to the status quo.

42 Jacobsen, R. and Ensia, *Scientific American* (19 July 2016), 'Israel Proves the Desalination Era is here'.
43 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.

Growing populations will drive continued demand for infrastructure investments in the region

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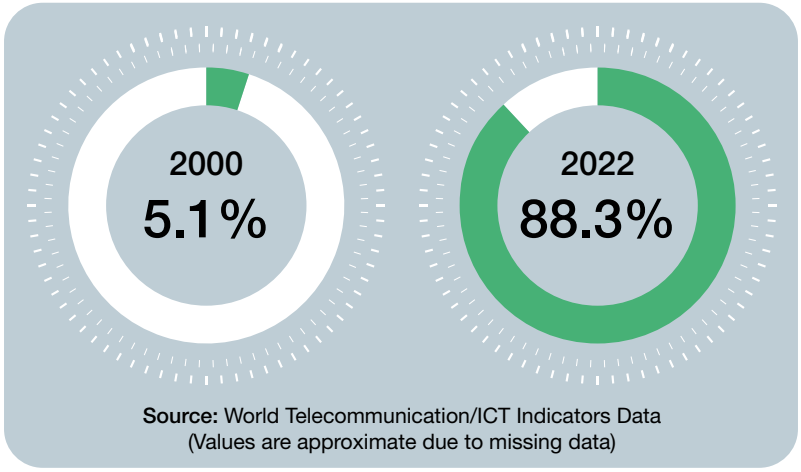
Although home to high-profile projects such as The Palm Islands in Dubai and The Line in Saudi Arabia, much of the region is in urgent need of new infrastructure investment. Syria and Yemen, for example, have some of the lowest quality of infrastructure in the world.[44] However, even in areas not experiencing conflict, continued demographic growth means that all states will face demand for new or improved roads, bridges, and Internet and electricity provision, while rising sea levels also threaten to damage the infrastructure in densely populated coastal areas.[45]

The Line, Saudi Arabia

The Line seeks to apply innovative design and city management to enable high-density living with low environmental impact. Billed as the world's biggest earthworks, the construction site is already visible on open-source satellite imagery and has an ambitious completion date of 2030 (in support of Saudi Arabia's Vision 2030). In contrast to developing or retrofitting an existing urban site, the concept aims to achieve efficiency by designing in transport links and essential services from the outset. Automated monitoring and city management will need to stay at the leading edge of technological development, and day-to-day maintenance and subsequent upgrades will test the inherent flexibility of the base design. However, once complete, how The Line interacts with other population centres will be illuminating for future smart city projects.

44 World Bank (2023), 'Quality of overall infrastructure'.
45 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.

Internet connectivity has already grown significantly in the region, from 32% of the population in 2011 to 77% in 2021.[46] Looking forward, it is predicted that most Gulf states will have reached 85–90% coverage by 2030.[47] Although only 17 per 100 people have fixed broadband subscriptions,[48] mobile data subscriptions per 100 people reached 122 in 2021.[49] Out to 2055, increased digital connectivity could boost economic growth in the region. However, future years are likely to see tension between citizens who seek to use digital connectivity as a tool for political activism and states that try to limit this by retaining or expanding existing domestic controls.



Average percentage of the population using the Internet in Southwest Asia and the South Caucasus

Investment in space technologies could boost economic diversification in some states, increasing resilience to falling commodity prices, as well as helping to address the region's environmental challenges. Many regional countries have already started to invest in space, launching their own programmes and developing new technologies while also pursuing cooperative endeavours with other states. Turkey has announced a plan to land a vehicle on the Moon, and many Arab states are pursuing orbital activities, with the UAE in particular driving developments. Despite relatively low levels of investment, the Israeli Space Agency has proved very cost-effective in the design, development and production of microsatellites; meanwhile, an Israeli not-for-profit organisation, SpaceIL, is working on its second lunar mission. Iran runs both a national space programme, aimed at primarily civilian applications but with potential for military use, and a project within the Iranian Revolutionary Guard Corps with purely military interests; it has also worked with Russia and North Korea in the pursuit of joint ventures.

The choice of infrastructure and technology development partners over the next 30 years will be a significant element of global power competition within the region. While China's Belt and Road Initiative will increase Southwest Asian and South Caucasian exports to South Asia, Europe and Central Asia,[50] it will also increase China's influence in the region, potentially at the expense of traditional partners.

46 World Bank (2023), 'Individuals using the Internet (% of population)' compared with 'Population, total' to produce a regional datapoint.
47 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.
48 World Bank (2021), 'Fixed broadband subscriptions'.
49 World Bank (2021), 'Mobile cellular subscriptions'.
50 de Soyres, F., et al., World Bank Policy Research Working Paper 8801 (April 2019), *Common Transport Infrastructure: A Quantitative Model and Estimates from the Belt and Road Initiative*.

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A range of factors mean that regional security is likely to remain a concern

Conflict and security

Regional security is likely to remain a concern out to 2055, due to a combination of stress factors such as enduring poverty, water and food shortages and continuing environmental degradation. Historic feuds and deep-seated antipathies based on racial, religious and ideological fault lines will continue to be a source of tension. External interventions, while often aimed at improving regional stability, have in some cases exacerbated the situation, reinforcing pre-existing differences and tensions. Without economic growth and more effective governance across the region, improved security appears unlikely in the long term.[51]

Due to its complex mixture of political, environmental and security factors, the Israel–Palestine conflict is likely to remain unsolved. Tensions and the trajectory of the conflict are likely to remain influenced by wider geopolitics, particularly Iran's power ambitions and use of proxies, as well as Israeli counteractions. In the long term, with a rapidly growing Palestinian Arab population and increasing frustrations at a lack of opportunities, tensions are likely to continue to vary in scale from low-intensity conflict to full war.

The long history of war in the region has resulted in a proliferation of weapons in the hands of non-state actors, increasing the likelihood of armed action by violent extremist organisations and serious and organised crime actors.[52] Low levels of trust in state governance structures and continued corruption increase the ability of violent extremist organisations and serious and organised crime to recruit and expand their posture. While the global death toll from terrorism rose again in 2023, mainly due to terrorist attacks in

51 DCDC (2018), *Global Strategic Trends – The Future Starts Today*.
52 Gaub, F., European Union Institute for Security Studies, Chaillot Paper 154 (September 2019), *Arab Futures 2.0: The Road to 2030*.

the Sahel, the figures in Southwest Asia and the South Caucasus remain at a low level[53] largely due to the territorial defeat of Da'esh. Nevertheless, regional stress factors and failures in governance could result in the creation of new vacuums, in which serious and organised crime actors and violent extremist organisations are able to establish pseudo states or shadow governance structures. Conversely, improvements in governance and social inclusion could see support for violent extremist organisations decline in some states, thereby helping to boost regional stability.

Investment in conventional armed forces has increased significantly across the region during the last decade, and interstate conflict will remain a possibility. The position will be complicated by the involvement of multiple combatants, both state and non-state, as well as third party involvement through the use of proxies.

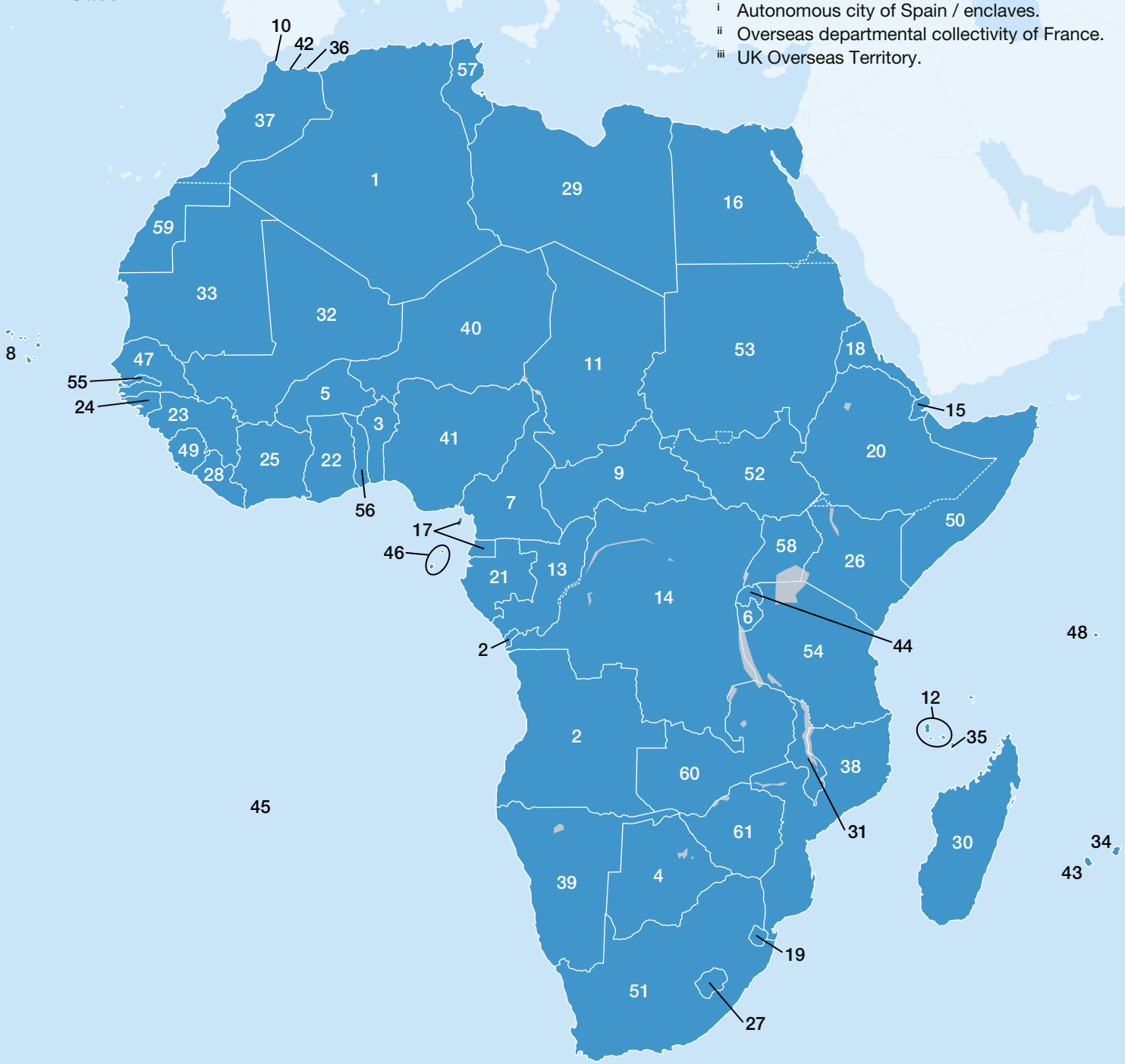
Turkey reflects the scale of interconnectedness and complexity seen throughout the region. Its pursuit of a '360-degree foreign policy'[54] has led to seemingly contradictory interactions with North Atlantic Treaty Organization (NATO) partners, Russia and Israel, including through defence sales.

The US and other Western partners currently have the largest military posture in the region, although Russia maintains a presence through the retention of military bases in some states. Both Russia and Turkey have a military presence in the South Caucasus. Regional tensions and power competition may see further increases in external military presence in the future. Looking forward, the desire to protect its Belt and Road Initiative investments, in combination with rising defence sales and wider offers of security provision to the region, could see a strengthening of China's military posture as well as increasing Chinese involvement in regional conflict resolution.

53 Institute for Economics & Peace (February 2024), *Global Terrorism Index 2024: Measuring the Impact of Terrorism*.
54 *The Economist* (16 January 2023), 'Turkey has a newly confrontational foreign policy'.

1 Algeria
2 Angola
3 Benin
4 Botswana
5 Burkina Faso
6 Burundi
7 Cameroon
8 Cape Verde
9 Central African Republic
10 Ceuta[i]
11 Chad
12 Comoros
13 Congo
14 Congo (Democratic Republic)
15 Djibouti
16 Egypt
17 Equatorial Guinea
18 Eritrea
19 Eswatini
20 Ethiopia
21 Gabon
22 Ghana
23 Guinea
24 Guinea-Bissau
25 Ivory Coast
26 Kenya
27 Lesotho
28 Liberia
29 Libya
30 Madagascar
31 Malawi
32 Mali
33 Mauritania
34 Mauritius
35 Mayotte[ii]
36 Melilla[i]
37 Morocco
38 Mozambique
39 Namibia
40 Niger
41 Nigeria
42 Peñón de Vélez de la Gomera[i]
43 Réunion[ii]
44 Rwanda
45 Saint Helena, Ascension and Tristan da Cunha[iii]
46 Sao Tome and Principe
47 Senegal
48 Seychelles
49 Sierra Leone
50 Somalia
51 South Africa
52 South Sudan
53 Sudan
54 Tanzania
55 The Gambia
56 Togo
57 Tunisia
58 Uganda
59 *Western Sahara*
60 Zambia
61 Zimbabwe

[i] Autonomous city of Spain / enclaves.
[ii] Overseas departmental collectivity of France.
[iii] UK Overseas Territory.



Africa

Current strategic context

Covering more than 20% of the Earth's land surface, Africa's size exceeds the combined territories of western and eastern Europe, China, India and the United States (US). Its environment is extremely diverse, ranging from rainforests to vast desert expanses and from mountain ranges to sweeping savannahs. Despite increasing development, it continues to be one of the least urbanised parts of the world, with its densely populated cities sitting in contrast with huge swathes of the continent that remain sparsely occupied and difficult to reach.

In recent decades, Africa's wealth of natural resources has contributed to a huge increase in external engagement and trade with other parts of the world. China, India and the United Arab Emirates now act as key trading partners for many African states, surpassing historically influential partners such as the US, the UK and other European countries. Over the next few decades, trade with Asian and Latin American countries is likely to increase further; in particular, India, Japan and Brazil may become more prominent trading partners. Elsewhere, historical, religious and cultural links have resulted in an upsurge in Southwest Asian engagement in some parts of the continent.

The post-colonial period has seen a significant increase in African regional cooperation. The African Union is becoming increasingly influential, and its Agenda 2063 provides a useful indication of its ambitions for the continent over coming decades. Alongside the African Union, the continent's eight regional economic communities (RECs) work to increase political and economic integration between member states. Although often criticised for their overlapping mandates and memberships, achievements have been made by some of these organisations; in the long term, if inter-REC cooperation can be achieved, they could act as building blocks for wider continental integration. Linked to this, the new African Continental Free Trade Area (AfCFTA) could help to improve economic cooperation and integration on the continent. This could provide a significant boost to not only intra-African trade, which is still low by global regional trade standards, but also enable higher levels of trade between African states and other parts of the world.

Over the next three decades, however, Africa will also continue to face a range of challenges, including environmental pressures, enduring poverty and continued state fragility in many countries. Civil wars and insurgencies have killed thousands of people in recent years and threaten to destabilise surrounding regions. In 2023, more than 50,000 troops were deployed on United Nations (UN) operations in Africa, with tens of thousands more taking part in regionally led missions; approximately half of the United Nations' peacekeeping missions operating around the world are in Africa.[1]

1 Klobucista, C. and Ferragamo, M., Council on Foreign Relations (12 December 2023), 'The Role of Peacekeeping in Africa'.

Environmental factors are already presenting a huge challenge for Africa, the hottest continent on the planet. Heatwaves, droughts and irregular rainfall are commonplace in many parts of the region, while other extreme weather events such as floods and tropical storms are also becoming more regular occurrences.

In the longer term, however, if such challenges can be overcome, there are factors which could point to a brighter future for the continent. If Africa can succeed in its ambitions for greater economic integration, improve levels of technology development, digital connectivity and access to energy, and harness the potential of its vibrant and energetic youth population, the opportunities for economic growth and social development could be huge.

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Key drivers of change

Global and regional power competition. As Africa becomes more integrated with the rest of the world, and global power interests in Africa grow, competition in the region could increase. At the same time, enduring tensions between states within the region will persist, limiting the potential for further cooperation. This may undermine the ability of African countries to work together and maximise their influence when dealing with other actors in the international system.

Pressure on governments. Good governance will continue to be a prerequisite for human and economic development in Africa. However, governance standards and state capacity will remain uneven. While steady improvements in electoral and liberal democracy on the continent are a positive sign, implementation will remain patchy and democracy may continue to lack substance in many countries.

Population growth. The massive explosion in Africa's youth population will bring unprecedented opportunities for economic and social development, which could change the face of Africa completely. However, population growth is already leading to increasing domestic demand for goods and services, placing pressure on governments, the environment and regional relations, potentially slowing or reversing human development gains and increasing reliance on food imports.

Increasing environmental stress. Environmental change will have a profound impact on Africa's populations, cities, food security, economies and infrastructure over the next 30 years. Global warming will affect the climate and environment of much of Africa, with many countries experiencing an increase in extreme weather events. Other forms of environmental degradation will also severely affect the continent, including deforestation and soil degradation.

Economic transition. The ability of African countries to transform their economies will have a fundamental impact on their future trajectory. In particular, the success or otherwise of current economic integration ambitions will be a key determinant of Africa's regional economic transformation, and will have profound implications for its future role and influence in the global economy.

Future key trends

Global power competition

African countries are likely to become increasingly integrated into global affairs over the next 30 years. While established partners such as the US, France, the UK and China are likely to remain important, a number of other states will become increasingly influential, notably India, Russia, Japan, South Korea, Brazil, Saudi Arabia, Turkey, the United Arab Emirates and Qatar. Increased resource competition may result in winners and losers in the region, with international actors seeking to boost their engagement with resource-rich countries at the expense of others.

The growing presence of China and Russia in the region may undermine Western influence on the continent. China is increasing its investment in the education of Africa's rapidly growing youth population and in professional training for African government officials and militaries; this, in tandem with its wider investment in African infrastructure and resource projects, may increase its influence still further.

Demands for reparations to atone for historical wrongs and to fund climate change action are also likely to influence future African approaches. However, traditional partners are likely to retain some degree of influence, and while relations with individual countries will fluctuate, the European Union in particular could remain a powerful influence through aid contributions and its role as Africa's top trading partner.

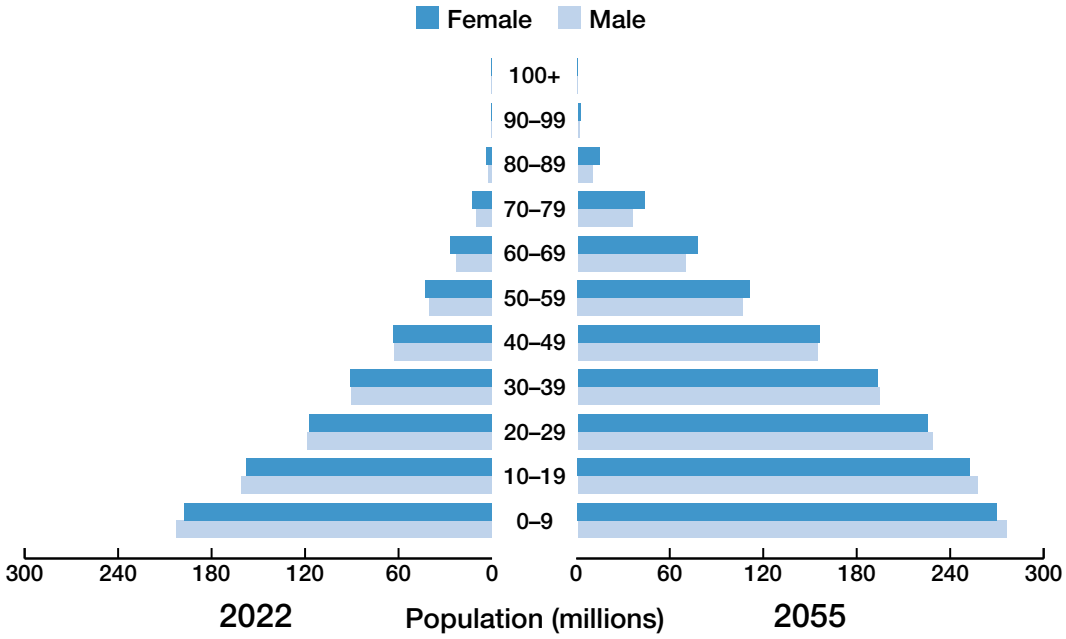
State actors may increasingly have to share influence with key international organisations, commercial entities and other non-state actors operating on the continent over the next three decades. The presence of new networks consisting of both state and non-state actors will make the character of competition more complex.

Despite these challenges, African agency may continue to grow in the coming decades, aided by continued economic development and potential increases in government, commercial and civil society capacity. Some states may potentially play an increasingly influential role at the global level due to the size of their populations and economic weight, although this will depend to a large extent on their domestic political trajectories. Increasing global interest in the Antarctic region may see the 'gateway city' of Cape Town in South Africa attracting growing global attention from external actors wishing to secure their own interests in that region, which could see its global geostrategic influence rise as a result.

Over the next 30 years, enduring regional tensions could limit the ability of African countries to set the agenda in favour of African interests and bring Africa's true weight to bear in global affairs. However, if African countries can succeed in overcoming tensions and work together through the African Union and integration mechanisms such as the AfCFTA, this could result in a more stable, confident and assertive Africa, which may exert increasing influence on the world stage. At the non-state level, Africa's increasing share of the global population, alongside the substantial African diaspora, may see its cultural influence increase as the continent becomes increasingly dominant in livestreaming music, film and theatre, resulting in a huge growth in African soft power.

Society

On current trends, Africa's population is projected to double to almost 2.65 billion by 2055.[2] Over the next 30 years, approximately half to two-thirds of world population growth will take place in Africa, meaning that by the middle of the century over a quarter of the world's population will be African.[3]



Source: United Nations Population Division (2022)

Population statistics projection for Africa by age range

The median age continues to rise in Africa, in part due to declining birth rates but also as increasing life expectancy means that African citizens are living longer. In 2055, the median age is predicted to be 25.0 years, in comparison with 47.5 years in Europe and 51.9 years in East Asia, placing Africa in a new demographic window of opportunity where the ratio of working age people to dependants could provide a significant boost to economic growth.[4] Entrepreneurship could boom on the continent, aided by an increase in digital connectivity and the growing availability of new technologies.

To benefit from these opportunities, governments will need to provide the necessary education and skills development for their young populations. For sub-Saharan Africa, this may present a challenge as less than half of the children in the region finish primary school with the minimum reading proficiency.[5] As the population continues to grow, the gap between education levels in Africa and those in the rest of the world is likely to increase further. Technology leapfrogs and new forms of distance learning may increase access to education; however, this will require significant investment and improvements in connectivity. Even if new ways of learning can be rolled out more widely, there will still be some, particularly girls in traditional households and children in poor rural areas, who might be left behind.

2 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
3 Ibid.
4 Ibid.
5 UN Educational, Scientific and Cultural Organisation (UNESCO) (2024), *Global Education Monitoring Report*, 'Monitoring SDG 4: Learning'.

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Unlocking the region's science, technology, engineering and mathematics potential will require greater investment in education

As technological developments such as digitalisation and automation begin to change the working environment and skills requirement for the African workforce, efforts will need to be made to educate young people for the meaningful and rewarding employment opportunities they will desire. At present, many countries employ outdated teaching methods and curricula, leaving students with inadequate skill sets.[6] Addressing this skills mismatch will be fundamental if African countries are to attain the human and economic development gains necessary for the continent to succeed in a global economic transformation.

If African countries succeed in maximising on the opportunities presented by their forthcoming demographic dividend, the continent should see average incomes rise and an increase in the size of the African middle class, who will wish to enjoy their new-found spending power and leisure time. This should provide a welcome economic boost, although it will also have an impact on resource use and the African environment, which may struggle to support this increase in demand.

Even if African states do successfully capitalise on this potential, many citizens will still not benefit from economic transformation. On current trends, it appears certain that Africa will miss the United Nations Sustainable Development Goals target of eliminating extreme poverty by 2030 by a very large margin.[7] Moreover, the number living in extreme poverty may increase as a result of Africa's rapid population growth. Over the next 30 years, rising inequality could see popular frustration and tensions increase, potentially leading to loss of trust in governments, instability and conflict. Of the ten most unequal countries in the world, seven are currently in Africa.[8]

The percentage of the African population living in towns and cities is likely to increase from 43.5% today to just under 60% by the middle of the century, making it the world's fastest growing urban population.[9] Whilst much of this is due to natural population growth within cities, many people move to cities to escape rural poverty. As a result, the number of urban

6 Obonyo, R., Africa Renewal (14 September 2022), 'Preparing young Africans for jobs of the future'.
7 Cilliers, J. (2020), *Africa First! Igniting a Growth Revolution*, page 118.
8 Ibid, page 126.
9 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.

poor is increasing, and currently over half of the urban population of sub-Saharan Africa live in informal housing.[10] Some predictions suggest that Africa could see its slum population triple by the middle of the century as governments fail to match urban population growth with the requisite job opportunities and properly planned housing and infrastructure.[11]

Africa will also see a growth in other forms of migration, which could accelerate further if governments fail to provide sufficient opportunities and services for their increasingly educated and young populations. Pressures such as enduring conflict, poverty, food and water shortages and the impact of extreme weather events contribute to high levels of migration in many parts of the continent, and could exacerbate levels further in the future. Currently, most migrants remain within the continent rather than travelling overseas, and their presence may place a strain on already stretched governments, in some cases leading to an increase in community tensions as competition for jobs and housing intensifies. However, European countries will remain attractive destinations for overseas migration, and changing migration policies in other global regions (including Asia and Northern America) due to ageing and declining populations could see overseas migration increase in the future.

Population growth will place increased demand on many governments, who will come under rising pressure to provide vital services such as housing and health care for their expanding populations. Africa's citizens have some of the lowest levels of access to basic services worldwide; in 2022, only 31% of the continent had access to safely managed sanitation facilities.[12] Infectious diseases continue to present a major challenge, and currently dominate the continent's health care needs. Out to 2055, poor quality and crowded housing in Africa's growing cities could facilitate the spread of new and existing forms of infectious disease, with global as well as regional implications.

As life expectancy and incomes increase and eating habits change, the continent (and particularly its cities) is also seeing a rise in the incidence of non-communicable or lifestyle diseases and health problems such as obesity and diabetes, which are likely to become the primary cause of death within the next decade. In 2022, the World Health Organization estimated that 24 million African adults suffered from diabetes, with this figure projected to rise by 129% to 55 million by 2045.[13] This double burden of disease will place an additional strain on African health care systems, and governments may struggle to finance the more sophisticated and often long-term treatments required to tackle chronic diseases such as heart disease, cancer and diabetes.

Whilst Christianity is likely to remain the dominant religion in the near to medium term, the proportion of the population following the Islamic faith will increase, largely due to higher birth rates.[14] By 2060, it is estimated that over a quarter of the world's Muslim population will live in sub-Saharan Africa, with that region's Muslim population surpassing that of North Africa and Southwest Asia by 2040.[15]

10 World Bank (2018), 'Population living in slums (% of urban population) – Sub-Saharan Africa'.
11 Cilliers, J. (2020), *Africa First! Igniting a Growth Revolution*, page 30.
12 United Nations Children's Fund (UNICEF) and World Health Organization (2022), *Progress on drinking water, sanitation and hygiene in Africa 2000-2020: Five years into the SDGs*.
13 World Health Organization (14 November 2022), 'African region tops world in undiagnosed diabetes: WHO analysis'.
14 Pew Research Center (2 April 2015), 'The future of world religions: population growth projections, 2010-2050'.
15 Pew Research Center (19 April 2017), 'Sub-Saharan Africa will be home to growing shares of the world's Christians and Muslims'.

An increase in citizen activism will require more agile responses from African governments

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Although recent years have seen a marked increase in state capacity in Africa, there remains huge variation in the quality of governance on the continent. The *Freedom in the World 2023* report categorises nine African states as 'Free' (based on Freedom House scorings) and of the rest, 21 are categorised as 'Partly Free' and 25 as 'Not Free'.[16] While the US and Europe have encouraged and supported democratic development in the years since independence, other powers have also influenced African leaders, most notably the Soviet Union, which throughout the Cold War had significant impact through its support for some of the continent's less Western-oriented regimes. More recently, other powers such as China have started to exert increasing influence, providing African leaders with an alternative model for political and economic development. However, African citizens' enthusiasm and appetite for democracy remains high, and the recent wave of popular protests in several countries may indicate increasing pressure on governments to enact meaningful democratic and social reforms in future.

African citizens will see themselves increasingly empowered through improved access to information, education and finance, with rising connectivity enabling large groups to mobilise and challenge existing norms and standards. This increase in citizen activism will require more agile responses from African governments, which will come under growing pressure to demonstrate visible progress and results. However, state capacity will not always be applied for the benefit of citizens, and some of Africa's more authoritarian states may prioritise their own internal security agendas by using new surveillance and control mechanisms to quell protest and large-scale unrest.

In other cases, new technologies may strengthen non-state actors and networks at the expense of state governments, allowing citizens to bypass official channels. The ability of African governments to control the narrative and access to information may therefore decrease, resulting in an increasingly diverse range of 'facts' and opinions. Control over the development of digital technology and information systems will benefit those seeking to promote particular messages, thereby increasing their influence over African governments and populations.

16 Freedom House (2023), *Freedom in the World 2023: Marking 50 Years in the Struggle for Democracy.*

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Africa's growing workforce may provide a boost to its manufacturing sector

Economy

With significant potential to develop its economy further over the next few decades, Africa is regarded by some as the future economic growth engine of the world. Average growth dipped to an estimated 3.8% in 2022, largely as a result of supply chain disruptions and reduced demand for African exports due to financial constraints at the global level; however, it remained above the global average of 3.4%, and was expected to stabilise at 4.1% in 2023–24, just behind Asia's projected average of 4.3%.[17] Although the global financial situation remains uncertain at the present time, if African countries are able to recover from such setbacks, and capitalise on the promise of the nascent AfCFTA to boost levels of intra-African trade, this could see them resume their trajectory of sustained economic growth in the longer term.

Nevertheless, challenges remain if Africa is to achieve the economic success that some predict. In particular, commodity reliance and a lack of diversification in many countries represent enduring barriers to progress. At present, Africa is home to eight of the world's 15 least diversified economies,[18] and only a few countries have succeeded in achieving a broad range of economic activities (for example, Ethiopia, Rwanda, Senegal and Uganda). Low-end services, smallholder agriculture and exports of primary commodities such as minerals, oil and timber still dominate the economies of many countries. In contrast, manufacturing, which could provide a significant boost to productivity, continues to falter, having peaked at below 15% of gross domestic product (GDP) in 1988 and declined since;[19] however, it is always possible that future decades may see Africa's manufacturing sector boosted as businesses in Asian countries seek to shift production to developing states to take advantage of lower wage costs.

17 African Development Bank (2023), *African Economic Outlook 2023: Mobilizing Private Sector Financing for Climate and Green Growth in Africa*.
18 Usman, Z. and Landry, D., Carnegie Endowment for International Peace (30 April 2021), *Economic Diversification in Africa: How and Why It Matters*.
19 Cilliers, J. (2020), *Africa First! Igniting a Growth Revolution*, page 6.

Deforestation not only affects carbon capture, but also amplifies changes in rainfall patterns

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Another key challenge is the persistent dominance of the informal economy in Africa. This sector continues to dominate in sub-Saharan Africa in particular, being responsible for 38% of GDP in the region (in comparison with 16% in Organisation for Economic Co-operation and Development countries) and 86% of all employment.[20] Although it is anticipated that economic formalisation will increase gradually over time (due to improvements in state capacity and the impact of digitalisation), pockets of resistance may remain due to varying levels of trust in state governance structures, and concerns over persistent corruption and elite capture of resources in some countries.

Given these complexities, and despite the continent's recent record of economic growth, Africa's share of global GDP is likely to remain small. Although GDP per capita is gradually improving, the gap between Africa and the rest of the world is likely to widen, and by 2040 African GDP per capita is projected to be less than a quarter of the global average.[21]

However, the ability to improve levels of economic integration on the continent could provide a significant boost to the African economy over the next three decades. While the RECs have already made some progress in this area, and are likely to remain key building blocks in any future integration initiatives, the successful implementation of the AfCFTA could see continental GDP boosted by 7% and wages increase by 10%, lifting 30 million people out of extreme poverty.[22] Although this is an ambitious project that will require long-term commitment and political will to come to fruition, the benefits in terms of trade and economic and social development could be huge.

Over the next few decades, it is likely that established trading partners such as Europe and the US will increasingly be rivalled by others, who will look to boost their trade relationships with Africa as their need for resources grows. In 2000, France was the top trading partner for 15 African countries, the US for six, the UK for five and China for only two; by 2020, this had switched to China being the top trading partner for 29, the United Arab Emirates for

20 Cilliers, J. (2020), *Africa First! Igniting a Growth Revolution*, page 162.
21 Ibid, page 3.
22 Charalambides, N. and Capon, C., South African Institute of International Affairs, Policy Insights 138 (September 2022), *Is the AfCFTA the 'Game Changer' for Africa?*

six and France for only three, with the US and the UK no longer the top trading partner for a single African country.[23] China is likely to become increasingly influential and has stated its ambition to replace the European Union as top trading partner for the continent as a whole by 2030.[24] However, Europe will continue to be an important trading partner for North African countries in particular, with the Mediterranean Sea acting as an important conduit for trade.

Africa has vast oceanic potential and its maritime environment is likely to be regarded as increasingly significant by both African and external actors. There are 38 African countries that are coastal states and the continent has more than 48,000 kilometres of coastline and 13 million square kilometres of exclusive economic zones.[25] The African Union estimates the current value of the African blue economy to be US $296 billion, and responsible for 49 million jobs; this could reach US $405 billion and 57 million jobs by 2030.[26]

Environment

Climate change and environmental degradation are likely to have a severe impact on Africa's populations, cities, food production, economies and infrastructure over the next century. The continent is likely to see average temperature rises of 2° Celsius by the middle of the century, with the drier regions of North and Southern Africa potentially seeing more substantial increases.[27] Many countries will continue to experience an increase in the number and intensity of severe weather events such as droughts, floods, heatwaves and storms. Africa's coastal populations and cities could be particularly at risk, with rising sea levels potentially displacing up to 1.4 million Africans over the next three decades.[28]

As the effects of climate change and environmental degradation worsen, more Africans will be exposed to famine, floods and other forms of humanitarian disaster. Without technological solutions and better environmental management, this may increase the requirement for humanitarian assistance and disaster relief operations. Heat stress and more irregular rainfall patterns could lead to poor crop yields and lost harvests. An increase in extreme weather events could have an adverse impact on economic and transport infrastructure and connectivity on the continent, hampering wider integration and economic development ambitions. Low state capacity to respond effectively could result in an increased lack of trust in governments and potentially lead to instability.

As Africa's population and economies grow, demand for food, water and energy will rise, leading to greater pressure on resources. Changes to land use will have a significant effect on the continent's environment. In particular, deforestation in the Congo basin will have a major impact on carbon capture and on rainfall. The continuing dominance of biomass, still used as a fuel source for cooking by the majority of the population in some countries, will continue to contribute to the degradation of woodlands and vegetation. However, the destruction of forests to clear land for subsistence agriculture currently remains the largest driver of deforestation in Africa.[29]

23 Brookings Africa Growth Initiative (2022), *Foresight Africa: Top Priorities for the Continent in 2022*, page 16.
24 Ayeni, T., The Africa Report (8 August 2022), 'China to overtake the EU as Africa's biggest trade partner by 2030'.
25 Faleg, G., (Ed.), European Union Institute for Security Studies (9 March 2021), *African Futures 2030*, page 41.
26 Ibid, page 43.
27 Richardson, K., UK Met Office Hadley Centre (September 2015), *Climate Change in Africa: a review to inform DCDC's Africa Regional Survey 2045* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
28 DCDC (2016), *Africa out to 2045*.
29 Kissinger, G. M., et al. (August 2012), *Drivers of deforestation and forest degradation: A synthesis report for REDD+ policymakers*.

Africa's renewable energy potential is vast, and with investment could meet its own growing demands as well as enabling export to others

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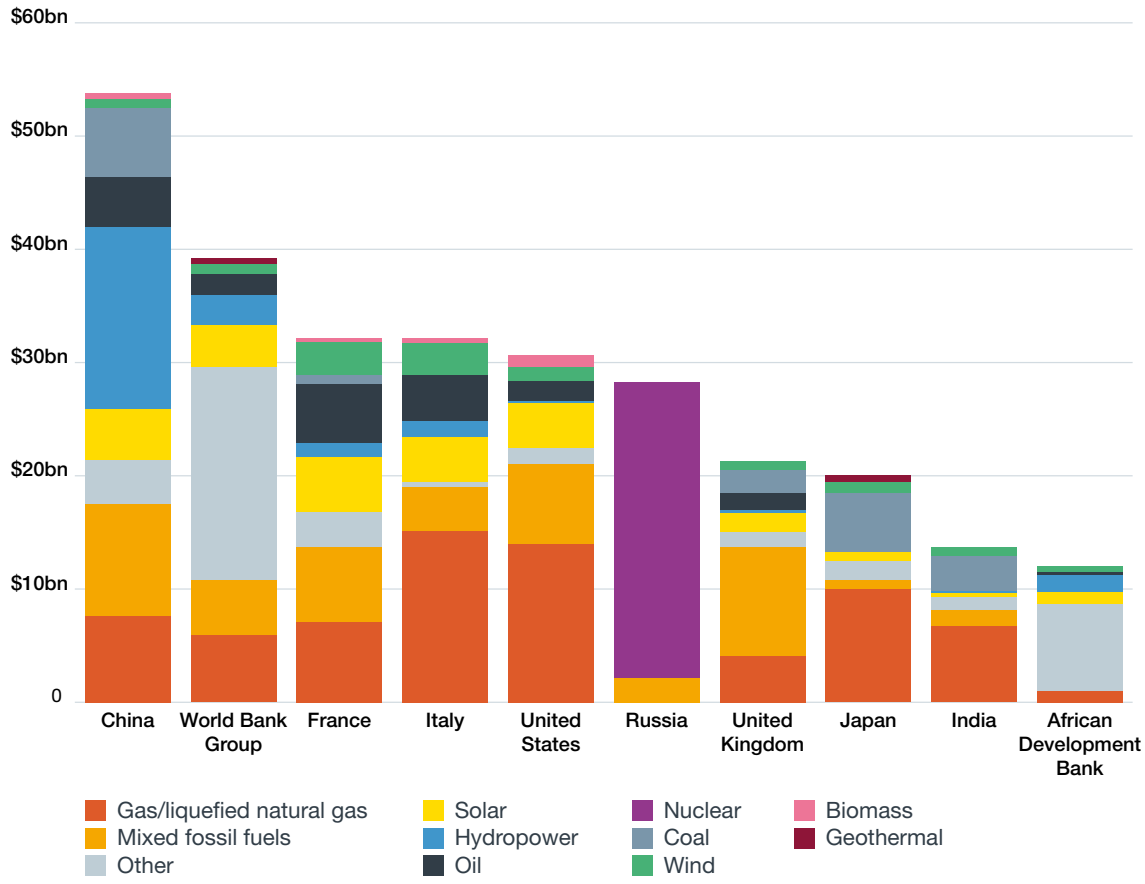
Africa is estimated to contain 37% of the world's total supply of natural resources. A large percentage of oil and gas discoveries made in recent years have been in sub-Saharan Africa;[30] and the continent is also responsible for 18% of global uranium production.[31] In addition, Africa contains a significant share of the world's critical minerals, many of which are vital for today's technologies, and may be required for the green energy transition. For example, the Democratic Republic of the Congo currently produces over two-thirds of the world's cobalt, and South Africa over 70% of the world's platinum. Depending on future technological developments, these may become increasingly sought after and potentially a growing area for competition. While rising demand could lead to financial gain for some countries, it may also increase the risk of environmental degradation in the long term.

Fossil fuels continue to dominate African energy production; the main energy sources used for electricity generation in 2018 were coal (30%), gas (40%) and oil (9%), with renewables making up only 21% of the total.[32] However, Africa's potential to develop its renewable energy supply is huge. Over the next few decades, renewables may begin to play a greater role in meeting Africa's growing energy demand, as well as boosting the economies of some African countries through energy exports. Saharan countries have significant potential in that regard due to their high levels of sun exposure and proximity to European energy markets, and plans are already under way to export solar energy from Morocco to the UK via undersea cables. By 2040, Africa's use of hydropower could almost quadruple (aided by projects such as the Grand Ethiopian Renaissance Dam) and the use of solar power increase a hundred-fold, taking their shares of total electricity generation to around 19% each.[33] Given Africa's current shortfall in energy provision, and the projected future increase in energy demand as its population and economies grow,

30 DCDC (2016), *Africa out to 2045*.
31 Dasnois, N., South African Institute of International Affairs, Occasional paper number 122 (September 2012), *Uranium Mining in Africa: A Continent at the Centre of a Global Nuclear Renaissance*.
32 International Energy Agency (November 2019), *Africa Energy Outlook 2019: World Energy Outlook Special Report*.
33 Ibid.

the ability to fulfil the potential of its renewables sector will be vital to achieve a sustainable energy future for the continent.

However, to achieve this, Africa will require significant support and investment, including knowledge- and technology-sharing and financial support. The International Energy Agency estimates that Africa will need US $2 trillion of green energy investment over the next two decades;[34] given African countries' own limited state finances, much of this, in the short term at least, will need to come from external actors. China has highlighted recent investments by Chinese companies in clean energy projects on the continent;[35] according to the International Energy Agency, new capacity addition projects in which Chinese firms are the main contractor account for 30% of total projects in sub-Saharan Africa, of which 56% are in the renewables sector.[36] Aside from investing in the African renewables sector, Chinese and Russian firms have forged agreements to develop nuclear energy capability in several African countries, including Kenya, Tanzania, Nigeria, Uganda and Sudan.[37] Although this may help to address Africa's current energy shortfall, infrastructure investment, through-life maintenance and waste management may present a challenge, and there may be security concerns in the event of a surge in instability in a host country.



Source: Carnegie Endowment for International Peace (2023)

Top ten providers of energy finance to Africa by energy source, 2012–21

34 International Energy Agency (November 2019), *Africa Energy Outlook 2019: World Energy Outlook Special Report*.
35 Opali, O., China Daily (30 August 2022), 'China's clean energy investments growing rapidly in Africa'.
36 Lema, R., et al., *World Development*, Volume 141 (May 2021), 'China's investments in renewable energy in Africa: Creating co-benefits or just cashing in?'.
37 Goodrich, G., Energy Capital & Power (21 April 2022), 'Examining the State of Nuclear Power in Africa'.

Africa's burgeoning youth population is increasingly calling for action on environmental issues

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Africa will inevitably see a net increase in climate impact as it addresses internal challenges of energy distribution, resource access, economic development and infrastructure improvements, and the political will to act on climate change will be primarily driven and limited by internal economic and developmental considerations. However, issues such as waste and pollution will have a pressing and visible effect on Africa and this may drive public pressure to address environmental and health stress points. Africa's growing youth population may show an increasing commitment to the global climate action agenda, inspired by youth activists in other countries, which may place increasing pressure on leaders to act to address the issue of climate change.

Increasing state capacity and popular commitment to environmental agendas may see a growth in regeneration initiatives such as the Great Green Wall (an aspiration to grow an 8,000 kilometre 'natural wonder of the world' across Africa through tree-planting schemes and biodiversity projects). Future decades may see greater use of climate smart agriculture technology to improve rates of production. However, developing the African skills base and realising improvements in digital connectivity and access to energy will be vital if such endeavours are to realise their full potential. For farmers in Africa's less developed countries, basic climate resilience through improvements in soil and water management and the dissemination of new climate-resilient seed varieties will remain the most pressing concern.

Climate smart agriculture in Africa

In Kenya, PlantVillage leverages smartphone technology, drones and satellites to make climate information available to smallholder farmers and pastoral communities. This not-for-profit organisation has developed an algorithmic model that aims to increase yield and profitability for millions of farmers. The algorithms are based on the integration of artificial intelligence, satellite technology and observations provided by PlantVillage's 'Dream Team' of university graduates and researchers. Once a farmer inputs critical details such as crop type, location and date of planting, the algorithm is then able to respond with cultivation advice, including the prevention and handling of pests and diseases, via smartphone, SMS, television or social networks.

Technology, infrastructure and communications

Infrastructure development will continue to challenge African governments out to 2055. Africa trails globally in every aspect of infrastructure, with the largest deficits being in electricity generation, transport and roads, the provision of clean water and improved sanitation. However, government investment in infrastructure appears to be rising fast, and this, combined with international infrastructure investment programmes (such as China's Belt and Road Initiative) aimed at improving access to African resources, should result in significant improvements.

The next three decades could see significant investment in smart city development in some of Africa's more prosperous countries. Initiatives such as Eko Atlantic in Lagos and Innovation City in Kigali, which aims to drive Rwanda's economic growth through digital transformation, give some indication of levels of ambition on the continent. While both are still under development, the period out to 2055 is likely to see such projects becoming increasingly widespread.

Eko Atlantic: a city within a city

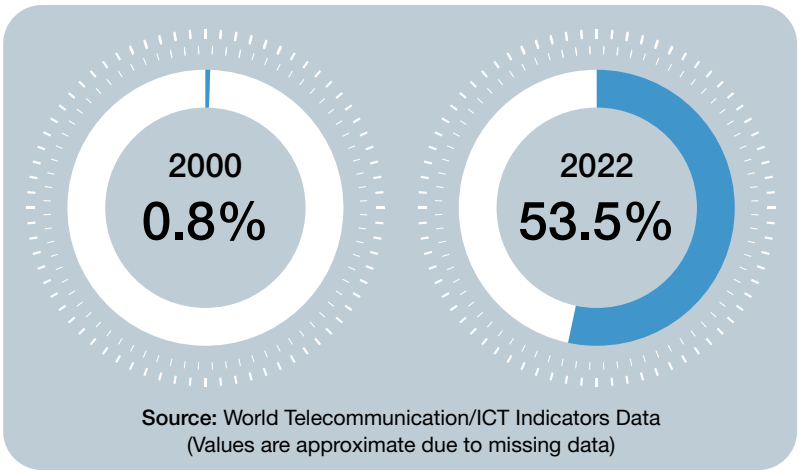
Eko Atlantic is a new development being constructed on reclaimed land in the Nigerian city of Lagos, which when completed will cover an area the size of Manhattan. The development is intended to be self-sufficient and sustainable, equipped with state-of-the-art urban design and advanced telecommunications, and it will supply its own clean water and electricity. As well as providing a new business district in the West African region, generating employment and addressing a requirement for additional commercial, residential and tourist accommodation in Lagos, Eko Atlantic is also designed to prevent the erosion of the Lagos coastline, and will be protected by an 8.5 kilometre sea wall, known locally as the Great Wall of Lagos.[38]

However, improving access to electricity remains a key requirement if Africa is to achieve the gains in human and economic development that it requires to close the gap with the rest of the world. There are currently approximately 600 million people living without electricity in Africa, representing almost 50% of the total population.[39] As such, African electricity access remains the lowest in the world, with three-quarters of the global total of those lacking connection to a reliable electricity source being in Africa.[40] However, improvements in infrastructure and technology development (including in the field of renewable energy), as well as the increasing concentration of people in urban areas, could see the percentage of the population with access to electricity increasing over the next few decades.

Improvements in energy distribution and transmission should also help to connect Africa in other ways. The rollout of digital communications to a greater number of citizens will be vital if new technologies are to succeed in transforming everyday lives on the continent.

38 Burbano, L., Tomorrow.City (15 November 2022), 'Africa and smart cities: between a necessity and an emergency'.
39 International Energy Agency (November 2019), *Africa Energy Outlook 2019: World Energy Outlook Special Report*.
40 International Energy Agency (October 2020), *World Energy Outlook 2020*.

At present, digital connectivity remains low by global standards, with only 36% of the population having access to broadband Internet in 2022.[41] However, attempts by an increasing number of African countries to develop their own national space programmes, including the launch of new satellites by Uganda and Zimbabwe in 2022, may help the continent to realise improvements here, although this could also become a source of global competition. The next few decades are likely to see a surge in African Internet usage, which could enable Africa's entrepreneurial urban youth to drive further innovation at a national, regional and global level. However, there remains a risk that not all will benefit equally, and women and the rural poor may see themselves left behind in an enduring digital divide.



Average percentage of the population using the Internet in Africa

Conflict and security

Levels of security on the continent remain a cause for concern, with 20 African states being ascribed 'alert' status and 30 'warning' status in the *Fragile States Index 2023*.[42] Violent conflict continues to pose a significant threat, with Africa remaining the continent with the highest number of state-based conflicts in 2022 according to the Uppsala Conflict Data Program, a position it has held for several years, and recording the highest number of battle-related deaths.[43] However, this concentration on conflict often masks the growing threat presented by non-conflict-related criminal violence on the continent, which is likely to remain responsible for more African fatalities than war over the next few decades.

Terrorism remains an enduring challenge for Africa. Of the top 20 countries most severely impacted by terrorist activity in 2022, ten were in Africa, with 60% of all global deaths from terrorism taking place in sub-Saharan Africa. In addition, terrorism looks to be on the increase, with sub-Saharan Africa recording the largest deterioration in score in the *Global Terrorism Index 2023*, with the Sahel highlighted as a particular area for concern.[44] Islamist extremist groups are likely to continue to pose a threat and could establish an increasing foothold in some areas of the continent.

41 World Bank, Results Briefs (26 June 2023), 'From Connectivity to Services: Digital Transformation in Africa'.
42 Haken, N., et al., Fund for Peace (14 June 2023), *Fragile States Index Annual Report 2023*.
43 Davies, S., et al., *Peace Research Institute Oslo*, Volume 60, Issue 4 (13 July 2023), 'Organized violence 1989–2022, and the return of conflict between states'.
44 Institute for Economics & Peace (March 2023), *Global Terrorism Index 2023: Measuring the Impact of Terrorism*.

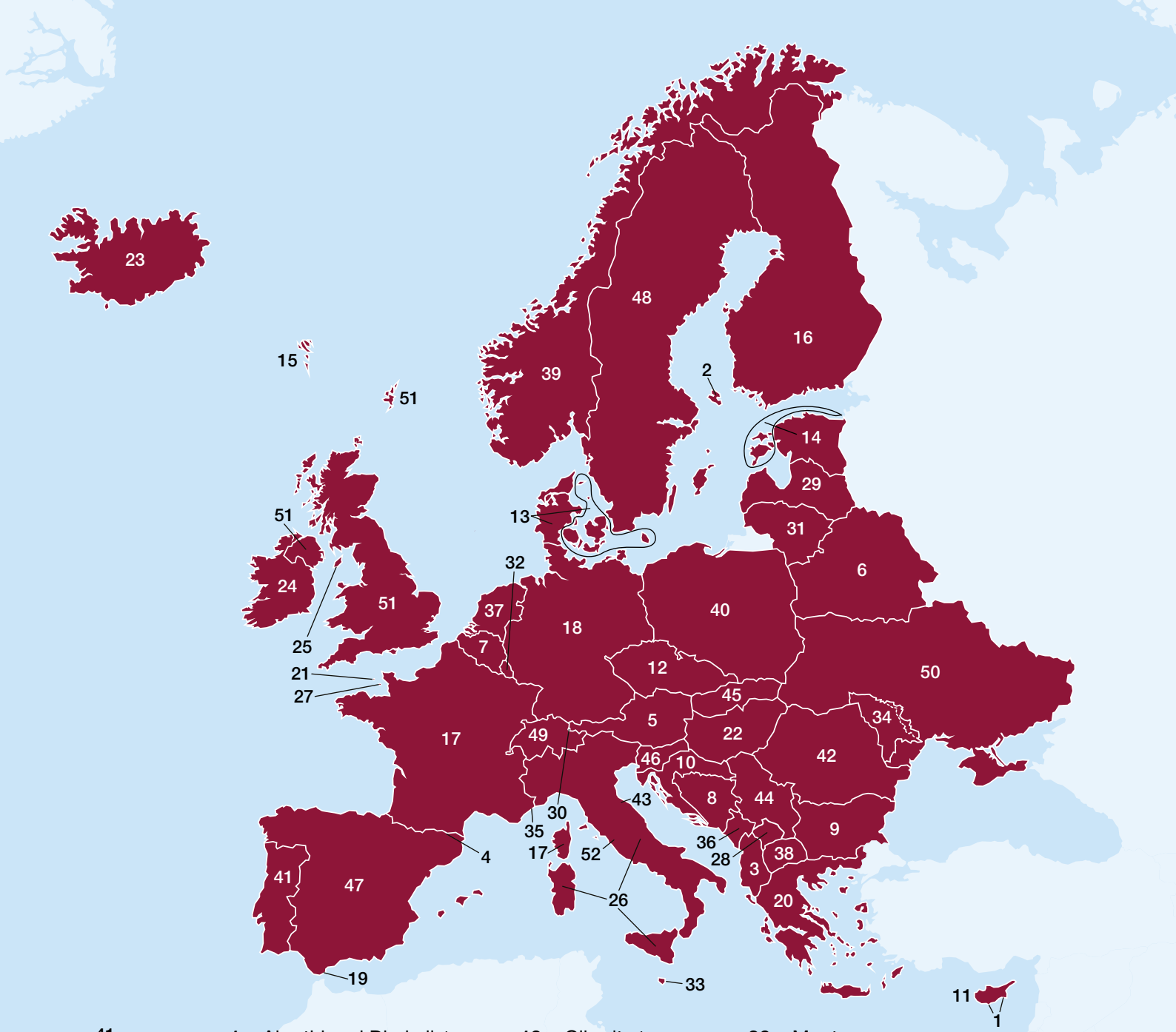
The continued presence of violent extremist organisations and terrorist actors on the continent could encourage states to increase the capability of their security forces, which in some cases may then be used to quell domestic opposition and unrest. Total African military expenditure increased by 17% in the decade to 2019, with expenditure in North Africa increasing by 67%.[45] Overall, military expenditure remains volatile, with rates driven largely by developments in the region's armed conflicts. Africa seems likely to continue to require global assistance to fund and resource peacekeeping and other security missions in the coming decades, notwithstanding criticisms of the efficacy and conduct of some of these military activities. While the United Nations and African Union are likely to remain the largest providers of such support, localised regional security cooperation could also increase, although in some cases this may blur the boundary between peacekeeping and active involvement in conflicts. Future decades could see regional governments increasing their reliance on overseas private military and security companies to help them tackle existing and emerging security concerns; this could lead to a growing dependence on external security providers, influence by external actors and uncertainty over state viability if support is suddenly withdrawn.

Military coups have become more prevalent on the continent in recent years, with 2021 seeing more African coups than any other year in the previous two decades, and further coups taking place in Burkina Faso, Gabon and Niger since then. As well as exacerbating insecurity in the countries concerned and in neighbouring countries, and hindering regional cooperation and integration initiatives, this may also be an early indication of further democratic backsliding on the continent.

Africa's seas contain a wealth of resources, which Africa will seek to capitalise on over the next few decades. However, protecting these valuable assets from threats such as climate change, criminal activity and exploitation by other actors will continue to present a challenge. In addition, maritime boundary disputes represent an enduring source of tension, which may be exacerbated as demand for resources intensifies.

African governments face significant challenges from the presence of serious and organised crime groups on the continent. Criminal actors constitute a persistent threat to peace and security, not least through their links to violent extremist organisations; their activities also pose an obstacle to long-term socio-economic development, and result in a significant financial burden. It is estimated that African economies lose US $88.6 billion (3.7% of GDP) annually in illicit financial flows, in comparison with overseas development assistance and foreign direct investment receipts of US $48 billion and US $54 billion respectively.[46] Serious and organised crime has proven highly adaptable, in particular by using new technologies, and is expanding rapidly in Africa by exploiting state fragility, corrupt governance and weak state capacity, as well as strengthening its links to criminal networks in other regions such as Latin America. However, increasing awareness of the threats that serious and organised crime and corruption present to society mean that illicit behaviour is being increasingly challenged. Improvements in governance standards and increased levels of legitimate economic growth may see these organisations placed under growing pressure over the next 30 years.

45 defenceWeb (28 April 2020), 'African military spending up nearly 20% over the last decade'.
46 UN Conference on Trade and Development (2020), *Economic Development in Africa Report 2020: Tackling Illicit Financial Flows for Sustainable Development in Africa*.



1	Akrotiri and Dhekelia[i]	**19**	Gibraltar[iv]	**36**	Montenegro
2	Åland[ii]	**20**	Greece	**37**	Netherlands
3	Albania	**21**	Guernsey[v]	**38**	North Macedonia
4	Andorra	**22**	Hungary	**39**	Norway
5	Austria	**23**	Iceland	**40**	Poland
6	Belarus	**24**	Ireland	**41**	Portugal
7	Belgium	**25**	Isle of Man[v]	**42**	Romania
8	Bosnia and Herzegovina	**26**	Italy	**43**	San Marino
9	Bulgaria	**27**	Jersey[v]	**44**	Serbia
10	Croatia	**28**	Kosovo	**45**	Slovakia
11	Cyprus	**29**	Latvia	**46**	Slovenia
12	Czechia	**30**	Liechtenstein	**47**	Spain
13	Denmark	**31**	Lithuania	**48**	Sweden
14	Estonia	**32**	Luxembourg	**49**	Switzerland
15	Faroe Islands[iii]	**33**	Malta	**50**	Ukraine
16	Finland	**34**	Moldova	**51**	United Kingdom
17	France	**35**	Monaco	**52**	Vatican City
18	Germany				

[i] Sovereign Base Areas, UK Overseas Territory.
[ii] Autonomous region of Finland.
[iii] Self-governing territory of Denmark.
[iv] UK Overseas Territory.
[v] UK Crown Dependencies.

Europe

Current strategic context

The region of Europe sits on the western part of the Eurasian continent. Stretching over eight lines of latitude, its climate ranges from the frozen tundra of the High North to the warm waters of the Mediterranean. Its diverse geography is increasingly impacted by climate change. Although the impact of this shifting climate will vary across the region, temperature rises will lead to increased intensity and frequency of a range of extreme weather events, including heatwaves, droughts and flooding in some countries. Wildfires have also become a more frequent occurrence in northern and southern parts of Europe. These events are already having an impact on agriculture, transport and infrastructure, as well as local economies and communities.

Population densities vary considerably, with densities in central and northwestern Europe being the highest and those in the Arctic the lowest; however, most European countries are highly urbanised. In the coming decades, most European states will see a decreasing working age population. Together with an ageing population, this will result in an increase in the dependency ratio.

Although levels of democratic development across the region vary and political polarisation has risen in a number of countries in recent years, in general, Europe remains one of the most prosperous, democratic, technologically advanced and innovative regions of the world. It is home to influential and successful middle powers such as France, Germany and the UK, all of which are major economies, and two of which are nuclear powers and permanent members of the United Nations Security Council (France and the UK). In addition, some of Europe's smaller countries have the highest standards of living in the world. The region is characterised by a high level of cooperation in defence and security and political and economic affairs through several mature organisations, including the North Atlantic Treaty Organization (NATO) and the European Union (EU). Europe also wields substantial soft power, leveraging its economic strength, trade, science, education, language, culture and political practices to exert influence.

European collaboration and security architecture over recent decades has been primarily shaped by the end of the Cold War and the breakup of the Soviet Union, which led to NATO and EU enlargement. The 2007–08 financial crisis and the subsequent eurozone crisis saw the EU coming under significant pressure, putting a brake on the European project due to dissatisfaction with its institutions and differences of opinion about how cooperation should develop. However, despite these shocks and the UK's recent departure from the EU, popular support has started to increase again, and it remained relatively stable throughout the COVID-19 pandemic,[1] despite several predictions that the EU would break up in the near future or that the euro would fail.[2]

1 European Union (2023), *Standard Eurobarometer 100 – Autumn 2023*.
2 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, page 10.

Russia's 2022 invasion of Ukraine, and the Western response to it, has introduced a strong element of external pressure on Europe and increased the attractiveness of EU and NATO membership to states geographically close to Russia; it has arguably had a more fundamental impact on Europe than any other post-Cold War development. The outcome of the war and the future trajectory of Russia will continue to be a key influence on the future development of Europe, as well as its relationship with Russia, China, the United States (US) and emerging powers.

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Key drivers of change

External pressures and global power competition. Europe will continue to face a range of threats and external pressures from the arc of instability which surrounds the region, forcing it to manage a wide range of security challenges. Increasing global power competition will have a profound influence on European geopolitical considerations, including its perception of its own global role and its relations with other global powers, in particular with the US and China.

Ageing populations. A combination of ageing populations and falling birth rates will result in a decreasing working age population in most European states. This will present multiple challenges for regional governments and public finances, including increased pension and health care costs and reduced taxation revenues. Over time, this may drive reform of welfare and health care systems and require unpopular policy choices, such as further increases in the retirement age.

Environmental stress. Climate change and other forms of environmental stress will have both direct and indirect consequences for Europe. The direct impact on Europe will be severe and will require substantial adaptation measures, increasing the pressure on government finances. Indirect consequences resulting from the effects of climate change on neighbouring regions may include the increased flow of migrants to the region.

Technology adoption and skills development. Technological change and increasing competition from emerging powers will challenge Europe's leading position in many areas of industry, technology and research. Europe's ability to maintain a skilled workforce and retain its competitive edge will be key to its future prosperity and global power.

Pressure on governance. Social fragmentation, political polarisation and rising authoritarianism in some states will place increasing pressure on European liberal democracy and governance structures, and may undermine attempts at wider collaboration through multilateral institutions. The ability to maintain a well-functioning welfare state will become increasingly difficult, exacerbating inequality and potentially leading to rising tensions and a loss of trust in governments.

Future key trends

Global power competition

Over the next three decades, Europe will continue to face complex challenges as it navigates relationships with major powers and strives to maintain cohesion within the region. The future of Europe–Russia, Russia–China, and Europe–China relations will have a significant impact on the dynamics of the European geopolitical landscape. However, it should be remembered that Europe is made up of many individual countries, and its internal power dynamics – within the EU, but also between the EU and wider European states, including the UK – will be key to determining the region's future trajectory.

European states and the EU will continue to exert significant global influence, including through their outward-facing activities in regions such as Africa and their high levels of overseas aid expenditure, although they will face increasing competition from other states. In some cases, influence will be achieved through the EU and individual states developing closer relations and networks with global partners, including emerging middle powers; in other cases, European states with shared strategic aims and interests will continue to cooperate at the subregional level to further their common objectives.

The EU and many European countries will seek to extend their global influence through acting to strengthen multilateral institutions and by brokering international agreements on standards and norms, and in so doing protect themselves from economic, security and political risks. In a world of increasing power competition, the EU will use its large single market and regulatory capacity to lead in areas such as data privacy, consumer health and safety, and competition policy.[3]

Russian demands for a new European security order, manifested most recently through its 2022 invasion of Ukraine, will continue to present a key security challenge for European states. Russia is likely to maintain its great power ambitions and view many of its neighbours in Europe, the Caucasus and Central Asia as part of the Russian sphere of influence. Although the outcome of the war in Ukraine remains uncertain, further episodes of overt Russian aggression are likely to reduce differences between regional states and elevate Russia on individual states' security agendas. However, attitudes towards Russia continue to vary, and increasing economic disparity within Europe could make some countries more susceptible to Russian and Chinese influence and expose Europe to 'divide and rule' tactics. Nevertheless, Russia's precarious economic situation, combined with Europe's progress in improving its energy security and efforts to counter disinformation and cyber intrusions, is likely to strengthen European resilience to Russian influence in the coming decade.

3 Office of the Director of National Intelligence (March 2021), *Global Trends 2040: A More Contested World*, 'Five-year regional outlooks – Europe', page 3.

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Chinese investments in European critical infrastructure have raised growing security concerns

Ongoing security issues in Southwest Asia and Africa could lead to continued migration through the south of Europe. Although the 2011 protests, commonly known as the Arab Spring, and revolutions in Tunisia, Egypt, Libya and across the Arab world initially generated great optimism in Europe,[4] subsequent developments, including the war in Syria, have contributed to a zone of growing instability in Europe's southern neighbourhood. This has seen an increase in the flow of migrants to the region in the last decade. If this instability continues or worsens over time, this could see the ongoing migrant crisis putting a considerable strain on European unity.

Turkey, deeply connected to Europe economically and militarily through NATO, has become increasingly important to Europe in recent years through its role in reducing migrant flows. However, as an emerging middle power with ambitions of increased influence, Turkey's future strategic choices – including its relationship with Europe – appear more uncertain. Its relationship with both the US and Russia, as well as with neighbouring powers in Southwest Asia, will impact on its future ties with Europe. While Europe and Turkey could have common interests in the Black Sea region, Southwest Asia and Africa, a future rise in tensions could potentially have a negative impact, particularly on Balkans stability.[5]

The growing global influence and military power of China, including its relationship with Russia, the US and other Indo-Pacific states, may introduce additional frictions to the Europe–China relationship. Chinese ownership of European critical infrastructure, such as telecommunications networks, major harbours in Greece and Germany, and an airport in France, and the use of Chinese technology in this infrastructure, is likely to cause increasing concern in many European countries. However, economic dependencies mean that China is likely to retain a degree of influence in Europe. Over coming decades, the actions of China and the evolution of its governance system could lead to Europe either further hardening or potentially softening its stance on China.

4 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, page 9.

5 Office of the Director of National Intelligence (March 2021), *Global Trends 2040: A More Contested World*, 'Five-year regional outlooks – Europe', pages 3–4.

Most European countries will experience a decline in their population within the projected time frame

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Transatlantic cooperation will remain crucial for most European states, although increasing political polarisation in the US may raise questions about the reliability and longevity of its commitments. The US focus on the Indo-Pacific region is likely to be an enduring trend, and over time may impact on US engagement in the Euro-Atlantic sphere. While a reduced US focus on Europe may drive European states to boost their own defence capabilities, intra-European divisions over security priorities and social fragmentation within European societies could open up opportunities for Russia and China to pressurise European states to accept their agendas. Nevertheless, Europe is likely to remain close to the US on many issues such as international trade and the Russian security threat, and may also increasingly align with the US view on China, although this remains less certain in the long term.

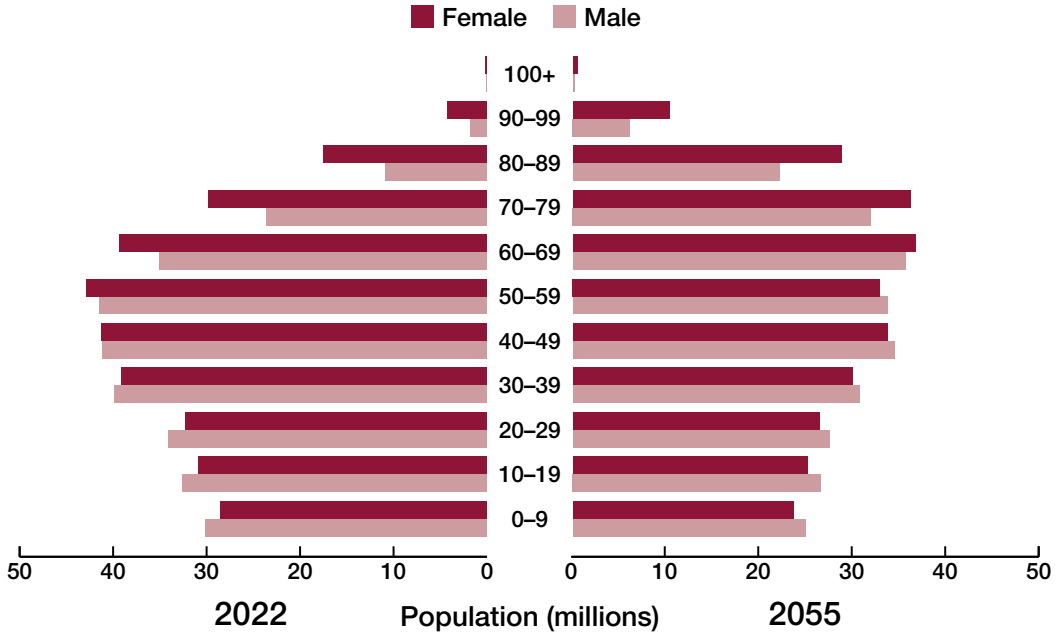
It is likely that political and societal appetite for further EU integration and enlargement will continue to fluctuate over the next three decades in response to internal frictions and external pressures. While support for EU cooperation and enlargement is currently strong, it is reasonable to assume that a pattern of enlargement and integration followed by consolidation and even reversal will reoccur in coming decades. A potential source of EU fragmentation might come from economic differences between the wealthier and more fiscally restrictive north (growing more resentful of EU spending) and the more indebted south (where the risk of defaults on debts persists).[6] However, the EU is likely to remain in some form by 2055, even if there are significant setbacks. In the long term, increased external pressures from the wider neighbourhood may drive further integration, or at least reduce the risk of fragmentation, leading to a stronger and more cohesive organisation.[7]

Society

Over the next 30 years, most countries in Europe will face the challenge of an ageing population and a decrease in the size of their working age populations due to low birth rates. However, there will be significant variation between countries, with France, Ireland, Norway and Sweden projected to see an increase in their working age populations out to

6 Office of the Director of National Intelligence (March 2021), *Global Trends 2040: A More Contested World*, 'Five-year regional outlooks – Europe', page 3.
7 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, pages 10 and 52.

2060, whereas most eastern European states will see a sharp decline. Overall, Europe will start experiencing a population decline from the 2030s; eastern and southern Europe are already in decline, western Europe will enter a decline in the late 2030s and the population of northern Europe will plateau in the 2050s.[8] Increasing cross-border workforce migration to other parts of Europe will continue to contribute to the population decrease of some European countries and regions, particularly rural areas and regions in economic decline, which may increase regional inequalities and exacerbate existing social and political divides.[9]



Source: United Nations Population Division (2022)

Population statistics projection for Europe by age range

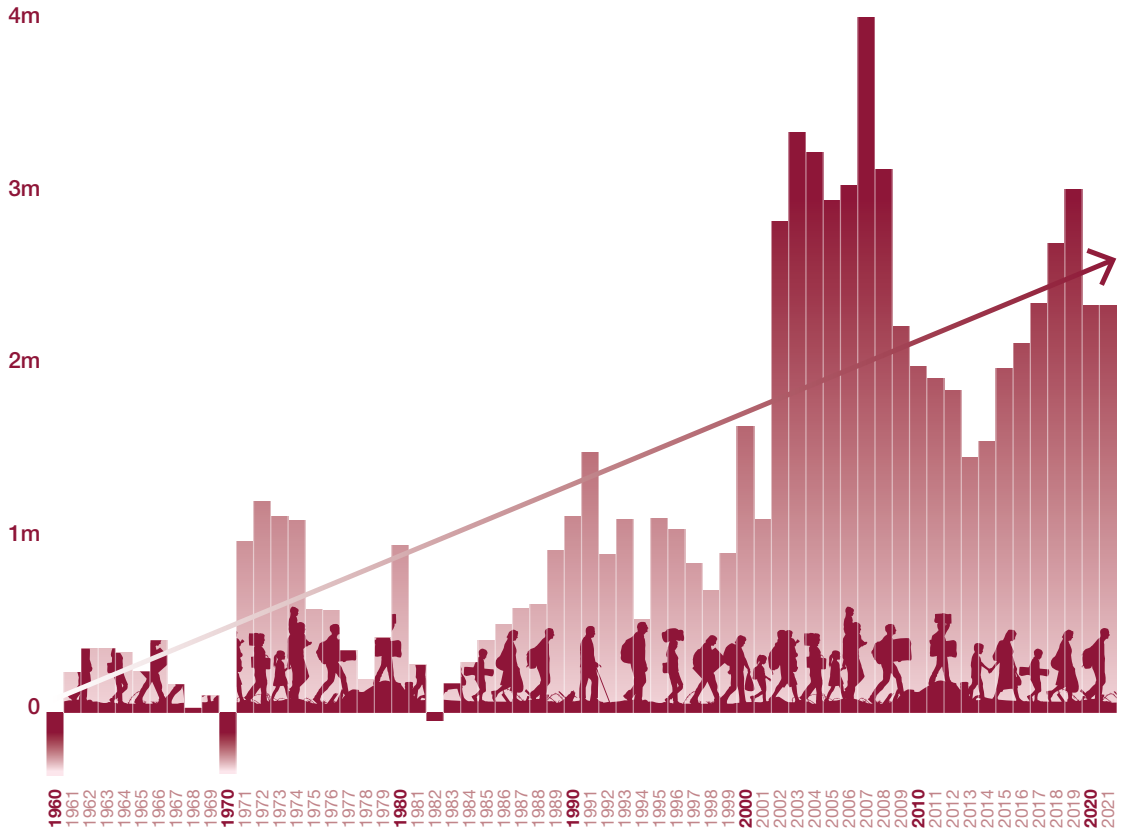
In 2021, the average life expectancy in Europe was 78.3 years, with large differences between countries. For example, in Moldova the life expectancy was less than 70 years, compared with 84 years in Switzerland.[10] By 2055, rates are likely to have converged and risen to an average of 84 years.[11] This ageing population will lead to rising pension costs as well as increasing health care and welfare costs; taken together with a declining tax base, this will present a significant challenge for European governments. The resulting financial burden could reach unsustainable levels, prompting wholesale reform of welfare state systems or potentially the introduction of unpopular policies such as further increases in the retirement age.

Urbanisation will continue (although at a slower rate than it has historically been), as a growing number of people move to work and live in major European cities, driven by the increasing geographic concentration of employment.[12] Northern Europe will see a higher

8 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
9 Smit, S., et al., McKinsey Global Institute (June 2020), *The future of work in Europe: Automation, workforce transitions, and the shifting geography of employment*, pages 14–15.
10 UN, Department of Economic and Social Affairs (2022), *World Population Prospects 2022: Summary of Results*.
11 Ibid.
12 UN, Department of Economic and Social Affairs, Population Division (2018), 'World Urbanization Prospects 2018: Maps'.

rate of employment growth than southern or eastern Europe. It has been estimated that 48 cities could capture more than 50% of Europe's potential job growth between 2020 and 2030.[13]

Migration to Europe from other regions with younger populations, such as Africa, could ease some of the challenges posed by an ageing Europe, provided that these migrants can be properly integrated into the workforce and wider society.[14] However, large-scale migration to Europe from the south will continue to be a highly divisive issue; high levels of migration in the future could see an increase in support for nationalist and populist movements and become the dominant security concern for several European states. A challenge for Europe may be how to remain an attractive destination for skilled migrants while simultaneously managing total migration flows from its wider neighbourhood.



Source: World Development Bank (2022)

Migration into Europe, in millions

Europe is home to many of the highest ranked universities in the world, including some that have attracted top students from around the world for many years. The region currently accounts for more than one third of the top 100 universities, although the US has many more than Europe among the top 25.[15] Europe is also strong in the field of vocational education.[16] Future challenges for the European education sector will be to increase the volume of science, technology, engineering and mathematics (STEM)

13 Smit, S., et al., McKinsey Global Institute (June 2020), *The future of work in Europe: Automation, workforce transitions, and the shifting geography of employment*, pages 10–12 and 25–28.
14 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, pages 14–17.
15 Times Higher Education (2024), *World University Rankings 2024*.
16 Smit, S., et al., McKinsey Global Institute (22 September 2022), *Securing Europe's competitiveness: Addressing its technology gap*.

education to remain competitive with Northern America and East Asia in an era of rapid technological change, and to improve the provision of lifelong learning, which will be a vital tool in addressing socio-economic inequality in the region.

A few European countries have seen a decline in democracy and openness over a number of years, whereas others have seen voters turn away from illiberal leaders.[17] The rise of populist nationalist political parties in some countries could result in policy fluctuations and a loss of consensus in Europe, increasing tension within the EU. Looking forward, political polarisation may be exacerbated by issues such as the war in Ukraine, increasing inequality, and populist opposition to migration and further European integration; in addition, there may be continuing controversies surrounding the cost and speed of implementing green policies. Parts of southeastern Europe may continue to struggle with widespread corruption and weak democratic governance. Balkan states could either move closer to a western European political model and become EU members or backslide into authoritarian rule and a return to instability.[18]

Large-scale disinformation, powered by new tools and online platforms, will pose an increasing challenge for democratic governments, potentially undermining the fundamental preconditions for democracy and driving a new type of information warfare. This could prejudice European democratic development, polarise debates and pose safety and security risks to governments and societies.

Economy

The region will remain a strong economic actor, prosperous by international standards, and a major partner in trade with the rest of the world, but its global economic weight and share of the world economy will decrease over the next 30 years. Europe's economic growth has been relatively low since the 1990s and this trend is likely to continue, driven by ageing populations and lagging technological innovation in some sectors compared with the US and some other countries.[19] Projections indicate that the EU's share of global gross domestic product (GDP) may fall from 18.3% in 2019 to 11.3% in 2050, which would make it a smaller economy than India at 12.8%.[20]

The recent pattern of low economic growth has led to high rates of unemployment in some countries, especially among young and low-skilled workers.[21] Southern EU member states and the western Balkans have experienced the highest youth unemployment rates in Europe, with Spain around twice the EU average in 2023.[22] Looking forward, it is possible that the period of economic convergence between states, where the poorer European countries had higher growth rates, will come to an end due to ageing populations, differences in migration patterns, and structural changes in the global economy. In particular, the economic gap between EU and non-EU states in southeastern Europe is likely to grow, leading to increasing economic and social inequality within the region.

17 Freedom House (2023), *Nations in transit 2023: War Deepens a Regional Divide*.
18 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, pages 46–48.
19 Ibid, pages 18–19.
20 European Commission (8 September 2021), *2021 Strategic Foresight Report: The EU's capacity and freedom to act*, pages 6–7.
21 Cedefop, Eurofund, Cedefop reference series number 108 (December 2018), *Skills forecast: trends and challenges to 2030*.
22 Organisation for Economic Co-operation and Development (2024), 'Unemployment rate (indicator)'.

Most European countries are part of the European Economic Area, the world's most open and connected large economy

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An accumulation of shocks and financial turmoil over the past two decades has resulted in several European states suffering debt crises and going through difficult bailout programmes, with varying degrees of success.[23] Current pressures mean that the national debt burden is continuing to rise in some states, adding to the economic challenges that governments face. Over time this could lead to a call for looser monetary and fiscal policies within the EU,[24] as well as difficult choices for regional governments over conflicting spending priorities.

With most European countries a part of the European Economic Area (EEA) and additional countries having trade access to the EEA market, Europe today has the significant advantage of being the most open and connected large economy in the world.[25] The reduced trade costs have resulted in a 3.1% increase in GDP for the Netherlands, for example.[26] Out to 2055, many European economies will benefit from and remain dependent on the internal market of the EEA, enabling them to trade with little or no friction. The economic benefit of the internal market is one of the key points which will continue to attract new members to the EU and multinational corporations to have a presence within the EEA. Out to 2055, this may encourage EU member states to remain when they are in dispute with EU institutions or other member states.

23 Burrows, M. and Burwell, F., Atlantic Council Strategy Paper (29 March 2017), *Europe in 2022: Alternative Futures*, page 30.
24 Office of the Director of National Intelligence (March 2021), *Global Trends 2040: A More Contested World*, 'Five-year regional outlooks – Europe', page 2.
25 Smit, S., et al., McKinsey Global Institute (22 September 2022), *Securing Europe's competitiveness: Addressing its technology gap*.
26 Freeman, D., et al., CPB Netherlands Bureau for Economic Policy Analysis, CPB Communication (January 2022), *Trade benefits of the EU and the Internal Market*.

Environment

Climate change will result in an increase in average temperatures across Europe. Parts of central and southern Europe are already under medium to high levels of water stress, and this is projected to increase further over time.[27] Although the impact of climate change will vary across Europe, a further increase in temperatures will lead to increased intensity and frequency of extreme weather events such as heatwaves, droughts, wildfires and floods, including in previously unaffected areas.[28] This will create increasing disruption in areas such as agriculture and transportation and will require significant investment in adaptation measures on the part of regional governments.

The Doomsday Vault, Norway

On a remote island in the Svalbard archipelago, Norway, in collaboration with NordGen and the Crop Trust, has constructed a vault that is sometimes referred to as the 'Doomsday Vault'.[29] The vault is set deep into the permafrost of a mountain and consists of three main chambers with room for up to 4.5 million crop samples, which are stored at -18° Celsius. At the beginning of 2024, it housed approximately 1.2 million seed samples from all around the world.[30] By acting as backup storage for as many crop seeds as possible, the vault may be used to secure the world's future food supply and safeguard biodiversity in case of major conflict, drought or similar catastrophe. The vault is part of a United Nations-led international system for conserving plant genetic diversity.

Europe will also be indirectly impacted by climate change and environmental degradation in its southern neighbourhood, which has the potential to result in higher rates of migration, as well as rising levels of food insecurity through a reduction in food imports to the region.[31] Increasing water stress in Southwest Asia and Africa may lead to a growth in tension and conflict, exacerbating population displacement.

Higher temperatures will also lead to an increase in Arctic ice melt, which will make new waterways (including the Northern Sea Route from Europe to East Asia) increasingly viable and facilitate the exploitation of natural resources in the Arctic.[32] This will lead to increased geopolitical competition in Europe's High North, where China, Russia and the US are already investing to enhance access.

27 European Environment Agency (11 March 2024), *European climate risk assessment: Executive summary*.
28 European Environment Agency, Report No 1/2024 (11 March 2024), *European climate risk assessment*.
29 Greenfield, P., *The Guardian* (3 March 2023), 'Svalbard's mysterious 'doomsday' seed vault offers glimpse inside with virtual tour'.
30 Crop Trust (2024), 'Svalbard Global Seed Vault'.
31 European Strategy and Policy Analysis System (April 2019), *Global trends to 2030: Challenges and Choices for Europe*, pages 24–25.
32 Meyer, C., et al., European Parliament (10 June 2021), *Preparing the CSDP for the new security environment created by climate change*, pages 9–10.

Increasing investment in renewables is likely to lead to a growing diversification in energy supply for the continent

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The EU aims to be climate neutral and have net-zero greenhouse gas emissions by 2050 through the European Green Deal.[33] However, the system of emission rights and other aspects of EU climate policy have been challenged by several member states due to concerns over energy prices and energy resilience; in the short term at least, the ongoing war in Ukraine will continue to exacerbate this. Elsewhere, popular resistance to the cost and speed of green energy transition measures may place increasing pressure on governments to delay targets. While a short-term focus on energy security may lead to some targets being delayed due to political, economic and technology considerations, the long-term net-zero goal is likely to remain due to increasing investment in renewable energy sources. However, the fact that the goal is likely to stay in place does not mean that all European states will succeed in meeting it.

While several European countries, including Denmark, Germany, Poland, Norway and the UK, produce fossil fuels, Europe as a whole is a significant net importer of fuel. The EU's energy dependency was 62.5% in 2022,[34] although estimates suggest that reaching its climate neutrality target by 2050 could help reduce this to 15%.[35] Going forward, increasing investments in energy security, of which renewables will form an important part, are likely to lead to a growing diversification in supply and energy sources, rather than making Europe completely independent of energy imports. In the future, Europe is unlikely to risk becoming as dependent on a single supplier of energy as it was on Russia in the years up to 2021, when 20% of the primary energy consumed in the EU originated from Russia, including about 30% of its oil.[36]

33 European Commission (8 September 2021), *2021 Strategic Foresight Report: The EU's capacity and freedom to act*, pages 9–10.
34 Wettengel, J., Clean Energy Wire (3 April 2024), 'Germany, EU remain heavily dependent on imported fossil fuels'.
35 European Commission (8 September 2021), *2021 Strategic Foresight Report: The EU's capacity and freedom to act*, page 9.
36 Meyer, C., et al., European Parliament (10 June 2021), *Preparing the CSDP for the new security environment created by climate change*, page 10.

At present, Europe is dependent on imports of many critical materials from non-European states (including China, Kazakhstan, Turkey, the Democratic Republic of the Congo, Guinea, Brazil and Chile), which out to 2055 may be increasingly important for technological development and energy security.[37] In many cases, the reason is not a lack of mineral deposits within Europe, but rather environmental considerations or cost issues related to extraction or processing. In response to growing resource competition, including from Russia and China, and in line with the Versailles Declaration made in response to the 2022 Russian invasion of Ukraine, there will be an increase in European initiatives to become less dependent on the import of critical materials and to diversify sources of supply.[38]

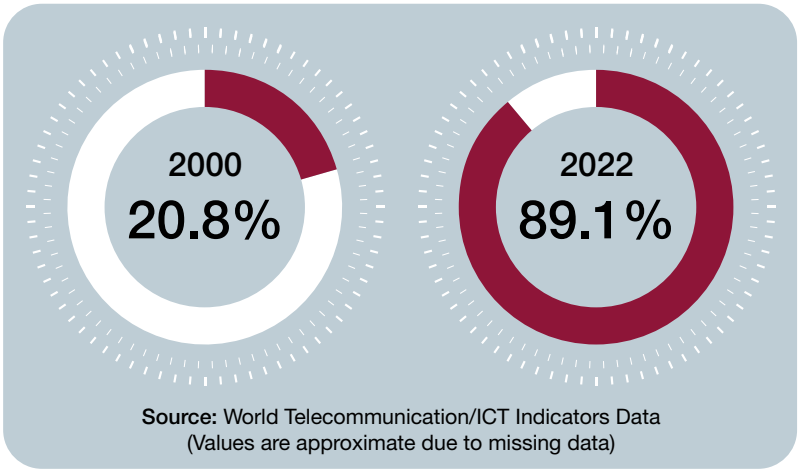
Technology, infrastructure and communications

European countries are advanced or world leading in many areas of technology development. For example, three of the top five countries in the world for aerospace products are European (France, Germany and the UK),[39] as well as the top three countries for biotechnology research and development intensity (Belgium, Switzerland and Lithuania).[40] Other areas of note include pharmaceuticals, advanced manufacturing and materials, smart and sustainable transport and low-carbon technologies.[41] However, while Europe is likely to remain on the leading edge in some of these sectors, over the last few decades it has slowly lost some of its competitiveness and may increasingly fail to keep up with the global leaders in information and communications technology.[42] European capabilities are usually assessed to be behind those of the US and China in areas such as artificial intelligence, big data, robotics and key quantum technologies, as well as behind these and other countries, such as South Korea and Japan, in the field of semiconductors.[43] Although the EU accounts for almost 20% of the world's total research and development, publications and patenting activity, it may continue to lag behind global competitors in areas such as private research and development investment, as well as in the number of STEM graduates.[44]

Europe, and in particular the EU, already plays a leading international role in standard setting, enabled through a variety of factors, including the size and openness of its internal market, its strength in international trade, and its achievement of first mover advantage.[45] This combination of factors means that Europe is likely to remain a leader in standard setting, although its position may be increasingly challenged by China and other emerging technology powers seeking to use a combination of technology progress and rule-making to boost their own competitiveness.[46]

37 Grohol, M. and Veeh, C., European Commission (2023), *Study on the Critical Raw Materials for the EU 2023 – Final report*.
38 Ibid.
39 Workman, D., World's Top Exports (2022), 'Aerospace Exports by Country'.
40 Adam, J., Labiotech (3 January 2024), 'The top-performing countries in biotechnology (according to the OECD)'.
41 European Commission (8 September 2021), *2021 Strategic Foresight Report: The EU's capacity and freedom to act*, page 3.
42 Smit, S., et al., McKinsey Global Institute (22 September 2022), *Securing Europe's competitiveness: Addressing its technology gap*.
43 European Round Table for Industry (2022), *European Competitiveness and Industry: Benchmarking Report 2022*, page 3.
44 Ibid, page 21.
45 European Commission (8 September 2021), *2021 Strategic Foresight Report: The EU's capacity and freedom to act*, page 5.
46 Bjerkem, J. and Harbour, M., European Policy Centre (15 October 2020), *Europe as global standard-setter: The strategic importance of European standardisation*.

Although European infrastructure, including digital infrastructure, is mostly of a high standard in comparison with other parts of the world, the quality varies widely within and between states. For example, while more than 90% of all businesses in the EU had broadband access in 2022, the number of businesses making e-sales ranges from 42% in Ireland to 11% in Romania. Despite high levels of Internet access (almost 90% of the population accesses the Internet every week), only 54% possess basic or above basic digital skills.[47]



Average percentage of the population using the Internet in Europe

Some states will be faced with the challenge of catching up with the rest of the region, particularly in the field of digital communications infrastructure; in some cases, counties will require external support to do so. Even in states with high levels of infrastructure development, investment will be required to replace and maintain ageing infrastructure, and to meet green energy transition targets, which will require substantial investment in new power generation and power grids, green transport infrastructure and energy-efficient buildings. In addition, governments will need to invest to protect critical infrastructure and to make such infrastructure more resilient and resistant to cyberattacks. The level of infrastructure investment required may be challenging for some highly indebted European states to meet, resulting in tough spending choices for regional governments.

Digital citizenship and e-residency in Estonia

A small country in northeastern Europe has made itself the uncontested global leader in digital citizenship. All Estonian citizens have a digital identification, which can be used to access every government service online, from voting in elections to filing their taxes and registering the birth of their children. Everything, except marriage and divorce, can be done online. The system started when Estonia gained independence from the Soviet Union in 1991, when a lack of resources, people and legacy systems forced the country to adopt a paper-less bureaucracy. In 2014, the Estonian government expanded the programme with an e-residency initiative, which allows anyone in the world to register for an Estonian ID. With it, a new business can be set up in minutes, giving the owner access to the whole of the European single market.[48]

47 Eurostat (2023), *This is the state of digitalization in Europe in 2023.*
48 Collins, K., CNET (8 April 2022), 'Estonia's Embrace of Digital Citizenship Is a Model for Us All'; 'e-Estonia'.

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Ariane 5 on display at the European Space Agency spaceport outside Kourou, in French Guiana

European investments and activities in space have traditionally been conducted by the European Space Agency. However, during the last few years the EU has become a more active actor, especially concerning the security aspects of space activities, and space is now mentioned as an important domain in the EU's Strategic Compass.[49] Looking forward, it is likely that the EU will take more responsibility for European space activities and take a more active role in shared space-based services such as the global navigation satellite system and satellite communications. European states are likely to continue to be important space actors with considerable stakes in the global space economy; between 2016 and 2020 countries in the EU accounted for the majority of granted patents for space-related technologies.[50] Several countries (Germany, Norway, Portugal, Spain, Sweden and the UK)[51] are competing to operate the first active spaceport in Europe and it is highly likely that there will be at least one operative launch site in mainland Europe by 2055. European states are likely to look to expand their influence and will form partnerships with aligned states, namely the US, Canada, Australia and Japan. However, while European states will continue to champion space exploration and invest in Earth observation and satellite communications (for example, the EU-funded Copernicus and Galileo), this is unlikely to significantly change the dynamics of the anticipated strategic competition in space between China, Russia, the US and others.

Conflict and security

Over the next few decades, Europe is likely to face a multitude of security concerns, including increasing competition in the Arctic and North Atlantic, the continued threat from Russia to its east, and ongoing instability resulting in continued migration from the south and southeast. European states will prioritise these security challenges differently, based on their geographical location as well as other factors.

49 European Union External Action (2022), *A Strategic Compass for Defence and Security*.
50 Organisation for Economic Co-operation and Development (15 December 2023), *The Space Economy in Figures: Responding to Global Challenges*.
51 Eurostat, European Union (2023), 'Digitalisation in Europe – 2023 edition'.

NATO remains a critical element of the European security architecture

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The 2022 Russian invasion of Ukraine, the largest conflict in Europe since the Second World War,[52] will have a long-lasting impact on European perceptions about conflict, security and defence. Going forward, it is likely to be a driver for long-term investment in the improvement of defence capabilities and strategic resilience. While European defence budgets have been rising since 2014, there is still ground to make up to reach NATO's 2% of GDP goal (which is itself considerably lower than levels of defence spending during the Cold War). However, efforts to achieve this benchmark may remain constrained due to competing spending priorities and other economic considerations.

It is likely that NATO will continue to play a vital role in European security over the next three decades. The threat of the use of nuclear weapons has resurfaced in Europe, influencing deterrence and missile defence strategies. European strategic autonomy has long been an aim for some regional states; however, as long as there is a perception of a substantial military threat and the transatlantic link remains, it is likely that this will evolve to complement NATO rather than compete with it. Recent events have reignited interest in NATO membership, with Finland and Sweden joining the Alliance in 2023 and 2024 respectively. In addition, NATO's role in developing interoperability and uniting major EU member states, the UK, Norway and Turkey into a single alliance remains vital for European security.

While the UK and France have significant power projection capabilities, and Germany is likely to develop its military capacity considerably over the long term, Europe as a whole has just started to recover lost or reduced defence capabilities. In the short to medium term, Europe will remain dependent on the US for a number of its defence functions. However, the long-term commitment of the US to European defence and security will continue to generate concern in the region. As a result, the development of subregional defence cooperation initiatives, such as the Joint Expeditionary Force, the Combined Joint Expeditionary Force and the Northern Group, and of bilateral defence agreements between European states, is likely to increase, potentially boosting freedom of action.

52 Stockholm International Peace Research Institute (SIPRI) (2022), *SIPRI Yearbook 2022: Armaments, Disarmaments and International Security*.

Europe's ongoing support to Ukraine has highlighted the requirement for mass production of weapons and munitions, supported by flexible and resilient supply chains. Going forward, the demand for increased national resilience, not just in terms of energy security but also in terms of being prepared for war, will be another important long-term driver of resource demand and an enduring part of European strategic thinking and collaboration.

Over the next few decades, NATO and European states could become more involved in contributing to the defence of partners outside Europe, as well as dealing with security challenges in the wider neighbourhood. Ongoing instability in Southwest Asia, the South Caucasus and Africa, coupled with climate change and environmental stress, could lead to an increased requirement for peacekeeping support, as well as humanitarian assistance and disaster relief operations. Further afield, tensions in the Indo-Pacific region may have implications for Europe.

Terrorism will remain a significant security concern for Europe. Several European states continue to deal with regional separatist movements and domestic terrorism; however, the past few decades have also seen a rise in Islamist extremism and terror attacks, as well as far-right attacks in some countries. Additionally, transnational serious and organised crime continues to expand in Europe, posing a major threat to states and economic prosperity. Managing these wider security challenges will continue to require coordinated efforts and cooperation between European states.

1	Anguilla[i]	**28**	Guyana
2	Antigua and Barbuda	**29**	Haiti
3	Argentina	**30**	Honduras
4	Aruba[ii]	**31**	Jamaica
5	The Bahamas	**32**	Martinique[iii]
6	Barbados	**33**	Mexico
7	Belize	**34**	Montserrat[i]
8	Bolivia	**35**	Navassa Island[iv]
9	Bonaire, Sint Eustatius and Saba[ii]	**36**	Nicaragua
		37	Panama
10	Brazil	**38**	Paraguay
11	British Virgin Islands[i]	**39**	Peru
12	Cayman Islands[i]	**40**	Puerto Rico[v]
13	Chile	**41**	Saint-Martin[iii]
14	Clipperton Island[iii]	**42**	Sint Maarten[ii]
15	Colombia	**43**	South Georgia and the South Sandwich Islands[i]
16	Costa Rica		
17	Cuba	**44**	St. Barthélemy[iii]
18	Curaçao[ii]	**45**	St. Kitts and Nevis
19	Dominica	**46**	St. Lucia
20	Dominican Republic	**47**	St. Vincent and the Grenadines
21	Ecuador		
22	El Salvador	**48**	Suriname
23	Falkland Islands[i]	**49**	Trinidad and Tobago
24	French Guiana[iii]	**50**	Turks and Caicos Islands[i]
25	Grenada	**51**	United States Virgin Islands[iv]
26	Guadeloupe[iii]	**52**	Uruguay
27	Guatemala	**53**	Venezuela

[i] UK Overseas Territory.
[ii] Self-governing country of the Kingdom of the Netherlands.
[iii] Overseas departmental collectivity of France.
[iv] Unincorporated organised territory of the United States.
[v] Unincorporated organised territory of the United States with Commonwealth status.

Latin America and the Caribbean

Current strategic context

Latin America and the Caribbean (LAC) spans over 20 million square kilometres (approximately 14% of the Earth's surface), from the huge continental land mass of South and Central America to the small island states of the Caribbean.[1] The region is home to over 662 million people – 8.2% of the global population[2] – from an array of socio-cultural backgrounds, with roots tracing back to both the original indigenous inhabitants and the first European settlers. Whilst geographically vast, LAC has the second highest urban population worldwide,[3] many of whom live in the region's six highly populous megacities of Bogota (Colombia), Buenos Aires (Argentina), Lima (Peru), Mexico City (Mexico), Rio de Janeiro (Brazil) and São Paulo (Brazil).[4]

Climate change and continuing environmental degradation are already having a significant impact on the region. In South America, land clearance and resource extraction in the Amazon and other areas, in combination with rising temperatures, is already leading to accelerating glacial melt in the Andes, disruption to weather patterns, an increase in water stress and increasingly severe weather events. Meanwhile, some of the Caribbean's smaller islands are facing an existential threat and severe consequences as the situation deteriorates.

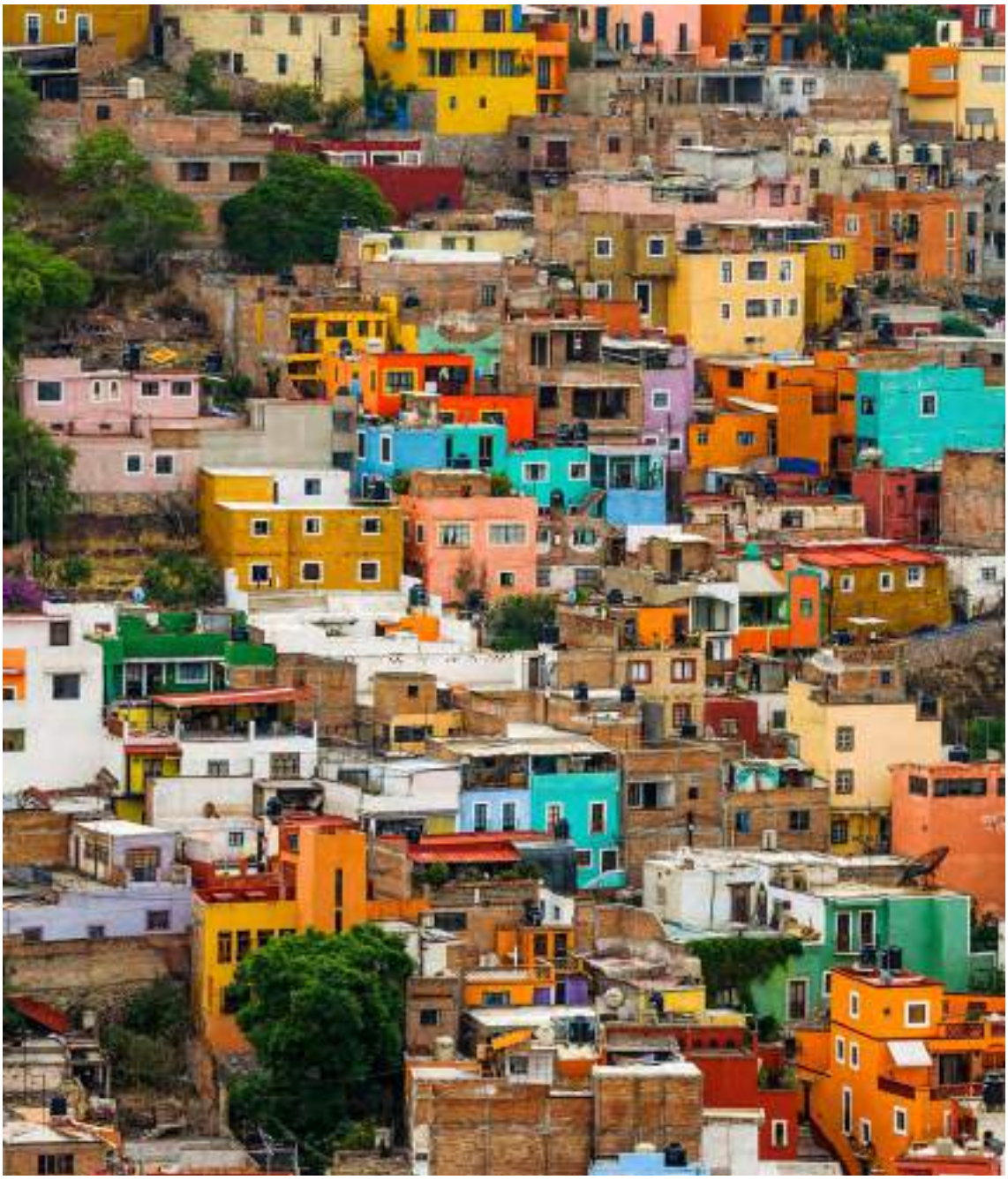
LAC supplies 20% of the world's agricultural products,[5] is a major fossil fuel exporter and has significant mineral deposits, such as lithium, copper and nickel, which may be critical to the green energy and digital transitions. Commodity exports are central to many LAC economies, making them particularly vulnerable to global market fluctuations.

Following the COVID-19 pandemic, LAC has one of the largest debt to gross domestic product (GDP) ratios and highest levels of inequality in the world. Serious and organised crime remains a major challenge, with weak state capacity in many countries allowing the cartels to expand into new areas of illegal activity, while also acting as alternative service providers for the region's population. Internal displacement, migration and narcotics flows have an impact across the Americas and globally.

1 World Bank (2020), 'Land area (sq. km) – Latin America & Caribbean'.
2 United Nations (UN), Economic Commission for Latin America and the Caribbean (ECLAC) (14 November 2022), 'The world has 8 billion people, 662 million of whom live in Latin America and the Caribbean'.
3 Population Reference Bureau, Statista (18 December 2023), 'Share of urban population worldwide in 2022, by continent'.
4 Designing Buildings (25 January 2023), 'Megacity'.
5 Georgetown Americas Institute (7 September 2023), 'The Nature Conservancy's Paula Caballero Discusses Sustainable Development in LAC'.

Structural inconsistencies, many deep-rooted in the region's history, have hindered the development of a collective regional voice. While there are over 11 regional cooperation forums, many are likely to see their influence diminish due to growing political divisions and dwindling membership; this may limit ambitions for regional integration, trade liberalisation and increased global leverage.

The traditional influence of the United States (US) in the region is increasingly being challenged by other global powers, including China through its growing trade, infrastructure, diplomatic and military interests. Other states are also paying increasing attention to the region, which over time may provide regional states with the opportunity to play off different external actors against each other. Elsewhere, a number of territories are seeking to assert their independence from former ruling states. LAC's response to this emerging global power competition, however, is likely to remain heavily influenced by the region's many domestic challenges.



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Key drivers of change

Global and regional power competition. Great power competition will increasingly dictate strategic narratives across LAC as China seeks to counter US influence in the region. Regional cooperation will continue to be stifled by political divisions and a lack of consensus, hindering progress towards integration. Serious and organised crime will also continue to be a pressing challenge within the region, particularly in areas where authority is weak and there are state failures in service provision, with organised crime spreading into these sectors to fill the gap left by governments.

Pressure on the environment. The environmental impact associated with global climate change will have economic, political and societal repercussions for the whole of LAC, which out to 2055 will have a profound effect on regional populations, economies, food production and infrastructure. The implications of wider forms of environmental damage will be equally disruptive, particularly as polarised views on climate change and natural resource depletion may hinder a unified approach towards sustainability.

Economic turbulence and transition. The economic trajectory of many LAC countries will remain deeply uncertain out to 2055, with some having experienced near historic levels of growth in recent decades, at the same time as others continue to suffer economic downturn. A key challenge for many LAC economies will be diversifying away from reliance on volatile commodity markets towards value-added products. Attracting and securing external investment will be paramount to sustaining current levels of growth.

Socio-economic inequality. Socio-economic inequality will be an enduring challenge across LAC. Social marginalisation, poor levels of economic growth, weak state finances and a lack of foreign and domestic investment have driven growing disparities within and between states. These factors will continue to dictate the opportunities available to citizens, particularly in terms of education and employment, propelling this cycle further and exacerbating existing inequalities. If left unaddressed, this will drive increasing social and political divisions, which may amplify tensions across the region.

Demographic pressures. LAC has a relatively young population which, if employed effectively and provided with the meaningful opportunities it desires, may serve as an engine for economic growth, productivity gains and social mobility. Conversely, an underemployed, unproductive pool of youth could lead to increased migration, political instability and greater criminality. An equally pressing concern will be the ability of states to deal with growing levels of intraregional migration, and find a balance between managing short-term pressures on social programmes and reaping the longer-term economic opportunities offered by migrants.

Future key trends

Global power competition

Out to 2055, the US will continue to exert significant influence in the region through private investment, defence sales, leverage in international financial institutions and geographical, cultural and diaspora ties. One way it might do this is through expanding the United States–Mexico–Canada Agreement to include other Latin American states. European and other Western states are also likely to remain active in the region. However, over time, these traditional partners will increasingly be challenged by other actors, including China. China's regional presence has expanded significantly over the past decade as it seeks to secure access to food, energy and other resources. Of the 33 South American states, 21 have now joined China's Belt and Road Initiative, resulting in substantial investment in dams, ports, railways and other infrastructure. Although ongoing investment by China will be dependent on its continued economic growth, which remains uncertain in light of its recent economic slowdown, it seems likely to remain a key actor in LAC.

LAC received US $224 billion in foreign direct investment in 2022, a record high and 55% higher than in 2021.[6] The countries that received the highest inflows were Brazil (33% of the total), Mexico (23%), Chile (11%), Colombia (7%), Peru (5%) and Argentina (5%). The US and the European Union (excluding the Netherlands and Luxembourg) were the region's main investors in 2022, representing 38% and 17% of the total respectively.[7] The US is also LAC's largest trading partner, with the total trade between the US and LAC totalling US $568 billion in the first six months of 2022 alone.[8] However, China is rapidly seeking to become an increasing economic competitor in the region and challenge US dominance. This is perhaps best demonstrated by China and Latin America's bilateral trade increasing from US $18 billion in 2002 to US $450 billion in 2021,[9] with estimates suggesting that this is on course to exceed US $700 billion by 2035.[10]

China is likely to expand its diplomatic efforts in LAC; it has increasingly employed economic and commercial leverage to exert pressure on regional states, and the next few decades could see further examples of China using economic measures to secure diplomatic support. However, there are increasing concerns about the potential downside of China's growing regional presence. As a result, many regional leaders may seek to balance their growing dependence on China against their relationships with the West and may increasingly enter into partnerships with other global actors, including Russia and Iran. Whilst largely focused on former Cold War partners, Russia's diplomatic influence is growing, and trade with the region increased by 44% to US $12 billion between 2006 and 2016.[11] Iran has also been playing an increasing role in the region, and the next few decades may see its presence and influence increase further, including through providing military support.

6 UN, ECLAC (July 2023), *Foreign Direct Investment in Latin America and the Caribbean 2023*.
7 Ibid.
8 UN, ECLAC (January 2023), *United States-Latin America and the Caribbean Trade Developments 2022*.
9 Daye, C., *Global Times* (8 June 2022), 'US initiative cannot match BRI in Latin America as countries welcome cooperation, not ideological confrontation'.
10 Zhang, P. and Prazeres, T.L., World Economic Forum (17 June 2021), 'China's trade with Latin America is bound to keep growing. Here's why that matters'.
11 Gurganus, J., Carnegie Endowment for International Peace (3 May 2018), *Russia: Playing a Geopolitical Game in Latin America*.

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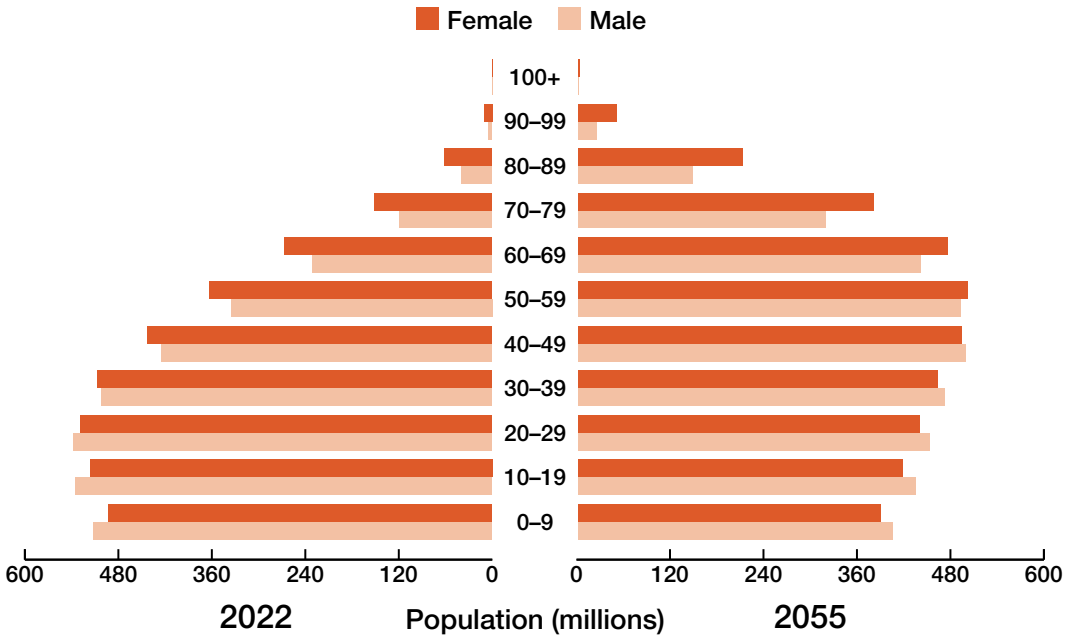
The BRICS group offers an opportunity for regional states to foster global links

South–South cooperation is likely to increase over the next 30 years, with the region building closer relationships with a number of Asian and African partners, including through the BRICS group. With intraregional cooperation continuing to present a challenge, many Latin American states will turn to East and South Asia to develop economically beneficial partnerships. For example, Chile, Mexico and Peru are all members of the Asia-Pacific Economic Cooperation forum, with four more Latin American countries applying for membership (Costa Rica, Colombia, Panama and Ecuador). Mexico, Peru and Chile have become members of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, and Chile has requested to join the Association of Southeast Asian Nations (ASEAN)–Australia–New Zealand Free Trade Area as its first Latin American member. Growing desire in some regional countries to put an end to colonial-era ties may lead to the loss of overseas territories for some European powers over the next 30 years.

Society

The LAC population is expected to increase from 662 million in 2022 to 752 million by 2055.[12] However, population growth is slowing, due in part to declining birth rates, which will continue to fall out to 2055, and the region is expected to reach peak population by the same time.[13] Despite this, the region will continue to enjoy a relatively youthful demographic structure, with 20% of the population aged between 15 and 24,[14] and the working age population will continue to grow until at least the 2040s.

12 UN, ECLAC (2022), 'Interactive Demographic Indicators'.
13 UN, Department of Economic and Social Affairs, Population Division (2022), *World Population Prospects 2022: Summary of Results*.
14 UN, ECLAC (2013), *Regional overview: Latin America and the Caribbean*.



Source: United Nations Population Division (2022)

Population statistics projection for Latin America and the Caribbean by age range

While this youthful population could drive economic growth, failure to provide young people with the education and meaningful employment opportunities they desire could also result in growing discontent and migration. LAC has huge disparities in educational standards within and between countries, with remote and vulnerable communities being particularly disadvantaged. Prior to the COVID-19 pandemic, around 12 million children and adolescents were already outside the education system, but the pandemic highlighted this divide further as well as the region's digital divide (an estimated 43% of primary schools and 62% of secondary schools lack access to the Internet).[15]

The number of over-65s is expected to double by the middle of the century, rising to over 18% of the population.[16] While lower than the average for Organisation for Economic Co-operation and Development (OECD) countries, the speed at which this is occurring is unprecedented and could significantly impact the ratio of working age people to dependants, placing further strain on some of the region's states. Alongside the costs of funding retirement and social care for those in the formal economy, there is also a risk that ageing workers in the region's large informal sector could be forced into poverty and social marginalisation.

Poverty and inequality will remain an enduring challenge for the region. The COVID-19 pandemic has had a significant impact on poverty rates, resulting in the highest increase in 12 years; this is estimated to have pushed millions into poverty, reversing the previous long-term downward trend. Across Latin America, 47% of indigenous people and 26% of Afro-descendants live in poverty, compared with just 16% of those of European and other descent.[17] Gender inequality also remains significant; while

15 World Bank (March 2021), *Acting now to protect the human capital of our children: the costs of and response to COVID-19 pandemic's impact on the education section in Latin America and the Caribbean*.
16 Organisation for Economic Co-operation and Development (OECD) and The World Bank (16 June 2020), *Health at a Glance: Latin America and the Caribbean 2020*.
17 Sabatini, C. and Bata, A., Chatham House (2021), *Latin America and the Caribbean: Dissensus, Divergence and Development* (research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).

female participation in the labour market had risen to 42% by 2023, women are still under-represented in high-level management jobs,[18] and they occupy 60% of insecure, informal and lower-paid roles.[19]

Regional states will continue to see massive disparities in living standards. For example, São Paulo is the biggest megacity and an emerging economic powerhouse for Latin America,[20] possessing a GDP higher than that of Argentina.[21] Much of this success can be attributed to investments in infrastructure, technology, public services and environmental protection measures. However, most of the population growth takes place on the city's periphery, and in particular in the favelas. The city has one of the highest levels of income inequality in the world, being home to 30,000 millionaires (approximately one for every 100 of the city's poor).[22] This trend looks likely to continue.

An estimated 40 million LAC citizens live outside their countries of origin, equivalent to 15% of the world's migrant population.[23] In the LAC region itself, the number of migrants doubled from 8.3 million in 2010 to 16.3 million in 2022, although much of the migration has been movement between countries within the region.[24] While much attention is paid to the flow of migrants from Mexico to the US, the Northern Triangle countries of Guatemala, El Salvador, Honduras, Mexico and Nicaragua also receive significant numbers of migrants.[25] Perhaps most strikingly, over 7 million Venezuelans have fled the country since 2015 due to myriad internal issues.[26]

Over time, environmental degradation, reduced economic prospects and the prevalence of serious and organised crime may drive further increases in migration across the region. While in the long term these new residents may boost economic growth in their adoptive countries, in the short and medium term they could place increasing pressure on already strained social programmes and compete with domestic populations for jobs. Within the region, as economic growth lags and the flow of migrants continues, there is a heightened risk of violent reactions by local populations.

Health care deficiencies will continue to affect many regional countries. In 2020, health care spending accounted for just 3.8% of GDP, a figure significantly lower than the OECD average of 6.6%.[27] On average, the region has only two doctors per 1,000 members of the population, a figure below the OECD average of 3.5, with only Cuba, Argentina, Uruguay and Trinidad and Tobago above the OECD average; in contrast, Haiti, Honduras and Guatemala have the lowest ratios, at or below 0.3 doctors per 1,000.[28]

18 World Bank (2023), 'Labor force, female (% of total labor force) – Latin America & Caribbean'.
19 UN, ECLAC (February 2021), *The economic autonomy of women in a sustainable recovery with equality*.
20 Designing Buildings (25 January 2023), 'Megacity'.
21 Doria, J., World Economic Forum (13 February 2020) 'How to unleash the potential of regions like São Paulo'.
22 UN Human Settlements Programme (2010), *São Paulo: A Tale of Two Cities*.
23 Blyde, J., et al., Inter-American Development Bank (June 2020), *The Profiles of Immigrants in Latin America and the Caribbean: A Focus on Economic Integration*.
24 Selee, A., et al., Migration Policy Institute (11 April 2023), 'In a dramatic shift, the Americas have become a leading migration destination'.
25 Organization of American States, OECD, UN ECLAC (2011), *International Migration in the Americas: First Report of the Continuous Reporting System on International Migration in the Americas (SICREMI)*.
26 Arena, M., et al., International Monetary Fund (7 December 2022), 'Venezuela's migrants bring economic opportunity to Latin America'.
27 OECD and The World Bank (16 June 2020), *Health at a Glance: Latin America and the Caribbean 2020*.
28 Ibid.

Latin America has the world's largest reserves of lithium, demand for which is expected to grow

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Narcotics will pose an increasing challenge for the region, driven by growing socio-economic inequality, a lack of opportunities and increased availability. It is estimated that 35 million people in LAC suffer from drug use disorders, with 585,000 deaths annually.[29] It is likely that increased drug dependency will further fuel the demand for narcotics in the future, not just in the region but globally, leading to health and other societal issues, as well as increased levels of serious and organised crime in the region.

Although polling suggests that 50–60% of the population support democracy, public trust in regional governments has decreased over time, and may continue to do so in the future.[30] LAC scored 5.83 out of 10 in the Economist Intelligence Unit's *Democracy Index 2022*, a figure which has declined for seven consecutive years; Uruguay, Chile and Costa Rica were the only countries classed as 'full democracies', while Cuba, Nicaragua and Venezuela were classed as 'authoritarian regimes' and the remainder either as 'flawed democracies' or 'hybrid regimes'.[31] The political landscape may become increasingly volatile out to 2055, fuelled by social media and disinformation campaigns, and political power may increasingly swing between far left and far right parties. Corruption is likely to remain a major factor in public distrust.

Economy

LAC will continue to experience fluctuations in economic performance. Regional economies grew by an average of 2.5% between 2000 and 2015,[32] with Peru, Chile, the Dominican Republic, Panama and Brazil growing at near-historic rates during this period. However, failure to capitalise on this windfall by investing in greater productivity

29 OECD and The World Bank (16 June 2020), *Health at a Glance: Latin America and the Caribbean 2020*, 'Drug use'.
30 *The Economist* (16 June 2022), 'A region caught between stagnation and angry street protests'.
31 Economist Intelligence Unit (2022), *Democracy Index 2022*.
32 Cadena, A., et al., McKinsey Global Institute (April 2017), *Where Will Latin America's Growth Come From?*

and economic diversification meant that when commodity markets contracted, so too did the region's economies, with the growth rate dropping to less than 1% by 2019.[33] The COVID-19 pandemic exacted a further toll on economic growth, with the region's debt-to-GDP ratio reaching its highest levels since the early 1990s.[34]

With all its major economies except Mexico being net commodity exporters, LAC's economic trajectory will remain intrinsically linked to commodity prices.[35] Therefore, in the short term at least, global market fluctuations will continue to cause fiscal uncertainty. As a result, countries such as Argentina and Brazil could suffer economic volatility in future decades unless governments take steps to contain fiscal profligacy and open up their economies to external investment. Diversification away from commodity extraction and towards value-added production will be key to this. Countries such as Venezuela, Haiti, Bolivia and much of Central America (with the exception of Costa Rica and Panama) may continue to see their economies struggle and even decline.

Out to 2055, the green energy transition may pose a significant risk for the region's energy producers, which will see a decline in revenue and may be unable to profit from untapped resources such as Venezuelan oil and Argentinian and Brazilian shale fields. However, changing energy demands may result in opportunities for some regional states; in particular, the region is well positioned to grow its critical mineral exports, being rich in products such as lithium, copper and nickel. Peru and Chile are the world's two largest copper producers and Brazil is home to 17% of all nickel reserves.[36] This may attract increasing attention from external actors, both state and non-state, in the future, potentially resulting in increasing geopolitical focus on the region.

South America's Lithium Triangle

Latin America is the region with the largest amount of lithium, a mineral of increasing global importance, often referred to as 'white gold'.[37] The Lithium Triangle, a lithium-rich region in southwest South America, spans the borders of Argentina, Bolivia and Chile, which between them contain approximately 58% of the world's lithium resources.[38] At present, lithium is of critical importance in a range of current and emerging technologies, from communications to energy storage. Assuming lithium continues to be a vital component in new technologies that emerge in the future, these countries may become increasingly important and possibly influential. The ability to control the lithium industry could be a major benefit in the future; however, it could also become a source of competition between states.

33 Sabatini, C. and Bata, A., Chatham House (2021), *Latin America and the Caribbean: Dissensus, Divergence and Development*, a research paper commissioned by DCDC.
34 Deloitte Global Economics Research Center (23 June 2022), 'Latin America economic outlook, June 2022'.
35 World Bank (June 2022), *Global Economic Prospects, June 2022*.
36 Lu, C. and Fabbro, R., Foreign Policy (27 February 2023), 'China's Latin American Gold Rush is All About Clean Energy'.
37 Berg, R. and Sady-Kennedy, T.A., Center for Strategic and International Studies (17 August 2021), 'South America's Lithium Triangle: Opportunities for Biden Administration'.
38 Gonzalez, E., Americas Society/Council of the Americas (17 February 2021), 'Explainer: Latin America's Lithium Triangle'.

Agriculture will remain important for the region's economies, accounting for 5–18% of GDP in 20 LAC countries.[39] However, as global demand increases and supplies are diverted to world markets, there could be increasing discontent among the local populations of leading agricultural producers such as Argentina, Brazil, Paraguay and Uruguay, who may suffer rising prices and food shortages.

Where economic growth does occur, it is likely to be driven largely by a combination of global demand for resources and the increase in the region's working age population. Almost 80% of the region's GDP growth over the past 15 years has resulted from growing populations rather than rising productivity; between 2000 and 2015, for example, employment grew at an annual rate of 2.3%, but productivity growth was only 0.6%.[40] Over time, as population growth decreases, this could lead to a slowdown in economic performance in those countries that fail to modernise their economies effectively and boost productivity.

Despite these risks, LAC will remain attractive to external investors. Venture capital investment injected US $15.7 billion into the region in 2021, exceeding the combined total for investment into Southeast Asia, Africa and Southwest Asia.[41] However, despite financial commitments from private investors and multilateral institutions, Latin America still needs an additional US $120–150 billion investment per year to maintain current growth levels.[42] New submarine cable projects to improve connections between the East and West are one area which may provide opportunities for the region, with Brazil potentially becoming an increasingly important telecommunications hub. Although external actors will continue to invest in the region, not all states will benefit equally, resulting in some being left behind and unable to capitalise on the resources they hold.

Environment

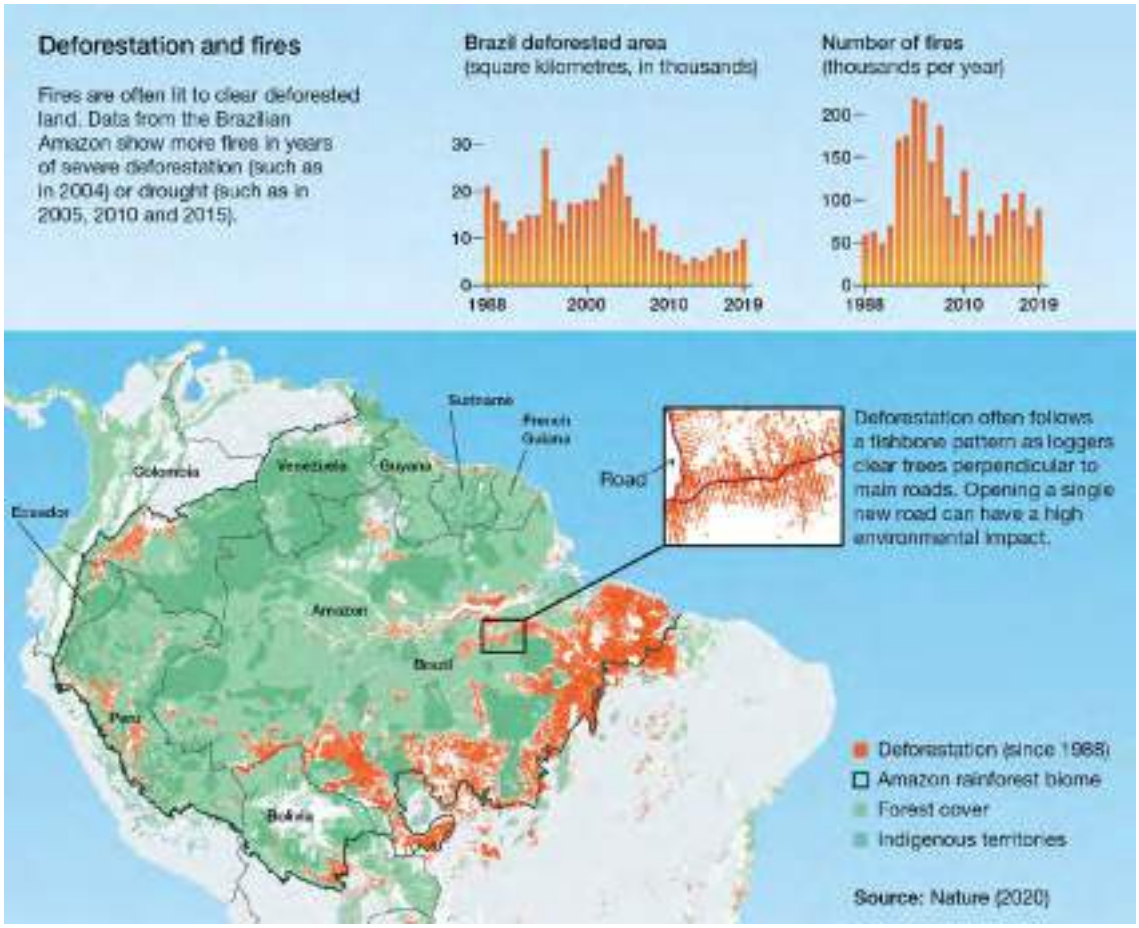
LAC will be significantly impacted by the effects of climate change and other forms of environmental degradation. The next 30 years will see increased frequency and intensity of extreme weather events such as hurricanes, droughts and flooding, leading to growing water stress, reduced agricultural productivity and rising food insecurity in many parts of the region.[43] The region may also be close to a range of environmental tipping points, which could see these climate impacts accelerate in the future.

For the 30 million people living in or near the Amazon rainforest, it will remain a critical enabler, facilitating transportation and trade links and supporting economic activity, including fishing, logging and extracting non-timber forest products. In Brazil alone, products originating from the rainforest contribute approximately US $8.2 billion towards the country's economy.[44] The Amazon is ingrained in the cultural identity of the region and is important to indigenous populations; however, these populations are also likely to be

39 World Bank (12 November 2020), 'Agriculture and Food Systems in Latin America and the Caribbean Poised for Transformational Change'.
40 Cadena, A., et al., McKinsey Global Institute (April 2017), *Where Will Latin America's Growth Come From?*
41 *The Economist* (16 June 2022), 'A region that seems unable to reach its potential'.
42 Zhang, P., Atlantic Council (8 October 2019), 'Belt and Road in Latin America: A regional game changer?'.
43 Sabatini, C. and Bata, A., Chatham House (2021), *Latin America and the Caribbean: Dissensus, Divergence and Development*, a research paper commissioned by DCDC.
44 Strand, J., et al., *Nature Sustainability*, Volume 1 (13 November 2018), 'Spatially explicit valuation of the Brazilian Amazon Forest's Ecosystem Services', pages 657–664.

most impacted by deforestation, water stress and displacement to make way for farming and mining activity. Temperature rises, forest fires, poor governance and the expansion of agriculture and mining have already seen 18% of the Amazon basin deforested and a further 17% degraded;[45] estimates suggest that around 40% of the rainforest could be lost by the middle of the century.[46] Deforestation will also pose a critical risk to regional species, putting 8,000 plants and 2,300 animals at risk of extinction,[47] as well as having an impact on agricultural, industrial and hydropower production through disruption to rainfall patterns.

The continued destruction of the Amazon rainforest will have global as well as regional ramifications. Covering 2.6 million square miles, the Amazon had long been considered an important 'carbon sink', offsetting global emissions. However, deforestation has already resulted in some parts of the Amazon becoming a net emitter of carbon, exacerbating global climate warming.[48] Disruptions to rain cloud circulation may have an increasing impact on weather patterns in the South Atlantic and even beyond into the Northern Hemisphere.



Rainforest loss in the Amazon area

45 Science Panel for the Amazon (2021), *Amazon Assessment Report 2021*.
46 World Wildlife Fund (January 2022), 'WWF briefing for Westminster Hall debate on deforestation in the Amazon'.
47 Science Panel for the Amazon (2021), *Amazon Assessment Report 2021*.
48 Gatti, L.V., et al., *Nature*, Volume 595, (14 July 2021) 'Amazonia as a carbon source linked to deforestation and climate change', pages 388–393.

Climate change could have a fundamental impact on the Caribbean tourist industry

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The region's subtropical grasslands and savannahs, which have functioned as a sump for rainfall from the Amazon in the past, have also been extensively cleared, and the resulting soil erosion is creating cycles of drought and floods, which over the coming decades will place major cities and infrastructure at risk. Elsewhere, the region's rivers and waterways will be susceptible to gradually increasing water stress through climate change and the depletion of freshwater sources. Global warming has accelerated glacial melt in the Andes, which has lost between 30 and 50% of its ice cover in the last 40 years;[49] in addition, water flow is being diverted for mining and other activities. Chile, Mexico and Guatemala will see rising levels of water stress, while Brazil's hydroelectric power sector will be increasingly affected.

Despite being a major food exporter, 191 million people – almost a third of the population – were affected by food insecurity across LAC in 2019.[50] Out to 2055, without targeted management initiatives, governance interventions or technology developments, levels of food insecurity are likely to rise further, with those areas dependent on rain-fed farming techniques, including parts of Central America, the Andean region and Argentina and Brazil, being particularly vulnerable. The effects will also increasingly be felt in the region's megacities, as growing and densely packed populations struggle to obtain food and water.

The region will also be increasingly vulnerable to extreme weather events. Between 1990 and 2018 there were 288 incidents with an increase of 3% yearly;[51] 84,000 people were killed and 163 million were directly impacted.[52] Latin America's coastal megacities and infrastructure will be particularly vulnerable, with poor, indigenous and Afro-descendant inhabitants being most at risk.

LAC is considered to be one of the most important global maritime areas, offering vital commercial links, tourism opportunities and unique marine biodiversity, including the second largest barrier reef in the world and the highest proportion of global marine ecoregions.

49 UN Environment Programme (15 March 2023), 'Shrinking glaciers upend lives across South America'.
50 Pan American Health Organization, et al. (2021), *Regional Overview of Food Security and Nutrition in Latin America and the Caribbean 2020 – Food security and nutrition for lagged territories – In Brief*.
51 Bárcena, A., et al., UN ECLAC (June 2020), *The climate emergency in Latin America and the Caribbean: The path ahead – resignation or action?*.
52 Ibid.

Out to 2055, however, rising sea levels will pose a significant risk to the region's coastal communities and marine resources. For some Caribbean islands, given the potential impact on tourism, fishing, arable land and infrastructure, this could amount to an existential threat.

There are 2.3 million people working in LAC's fishing sector, which generates more than 11 million tonnes of produce per year.[53] The growth of illegal, unreported and unregulated fishing poses an increasing threat to local livelihoods, as well as to coastal ecosystems and fish stocks. While in the Caribbean illegal, unreported and unregulated fishing is mainly perpetrated by small-scale fishers from within the region, more sizable national fleets operate elsewhere, with large Chinese fleets responsible for significant illegal, unreported and unregulated fishing along Latin America's Pacific coast.[54] These vessels operate in Latin America's oceans throughout the year, and the number of Chinese-flagged vessels in the region continues to grow annually.

Despite the significant impact that it will have on the region, views on climate change in LAC are extremely polarised, and will remain highly influenced by historical grievances, regional politics and mistrust of external motivations. Out to 2055, the degree to which countries can overcome divisions and work together to address this common challenge will be key to the region's future trajectory.

Technology, infrastructure and communications

Over the next 30 years, the need to balance dependence on resource exports with environmental concerns and economic imperatives will be critical to many regional governments. However, technology innovation could offer a number of ways to balance these demands, potentially providing a model for other global regions. For example, LAC is seeing an increasing number of agrotechnology innovations and start-ups, which over the next few decades may see the region finding sustainable ways to boost food production without further degrading the environment. Deep-sea exploration may also be a possible growth area, where the potential for governments to drive innovation and improve monitoring in ungoverned areas may be significant.

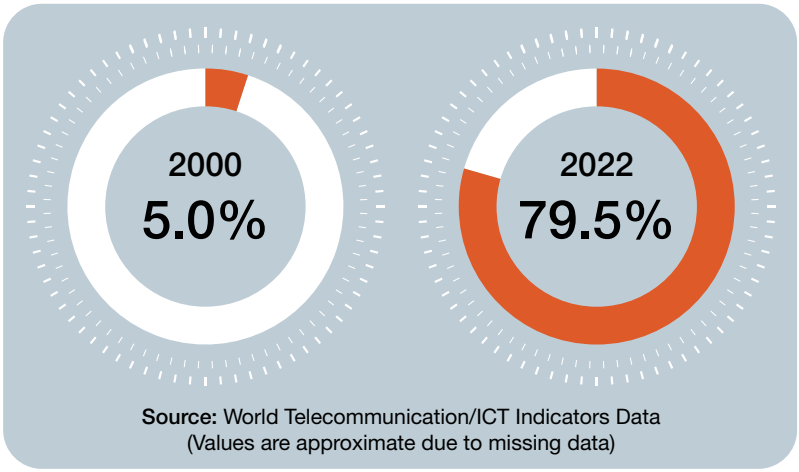
Renewable energy in Chile

Chile is using its renewable energy credentials to establish itself as an influential player in international climate negotiations. In recent years, it has benefited from broad-based political support, private–public partnerships and the use of groundbreaking green technologies to accelerate its energy transition. Green hydrogen, a clean energy source that splits water into hydrogen and oxygen using renewable electricity, sits at the heart of Chile's energy transition. Chile's National Green Hydrogen Strategy promotes the incorporation of green hydrogen into the country's mining and commodity sectors, as well as other carbon-reliant local supply chains. Chile has set a goal to convert 70% of its total energy consumption to renewables by 2030 and has pledged to become carbon neutral by 2050.[55]

53 Food and Agriculture Organization of the United Nations (21 June 2017), 'Latin America and the Caribbean creates the world's first model law on small-scale fisheries'.
54 Myers, S.L., et al., *The New York Times* (26 September 2022), 'How China Targets the Global Fish Supply'.
55 Conley, T., World Economic Forum (4 January 2023), 'How Chile is becoming a leader in renewable energy'.

Investment in technology research and skills development will be critical to progress. Latin American investment in research and development is currently relatively low, with Brazil being the only country spending more than 1% of GDP;[56] most commit less than half of that, which is considerably lower than the global average for lower middle income economies. Financial technology in the region doubled between 2018 and 2021 to 2,482 platforms, a quarter of the global total.[57] However, the longer-term direction of this trend remains uncertain and it is likely that regional governments will require significant levels of external investment and support over the next few decades to realise success in this area.

Widespread digital connectivity will also be a key enabler for technology advances. While mobile phones are widely used, Internet access differs greatly within and between countries. Although 71% of urban citizens have access to the Internet, coverage in rural areas is significantly worse, with only 37% having access.[58] Affordability remains a significant barrier, with the region's poorer citizens being disproportionately affected. Out to 2055, continuing disparities in digital connectivity could hinder the development of a digitised economy, limiting innovation, food production and economic growth.



Average percentage of the population using the Internet in Latin America and the Caribbean

Given these challenges, many regional countries have turned to China to provide digital infrastructure, including telecommunications, big data analytics, cloud computing and smart city technology. While in the short term this may help governments to improve digital connectivity and tackle challenges such as serious and organised crime, in the long term, there are concerns that these technologies may allow access for monitoring and espionage, as well as enabling some of the region's more authoritarian governments to boost their own surveillance powers.

56 OECD (20 March 2020), *Government at a Glance: Latin America and the Caribbean 2020*.
57 Inter-American Development Bank (IDB) (26 April 2022), 'Study: Fintech Industry Doubles in Size in Three Years in Latin America and the Caribbean'.
58 Ziegler, S., et al., Inter-American Institute for Cooperation on Agriculture, IDB and Microsoft (2020), *Rural connectivity in Latin America and the Caribbean: A Bridge for Sustainable Development in a Time of Pandemic*.

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The transcontinental Bi-Oceanic Road Corridor will link the east and west of the continent

Interest in the region's space potential is likely to increase over the next few decades, particularly given the access that it offers to much sought-after equatorial and polar orbits. Argentina, Brazil, Peru, Mexico, Uruguay and Bolivia have national space agencies, with Argentina and Brazil also having space launch sites. At present, 11 regional states own or operate satellites, a number which is likely to increase further. While many states rely on the US, Russia or Europe for technical expertise, equipment and joint partnerships, Mexico and Argentina formed the Latin American and Caribbean Space Agency in 2020; Bolivia, Ecuador, El Salvador and Paraguay have joined since, with Colombia and Peru as observers. Out to 2055, the choice of external space partners will be another feature in the accelerating global power competition now impacting the region. China, for example, is accessing or building an increasing number of space facilities in regional countries, including one in Argentina, which is suspected of having both military and civilian purpose.[59]

LAC currently has significant gaps in its physical transport infrastructure due to low levels of investment in many parts of the region.[60] More than 60% of the region's roads still unpaved, despite the fact that over 85% of freight is transported via this means. Similarly, LAC is home to a limited rail network, with passenger railways moving only 38 million passengers per kilometre, a figure significantly below the global average of 484 million passengers per kilometre.[61] Despite this, urban transportation has improved in recent decades and many cities now have multiple modes of public transport.[62] While governments in the region have demonstrated some success in improving transport infrastructure – including Brazil repaving the flood-prone BR-319 highway, Mexico developing the Tren Maya railway, and the transcontinental Bi-Oceanic Road Corridor linking the east and west of the continent – LAC states will need to invest the equivalent of 1.37% of regional GDP per year if the region is to meet its United Nations Sustainable Development Goals for transport.[63]

59 Londoño, E., *The New York Times* (28 July 2018), 'From a space station in Argentina, China expands its reach in Latin America'.
60 Harr, J., Wilson Center (13 March 2023), 'Latin America Must Prioritize Infrastructure to Spur Economic Growth'.
61 Canning House (20 March 2023), *Transport: The Road to Latin American Sustainable Development*.
62 Harr, J., Wilson Center, (13 March 2023), 'Latin America Must Prioritize Infrastructure to Spur Economic Growth'.
63 Canning House (20 March 2023), *Transport: The Road to Latin American Sustainable Development*.

Corruption remains a key driver of unrest in the region

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Conflict and security

Despite high levels of distrust between regional countries, the risk of interstate conflict in LAC has decreased in past decades. Instead, regional security agendas are increasingly dominated by domestic concerns, most notably serious and organised crime. Public concerns over crime and security have increased in the region, as have the actual incidences of violence and crime. Although home to just 8% of the global population, LAC accounted for 33% of the world's homicides in 2018.[64]

Persistent corruption and a loss of faith in state governments, as well as high levels of inequality and a lack of education and employment opportunities, will continue to provide a fertile environment for serious and organised crime to boost its power and influence in the region. Criminals will increasingly rely on social media and other methods to present themselves as alternative service providers to generate support, while those who oppose them will risk death or displacement. Expansion into other areas of illegal activity, including illegal logging, fishing and mining, counterfeiting and human trafficking, will also contribute to the spread of criminal influence. Serious and organised crime currently absorbs at least 3.5% of the region's economic output, comparable to the amount spent on infrastructure, and the next few decades may see this increase further.[65]

As digital connectivity increases across the region, the use of digital platforms for criminal activity is expected to increase. The next 30 years are also likely to see an increase in cybercrime, money laundering and other illicit activities, often in collaboration with networks in Asia, Russia, Central Asia and Africa. The use of financial technology and cryptocurrencies for illicit purposes, both by state and private actors, may also increase.[66] While the need to enhance cybersecurity is increasingly recognised in the region, it will continue to present a key challenge for the foreseeable future.

64 de Lourdes Despradel, M. and Matera, M.A., Center for Strategic & International Studies (15 January 2020), *Latin America and the Caribbean in the New Decade: How Did we Get Here?*
65 Jaitman, L., Inter-American Development Bank (December 2018), *Frontiers in the Economics of Crime: Lessons for Latin America and the Caribbean*.
66 Sabatini, C. and Bata, A., Chatham House (2021), *Latin America and the Caribbean: Dissensus, Divergence and Development*, a research paper commissioned by DCDC.

Once largely confined to Colombia, Peru and Bolivia, narcotics cartels have spread across the region and out to 2055 are likely to pose a growing concern for state governments, especially when combined with the opportunities that digital communications and big data offer to criminals. The region's armed forces may be increasingly used to bolster domestic law enforcement, meaning that they may be less well prepared to deal with external threats. Given their role in the region's recent history, and the tendency of some of its authoritarian regimes to use their militaries to control rather than protect their populations, this also risks undermining popular trust in military structures.

It is likely that the region will remain reliant on external actors for a significant proportion of its military capability development out to 2055. China is currently seeking to develop closer military ties with regional states, including through arms sales, military exchanges and joint training programmes. While Venezuela has become the region's top purchaser of Chinese military hardware following the US prohibition on arms sales, Bolivia, Ecuador and Cuba have all sought closer military links with China, from purchasing military equipment through to hosting Chinese port visits. Russia and Iran may also increasingly look to strengthen ties with old partners, with current activities including military exercises and deployments, port access agreements and military equipment sales.

Over the next three decades, initiatives such as the Zone of Peace and Cooperation of the South Atlantic[67] may serve to boost intraregional cooperation and further limit the possibility of interstate conflict in the region. However, although conflict between regional states is unlikely, it cannot be ruled out, particularly in an era of increasing global power competition as other external powers seek to expand their role in the region and secure access to valuable resources. Support to regional regimes and non-state actors could see countries drawn into proxy conflicts, potentially exacerbating regional tensions further.

67 Edwards, M., Ideology Theory Practice (11 February 2021), 'The ZOPACAS: a return to prominence'.

1 Bermuda (UK Overseas Territory)
2 Canada
3 Greenland (self-governing territory of Denmark)
4 Saint Pierre and Miquelon (overseas collectivity of France)
5 United States

Northern America

Current strategic context

Northern America is a vast, resource-rich region with enormous diversity in population, culture and economic power. It represents a significant part of the global economy and is a vital hub for global finance, innovation and technology, as well as space exploration, manufacturing and energy production. It attracts people from across the world as a destination for employment and study, and the United States (US) and Canadian populations are expected to grow significantly in coming decades through inward migration.

The region hosts one superpower with full global outreach, the US, and one influential middle power, Canada. Both are members of the North Atlantic Treaty Organization (NATO) (together with Greenland, as part of Denmark) and the Group of Seven (G7). Despite a decline in relative influence, the US still has the biggest military and economy in the world and is a respected leader of global alliances. Their location between two oceans makes the US and Canada both Atlantic and Pacific powers at the same time and, together with the presence of a US island state (Hawaii) and other US interests in the Pacific, this shapes their geostrategic thinking.

Extending from Greenland and the Canadian archipelago in the north to the US–Mexico border in the south, Northern America is characterised by extreme variation in climate and geography, from the ice and snow of the Arctic tundra to the tropical wetlands of southern Florida. Looking forward, the northern part of the region will attract growing attention as climate change and technology developments make it increasingly easy to access. With the easternmost point of Russia only 55 miles across the Bering Strait from mainland Alaska, this will add to its significance as a theatre for competition.

Greenland's status, as a self-governing, autonomous country within the Kingdom of Denmark, politically in Europe but geographically in Northern America, remains complicated. Whether its status will change in the long term remains uncertain.

Northern America has historically been regarded as a frontier region, with high levels of inward migration making it a melting pot of cultures and ideas. While this has acted as a driver for innovation and modernisation, it has also resulted in social tensions and, at times, revolution. Radicalism, born out of wars of independence and internal political divides, is still evident and violent civil disturbance, while uncommon, has been a consistent undercurrent in recent history. While the region enjoys high levels of socio-economic development, income inequality has increased dramatically since the 1990s. The impact of climate change-related severe weather events is taking an increasing toll on regional economies and societies, driving further inequality and threatening food security in large parts of the region.

Despite these challenges, Northern America remains one of the most stable regions in the world. It has broadly followed in the wake of the US' journey from pre-Second World War isolationism to its current status as a global superpower, where its unmatched economic and military power and its global alliances and partnerships make it hard to bet against. Inevitably, the region is shaped by the influence of the US, and hence other regional states, while independent entities, rely heavily on its powerful presence. Ultimately, however, US regional and global leadership will be determined by its own politics; domestic challenges, including social and economic pressures, could mean a re-evaluation of its global engagements and alliances in the future.

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Key drivers of change

Resources and the energy transition. Northern America has a wealth of natural resources, including energy sources, which will continue to shape economic activity and provide opportunities for wealth creation. While fossil fuels will remain a key export in the near to mid term at least, in the long term, the green energy transition will significantly shape Northern American societies and economies and drive demand for new resources. Out to 2055, access to shared spaces will provide new opportunities for the exploitation of fresh sources of critical resources, although these will become increasingly contested.

Environmental change. The effects of climate change, particularly on low-lying coastal population centres and agricultural belts, could drive an increase in internal migration and have a major impact on regional food security. The economic, societal and environmental impacts on the region's population is likely to be a key driver in regional politics.

Demographic pressures. As well as driving increased demand for health and social care, ageing populations will result in reductions in the available workforce in many regional countries. While in some sectors this will be balanced by the increasing use of automation, the need to attract skilled labour will nevertheless be an integral part of government and business strategies. Continuing inward migration, in parallel with an ageing domestic population, means that some regional states will see significant changes to their ethnic and demographic composition.

Technological advantage. Northern America is home to some of the most advanced technology firms in the world. The region could lead on technology developments to mitigate the effects of climate change over the next three decades and it is well placed to drive advances in automation and other disruptive technologies. Technological advantage has given the region, particularly the US, unique global shaping power; losing this lead could potentially result in a change in the global order in the long term. Maintaining technological advantage is therefore likely to be a key priority for the US and Canada.

Domestic pressures. Enduring socio-economic inequality, a changing demographic profile, continuing ethnic tensions and a decline in trust in state institutions will continue to present major challenges for the region, and the US in particular. This may drive further polarisation and tension out to 2055, potentially leading to unrest. Over time, this may lead to more inward-focused politics, with implications for global security and stability. A series of shocks may drive radical changes in policy (such as increases in federal welfare spending, universal health care and equitable access to higher education), propelling the region forward.

Future key trends

Global power competition

The countries of Northern America will strive to maintain the region's status as one of the most powerful and influential in the world. The US will face stiff competition from other powers, particularly China and India, but also from Russia as a legacy competitor and potentially from new emerging middle power blocs.

The US and Canada are likely to retain their global economic and security footprints in the coming decades. The US is likely to retain its economic and military lead, and both are likely to remain strong supporters of multilateralism and international institutions. The scale of their economic, political and security interdependencies means that it is difficult to imagine US–Canada relations weakening, and their continuing closeness will influence both countries' approaches to common transnational challenges and regional cooperation. However, Canada will wish to avoid being too dependent on the US, particularly if a future US government is distracted by growing domestic pressures, and it will increasingly look further afield in its economic and political relationships, in particular to Southeast Asia and Europe. Canada's vast natural resources and location between the Atlantic and Pacific Oceans mean that it will continue to attract foreign investment from both Europe and Asia, including China. While China will remain a major market for Canadian exports, Canada's concerns over China's human rights record and cybersecurity are likely to constrain their ties in future.

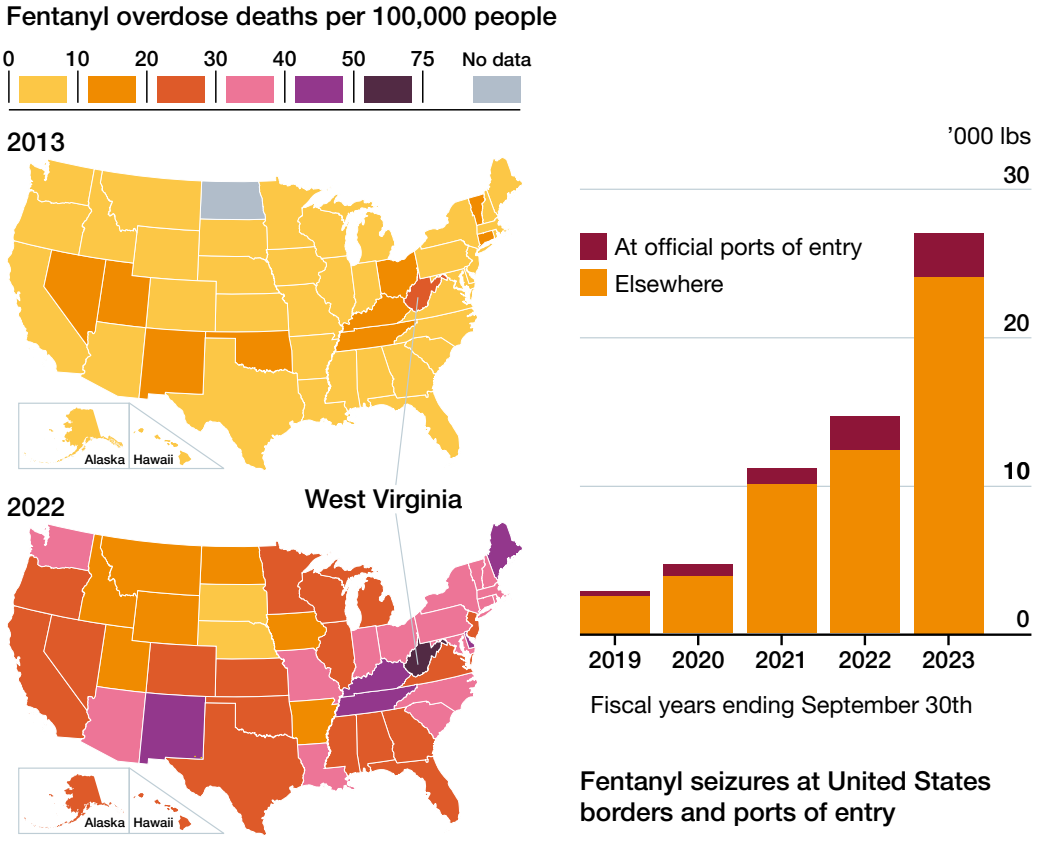
Over the next 30 years, the strength of NATO will depend very much on the role of the US and Canada as two of its key players. The future relationship between Northern America and Europe will be affected by US security priorities as well as the strength of Europe. A more unified and militarily capable Europe could emerge as a stronger security partner; however, it could also result in relations becoming increasingly challenged due to competing economic and strategic priorities. Either way, the US will continue to look further afield for wider security alliances, pursuing closer cooperation with partners in the Indo-Pacific region, such as South Korea, Japan, Singapore and other Southeast Asian states, as well as Saudi Arabia and the United Arab Emirates in Southwest Asia.

Rising global power competition in coming decades will see Saint Pierre and Miquelon, Bermuda and Greenland striving to navigate against the competing geopolitical interests of major powers. The ability to maintain strong ties with neighbouring states while also safeguarding their own interests will be crucial for their future stability and growth. Their vast natural resources, including critical minerals and fossil fuels, will attract growing interest from regional and global powers, particularly China and India, which will look to secure access through trade and economic leverage. Saint Pierre and Miquelon's fisheries and offshore oil and gas reserves could become the subject of increasing competition, and it may seek closer economic integration with the US and Canada in exchange for maritime security arrangements.

The next 30 years will see increasing competition in the High North and Arctic parts of the region, which have vital strategic importance for regional states. Out to 2055, sea ice melt will see new Arctic shipping routes being opened and may enable access to previously untapped natural resources. Overlapping territorial claims on the part of Russia,

Canada and Denmark/Greenland will fuel tensions over control of the Northern Sea Route, which could offer a shorter shipping route between Asia, Northern America and Europe, potentially reducing transport costs and boosting trade. Competition for influence and resources is likely to drive closer cooperation between Canada, the US and Denmark/Greenland to strengthen the region's northern flank, particularly in areas such as maritime security, resource management and preserving the ecosystem.[1] Cooperation to protect the Northern American mainland against missile attacks is likely to take further steps forward.

As the size of its Hispanic population increases, the US may look more closely to its relationships in Latin America and the Caribbean, where it now faces growing competition from a number of external actors, notably China. The future could see the US and Canada expanding the United States–Mexico–Canada Agreement (USMCA) to include other Latin American states, strengthening their geopolitical and economic reach and potentially acting as a counter to China's increasing influence in that region. At the same time, migration and the spread of drugs and serious and organised crime from Latin America and the Caribbean is likely to be an enduring concern for the US, influencing US domestic politics and constraining relations with countries to its south.



Source: United States Customs and Border Protection (2024)

The increasing use of drugs such as fentanyl is causing challenges across the region

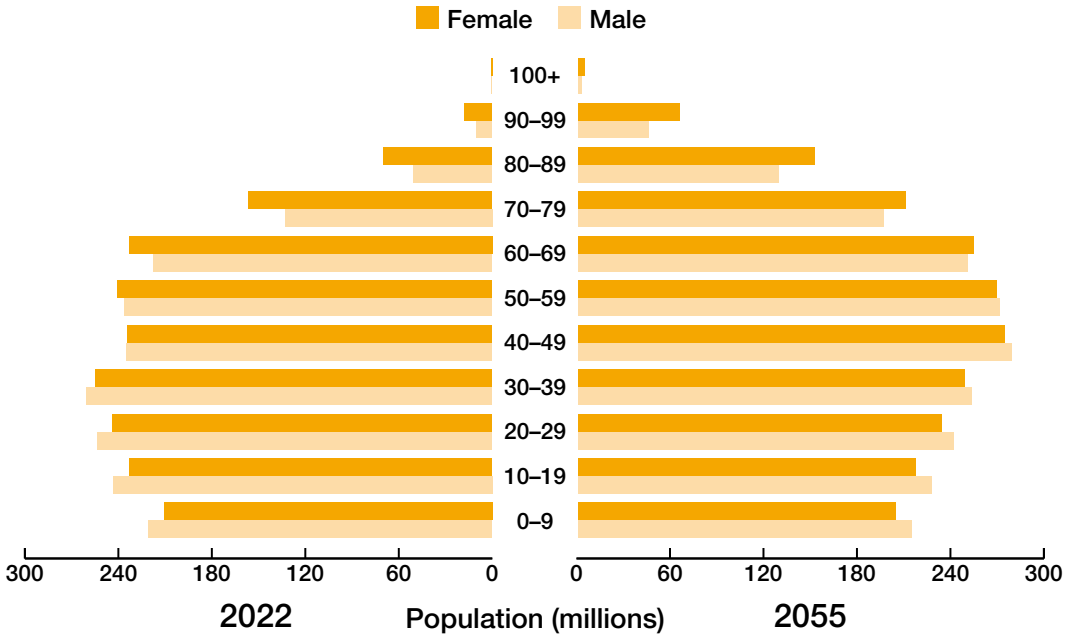
Northern American countries will continue to prioritise investments in innovation, research and development and education to maintain their competitive edge. If the US and Canada fail to retain their technological lead, the risk of losing ground to China, India and the expanding economies of Southeast Asia will increase. As geopolitical, economic and

1 Arctic360, 'Strengthening the Northern American Arctic'.

resource competition intensifies, the US is likely to take a more assertive stance towards its geopolitical rivals. This could lead to further technology protectionism and could see cyber espionage becoming more prevalent in the region.

Society

The population of Northern America will grow by over 45 million over the next 30 years, not peaking until well after 2055.[2] Approximately half the population will be of working age and around a quarter over retirement age, with Canada having the largest proportion of retirement age individuals in the region. On average, the life expectancy of the region is expected to continue to increase, with median estimates suggesting a rise of 5–10 years to around 84 years in 2055.[3]



Source: United Nations Population Division (2022)

Population statistics projection for Northern America by age range

The region's ageing population means that the level of the working age population, as a percentage of the overall number of people, could potentially be in decline by 2055. In Canada, for example, an ageing population combined with low birth rates will see fewer people being in the labour force for every person who is retired; by 2036, the ratio[4] could be fewer than three workers for every person aged over 65.[5] Similar trends will impact the US,[6] Greenland and Saint Pierre and Miquelon. As a result, both the US and Canada are likely to rely increasingly on inward migration to provide skilled labour. At the same time, shifts in global production and value chains, together with the impact of automation on low- and semi-skilled jobs in the manufacturing and service sectors, could result in a growth in unemployment in some areas, driving an increase in welfare spending in the long term.

2 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
3 Ibid.
4 Martel, L., Canada Statistics (20 March 2019), *The labour force in Canada and its regions: Projections to 2036*.
5 Deloitte, Future of Canada Centre, Catalyst (2020), *A vision for a thriving Canada in 2030*.
6 Toossi, M., U.S. Bureau of Labor Statistics (September 2016), Spotlight on Statistics: 'A look at the future of the U.S. labor force to 2060'.

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Inward migration and high birth rates will shift the ethnic make-up of the region towards Hispanic, Asian and African American populations

Increasing life expectancy and the need to maintain the health of individuals into older age will place pressure on regional health care systems. In the US, for example, the number of individuals aged 50 or older with at least one chronic condition is projected to increase by 99.5%, from 71.522 million in 2020 to 142.66 million by the middle of the century.[7] A similar trend is expected in Canada, with a recent assessment in the largest province of Quebec estimating that the number of people requiring long-term care could double in the same time frame.[8]

Inward migration and high birth rates among some groups means that the region will see significant shifts in its ethnic make-up and a rapid expansion of its Hispanic, Asian and African American populations, particularly in the US. In contrast, the non-Hispanic white population of the US is expected to drop below 50% within the next three decades.[9] Due to extensive inward migration, approximately 50% of the Canadian population is expected to be either foreign born or the offspring of foreign-born parents by 2040; at the same time, the indigenous population of Canada is likely to double.[10]

Canada has a much more favourable policy towards migration than the US at present, creating advantages for Canada's skilled labour force and its technical industrial base. Canada currently admits approximately 12 times more economic migrants than the US; given the political impetus to maintain this and current economic imperatives, this is likely to continue. In contrast, the US remains politically divided over immigration. Given the likely decline in its working age population, and its increasing requirement for highly skilled workers, this may put it at an increasing disadvantage by 2055.

7 Ansah, J. and Chiu, C., *Frontiers in Public Health* (13 January 2023), 'Projecting the chronic disease burden among the adult population in the United States using a multi-state population model'.
8 Clavet, N., et al., Research Chair on Intergenerational Economic Issues (February 2021), *Funding autonomy support for the elderly at a crossroads*.
9 Vespa, J., et al., United States Census Bureau (2020), *Demographic Turning Points for the United States: Population Projections for 2020 to 2060*.
10 Statistics Canada (27 April 2023), *Population Projections for Canada (2018 to 2068), Provinces and Territories (2018 to 2043)*.

The combination of a changing age profile and increasing ethnic diversification may lead to further political polarisation in the region, potentially resulting in an increase in tensions between different societal groups. The increasing prevalence of social media, misinformation and disinformation will continue to shape perceptions and political views, driving divisions within society and undermining attempts at political consensus. This could see the US, and potentially Canada, focusing increasingly on domestic priorities, impacting on public spending decisions and potentially seeing a reduction in funding for defence and overseas aid.

Religion is likely to remain a key influence in the region, particularly in the US. The majority of inward migration over the coming decades is expected to come from Africa, Asia and Latin America, influencing the religious composition of regional societies in the long term. Given this changing cultural mix, there is the potential for religious beliefs to become even more influential, potentially driving shifts in policy and a hardening of political attitudes.

While Northern America generally has a low population density of roughly 23 inhabitants per square kilometre,[11] some of the region's cities will experience rapid growth over the next three decades, due to population growth in urban areas[12] and inward migration. A handful of Canadian cities are expected to grow by many millions, increasing the requirement for city planning. By 2055, Canada may have some of the most advanced urban areas in the world.[13]

Economy

Northern American countries are likely to continue to constitute a significant part of the global economy over the next three decades. The region includes the largest and most technologically advanced economy in the world, the US; Canada, currently the tenth largest economy in the world, is another highly advanced, diverse economy. With its huge and well-established global financial centres, Northern America is likely to continue to be a strategically vital hub for global finance and services, as well as highly competitive in information technology, space exploration, manufacturing and the trade in energy.

However, an ageing population and changes in the workforce, in particular declining rates of participation in the labour force, will have implications for the regional economy. Automation is likely to increase across all sectors, growing by nearly 40% in the US and Canada by the 2030s and potentially seeing an exponential rise by 2055.[14] While this might compensate for worker shortages in some sectors, the bulk of the impact could be on low- and medium-skilled jobs, reinforcing the need to invest in skills development and provide accessible tertiary education for a greater proportion of the population. However, entrenched socio-economic inequalities could see the US higher education system remaining inaccessible to large parts of the population, limiting its ability to exploit the potential of its diverse population, and reducing the size of its skilled workforce. In contrast, Canada's more accessible education system could reinforce its competitiveness, boosting economic growth.

11 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
12 UN, Department of Economic and Social Affairs (16 May 2018), '68% of the world population projected to live in urban areas by 2050, says UN'.
13 Statistics Canada (27 April 2023), *Population Projections for Canada (2018 to 2068), Provinces and Territories (2018 to 2043).*
14 Hawksworth, J., et al., PricewaterhouseCoopers (PwC) (2018), *Will robots really steal our jobs? An international analysis of the potential long term impact of automation.*

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While Greenland's economy is likely to remain dependent on its fisheries, energy, minerals and tourism also make a contribution

The Northern American economy continues to be dominated by the service sector, followed by industry/manufacturing and the agriculture sector, which despite its importance for regional and global food security represents less than 2% of gross domestic product (GDP) for Bermuda and Canada and 1% for the US; the exception in the region is Greenland, where agriculture accounts for approximately 18% of GDP. As a percentage of each country's GDP, 93% of Bermuda's economy, 70% of Canada's economy, 78% of the US economy and 63% of Greenland's economy was generated by the service sector in 2022. Out to 2055, the service sector can be expected to remain dominant.[15] Despite much automation of banking and other customer-service roles, employment will remain high in sectors that cannot yet rely on machines, such as health care and education.

Greenland's economy is expected to remain dependent on its fisheries, with minerals, energy and tourism also making a contribution.[16] A desire for economic independence may drive Greenland to actively seek investment into its increasingly accessible mineral and fossil fuel deposits; the main interest is likely to come from other Northern American countries and Europe, as well as China with its growing appetite for critical minerals. With its huge consumer and tourism markets and as a major importer of fish, China could be responsible for significant increases in Greenland's GDP and raise the prospects for independence.[17]

Bermuda's status as an international finance hub will face growing competition from emerging financial centres out to 2055. This will intensify the need for economic diversification and to explore new opportunities for the island.

15 World Bank (2024), 'World Development Indicators: Economy, 4.2 – Structure of value added'.
16 Visit Greenland (2023), 'Greenland's Modern Path to Independence'.
17 Chen, C., *Polar Research*, Volume 41 (17 March 2022), 'China's engagement in Greenland: mutual economic benefits and political non-interference'.

Despite competition from other currencies, the US dollar should keep its status as the world's primary reserve currency

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The ability to maintain access to global markets will be key to strengthening the economic resilience of the region over coming decades. At present, 76% of Canada's total exports are to the US and 18% from the US to Canada, highlighting Canada's dependence on trade with its southern neighbour, as reinforced by the USMCA trade agreement.[18] However, out to 2055, Canada could see its trading relationships with global partners external to the USMCA increase, reducing its dependence on US markets.

Primary commodities, and fossil fuels in particular, will continue to form a significant proportion of US and Canadian exports, as well as remaining key to regional energy security in the near to mid term at least. However, the region will also look to transition away from fossil fuels in favour of green energy sources as the pressure to act on climate change increases.

The US dollar is likely to remain the world's primary reserve currency, but may face increasing competition from other currencies such as the renminbi and euro.[19] Despite its currently high levels of peacetime debt, if inflation remains low the US will maintain its ability to borrow at low rates, allowing US corporations to continue to dominate globally.

Technology protectionism could continue to drive the economic decoupling of the US and China over the next three decades. This has been in progress for some time, with some major US technology companies having already chosen to relocate their manufacturing from China to other countries; China's investment in the US has also dropped, with the relocation of former US-based Chinese companies. Rising tensions between China and the US could increase technology protectionism still further. However, major economic dependencies are likely to remain; for example, US and Canadian manufacturing firms may continue to rely on inputs from China and other parts of the world, and the US will remain a considerable, almost irreplaceable, market for Chinese exports.[20]

18 International Trade Administration, U.S. Department of Commerce (11 March 2023), 'Canada Country Commercial Guide: Agricultural Sector'.
19 Parakilas, J. (2021), *Facing Rivals, Facing Itself: the US to 2050* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
20 Ibid.

Environment

Climate change will have significant implications for Northern America over the coming decades. Already under huge pressure, the region is likely to suffer from more frequent and intense extreme weather events, including droughts, heatwaves, forest fires, heavy rainfall and flooding.[21] In the absence of policy interventions to address its effects, the impact of climate change on the region's societies and economies could be substantial over the next 30 years.

The impact of severe weather events on low-lying coastal populations and financial centres, and on inland agricultural belts, could result in extensive economic loss, pressure on food production and significant internal migration, especially in the US. Rising sea levels will present one of the largest risks, with many of the country's key population centres sited by coastlines; protecting these areas will be extremely expensive. Building sea walls for storm surge protection for coastal cities with more than 25,000 residents will require at least US $42 billion; if this were to be expanded to communities under 25,000 people, the cost would increase to US $400 billion.[22] Mitigation and adaptation measures are likely to be primarily focused on major urban and financial centres, exacerbating existing urban-rural divides in an already fractured US political system.[23]

One third of the Canadian coastline is moderately or highly sensitive to sea level rise, including 80% of the Nova Scotia, New Brunswick and Prince Edward Island coasts. The high concentration of people and infrastructure in Vancouver makes this area particularly vulnerable. The annual cost of flooding to dwellings due to baseline risks and climate change could be between US $4 billion and US $17 billion by the middle of the century.[24]

The Vancouver Gateway

The Port of Vancouver holds a significant position in global trade due to its strategic location (being situated on the west coast of Canada and serving as a key gateway between Asia and Northern America), its high capacity to handle a diverse range of cargo, and its intermodal connectivity. The port is projected to increase its market share of trade by approximately 5.3% (3.5% for exports) by 2060.[25] As trade volumes increase, the port could see its container traffic doubling, or even tripling, by 2055. However, vulnerability to flooding will remain an issue and could cause significant disruption in the future. In 2021, for example, heavy rain caused flooding and landslides, preventing rail access to the port and causing significant delays to shipments.[26]

21 University of Vermont (2021), *Vermont Climate Assessment 2021*.
22 Morrison, J., YaleEnvironment360 (5 August 2019), 'Who Will Pay for the Huge Costs of Holding Back Rising Seas?'.
23 Parakilas, J. (2021), *Facing Rivals, Facing Itself: the US to 2050*, (a research paper commissioned by DCDC).
24 National Round Table on the Environment and the Economy (2023), 'Paying the Price – Coastal Areas'.
25 Drewry, report prepared for Port of Vancouver (October 2020), *VFPA Long Term Container Forecast: 2020 – 2060 Final Report*.
26 Gajda, A. and Nickel, R., gCaptain (16 November 2021), 'Flood Damage Cuts All Rail Access to Port of Vancouver, Canada's Largest Port'.

Bermuda, Saint Pierre and Miquelon and Greenland will increasingly be exposed to climate change threats

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Altogether, the impacts of climate change are likely to be felt across multiple sectors. Agricultural productivity in the region, and in the US in particular, is likely to shift as a result of rising temperatures and changing rainfall patterns. Some areas may observe longer growing seasons; however, drought may be responsible for declining yields in areas that are productive today. Fisheries and aquaculture could be affected by changes in sea temperature and acidity levels, leading to the migration of fish stocks. Energy consumption and production will also be impacted, with rising temperatures and more frequent heatwaves resulting in increasing demand for air conditioning. The increased frequency of floods and wildfires and intensity of hurricanes could see extensive damage to critical infrastructure, with corresponding implications for regional economies and social development.

Northern American countries stand to see some benefit as their northern territories open up as a result of climate change, potentially enabling access to new areas of agricultural land and mineral deposits. In Canada, the availability of previously non-viable sub-Arctic territory for crop production and grazing could provide a boost to regional food production, potentially increasing reliance on Canada for regional and global food security and improving its ability to negotiate favourable trade deals.

While the region's major countries have the wealth and geographical size to absorb the financial and social impact of climate change, the low-lying islands of Bermuda and Saint Pierre and Miquelon will face an existential threat from sea level rise and heightened temperatures. Historical temperature trends in the sub-Arctic archipelago of Saint Pierre and Miquelon, for example, show an increase of around 1.6° Celsius in the last 33 years.[27] Out to 2055, these islands will inevitably view adaptation measures, including relocation of communities, as an urgent priority for their vulnerable coastal areas.

Northern America's consumerist culture could limit popular acceptance of policies aimed at addressing the threat of climate change. A disaffected electorate, combined with an influential energy sector and an industrial base that still relies heavily on fossil fuel use, will be difficult obstacles for the environmental lobby to overcome. Nevertheless, recent green energy initiatives have already started to influence the region's energy mix, and if such programmes receive further investment, Northern America may pull ahead of Europe in this area. Canada and Greenland, for example, generate around 84% of their energy from

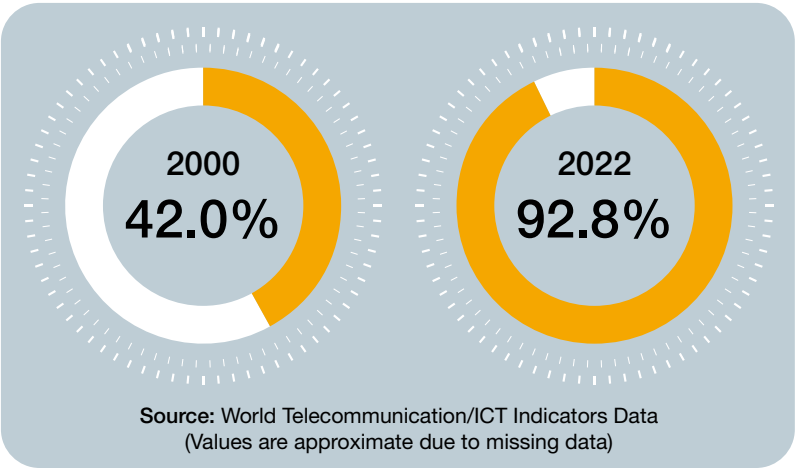
27 WorldData.info (October 2023), 'The climate in Saint Pierre and Miquelon'.

non-emitting sources such as nuclear, wind and hydropower;[28] in 2022, the US introduced the biggest national climate package ever seen through its Inflation Reduction Act. In addition, high fossil fuel prices will increase the incentive to implement change, speeding up the transition process.

The region could see new collaborations to combat the effects of climate change, for example, with Mexico. If the requirement to address environmental challenges becomes a priority in politics, and regional powers find ways to work together to implement policies at the national and global level, Northern American countries could be key contributors to global efforts to tackle climate change.[29]

Technology, infrastructure and communications

Technology has traditionally been a strength for Northern America and out to 2055 the US, as the region's leading technology power, will work hard to retain the global primacy that it still enjoys in many fields. With over 97% of its population having access to the Internet (around 300 million Internet users), an increase of over 20% from 2012, the US is one of the biggest online markets in the world.[30] In space exploration, the US will continue to benefit from an unparalleled skills and investment ecosystem, with high levels of cooperation between state and business. The US will also remain influential in media and entertainment technology, big data and artificial intelligence.[31] Canada will continue to perform strongly in cybersecurity, cloud services and the Internet of things, as well as artificial intelligence, robotics and augmented reality.[32] In addition, its global leadership in high-tech industrial and scientific research on novel materials and energy means that Northern America is likely to remain a key player in identifying viable technological solutions to combat the effects of climate change. A number of highly competitive cities and technology hubs in the US and Canada will further reinforce the region's global outreach.



Average percentage of the population using the Internet in Northern America

28 Government of Canada, Environment and Climate Change Canada (10 August 2023), 'News release: Canada powers toward more clean, affordable, and reliable electricity with draft regulations'; LowCarbonPower, 'Electricity in Greenland in 2021'.
29 Government of Canada, Environment and Climate Change Canada (2016), *Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy*.
30 DataReportal, et al., Statista (1 February 2024), 'Percentage of population using the internet in the United States from 2000 to 2024'.
31 Diplomatist Bureau, *The Diplomatist* (2 March 2022), 'How the Tech Industry is Driving the US Economy'.
32 International Trade Administration, U.S. Department of Commerce (11 March 2023), 'Canada Country Commercial Guide: Information and Communications Technology (ICT)'.

Canada's hydrogen strategy could give it a significant advantage in the energy transition

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In the next three decades, the National Aeronautics and Space Administration (NASA) is likely to return crewed missions to the Moon through the Lunar Gateway and will pursue ventures to land the first humans on Mars with the Orion Multi-Purpose Crew Vehicle. The US will leverage civil space activities through its growing space industry, with wider socio-economic effects in the region.

Canada, while not at the scale of the US, nevertheless benefits from a technology sector worth approximately US $120 billion, employing nearly 7% of its labour force.[33] Canada's space strategy will remain a vital part of its push for scientific excellence, and its efforts to reap the socio-economic benefits of space exploration and combat the effects of climate change. Out to 2055, Canada, like the US, will view space as a strategic national asset and will seek to foster innovation to unlock its full potential.[34]

In addition, Canada will continue to develop its hydrogen strategy, which may also potentially provide it with a technological advantage. The country aims to become a world-leading supplier of clean hydrogen and fuel cell technologies by the middle of the century, helping it to reach net-zero targets.[35]

Northern American technology companies are likely to be at the forefront of advances in automation; this will be a key enabler for the region to address the challenge of a tight labour market without losing its manufacturing market share to China, India and other countries. Importantly, however, the automation of manufacturing and routine administrative services could see mass displacement of workers in some sectors, leading to large-scale unemployment. If not met with adequate reskilling support or welfare assistance, this could substantially increase levels of socio-economic inequality, and lead to a rise in economic migration within and possibly out of the region.

33 Bennett, N., Business in Vancouver (29 November 2023), 'Nearly 7% of Canada's workforce are technology workers'.
34 Government of Canada (2019), *Exploration, Imagination, Innovation: A New Space Strategy for Canada*.
35 Government of Canada (12 March 2024), 'What success looks like: Our vision for 2050'.

Advances in artificial intelligence have led to the automation of relatively sophisticated decision-making processes in financial services and banking, which could see the replacement of large numbers of jobs at middle management level across a range of service sector industries. Although this could partly be mitigated by the creation of new roles in programming and robotic support, there is a risk in terms of overall employment opportunities and working patterns.

The region's agriculture is likely to be revolutionised by technological developments such as synthetic food manufacture and robotic farming, as well as the use of vertical farming techniques in urban areas to save on space and transport costs. As the impact of climate change increases, the US could mitigate declines in agricultural production by developing high-tech food production solutions. However, substantial private capital investment is likely to be required to maximise on the opportunities that such advances offer.

Northern America: a technology hub

According to the 2022 Global Innovation Index, the top 100 science and technology clusters remain highly concentrated in Northern America, Europe and Asia, but especially in the US and China, which lead the field with 21 clusters each. The US took second place to Switzerland in the overall innovation rankings, with Canada in fifteenth place. The US was judged to perform best in market sophistication (in first place worldwide), business sophistication (third) and knowledge and technology outputs (third), while Canada scored highly in venture capital recipients (first), joint venture/strategic alliances (first) and computer software spending (third).[36]

Conflict and security

In recent decades the US has relied on the size, skill and technological edge of its armed forces to sustain its global outreach and military supremacy, and with it its status as a global hegemon. In the future, however, there will be increasing uncertainty as to whether the US can retain this lead, with China catching up in key technologies and even bypassing the US to some extent in critical mass.

Current defence spending, global reach metrics and levels of investment in military technology suggest that out to 2055 the US will remain a global military power, with available personnel almost ten times that of Canada. Within the region, the US will continue to dominate in all areas of capability, both in terms of mass and the sophistication of its technology.[37] This is significant when seen in the context of NATO and other alliances involving US and Canadian defence forces, where the US lead and commitment forms the core of these.

36 World Intellectual Property Organization (2022), *Global innovation Index 2022: What is the future of innovation-driven growth?*
37 Global Firepower (2024), 'Comparison of United States and Canada Military Strengths (2024)'.

Despite the dynamics of its domestic politics and cross-regional challenges, the United States is likely to remain a key contributor to NATO and strategic stability

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Both Canada and the US are likely to continue to commit their forces to interventions beyond their own borders and hemisphere, and will most likely continue to be key supporters of NATO, as well as a range of other alliances. The Northern American region will retain its close security cooperation with Europe, in particular through US and Canadian involvement in NATO, with a resurgent Russia being regarded as the key threat in the near term at least. However, China will continue to be viewed as the long-term security challenge, for the US in particular. Out to 2055, the US will retain its focus on regional stability in the Indo-Pacific region, providing security guarantees from the Indian Ocean to the Korean Peninsula and all the way through to Australia and New Zealand. US military bases in Hawaii and Guam will be instrumental in providing it with access to the region, and will remain pivotal to its status as a Pacific power.

Although Russia's future trajectory remains uncertain, it is likely that the next 30 years will see China gradually overtake Russia as the region's most advanced adversary in both military and technological terms. This could lead to an arms race between the US and China as countries seek to retain or gain advantage in areas such as electromagnetic warfare, hypersonic vehicles, human augmentation, directed energy weapons and counterspace and undersea capabilities. Competition will extend into space and onto the Moon, particularly as China seeks to establish a permanent presence on the Moon and Mars.

Cybersecurity will be an increasing concern for Northern American countries, with distributed denial of service attacks, targeting of critical infrastructure and cyber espionage becoming more major threats.[38] Current threats to cybersecurity in Northern America, and particularly to the US and Canada, primarily originate from China, Russia, North Korea and Iran.

38 SOCRadar (6 April 2022), 'What are the Biggest Cybersecurity Risks in North America?'.

However, out to 2055, the greatest threat to regional countries may still come from domestic security challenges, including the impact of increasingly powerful transnational crime networks, home-grown radicalism, extremist violence and terrorism, and gun violence. In addition, the hugely destructive impact of climate change and resulting movement of people will add to the burden on regional states. As a consequence, homeland security will remain the primary focus for the region as Northern America struggles to respond to the domestic impact of transnational challenges.

Shared spaces

Arctic states
1 Canada
2 Finland
3 Greenland (self-governing territory of Denmark)
4 Iceland
5 Norway
6 Russia
7 Sweden
8 United States
Arctic Circle
Arctic
1
8
6
5
3
4
2
7
5

The Arctic

Current strategic context

The Arctic Circle covers an area of approximately 14.5 million square kilometres, equivalent to just under 3% of the Earth's surface.[1] At the Arctic's centre is the Geographic North Pole, which is surrounded by the Arctic Ocean basin and the northernmost parts of the eight Arctic states (Canada, Denmark (via Greenland), Finland, Iceland, Norway, Russia, Sweden and the United States (US)). Unlike Antarctica, the northern polar regions have a long history of human presence, with indigenous inhabitants present over 30,000 years ago. European exploration and colonisation began as early as the 9th Century; starting as a search for animal commodities, this subsequently resulted in sea passages connecting the Atlantic and Pacific Oceans. These journeys exposed the full scale of the region's resources, from whale oil and seal fur to minerals, including coal, diamonds, nickel and copper, leading to commercial exploitation at often near-unsustainable levels. The Arctic's oil and gas reserves remain a focus to this day.

During both World Wars and the Cold War, the geostrategic importance of the Arctic became evident as an arena of tension and strategic posturing, often serving as the shortest route between competing powers. Militarisation grew throughout the 20th Century, including the placement of nuclear weapons, intercontinental ballistic missiles, long-range bombers and military personnel, and the region effectively became a military front line.

Mikhail Gorbachev's 1987 Murmansk speech heralded the start of a more cooperative relationship between Moscow and the West, paving the way for the formation of the Arctic Council. The eight Arctic states signed the Ottawa Declaration establishing the Council in 1996. The Declaration prevents discussions on military security, instead focusing the Council on the rights of indigenous peoples and resource and environmental issues.

Today, however, a combination of geopolitical and environmental factors means that the region is once more becoming increasingly contested, placing the Arctic Council under growing strain. Global warming has opened up new maritime routes and further exposed resource deposits. The region is also becoming an attractive tourist destination and is seeing an expansion in global fishing activity. The Arctic is therefore becoming a region of interest to a broader range of state and non-state actors, many geographically distant. This is occurring at a time when the international order is facing a number of challenges, including renewed tensions between Russia and the North Atlantic Treaty Organization (NATO) and between China and the West, leading other states to position themselves to take advantage of the emerging multipolar world order. As a result, some states have started to modernise and expand their military presence in the region to protect their interests, potentially undermining Gorbachev's 1987 vision of the Arctic as a zone of peace and cooperation.

1 Means, T., Live Science (8 July 2020), 'The Arctic Circle: Polar portal to the Arctic'.

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Key drivers of change

Geopolitical competition. The eight Arctic states will seek to maintain their sovereignty in the region but will encounter growing geopolitical challenges from a broad range of state and non-state actors – including those geographically distant to the region. Russia will continue to view the Arctic as a strategic theatre through which to challenge NATO member states, and its current political isolation will lead it to seek partnerships with non-Western powers, notably China and India. As the security paradigm in the region changes, there may be an upwards trend in militarisation as states seek to protect their defence and economic assets, further heightening tensions across the region.

Changing Arctic environment. Climate change is having a more rapid and visible impact on the Arctic than anywhere else in the world, and out to 2055 will cause the geophysical characteristics of the region to change dramatically. The changing Arctic environment will have not only regional but also global implications, affecting weather patterns and sea level rise. Native Arctic species will continue to be threatened by a combination of a warming climate and increased human activity; however, shifting migratory patterns and changing habitats may also offer new economic opportunities.

Demographic and societal shifts. Demographic projections in the Arctic are likely to remain relatively stable and any growth is likely to come from inwards migration, potentially leading to wider societal changes, which may give rise to tensions at a community and regional level. Urbanisation will continue, with the region's frontier towns and cities becoming increasingly important as economic hubs and as centres for employment, education and government services. Indigenous populations will strive for a greater voice in matters of regional importance and may challenge state authorities for influence; however, these communities may be increasingly threatened by the worsening climatic situation and social transformation.

Commercial value of the Arctic. The economic importance of the Arctic will increase by the middle of the century, with both state and non-state actors competing for greater influence and control over the region's assets. Retreating sea ice may open up new sea lanes for maritime vessels for longer periods, thereby shortening commercial transit routes. Similarly, the changing landscape will reveal new resource deposits, fuelling disputes around ownership, delineation of territory and the extraction of these materials. As the Arctic's commercial value continues to grow, and a wider array of actors look to establish a foothold, this could lead to a change in regional security dynamics.

Challenges to governance. Whilst the Arctic Council is likely to endure as the leading forum for regional governance, relationships between Arctic and non-Arctic states will remain inconsistent and based largely around cooperation with like-minded actors. A key determinant of the Council's longevity and global recognition in the future will be its willingness to extend membership to an array of new actors – both state and non-state – that out to 2055 will become increasingly interested in the region. Whilst it is not a defence forum, the Council cannot remain separated from the relationship between NATO and Russia, and its ability to operate effectively will be affected by regional security dynamics.

Future key trends

Global power competition

Russia's geographical position and deep-rooted history in the region mean that it is likely to continue to be a major Arctic power out to 2055. Protection of its long northern border and control over the Northern Sea Route between Europe and Asia will be key priorities, with Russia intending to open up this passage as an alternative to the Suez Canal to boost its economy. In the wake of its invasion of Ukraine, Russia's current political isolation is likely to see it seeking to strengthen relationships with non-Western actors present in the Arctic.

Source: The Wilson Quarterly (2022)

The Western-aligned Arctic states – namely Canada, Denmark, Finland, Iceland, Norway, Sweden and the US – will continue to focus on protecting their northern borders, as well as deterring Russian aggression and responding to China's growing interest in the region. All of the Arctic states will seek to maintain their territorial claims and exclusive economic zones, including ensuring access to the natural resources that lie within these areas. In recent years, Canada, Denmark, Norway, Russia and the US have made submissions to the United Nations to extend their continental shelves, including in sections of the Arctic Ocean where these claims overlap.[2] This is likely to endure as a contentious issue, as ice reduction improves accessibility to the region. Competition for the region's offshore resources will also continue, with the majority of Arctic states investing in ports and infrastructure, and in some instances upscaling military capabilities to protect these assets.

2 Fischetti, M., *Scientific American* (1 August 2019), 'Nations Claim Large Overlapping Sections of Arctic Seafloor'.

Claims/exclusive economic zones

Russia | Iceland | Canada | Contested areas
Norway | Denmark | United States

Source: based on an often-cited map from the International Boundaries Research Unit at Durham University

Maritime claims in the Arctic region

The European Union (EU) will look to exert influence through its Arctic Council members as well as through bilateral relations and alternative forums. For example, the European Commission is a member of the Barents Euro-Arctic Council, an intergovernmental forum for sustainable development in the region. Similarly, the EU engages with Iceland, Norway and Russia via the Northern Dimension, which focuses on strengthening ties with non-EU members. These links offer a potential route for the EU to increase its relevance in the region, as well as potentially (depending on future events in Ukraine) helping to reset future relations between the West and Russia.

China is likely to continue its efforts to secure favourable access to resources and strategically important sea lanes and areas, including access for polar space facilities.[3] Its deepening relationship with Russia plays to this objective, but also now creates challenges given Russia's deteriorating reputation. China will therefore seek to develop its relations with other Arctic states to offset this risk, while continuing to strengthen its ties with Russia. India is likely to adopt a more persistent presence in the region and could become a leading Arctic power by 2055. The country's history of positive cooperation with the Arctic Council puts it in a favourable position to expand its influence.

Other non-Arctic states will also seek to establish a foothold in the Arctic, including France, Germany, Italy, Japan, South Korea, Singapore and the UK. Current priorities include scientific cooperation, regional environmental policy and commercial interests, but this dynamic could shift if the wider geopolitical and security situation deteriorates. As a consequence, non-Arctic states will seek to form partnerships with like-minded actors to garner influence and establish a sense of collective strength in the region.

Out to 2055, geopolitical tensions could lead to a further deterioration in relations between Arctic Council members, with the very real risk that at some point the Council could cease to function. That said, its potential to offset rising global power competition through cooperation in areas of shared interest remains, and could see the Council seeking to increase the number of non-Arctic state members. However, Arctic states could block new applications for membership due to wider geopolitical tensions, which may further divide the Council. Over the next 30 years, intergovernmental and non-governmental organisations will also seek to increase their voice in Council affairs as environmental issues become more visible and have a greater impact on people across the globe.

Society

The Arctic region is home to 4 million people, mostly in Northern Scandinavia and Russia.[4] Out to 2055, the total population is likely to increase by only 1%;[5] however, this masks significant variation across the region. High birth rates and inward migration, for example, are likely to see the Arctic populations of Iceland, Alaska (the US) and Canada increase by more than 10% by the middle of the century.[6] Arctic Russia, conversely, is expected to experience a population reduction of more than 5% in the same time frame.[7] All Arctic states have ageing populations, with the largest absolute growth projected to be among the elderly and those of retirement age. Regional states have historically had a high ratio of males to females within their Arctic populations, but this is expected to become more balanced over the next three decades.[8]

3 Robinson, J., *The Journal of the Joint Air Power Competence Centre*, Edition 30 (September 2020), 'Arctic Space Challenge for NATO Emerging from China's Economic and Financial Assertiveness'.
4 European Environment Agency (11 May 2020), 'Arctic region briefing – The European Environment – State and Outlook 2015'.
5 Heleniak, T., Nordregio, Nordregio Working paper 2020:3 (4 May 2020), *Polar Peoples in the Future: Projections of the Arctic Populations*.
6 Heleniak, T., Nordregio (2020), *Polar Peoples in the Future: Projections of the Arctic Population – Executive Summary*.
7 Ibid.
8 Ibid.

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Traditional Arctic lifestyles will come under increasing pressure

The Arctic will become increasingly urbanised as people move away from smaller settlements and communities towards the region's larger towns and cities. By the middle of the century, more than 70% of the Arctic population will live in urban areas, having relocated in search of education and employment opportunities, health care and social services.[9] Indigenous communities are also increasingly moving towards urban centres to join the formal labour market as traditional lifestyles come under increasing pressure. This could see smaller Arctic settlements decline, with many abandoned entirely. These trends will result in a rise in living standards for some members of the population, but at the same time could exacerbate existing socio-economic inequalities within the region.

Over the next few decades, inward migration is likely to be a major source of population increase in many Arctic states. In Arctic Norway and Sweden, for example, net migration has accounted for 60% and 75% of population growth respectively since 1990. The proportion of foreign-born citizens in Iceland rose from 4.9% in 1996 to 14.9% in 2016. Net inward migration from both developed and developing countries can be expected to increase out to 2055, although precise levels will depend on economic conditions and employment opportunities. In Iceland, for example, the number of migrants rose in 2000 and then fell sharply in 2008 following the global financial crisis.[10]

Outward migration of young, educated people will continue to pose a challenge for the region, particularly when combined with an ageing population overall. Without a large, educated working age population, levels of productivity and economic growth may stall, meaning that the region could fail to fulfil its true economic potential. Arctic states are already attempting to identify new incentives such as tax breaks to attract young people, but so far these have met with limited success.

9 Chitturi, A., et al., Story Maps: ArcGIS (20 February 2021), 'Innovation and Adaptation in the Urban Arctic'.

10 Heleniak, T., Nordregio (2020), *Polar Peoples in the Future: Projections of the Arctic Population – Executive Summary*.

The region is rich in hydrocarbons and critical minerals, which are becoming increasingly accessible as the permafrost recedes

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The Arctic hosts a range of indigenous communities, each with their own distinct cultures, languages, histories and beliefs, which together make up 10% of the region's population in total.[11] Rights to land and natural resources are central to their cultures, and a number hold permanent positions on the Arctic Council. Formal legal frameworks of self-governance within states, such as the Sámi Parliament in Norway and the First Nations in Northern Canada, also provide avenues to protect their lifestyles. Nevertheless, industrialisation, social change and environmental challenges present a threat to the future of these communities, potentially increasing the support required from states and intergovernmental forums.

Economy

Over the next three decades, as global demand increases and the Arctic region becomes more accessible, there is likely to be increasing global interest in Arctic resources. It is estimated that the region possesses 90 billion barrels of oil (16% of the global total), 1,669 trillion cubic feet of gas (30%) and 44 billion barrels of natural gas liquids (38%), and approximately 22% of the world's undiscovered but technically recoverable fossil fuel resources.[12] Natural gas stored in frozen methane hydrates below the Arctic permafrost could also offer an alternative energy source.[13] Extraction has historically tended to focus on land deposits, but it is estimated that 84% of these fossil fuel resources lie offshore in continental shelves and deep ocean waters.[14] The Arctic also holds huge quantities of critical minerals and other resources, which out to 2055 may be required to enable the green energy and digital transitions. While the economic viability of extracting these resources, particularly in maritime areas, has been unfavourable until now, rising global demand for resources may see Arctic resource extraction becoming more financially viable, although the harsh Arctic climate will continue to pose a challenge.

11 Arctic Centre, University of Lapland (2022), 'Arctic Indigenous Peoples'.
12 Rowe, M., *Geographical* (12 August 2022), 'Arctic nations are squaring up to exploit the region's rich natural resources'.
13 Kastner, M., et al., *Energy&Fuels*, Volume 36, Issue 6 (24 February 2022), 'Energy transition and climate mitigation require increased effort on methane hydrate research', pages 2919–3346.
14 Keil, K., European Union Institute for Security Studies, *Arctic security matters* (1 June 2015), 'II. Economic potential', pages 21–32.

Estimated amount of undiscovered oil and gas in the Arctic

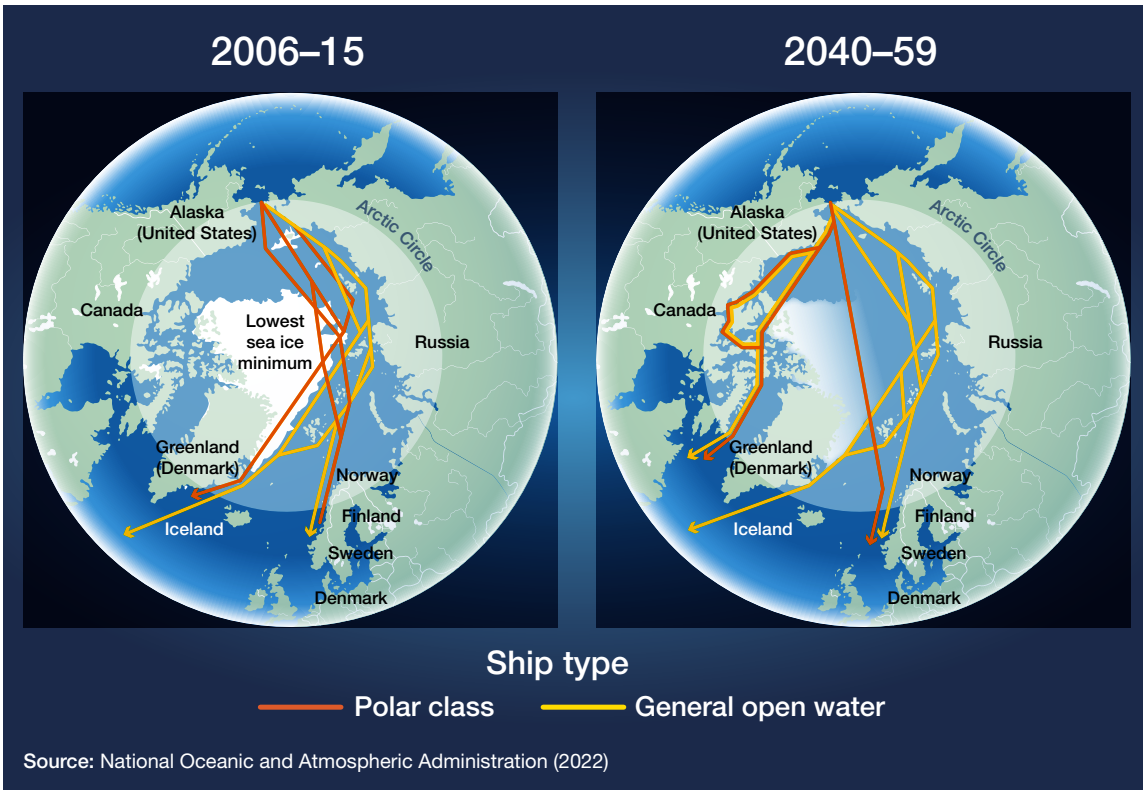
Over the next few decades, the ownership of resource deposits in the Arctic's international waters will become an increasingly contentious issue, which may intensify as the nature and value of resource deposits become better understood. This could see states' willingness to test or disregard international conventions on maritime territorial claims increase, as is likely to happen in other global regions.

The reduction in Arctic sea ice will continue to open up new maritime routes, which will stay navigable for longer periods of the year. These routes could be 30–50% shorter than the Suez and Panama Canal routes, reducing transit time by an estimated 14–20 days.[15] While this will facilitate global trade networks, the governance of these routes remains complex. In particular, Russia's claim to the Northern Sea Route and Canada's to the Northwest Passage remain disputed by some states, which regard both of these routes as international straits. This is likely to remain a source of contention out to 2055.

15 Lynch, A.H., et al., *Proceedings of the National Academy of Sciences*, Volume 119, Number 26 (21 June 2022), 'The interaction of ice and law in Arctic marine accessibility'.

Despite the shorter distances afforded by these Arctic shipping routes, the environmental conditions for transiting vessels are likely to remain hostile, creating navigational challenges and increased premiums on shipping insurance. Shipping companies may need to invest in more durable materials to protect vessels against these challenging conditions. Therefore, despite longer journey times, some shipping companies may continue to opt for alternative routes to avoid these additional costs.

A growth in regional maritime traffic is likely to see states investing in new port facilities. This may lead in turn to an increase in military presence to protect maritime vessels and supporting assets, to intercept illicit activity (such as illegal fishing and tracking), and to conduct search and rescue operations.



Model of future maritime ship traffic in the Arctic Ocean as new routes open

Arctic fishing accounts for approximately 10% of total global fish catches per year,[16] including around 50% of the EU's fish.[17] Fishing will remain a key economic activity for the region, and as sea ice continues to melt there may be new opportunities for exploitation of Arctic fish stocks, which could increase pressures on international agreements intended to protect these ecosystems. Warming ocean temperatures will also see an increasing volume of fish stocks move from territorial waters further north. Arctic states may refuse to renegotiate quotas because of changing migratory patterns, potentially fuelling tensions in the region.

Tourism in the Arctic has grown rapidly in recent decades, with a 35% increase in the number of passenger vessels operating within Arctic waters between 2013 and 2019.[18] Given rising global interest in the region and its growing accessibility, levels are expected

16 U.S. Climate Resilience Toolkit (2023), 'Arctic-Global Linkages'.
17 Troell, M., et al., *Ambio*, Volume 46, Supplement 3 (27 October 2017), 'Seafood from a changing Arctic'.
18 Arctic Council (10 May 2021), 'As Arctic marine tourism increases, how can we ensure it's sustainable?'.

to increase further out to 2055. Although tourism will be an important contributor to regional finances, the increasing environmental impact may pose a threat to regional ecosystems, through rising levels of pollution and the introduction of invasive species.

Environment

The Arctic has been warming at a rate three to four times faster than the rest of the world,[19] with a 2–3° Celsius increase in average surface air temperature since the pre-industrial era (1850–1900).[20] Its warmest years since 1900 occurred between 2016 and 2023.[21] While sea ice covers almost the entire Arctic Ocean during the winter (an area equating to approximately 6 million square miles[22]), this has declined by 31,100 square miles a year since 1979.[23] Since the 1980s, the Arctic has lost more than 40% of its summer sea ice;[24] in July 2020, sea ice covered just 2.8 million square miles, the lowest recorded measurement on record for that month. According to a United Nations Climate Panel report, even the most optimistic scenario will see Arctic summer sea ice disappear entirely at least once by the middle of the century.[25] Ice melt is already estimated to be responsible for 25% of global warming:[26] as oceans become increasingly exposed, they are becoming less reflective and more absorptive, reducing the Albedo effect and accelerating global warming.

As Arctic surface temperatures increase, the melting of terrestrial glaciers and ice sheets will lead to further sea level rise. The Greenland ice sheet – the second largest in the world – is losing around 250 billion metric tonnes of ice annually and is the largest contributor to sea level rise globally.[27] In the last decade, this has translated into an increase of approximately 1 millimetre per year,[28] but this rate could increase further. If the ice cap were to experience a heatwave every year similar to that recorded in 2012, for example, its contribution to global sea level rise would triple.[29] Recent studies have concluded that global warming is now at a point where it will contribute to irreversible ice loss on the Greenland ice sheet, resulting in 27.4 centimetres of global sea level rise. Although it is not currently possible to define the rate of change and a time frame within which this will occur,[30] this is likely to be on the scale of multiple centuries.

19 Bamber, J., World Economic Forum (15 August 2022), 'The Arctic is warming nearly four times faster than the rest of the world. How concerned should we be?'.
20 Easterling, D., et al., U.S. Global Change Research Programme (2018), *Fourth National Climate Assessment*, 'Chapter 2: Our Changing Climate'.
21 Lindsey, R. and Scott, M., National Oceanic and Atmospheric Administration (NOAA) Climate.gov (12 December 2023), '2023 Arctic Report Card: image highlights'.
22 Borunda, A., *National Geographic* (13 August 2020), 'Arctic summer sea ice could disappear as early as 2035'.
23 Lindsey, R. and Scott, M., NOAA Climate.gov (18 October 2022), 'Climate Change: Arctic sea ice summer minimum'.
24 Natural Environment Research Council, National Centre for Atmospheric Science (2022), 'What does Arctic climate change have to do with extreme weather in Europe?'.
25 Intergovernmental Panel on Climate Change (IPCC) (2021), *IPCC Sixth Assessment Report: Climate Change 2021 – The Physical Science Basis*.
26 Potenza, A., The Verge (10 May 2018), 'Here's what vanishing sea ice in the Arctic means for you'.
27 Harvey, C., *Scientific American* (13 October 2022), 'Greenland is disappearing quickly, and scientists have found a new reason why'.
28 Morlighem, M., et al., *Geophysical Research Letters*, Volume 44, Issue 21 (16 November 2017), 'BedMachine v3: Complete Bed Topography and Ocean Bathymetry Mapping of Greenland From Multibeam Echo Sounding Combined With Mass Conservation', pages 11051–11061.
29 Hubbard, A., Science: The Wire (5 September 2022), 'Whatever We Do, Greenland's Ice Loss Has 27+ cm of Sea Level Rise Baked In'.
30 Box, J.E., et al., *Nature Climate Change*, Volume 12 (29 August 2022), 'Greenland ice sheet climate disequilibrium and committed sea-level rise', pages 808–813.

Temperature rises in the region are affecting the previously stable foundations of houses and other infrastructure

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Rising temperatures will also accelerate permafrost melt, transforming landscapes and potentially causing widespread damage to infrastructure. As much as 50% of Arctic infrastructure is at high risk of damage by the middle of the century, potentially resulting in US $15.5 billion in maintenance costs and a further US $21.6 billion in damages.[31] Permafrost thaw will lead to the release of carbon dioxide and methane, which will exacerbate levels of global warming; it is estimated that Arctic permafrost contains enough carbon dioxide to raise global mean temperatures by over 3º Celsius.[32] The melting of Arctic permafrost also has the potential to release pathogens and other materials that are currently locked away in the ice, including ancient and undiscovered viruses, antibiotic resistant bacteria, and even radioactive waste from legacy Cold War equipment.[33]

Permafrost damage

In the Russian city of Norilsk, which is home to 177,000 people and located 180 miles above the Arctic Circle, almost 60% of the city's buildings have been compromised as a result of thawing permafrost, and 10% have had to be abandoned. In May 2020, permafrost loss at a fuel storage site close to the city caused a large leak of 21,000 tonnes of diesel, which has been assessed as the worst oil spill in the history of the Arctic.[34] Across the Arctic more generally, thawing permafrost could put as much as 45% of Arctic infrastructure at high risk of damage by the middle of the century.[35]

31 Hjort, J., et al., *Nature Reviews Earth & Environment*, Volume 3 (11 January 2022), 'Impacts of permafrost degradation on infrastructure', pages 24–38.
32 Meredith, M., et al., IPCC (2019), *Special Report on the Ocean and Cryosphere in a Changing Climate*, 'Polar regions', pages 203–320.
33 European Space Agency (22 October 2021), 'Permafrost thaw could release bacteria and viruses'.
34 Yaffa, J., *The New Yorker* (10 January 2022), 'The Great Siberian Thaw'.
35 Hjort, J., et al., *Nature Communications*, Volume 9 (11 December 2018), 'Degrading permafrost puts Arctic infrastructure at risk by mid-century'.

The increasingly visible impact of climate change in the Arctic will have global ramifications, in particular by altering ocean currents and weather systems. Alterations in the polar jet stream or the Labrador Sea convection system may result in changes to weather patterns and the frequency of extreme weather events such as droughts, heatwaves, extreme winds and heavy rainfall in other regions of the world.

The Arctic is home to more than 21,000 known species of cold-adapted mammals, birds, fish, invertebrates, plants, fungi and microbes.[36] The region's indigenous inhabitants are highly reliant on this biodiversity for food, materials and livelihoods, as well as it being deeply important for cultural reasons. However, the changing Arctic climate, combined with increasing human activity, is impacting on the behaviour and natural habitats of many of these species. Warming Arctic waters, for example, have seen cold-adapted fish species reduce significantly in number.[37] Warmer temperatures are also affecting bird populations and some species could potentially become extinct by 2055.[38] The changing Arctic landscape will also pose a threat to land-based mammals such as polar bears and seals; polar bears are now classed as vulnerable to extinction, with a 70% likelihood that their numbers will decline by a third before 2055.[39] Taken together, these changes to Arctic biodiversity will have a broad range of implications for wider ecosystems, food chains and livelihoods, many of which remain poorly understood.

Technology, infrastructure and communications

From shipping transits of difficult regions to deep sea mining opportunities, automation technologies will become increasingly important to Arctic activity out to 2055, reducing the need for humans to operate in its extremely hostile conditions. Automation has already achieved demonstrable successes in the region, from surface marine vehicles that monitor pollution and fish stocks to rudimentary personnel transport vehicles. This technology will continue to mature and increasing global interest in the Arctic region may provide a major incentive for higher levels of commercial investment. The Arctic could become a frontier for automated mining of oil, gas and critical minerals in both onshore and offshore settings in the next 30 years. Remote platforms will also potentially be used more routinely to maintain and sustain regional infrastructure.

Icebreakers will continue to be an important enabler for safe, reliable access to the Arctic, which, despite climate change impacts, will still have extensive sea ice for much of the year by 2055. Russia possesses the largest fleet in the world, with several more under development, and is currently the only state with a nuclear-powered variant. Russia's number of icebreakers is significantly higher than the number owned by any other Arctic state, meaning that these countries are forced to rely on Russia – a main strategic competitor for some – to fulfil their icebreaking needs.[40] Out to 2055, actors with the most technologically capable icebreakers, potentially including uncrewed variants, will be best adapted to operate in the treacherous Arctic waters. If relationships deteriorate (including

36 UK Parliament (29 November 2018), 'The Changing Arctic – Environmental audit committee'.
37 Steiner, N.S., et al., *Frontiers in Marine Science*, Volume 6 (10 April 2019), 'Impacts of the Changing Ocean-Sea Ice System on the Key Forage Fish Arctic Cod (Boreogadus Saida) and Subsistence Fisheries in the Western Canadian Arctic – Evaluating Linked Climate, Ecosystem and Economic (CEE) Models'.
38 Hoag, H., *The New Humanitarian* (12 May 2017), 'Ocean Warming Is Already Affecting Arctic Fish and Birds'.
39 Ashworth, J., Natural History Museum (17 June 2022), 'Greenland polar bears have learnt to hunt without sea ice'.
40 Di Pane, J. and Romaine, K., The Heritage Foundation (18 June 2021), 'U.S. Needs Icebreakers to Keep Up With China and Russia in Arctic'.

those with non-state actors, many of whom provide icebreaking capabilities as a service), then the freedom to operate in the region could be significantly hampered.

While there are currently few undersea cables in the High North, shrinking ice cover is changing the situation, allowing cables to be constructed over shorter distances as an alternative to longer routes further south. There are already a number of ongoing projects, including the Far North Fiber Express Cable through the Northwest Passage linking the Atlantic and Pacific Oceans. In 2021, a Russian state company announced plans to build a 12,650 kilometre cable around the north and eastern coast of Russia from Murmansk to Vladivostok. More projects could follow over the next three decades.

Far North Fiber Express Cable

The Far North Fiber Express Cable is a planned 17,000 kilometre subsea fibre-optic cable that will connect Asia to Europe via the Arctic's Northwest Passage. Due to become operational by 2027, the cable system will have landings in Ireland, Iceland, northern Greenland, four locations in Arctic Canada and Alaska and two locations in Japan, with plans for future branch connections in the Pacific, Canadian Arctic and Atlantic Oceans. This joint venture between US, Canadian, Finnish and Japanese companies will cost approximately US $1.17 billion, opening a more secure and faster route that connects three continents.[41]

New satellites in polar orbits will become increasingly important to understand climate change, monitor pollution, forecast weather and map geophysical changes to the Earth's environment. Within the region, satellite technologies will be increasingly relied on to ensure that land and maritime traffic can move safely, particularly as human activity grows over the next few decades. In addition, satellites will be used to map prospective resource deposits. These platforms will support multiple purposes, including military intelligence, surveillance and reconnaissance, and for monitoring illicit activities such as illegal fishing. Satellite technologies could also increasingly be used to support autonomous platforms operating in the region. While many of these functions can be carried out by technologically capable state actors, some will rely on greater interaction with commercial entities.

Conflict and security

The Arctic security situation is likely to evolve considerably over the next 30 years, as a growing number of actors increase their military profile in the region. Russia's military activity in the Arctic is likely to remain focused on protecting its nuclear capabilities in the Kola Peninsula, securing its northern flank and ensuring its ability to operate in the North Atlantic, as well as protecting its economic interests. Between 2014 and 2022, Russia reopened and modernised more than 50 Cold War-era bases, the majority concentrated along the western side of the Northeast Passage, including in the Barents and Kara Sea.[42]

41 Submarine Cable Networks, 'Far North Fiber'.
42 Rosen, K.R., Politico (17 December 2022), 'A Battle for the Arctic Is Underway. And the U.S. Is Already Behind'.

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The Arctic will continue to be of strategic importance, not least for NATO, as seven out of eight Arctic states are also NATO members

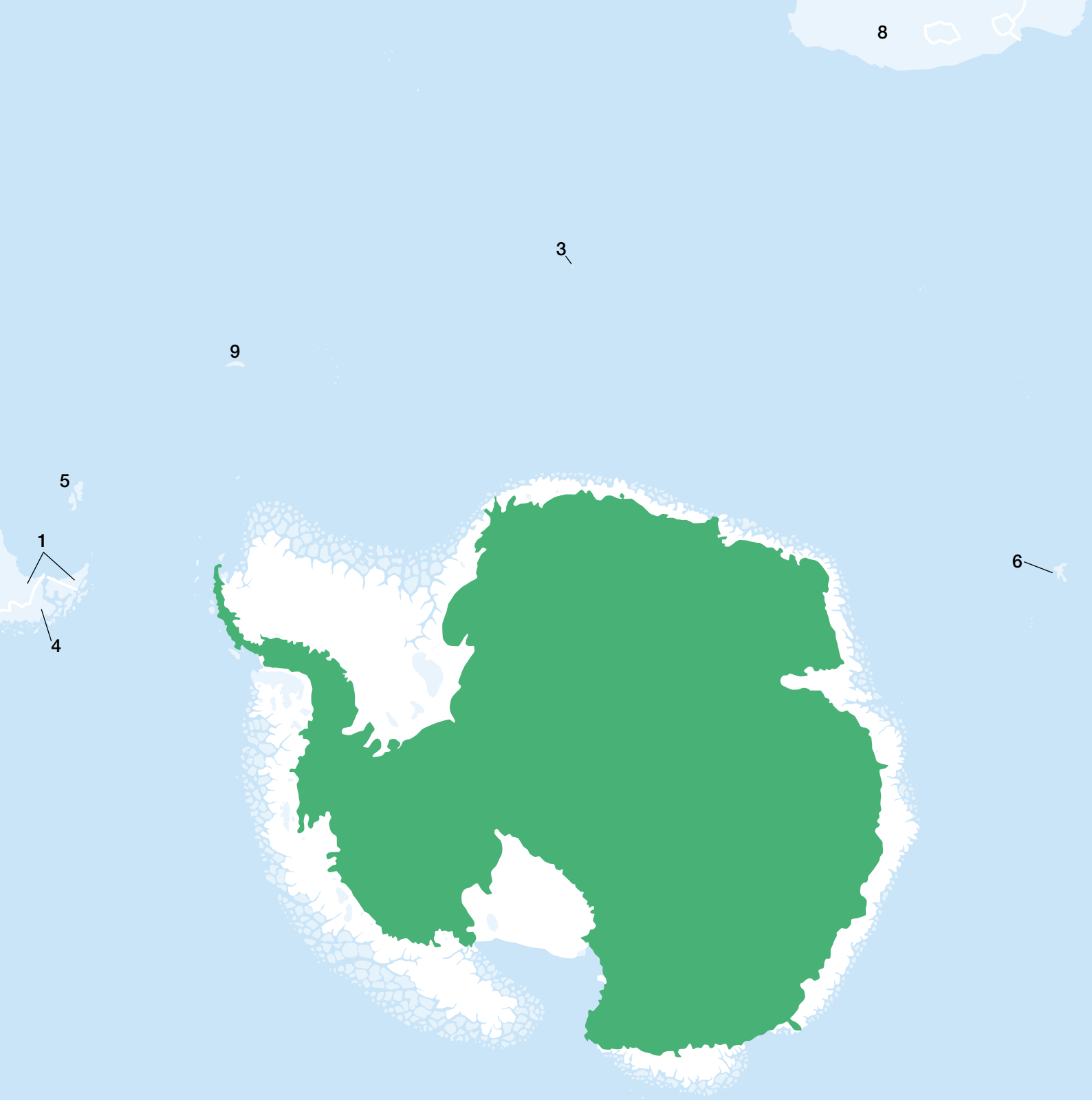
Safeguarding Russian interests in the Northern Sea Route and Northwest Passage will be pivotal to its defensive posture in the region, demonstrated by its efforts to upscale air defence capabilities and early-warning systems,[43] using both crewed and uncrewed platforms. Looking forward, Russia's growing sense of vulnerability and the diminishing strength of its conventional forces due to the conflict in Ukraine may result in Russia increasing the number of nuclear weapons deployed in the region.

China has also been increasing its military presence in the region, including the dispatch of naval assets on several occasions for goodwill visits but also potentially for power projection.[44] As China's interests in the Arctic continue to grow, it is likely that its military capabilities in the region will also increase.

The Arctic will continue to be of critical strategic importance to NATO. Seven out of eight Arctic states are now NATO members; Finland and Sweden's accession to NATO in 2023 and 2024 respectively has further strengthened NATO's northern flank.[45] Looking forward, a key challenge for NATO will be balancing the need for deterrence against a desire not to heighten tensions and re-militarise the region. Continued cooperation through the mechanism of the Arctic Council may offer one route to defuse tensions if competing interests can be bridged.

As the largest contributor to NATO, the US will maintain an assertive and significant military posture in the region to deter Russian and Chinese expansionism, including through new investments to secure its future interests. For other NATO countries, the duration and strength of Russian aggression out to 2055 will determine NATO members' willingness to maintain a deterrent posture in the High North through exercises and other means.

43 Boulègue, M., Chatham House (6 June 2022), 'The militarization of Russian polar politics'.
44 Doshi, R., et al., Brookings Institution (April 2021), 'Northern expedition: China's Arctic activities and ambitions'.
45 Burgess, A., ABC News (5 April 2023), 'Finland's NATO membership doubles alliance's border with Russia in major blow to Vladimir Putin'.

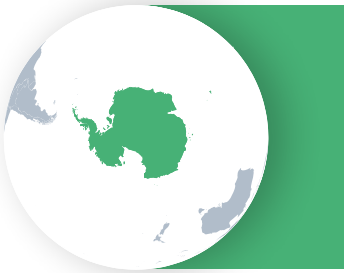


Countries adjoining the Antarctic region

1 Argentina
2 Australia
3 Bouvet Island[i]
4 Chile
5 Falkland Islands[ii]
6 French Southern and Antarctic territories[iii]
7 New Zealand
8 South Africa
9 South Georgia and South Sandwich Islands[ii]

[i] Dependent territory of Norway.
[ii] UK Overseas Territory.
[iii] French overseas territory.

The Antarctic



Current strategic context

Antarctica is the world's fifth largest continent, with a surface area of 14 million square kilometres.[1] Approximately 98% of the continent is covered by glacial ice that is 4 kilometres thick in places,[2] and it is estimated to hold 60% of the world's total fresh water.[3] The Antarctic is one of the most remote regions on Earth, with the nearest mainland coast located on the southern tip of South America nearly 1,000 kilometres away.[4]

Antarctica was the last continent to be discovered, in the 19th Century, leading to a race between states to lay claim to its vast spaces. To date, seven countries (Argentina, Australia, Chile, France, New Zealand, Norway and the UK) have made territorial claims, leaving 20% that is still unclaimed. However, the validity of these claims is not universally agreed between these countries or internationally. In particular, there are overlaps between the claims of Argentina, Chile and the UK.

Given fears that Antarctica could become a casualty of Cold War tensions, the United States (US) led negotiations that paved the way for the Antarctic Treaty System (ATS). The negotiating parties included the seven claimants and five other states which together had started multinational scientific collaboration, including establishing permanent research stations on the continent. This peaceful scientific collaboration has formed the basis for international relations since.

The ATS provides an overarching international framework for the governance south of 60ºS latitude, comprising the Antarctic Treaty, which was signed in 1959 by 12 countries and came into force in 1961, and subsequent conventions and protocols. Historically these have been successful in facilitating scientific research cooperation, banning mining, preventing new territorial claims, promoting environmental protection and avoiding militarisation. As of the beginning of 2024, 56 states are now party to the agreement.[5] There are 29 consultative parties – including all 12 original signatories – with the ability to vote and thereby dictate continental affairs.

The ATS is recognised as one of the most effective international agreements ever created, successfully balancing scientific and other national interests with diplomacy and international law. Whilst the Treaty does not have an expiry date, it states that any party can call for a review after 30 years. No party has yet done so. However, Antarctica's abundant resources have always remained of interest, and the 1991 Protocol on Environmental Protection (Madrid Protocol) that commits parties to 'comprehensive protection of the Antarctic environment' will become open for modification by any of

1 Redd, N.T., *Live Science* (21 September 2018), 'Antarctica: The Southernmost Continent'.
2 Davies, B., et al., AntarcticGlaciers.org, 'The Antarctic Continent'.
3 Natural Environment Research Council, British Antarctic Survey (2023), 'Polar Geography: Ice'.
4 Gross, M., *Current Biology*, Volume 32, Issue 6 (28 March 2022), 'Pristine Antarctica exposed to change', pages 203–320.
5 U.S. Department of State (14 February 2023), 'Antarctic Treaty, done at Washington December 1, 1959'.

the consultative parties to the Treaty in 2048. With ice melt exposing greater areas of its land mass, and technology potentially facilitating future access to commercial mineral resources, the risk of a breakdown in governance and associated geostrategic tensions could increase in future years.

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Key drivers of change

Geopolitical competition. Geopolitical dynamics in the Antarctic will become increasingly complex as a broader range of actors seek to exert their influence in the region. The changing landscape and shifting geophysical characteristics resulting from climate change may lead to new territorial claims, as well as spurring renegotiations of existing claims. Contestation of territorial claims is likely to become a more pressing issue, particularly once the location, value and accessibility of resource deposits becomes better understood.

Growing human presence. The number of humans present in the Antarctic will increase significantly, creating additional challenges for environmental regulation, maritime traffic and search and rescue operations. A rapid growth in tourist numbers and vessels will heighten the risk of environmental damage and human-made disasters. Scientific research on the continent will increasingly be used by states to bolster territorial claims, and states without an existing claim may potentially use this to position themselves for a future bid.

Global climate change. The effect of climate change on the Antarctic landscape, while still uncertain, is likely to pose an increased risk to humans, shipping and infrastructure operating on or near the continent. Significant loss of ice in parts of the region will contribute to sea level rise and changing weather systems at the global level. Pollution and climate change, as well as rising global food demand and illegal, unreported and unregulated fishing, will put substantial pressure on marine ecosystems in nearby waters.

Demand for resources. As global demand for resources increases and existing deposits become depleted, the need to identify new deposits could become a greater geopolitical priority, with the Antarctic potentially becoming a key focal point for competition. However, levels of commercial interest will be dictated by the economic viability of extraction, and accessible deposits elsewhere are likely to be more attractive and profitable in the near term. As global resource demand intensifies, the legitimacy of territorial claims is increasingly likely to be challenged if large deposits are identified in disputed areas, creating additional strain on the ATS and potentially disputes between parties.

Challenges to governance. The ATS is likely to endure but will face increasing pressure from parties to be more responsive to modern challenges, including climate change, rising global resource demand, a rapidly growing human presence and geopolitical tensions arising from a changing international order. Resource extraction will continue to be a source of contention between parties and may ultimately determine whether the ATS endures or fails in the future. Out to 2055 it is likely that new states will be admitted as parties to the ATS, with late joiners lobbying for equal opportunities on a par with original signatories.

Future key trends

Global power competition

As the geostrategic and economic value of Antarctica becomes better understood, global powers are increasingly likely to focus their attention on the continent, and it is highly likely that the region will become more congested and see increasing competition out to 2055.

All of the current territorial claimants will seek to protect their respective claims on the continent, using scientific research and infrastructure as levers to strengthen their footprint. However, the validity of territorial claims is likely to be increasingly questioned as states that were not original signatories or which do not have ATS voting status seek to exert greater influence in the region. In particular, the changing geography of the region as a result of significant ice loss could blur the delineation of existing sovereign boundaries and create new contests over territory. Although the Antarctic Treaty stipulates that no new claims and no enlargement of an existing claim to territorial sovereignty may be asserted while the present Treaty is in force, the risk of an existing Antarctic state or another actor making a new claim or challenging an existing claim cannot be ruled out. While a fresh territorial claim over currently unclaimed territory may lead to tension, the most inflammatory action would almost certainly involve a new counterclaim.

Many states have directly or indirectly indicated an interest in sustaining or building their Antarctic posture in the future, with the 2017–21 US Administration calling for a persistent US presence,[6] for example, and a Russian state-run corporation speculating in 2020 about the potential fossil fuel reserves that the continent could yield.[7] Both states maintain a basis of territory claim in the future under the ATS. China's interests in Antarctica are also likely to continue to grow out to 2055, initially in relation to research and fishing, but potentially heralding longer-term ambitions to lay claim to land, resources and minerals. China has four research stations in the Antarctic, with a fifth under development,[8] and has installed equipment to support its BeiDou satellite navigation system,[9] with ambitions to build a large permanent airfield.[10]

India may become a leading actor in the Antarctic out to 2055, through its membership of the ATS, its operation of several research stations on the continent and as a result of its growing international reputation. Italy, Japan, South Africa and South Korea all have growing Antarctic programmes that will see them demonstrate a more persistent presence in the region. Along with the seven territorial claimants, many of these countries will seek to collaborate on issues of mutual interest in the region, including environmental protection and combatting illegal, unreported and unregulated fishing.

6 Micallef, J.V., Military.com (9 September 2020), 'US Polar Strategy and the Geopolitics of Antarctica'.
7 Walters, T., PBS (23 May 2022), 'Gentleman's Agreement: Despite Mining Ban, Russia Scours Antarctica for Massive Fossil Fuel Deposits'.
8 Bremmer, I., *TIME* (28 April 2023), 'China's Ambitious Plans in Antarctica have Raised New Suspicions'.
9 Jakhar, P., BBC News (20 September 2018), 'How China's GPS 'rival' Beidou is plotting to go global'.
10 Fedschun, T., *Antarctica Journal* (26 May 2023), 'China looking to access Antarctica with permanent airfield'.

Antarctic Treaty System

Original signatories (voting status)

Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, Russia, South Africa, United Kingdom, United States

Consultative members (voting status)

Brazil, Bulgaria, China, Czechia, Ecuador, Finland, Germany, India, Italy, Netherlands, Peru, Poland, South Korea, Spain, Sweden, Ukraine, Uruguay

Non-consultative members (non-voting status)

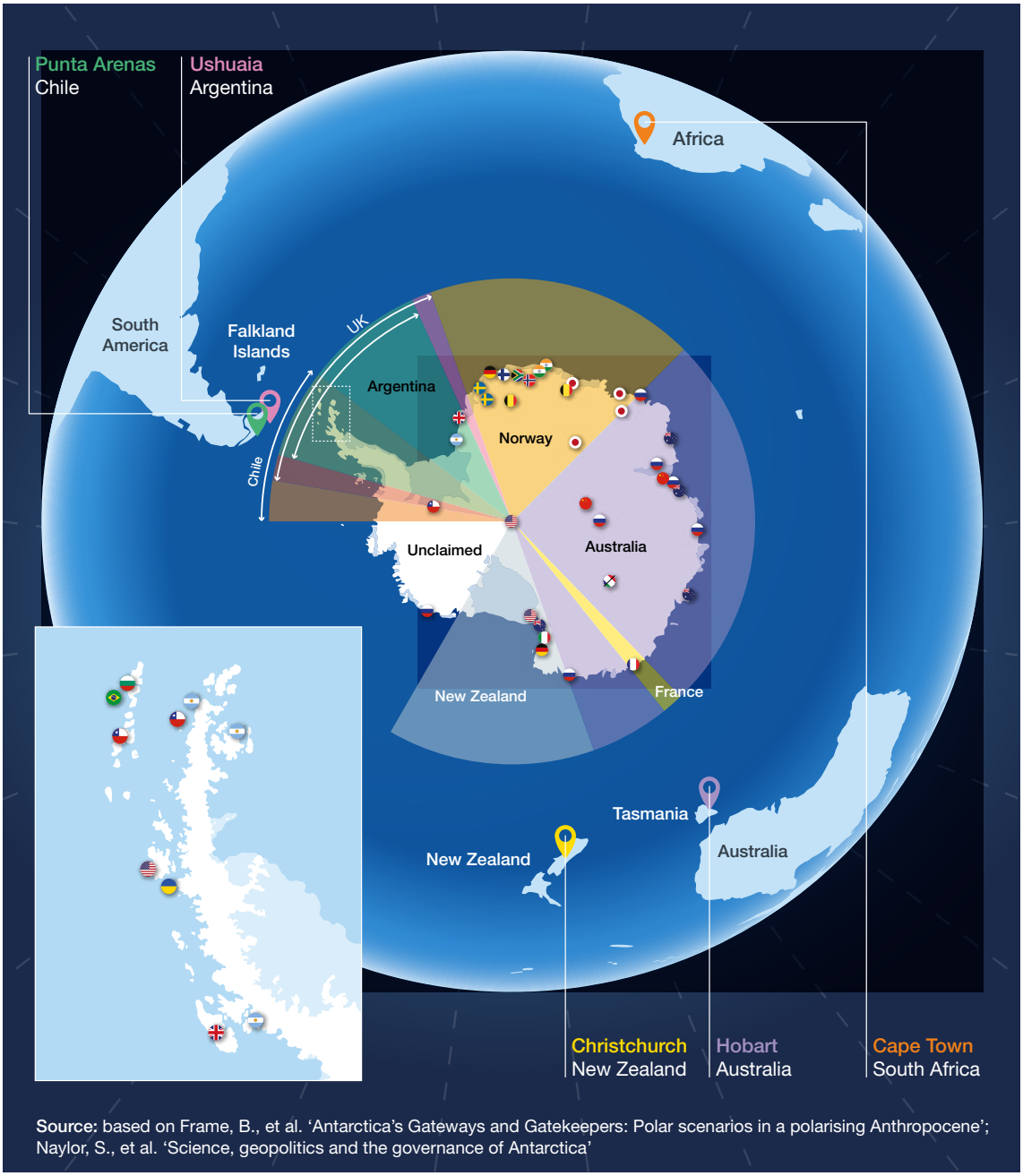
Austria, Belarus, Canada, Colombia, Costa Rica, Cuba, Denmark, Estonia, Greece, Guatemala, Hungary, Iceland, Kazakhstan, Malaysia, Monaco, Mongolia, North Korea, Pakistan, Papua New Guinea, Portugal, Romania, San Marino, Slovakia, Slovenia, Switzerland, Turkey, Venezuela

Source: Created by the Development, Concepts and Doctrine Centre, based on Secretariat of the Antarctic Treaty (2023), 'List of Parties'

The 'gateway cities' on the Southern Ocean rim (Punta Arenas (Chile), Ushuaia (Argentina), Cape Town (South Africa), Hobart (Australia) and Christchurch (New Zealand)), which enable access to the Antarctic region, will be of increasing geostrategic importance as interest in the continent grows. A formal statement of intent (Statement of Intent between the Southern Rim Gateway Cities to the Antarctic)

to share expertise between these cities has not yet delivered many tangible results,[11] and the cities could increasingly compete for primacy in the future.

In addition, future decades could see external actors increasingly competing for access and influence among the gateway cities to secure their interests and future ambitions in Antarctica. China, for example, has already signed a memorandum of understanding with Australia to use Tasmania as a port for Antarctic expeditions.[12]



Source: based on Frame, B., et al. 'Antarctica's Gateways and Gatekeepers: Polar scenarios in a polarising Anthropocene'; Naylor, S., et al. 'Science, geopolitics and the governance of Antarctica'

Territorial claims and gateway cities to Antarctica

11 Salazar, J.F., et al., The Conversation (7 October 2016), 'Five cities that could change the future of Antarctica'.

12 Sheikh, P. A., et al., Congressional Research Service (10 March 2021), *Antarctica: Overview of Geopolitical and Environmental Issues*; Bergin, A. and Press, T., Australian Strategic Policy Institute: *The Strategist* (27 April 2020), 'Working in the cold: Australia and China in the Antarctic'.

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A growing human presence will pose an increasing threat to Antarctica's biodiversity

Non-state actors, including those involved in scientific research, tourism, commercial fishing and environmental protection, are also increasing their Antarctic presence and they may hold growing influence over its governance by 2055. These entities are often represented at ATS meetings, either as part of a state's delegation or independently through representative organisations; for example, tourism companies are represented by the International Association of Antarctica Tour Operators, fishing companies by the Coalition of Legal Toothfish Operators, and environmental organisations by the Antarctic and Southern Ocean Coalition. Operating at the political level, these organisations can exert substantial influence over ATS decisions; for example, the Antarctic and Southern Ocean Coalition successfully lobbied to establish the Ross Sea Region marine protected area in 2016. The next three decades may see increasing political lobbying by these actors as their presence and influence on the continent increases.

Over the next three decades, it is likely that states will increasingly seek to exploit gaps in governance frameworks to pursue their own interests on the continent. Moreover, there is a significant chance that a party will seek to modify the ATS to enable environmental exploitation, resource extraction or another currently prohibited form of use. If this were the case, this may result in even greater interest in the region on the part of both state and non-state actors, leading to growing commercial activity and an increasing human presence in the region.

Society

A growing human presence will pose an increasing threat to the Antarctic region over the next 30 years. Today, despite being the only continent without an indigenous population, only about a third of Antarctica remains without a recorded human presence.[13] While scientific research has historically been the dominant driver of human presence on the continent, a rapid expansion in tourism will contribute to a more crowded land mass, as well as posing a greater threat to Antarctic ecosystems.

13 Wilson, M. and Feiger, L., *The Atlantic* (3 March 2021), 'Antarctica Is Crammed With Abandoned 'Ghost' Stations'.

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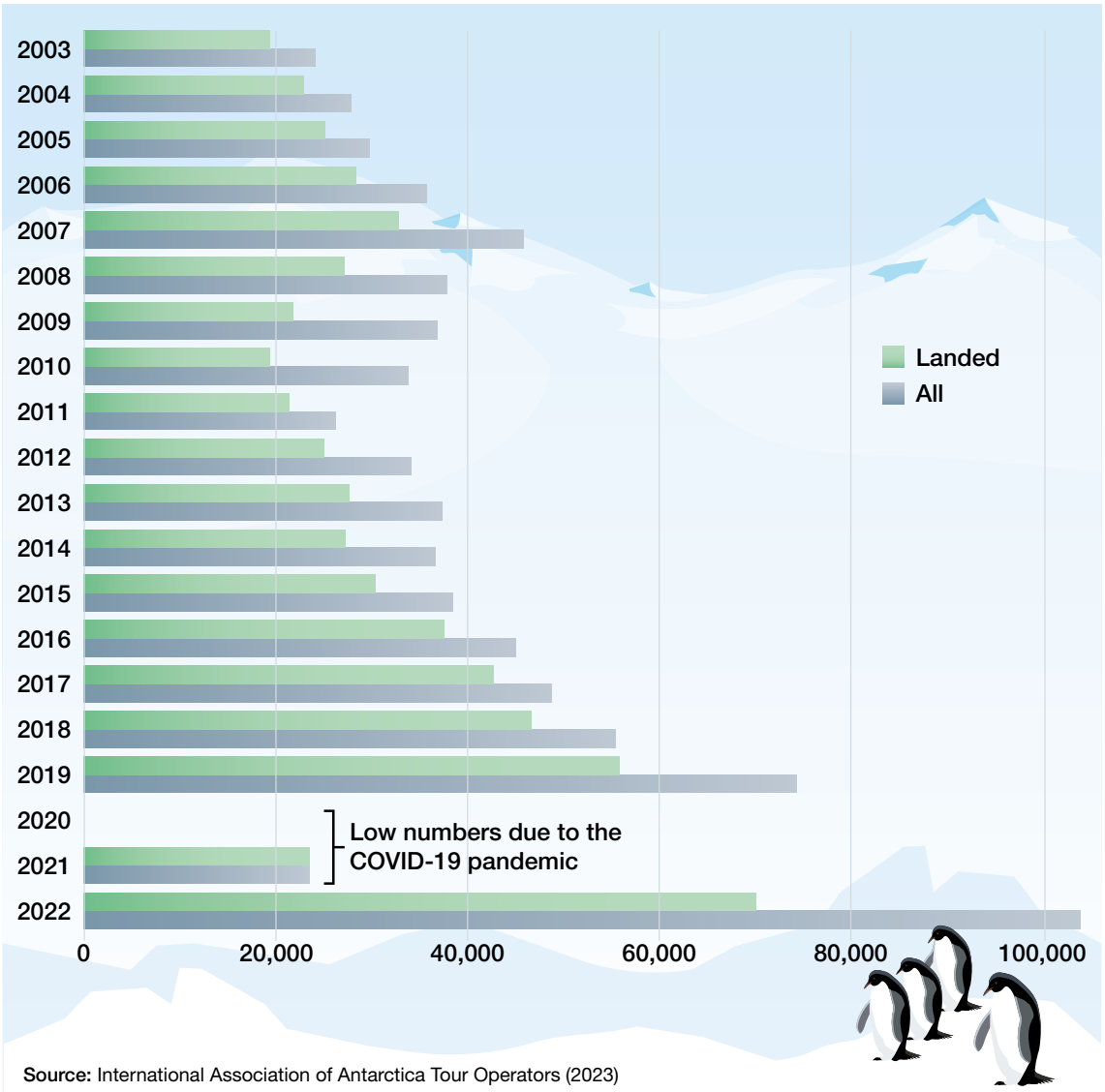
The number of tourists visiting the region continues to rise

Antarctica's year-round population is comprised mainly of scientific research staff, with numbers fluctuating between 10,000 scientists and support staff in the summer to 1,000 in the winter.[14] There are 30 signatories to the ATS that operate research stations on the continent or nearby islands. There are around 76 active research stations on the continent, half of which close for winter.[15] The number of research bases has grown gradually since the middle of the 20th Century and this trend is expected to continue. However, out to 2055, the boundary between tourism and scientific research could become increasingly blurred as citizen science projects and start-ups become increasingly involved in scientific research.

As the number of research bases rises, the demand for transport, resource supply, infrastructure maintenance and logistical support will grow, leading to a further increase in human presence in the region. Looking forward, proposals for a growing number of new research stations will increasingly challenge the ATS. There is already unease amongst some ATS parties who believe that scientific activity and the construction of research bases is being used to strengthen existing territorial claims and position states to assert future ones. Conversely, discontent with a perceived lack of fairness if future research applications are rejected could undermine the ATS's perceived legitimacy.

Commercial expeditions to the Antarctic started in the 1950s when Argentina and Chile transported several hundred fare-paying passengers to the South Shetland islands, and tourism has grown exponentially since. Between 2022 and 2023, a total of 106,006 tourists visited Antarctica, a 30% increase on 2019–20 pre-COVID-19 pandemic numbers.[16] Whilst the current peak season for Antarctic tourism is during the austral summer (November to March), ice thaw due to climate change could lengthen this period. Costs are also falling rapidly, with trips now available at less than US $4,000 per person,[17] a figure that is likely to decrease further as the number of tourist vessels and fare-paying passengers increases.

14 Natural Environment Research Council, British Antarctic Survey (2021), 'Antarctic Factsheet'.
15 Wilson, M. and Feiger, L., *The Atlantic* (3 March 2021), 'Antarctica Is Crammed With Abandoned 'Ghost' Stations'.
16 Cool Antarctic (2022), 'Antarctica Tourism – Human Impacts Threats to the Environment', data from International Association of Antarctica Tour Operators.
17 McClanahan, P., *The New York Times* (27 February 2020), 'Tourism in Antarctica: Edging Toward the (Risky) Mainstream'.



Growth in tourist numbers per year between 2003 and 2022

While providing economic and scientific benefits, an increase in tourism numbers to Antarctica may pose environmental and other related risks. Tourists are already permitted to undertake a broad range of recreational activities, including jet-skiing, photographic expeditions, kayaking and helicopter tours; as tourist numbers increase, the impact of these activities will grow. As the need to sustain growing numbers of tourists increases, the demand for permanent infrastructure such as hotels and restaurants is also likely to grow. Tourism has also been associated with the inadvertent introduction of invasive species to the continent, which poses a significant risk to local biohabitats. More tourists will result in a growing number of maritime vessels, land vehicles and aircraft; while accidents have been rare in the past, this growing volume of traffic will increase the likelihood of incidents, with potentially devastating consequences. Although efforts are being made to make tourism more sustainable, including using hybrid vessels to reduce harmful emissions, tourism to the Antarctic remains self-regulated under a voluntary forum, and entrenched commercial interests may mean that out to 2055 such proposals will achieve only limited success.

The tourism risk in Antarctica

Whilst major incidents relating to tourism in the Antarctic are rare, they are not unfamiliar. Perhaps most notoriously, in 2007, the MS Explorer cruise ship cracked its hull on submerged ice in waters near to the Antarctic,[18] resulting in the ship sinking with over 55,000 gallons of petrol, lubricant and gasoline on board, leading to an oil slick of nearly two square miles near the wreck site. Despite efforts to speed up the dispersal of the fuel, a report stated that the 'oil sheen' could still be seen more than a year later.[19]

Economy

Notwithstanding the potential future growth in tourism to the continent, offshore fishing is currently the largest economic activity in the Antarctic, centred primarily around Patagonian and Antarctic toothfish, mackerel and Antarctic krill.[20] Antarctica has a poor history of fishing practices, which have resulted in the near extinction of some species; out to 2055, illegal, unreported and unregulated fishing will pose an increasing threat to Antarctic ecosystems, fuelled by global population growth, rising incomes and increasing demands for protein. China, for example, has built the world's largest Antarctic krill trawler, and between 2019 and 2020 it more than doubled its catch of Antarctic krill to 118,353 tonnes.[21] South Korea and Russia are also developing more krill ships, the latter investing US $640 million in this sector.[22] Beyond the impact on fish stocks, fishing vessels operating near penguin colonies and whale grounds may strip their food sources and have a detrimental impact on the natural environment.[23]

Beyond tourism and fishing, the extraction of oil, gas and critical minerals may be the next frontier for economic development. Information on the exact size of resource deposits is limited due to a ban on exploration and the lack of ice-free land; however, deposits of oil, coal, ore, manganese, copper, lead, uranium and diamonds are believed to be substantial, and it is widely believed that other types of profitable minerals and materials may lay undiscovered. By the end of the century, ice-free areas in the Antarctic could increase by over 17,000 square kilometres,[24] significantly improving access to potential resource deposits, and increasing the potential for commercial exploitation.

18 Republic of Liberia, Decision of the Commissioner of Maritime Affairs (23 November 2007), *Report of Investigation on the Matter of Sinking of Passenger Vessel EXPLORER*.
19 McClanahan, P., *The New York Times* (27 February 2020), 'Tourism in Antarctica: Edging Toward the (Risky) Mainstream'.
20 Antarctic and Southern Ocean Coalition (2022), 'Antarctic Fisheries'.
21 Commission for the Conservation of Antarctic Marine Living Resources, Scientific Committee for the Conservation of Antarctic Marine Living Resources (26 October 2020), 'A summary of catches of target species in the Convention Area in 2018/2019 and 2019/2020'.
22 Stupachenko, I., SeafoodSource (5 June 2020), 'Russia exploring move into Antarctic krill fishery'.
23 Taylor, M., *The Guardian* (13 March 2018), 'Krill fishing poses serious threat to Antarctic ecosystem, report warns'.
24 Lee, J.R., et al., *Nature*, Volume 547 (2017), 'Climate change drives expansion of Antarctic ice-free habitat', pages 49–54.

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Scientists continue to research the impacts of climate change in the region

Despite this, the economic viability of extraction remains much less certain. Many deposits may be sparsely distributed, while harsh climatic conditions and the physical distances involved may further complicate the logistics and raise the costs of extraction.[25] Technologies such as remote drilling and autonomous shipping may offer opportunities to offset costs and reduce risks, but market demand will play a central role in any future extractive opportunities. With global energy demand set to almost double by the middle of the century,[26] and the search for materials to enable the green energy transition intensifying, the ATS could face increasing pressure to allow exploratory work to take place to establish the viability of the Antarctic as a potential source of resources. With the Madrid Protocol becoming eligible for review and potential modification in 2048, this could prove a pivotal moment in the balance of environmental versus economic interests.[27]

Environment

The increasingly apparent effects of global climate change will continue to contribute to a more unsettled and unpredictable Antarctic environment, changing the geophysical characteristics of the continent out to 2055. These changes will have direct implications for not only the region's climate, oceans and atmospheric processes, but also those across the globe.[28]

25 Talalay, P.G. and Zhang, N., *Earth-Science Reviews*, Volume 232 (September 2022), 'Antarctic mineral resources: Looking to the future of the Environmental Protocol'.
26 Gordon, M. and Weber, M., S&P Global Commodity Insights (6 October 2021), 'Global energy demand to grow 47% by 2050, with oil still top source: US EIA'.
27 Dodds, K., The Conversation (12 July 2018), 'In 30 years the Antarctic Treaty becomes modifiable, and the fate of a continent could hang in the balance'.
28 Noble, T.K., et al., Eos (12 November 2020), 'Antarctica in a Changing Climate'.

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An increase in 'high temperature' days recorded at research stations supports projections of a growing portion of Antarctica becoming ice free by 2055

Global climate change is likely to result in an increase in Antarctic temperatures. The continent is widely regarded as the most inhospitable environment on Earth, with average annual temperatures ranging from around -10º Celsius on the coast to -60º Celsius at the highest parts of the interior.[29] In early 2020, however, a new record high temperature of 18.3º Celsius was recorded in Antarctica.[30] In March 2022, Concordia research station witnessed a high of -11.8º Celsius, 40º Celsius above the average expected for that time of year.[31] While the scientific community is divided on whether climate change is solely responsible for these record temperatures, over the last 65 years there has been a rise in the number of 'high temperature' days recorded at Antarctic research stations, and the frequency is likely to increase further over future decades.

Temperature rises will have a significant impact on iceberg calving – the breaking off of large chunks of ice from a glacier front or ice shelves. Whilst glaciers and ice shelves are replenished by snowfall, this process can no longer keep up with the rate of ice loss, drastically changing the Antarctic coastline in recent years. Between 1997 and 2021, Antarctic ice shelves experienced a net loss of 12 trillion metric tonnes of ice.[32] In February 2023, Antarctica had less sea ice than any other time in the last 40 years since satellite observations began.[33] Less certain, though, is how Antarctica's ice loss will contribute to sea level rise. Modelling suggests that if global warming can be limited to 2º Celsius, Antarctica will continue to lose ice and contribute to an approximate 2 millimetre rise in sea level per year; if 2º Celsius is exceeded, however, this could increase to 5 millimetres a year by 2100.[34] These changes will also impact ocean currents, particularly in the Southern Ocean, with longer-term ramifications potentially including altered weather patterns and the loss of essential nutrients in marine ecosystems.

29 Department of Climate Change, Energy, the Environment and Water of the Australian Government, Australian Antarctic Program (2022), 'Antarctic Weather'.
30 Natural Environment Research Council, British Antarctic Survey (1 July 2021), 'New verified temperature record for Antarctic continent'.
31 Lu, D., *The Guardian* (21 March 2022), 'Extremes of 40C above normal: what's causing extraordinary heating in polar regions?'.
32 Rasmussen, C., The National Aeronautics and Space Administration (NASA) (9 August 2022), 'NASA studies find previously unknown loss of Antarctic ice'.
33 Amos, J. and Rivault, E., BBC News (17 February 2023), 'Antarctica sea-ice hits new record low'.
34 Stone, M., *National Geographic* (5 May 2021), 'Antarctica's ice could cross this scary threshold within 40 years'.

In the last two decades, the ozone layer that protects the Earth from harmful ultraviolet (UV) radiation had generally been observed to have been recovering, with the 1987 ban on chlorofluorocarbons (CFCs) found in refrigerants, propellants and aerosols playing a decisive role in this. However, in 2023, the size of the ozone hole above the Antarctic was found to be one of the largest on record, surpassing its size in the three years prior to this,[35] reaching 26 million square kilometres, which is approximately three times the size of Brazil.[36] Whilst the reason is unclear, it demonstrates the ozone layer's susceptibility to change, with resultant effects directly linked to the Southern Hemisphere's climate.

Technology, infrastructure and communications

Over the next 30 years, technology advances could improve protection of the Antarctic environment. For example, ice-penetrating radars carried on aircraft and uncrewed aerial vehicles are already being used to enhance understanding of the Antarctic shelf and such technologies could offer significant potential in the future. Low Earth orbit satellite observation of the continent is also likely to increase, offering new opportunities to monitor illegal, unreported and unregulated fishing. Increased observation data, in combination with artificial intelligence and big data analytics, could offer unprecedented opportunities to understand the Antarctic region, from detecting blue whale calls to predicting ice loss.[37]

Artificial intelligence detection of blue whale calls in Antarctic waters

Machine learning algorithms have been demonstrated to offer an improved means of studying the behaviour and population trends of blue whales in the waters surrounding the Antarctic. The research team, comprised of experts from the Australian Antarctic Division, Cornell University (US) and Curtin University (Australia), found that their system was able to detect the calls of this notoriously elusive animal with greater accuracy and speed than human experts, with a sample of data that required 10 hours of human effort taking the artificial system less than 30 seconds.[38]

Technology advances could also provide economic benefits, including mapping the resources that lie below Antarctica's surface. While advances in drilling technologies have allowed researchers to explore deeper into the ice, exposing the continent's geological and climatological past, they may also accelerate the viability of commercial activity. However, as these technologies become more sophisticated, it may be possible to extract deposits in a way that minimises impact on the environment.

35 Kessenich, H.E., et al., *Nature Communications*, Volume 14 (21 November 2023), 'Potential drivers of the recent large Antarctic ozone holes'.
36 European Space Agency (4 October 2023), 'Ozone hole goes large again'.
37 Revishvili, N., *Industry Wired* (31 August 2021), 'This Is How Artificial Intelligence Can Keep An Eye on Antarctica'.
38 Pat, L., Cornell Chronicle (28 September 2022), 'Machine learning bests humans in whale call detection'.

Disused facilities carry strategic value for Antarctic claimants by providing physical evidence of past activity

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Antarctica is the only remaining continent that is yet to be connected to the wider world via undersea Internet cables. Research stations have therefore had to rely on local systems and commercial cellular networks, the speed of connection often being so slow that physical storage devices are favoured over Internet uploads.[39] Out to 2055, however, this could change, if efforts to provide Internet cables prove successful. For example, Chile's Desarrollo País, H2 Cable (a Singaporean subsidiary) and Google are currently planning to build the 15,000 kilometre Humboldt Cable, to connect Chile to Australia with offshoots to New Zealand and the Antarctic.[40] Proliferation of low Earth orbit satellite Internet could also prove transformational, with Starlink currently being trialled in the region. As digital connectivity improves, however, the risk of cyberattacks will grow, potentially exacerbated by increasing competition between actors in the region; Antarctica has already experienced its first cyberattack.[41]

There are as many as 5,000 permanent structures across Antarctica, including basic huts, lighthouses, churches and research stations.[42] It is not known how many of these have been abandoned, as challenging conditions and limited access mean that it is often difficult to confirm their status with certainty. The Madrid Protocol theoretically requires any obsolete structures built after 1991 to be removed, unless these are sites of historical importance or their removal would cause environmental damage. However, for the states that own them, these structures continue to hold strategic value as markers of permanent presence, and hence they may be unwilling to comply. As a result, the amount of legacy infrastructure is likely to increase, in parallel with the construction of new infrastructure to support growing human activity out to 2055.

39 Swinhoe, D., Data Center Dynamics (24 February 2022), 'Antarctica comes in from the cold: Building subsea cables to the last unconnected continent'.
40 Swinhoe, D., Data Center Dynamics (12 January 2024), 'Google joins consortium for Chile-Australia Humboldt cable'.
41 Alshdaifat, S.A., et al., 20th European Conference on Cyber Warfare and Security (June 2021), 'Antarctica and Cyber-Security: Useful Analogy or Exposing Limitations?'.
42 Wilson, M. and Feiger, L., *The Atlantic* (3 March 2021), 'Antarctica Is Crammed With Abandoned 'Ghost' Stations'.

As with the Arctic region, icebreakers will be an important capability for ensuring access for both state and non-state actors operating in the Antarctic, and they may increasingly be used as a diplomatic tool to garner influence and deny access to others. As a consequence, it is highly likely that a greater number of states will seek to invest in new icebreaker capabilities as the Antarctic becomes more strategically important. Moreover, states with a limited number of icebreakers may need to make a choice between deploying them in the Northern or Southern Hemisphere. Nuclear-powered icebreakers may prove a far more energy-efficient alternative to diesel-powered equivalents, but will carry significantly higher environmental risk if damaged. Currently only Russia has a nuclear icebreaker, but China has also announced ambitions to build them, and other states may follow in the future.[43]

Conflict and security

The Antarctic Treaty prohibits all but peaceful activities in the Antarctic; however, defence personnel and equipment are permitted to support scientific and other operations in the region, including transport, research, and search and rescue. Military assets can also be used to deter, monitor and prohibit activities such as illegal, unreported and unregulated fishing. A baseline for military presence in the Antarctic has therefore already been established, and as human activity increases in the region, states may use this to justify greater militarisation, which could then drive a response on the part of other actors. An area of particular concern is dual-use technologies which, while ostensibly for non-combat purposes, could be repurposed if tensions arose.

Out to 2055, there may be increasing concern that capabilities such as remote sensing, satellite navigation, icebreakers, all-weather airstrips, autonomous vehicles and satellite ground stations, while supporting legitimate activity on the continent, could be being prepositioned for belligerent purposes. Hydrographic research in the region, for example, could easily be repurposed to support submarine navigation. Similarly, positioning equipment to support satellite navigation is commonplace in the region, used among other things to improve the accuracy of weather maps; however, it also has the potential to improve the precision of space assets, military command and control capabilities, and missile tracking.

From snow to space

The French–Italian owned Concordia research station routinely undertakes joint research with the European Space Agency, hosting scientists and technical specialists to collaborate on experiments that seek to understand how humans may function when undergoing long-duration spaceflight. Remote, devoid of much life and lacking regular day-night cycles, the station provides an extreme, hostile environment that offers an accurate representation of interplanetary exploration like no other on Earth.[44]

43 Di Pane, J. and Romaine, K., The Heritage Foundation (18 June 2021), 'U.S. Needs Icebreakers to Keep Up With China and Russia in Arctic'.
44 eoPortal (26 May 2020), 'Concordia Research Station in Antarctica'.

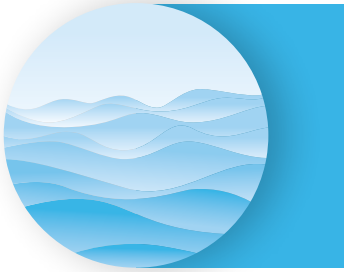
Top 20 container ports (by volume)

1. Shanghai
2. Singapore
3. Ningbo-Zhoushan
4. Shenzhen
5. Guangzhou Harbor
6. Busan
7. Qingdao
8. Hong Kong
9. Tianjin
10. Rotterdam
11. Jebel Ali
12. Port Klang
13. Xiamen
14. Antwerp
15. Kaohsiung
16. Dalian
17. Los Angeles
18. Hamburg
19. Tanjun Pelepas
20. Laem Chabang

Map showing the world's oceans from a single perspective viewpoint

Source: World Shipping Council (2021)

Oceans



Current strategic context

Covering 71% of the planet, the oceans contain between 50 and 80% of the Earth's life, with perhaps millions of species still undiscovered.[1] The oceans conceal the world's largest mountain range (the mid-ocean ridge) and deepest canyon (the Mariana Trench). While nearly all of the oceans have been charted, less than 10% of the seabed has been explored,[2] although efforts are under way to address this shortfall. Absorbing 30% of human-generated carbon and producing 50% of all oxygen,[3] the oceans also modulate the Earth's temperatures and weather patterns.

The oceans hold significant deposits of the world's natural resources. The seabed holds 30% of the world's oil[4] and 25% of its gas,[5] with significant deposits yet to be explored. More critical minerals could lie within the seabed than on all the continents combined. The oceans provided about 3.3 billion people with at least 20% of their average intake of animal protein in 2019, with an even higher proportion in many poor countries.[6]

In addition, the oceans support millions of jobs in shipping, fishing, energy, leisure, ports and facilities, finance, insurance and other services, and 80% of global trade and millions of passengers are transported by sea.[7] Increasing volumes of gas and over 95% of Internet traffic pass through seabed pipes and cables.[8] Many low-income and traditional communities depend on the oceans for food and livelihoods.

Historically, large merchant fleets and navies enabled states to wield significant global power. Today, however, a wider range of actors form what is now a highly globalised system. International agreements have sought to regulate the maritime environment, enabling commercial activity, setting limits on military action and providing frameworks for territorial claims. More recent agreements have sought to protect the environment and address climate change. However, as technology makes the oceans more accessible, this system is increasingly being challenged by conflicting commercial and security interests, and growing competition could see the world's current approach to oceans and seas become increasingly contested in the future.

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1 The MarineBio Conservation Society (2023), 'Did You Know…? Marine Life/Ocean Facts…'.
2 Gerretsen, I., BBC (13 January 2022), 'Could our understanding of the deep ocean help unlock the mysteries of outer space? Nasa's space mission is leading us to unexplored depths of our own planet'.
3 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
4 EIA, & Ensco, Statista (28 February 2023), 'Distribution of onshore and offshore crude oil production worldwide from 2005 to 2025'.
5 Statista (29 January 2023), 'Production of natural gas worldwide in 2022 with a forecast for 2030 to 2050, by project location'.
6 World Bank (3 April 2024), 'Blue Economy'.
7 United Nations (UN) Conference on Trade and Development (2022), 'Review of Maritime Transport'.
8 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).

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Key drivers of change

Energy transition. The green energy transition will have an impact on global ocean commerce and security, creating new regions of interest whilst increasingly crowding already congested (and contested) maritime zones with new offshore infrastructure, pipes and cables. Technological innovation could increase opportunities, and hence competition, to exploit ocean resources such as critical minerals and other deposits, and more effective environmental and other regulatory frameworks may become necessary.

Growing demand for resources. Growing populations, including a rise in the global middle class population, will lead to increased demand for resources, which the oceans are likely to play a significant role in meeting. Balancing exploitation of the oceans' abundant resources against potential environmental and societal impacts could become an increasing tension. Interference in international trade along ocean routes and choke points could become an increasingly important factor in global competition.

Climate change. Climate change will have a major impact on delicate marine ecosystems, as well as on the oceans' ability to moderate and modulate global weather patterns and carbon levels. Coastal cities, ports and infrastructure, as well as major maritime choke points, will be impacted by rising sea levels and more extreme weather events. The opening up of frozen passages, particularly in the Arctic, could also see patterns of global trade change significantly by 2055.

Emerging technologies. Emerging technologies will provide humankind with new options to monitor, mitigate and offset the impacts of climate change and environmental degradation, as well as enabling access to new resources and providing biotechnological and other benefits. Technological developments could see commercial exploitation expand into ungoverned areas, creating new security frictions.

Global competition. Energy transition and resource demand could see the world's oceans become increasingly congested and the subject of growing competition out to 2055, increasing frictions and potential flashpoints over contested maritime zones. Climate change could accelerate this trend as changing land masses bring the potential for new maritime claims; the resulting impact on choke points could also contribute to an increase in competition. New military technologies will make it easier to deny access to areas of the high seas and employ blockades as a way to coerce others. While states will continue to act collectively to protect the oceans, pressures that undermine existing maritime governance frameworks could also grow.

Future key trends

Global power competition

The world is likely to see increasing competition in the maritime environment over the next 30 years, driven by changing and growing resource demand, technology developments and the impact of climate change. This may drive global powers to increase their military and security capabilities, as well as providing them with growing incentives to withdraw from international treaties or violate customary laws and norms.

Although the ocean economy is currently dominated by oil and gas corporations, renewable energy could drive major changes in the global rankings over the next few decades. While offshore drilling for oil and gas is likely to remain a significant economic sector, wind and other renewable energy facilities will begin to play a more dominant role. Expansion of pipeline networks is already taking place as states seek to diversify energy sources, and future years should see the electricity grids of energy-importing states connected to solar-rich regions along extended networks.

The next 30 years could see significant changes in the commercial sector due to emerging economies' rising demand for resources, trade and freight transport, as well as to fisheries and sea-based leisure pursuits as diets change and more of the global population enter the middle classes. While market forces will drive this to a certain extent, some global powers may seek to assert more direct control, leading to market distortions. These changing trade patterns will also lead to changes in the world's maritime centres of gravity. For example, major ports in Europe and Northern America are already dwarfed by those in East Asia, with East Asian cities increasingly ranking amongst the world's major maritime cities. In the future, new 'megaports' in the Global South could change patterns of trade significantly, particularly if climate change and ongoing tensions threaten the viability of existing major choke points. Out to 2055, the increasing use of Arctic sea routes could also have an impact on global port rankings.

Governance of the oceans and seas is likely to be subject to conflicting pressures out to 2055. Environmental and technological issues as well as the rights of workers and local and traditional users have come into increasing focus since the implementation of the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Looking forward, future developments, such as a new United Nations (UN) High Seas Treaty, which was signed in 2023, could, if ratified, see the protections afforded within territorial waters extended to the high seas.[9] However, as commercial and environmental imperatives come into increasing conflict, this could lead to setbacks and reversals. For example, the International Seabed Authority has yet to find a compromise regarding deep sea mining, with the result that some states are threatening to begin operations regardless.[10] An expansion of ocean infrastructure could also place new pressures on governance and security.

9 UN Press Release – Secretary-General (19 June 2023), 'Note to correspondents – press release on historic agreement adopted for conservation and sustainable use of biodiversity in over two-thirds of the ocean'.

10 Hylton, W., *The Atlantic*, January/February 2020 Issue (2020), 'History's Largest Mining Operation is about to Begin: It's underwater—and the consequences are unimaginable'.

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Expanding use of the oceans could see existing governance structures coming under increasing pressure

From actions in the South China Sea to the Arctic, and on issues relating to maritime territories and the use of blockades, it is clear that some states are becoming increasingly willing to test existing rules and norms. Out to 2055, it is likely that some powers will prove increasingly willing to challenge the existing principles of UNCLOS. While states may continue to cooperate in areas of mutual interest, there is a risk that governance could become increasingly regionalised, and a major crisis might even see existing frameworks curtailed or abandoned.

Military maritime power and security capability are also likely to evolve over the next three decades. While the United States (US) is likely to retain its global posture, other powers will increasingly challenge the West's ability to control regional seas. Maritime power has always involved a combination of military and civilian capabilities, but this trend looks likely to develop further as coastguards, maritime militias, private military and security companies, and merchant and fishing fleets increasingly act alongside one another. Criminal actors such as pirates, terrorists and smugglers seem likely to be a persistent feature of the maritime environment, and could increase in reach and number as new regions rise to prominence.

Society

The growing use of the oceans for resources, transport and leisure activities could bring the safety and interests of seafarers into increasing focus over the next 30 years. Over 700 vessels were lost between 2013 and 2022[11] and 235,000 people drown each year, often in middle- and low-income countries.[12] These figures seem likely to rise as use of the seas increases and the impacts of climate change, such as flooding, become more frequent. Maritime norms requiring coastal states to enforce safety and security in their waters, and mariners to come to each other's assistance, are likely to remain the standard through which these dangers are addressed in future. With much of the maritime environment remaining ungoverned, however, future compliance will be increasingly dependent on the willingness and capacity of states, organisations and mariners to come to the aid of others.

11 Allianz, Statista (31 May 2023), 'Number of ship losses worldwide between 2013 and 2022, by vessel type'.
12 Royal National Lifeboat Institution (2023), 'The global drowning problem'.

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Pressure to conduct activities in a more sustainable, equitable and socially responsible manner is increasing

The next three decades are likely to see diverging trends in the treatment of maritime workers. While many commercial entities will continue to apply high standards, cultural and legal differences, as well as the question of flag state and port oversight, will continue to influence differences in working conditions. Forced labour, violence, mistreatment, and dangerous and unsanitary working conditions have become increasingly prevalent in fishing and other sectors. Although some regions such as the Indo-Pacific appear to be hotspots, this trend is also being witnessed in the maritime territories of wealthy liberal democracies.

As global resource demand rises, the impact of illegal, unreported and unregulated fishing on local and traditional communities will continue to grow. However, pressure to conduct activities in a more sustainable, equitable and socially responsible manner is also increasing. The UN Global Compact on Sustainable Ocean Principles (a non-binding pact to encourage businesses to adopt sustainable and socially responsible policies), as well as other initiatives such as the Sustainable Blue Economy Finance Principles or the Principle for Investment in Sustainable Wild-Caught Fisheries, could make this ideal more achievable in the future. New technologies could also enable greater oversight and regulation of activities on the high seas.

Economy

The ocean economy could witness significant changes over the next three decades, driven by shifts in energy use, growing resource demand and other factors. In the global energy sector, for example, rising demand in East and South Asia could benefit countries such as Saudi Arabia, Brazil, Iran, Russia, Mexico and the US, which currently dominate in the extraction and transport of oil and gas. However, some assessments suggest that global demand for hydrocarbons could decline from 80% of the energy market to 50% by 2055.[13] Conversely, offshore wind power, in which China currently dominates, could undergo a 50-fold increase in the same period,[14] potentially triggering major disruptions to the market. Emerging technologies could see some sectors advance rapidly in the coming decades, while others have already reached their full potential.

13 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
14 Ibid.

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The demand for container shipping is expected to grow over the next three decades

Demand for shipping is expected to increase out to 2055, driven largely by Asia. Container shipping, for example, could increase by as much as 90% by 2055 and bulk cargo by 20%, although coal, oil and gas shipping may see a decline.[15] Global shipping rankings are currently dominated by European and East and Southwest Asian companies, with Chinese firms at 4th, 13th and 15th behind the Mediterranean Shipping Company (MSC) (Switzerland and Italy), Maersk (Denmark) and CMA CGM (France); the highest ranking US company is at 28th.[16] However, China is positioning to take a more leading role in this growing market, potentially increasing from 10% to 26% of capital investment by the middle of the century, while Europe will see only a moderate rise from 11% to 14%. China, South Korea, Italy and the US have the largest shipbuilding, repair and maritime equipment corporations.[17] Cruise ship building, in which Italy, France, Germany, Japan and South Korea currently dominate,[18] is likely to benefit from significant increases in this tourist sector by 2055, and China is also rapidly building its stake in this market.

While most maritime companies are either listed or privately owned, 21 of the world's 100 largest ocean corporations are state controlled, either directly or indirectly.[19] Russia, Iran, India and China, for example, all maintain nationalised merchant fleets and other key assets, allowing them to weather market forces affecting commercial competitors. China also enjoys a controlling stake in many global ports, shipping lines and maritime services, which out to 2055 may cause increasing friction with Europe and the US. In addition, Chinese demand for fish is likely to increase by 25% by the middle of the century,[20] and China is positioning itself to not only meet its growing domestic needs but also attain a dominant global position in this sector. Some estimates put the size of China's fishing fleet at over 3,600 boats, which is as many as Japan, South Korea, Spain and Taiwan's fishing fleets combined.[21]

15 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
16 Ahmed, Z., Maritime Insight (30 March 2024), '20 Largest Container Shipping Companies In The World In 2024'.
17 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
18 Qubein, R., Cruise Critic (8 January 2020), 'Where Are Cruise Ships Built?'.
19 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
20 Ibid.
21 *The Economist* (8 December 2022), 'China's deep-water fishing fleet is the world's most rapacious'.

Over the next three decades, the port and maritime infrastructure landscape will continue to change. Of the world's ten busiest ports, nine are in Asia (with seven in China). Of these, Shanghai (China) heads the list, handling 47.03 million twenty-foot equivalent units (TEU) in 2021, with Singapore second and Busan (South Korea) sixth, moving 37.49 and 22.71 million TEU respectively. In comparison, the port of Rotterdam (Netherlands) – the busiest in Europe and tenth busiest in the world – handled 15.3 million TEU, while the busiest port in the US, Los Angeles, handled 10.62 million TEU.[22] However, by 2055 this pattern could change, with new megaports under construction in Africa and Latin America having the potential to realign trade flows in these regions.

Peru's new megaport

The first megaport in Latin America is being built by the Chinese company Cosco Shipping Ports in Chancay, Peru.[23] The project is costing US $3.5 billion; it is 70% complete and on track to be fully operational by the end of 2024.[24] The new port will serve as a hub for cargo originating from the east and the central highlands of Peru, potentially impacting the local, national and regional geopolitical landscape. With its ability to accommodate megaships, Chancay has the potential to rival important ports in Chile. Moreover, its strategic proximity to the Bi-Oceanic Corridor, which links Brazil to Peru, could make Peru a key distribution centre in the Pacific Ocean while also connecting it to the Atlantic coast of South America.

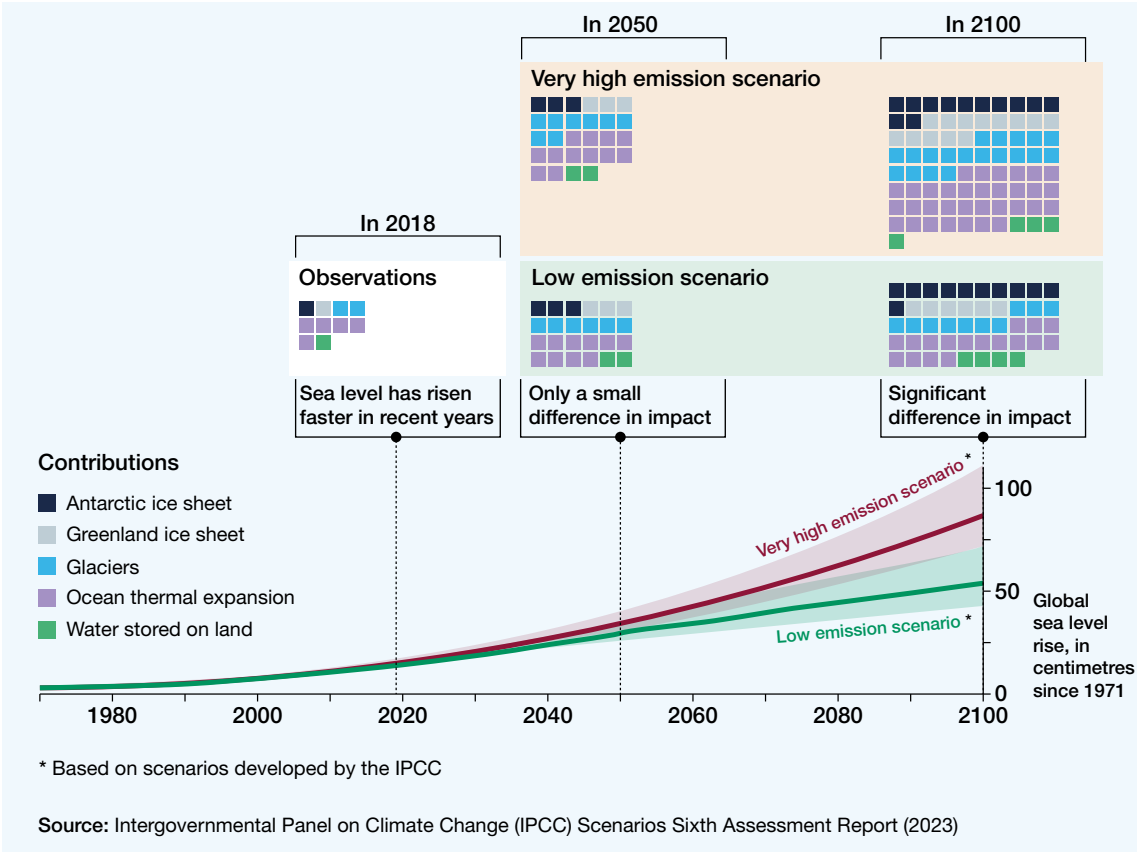
The world's most important maritime cities (ranked on maritime finance and law, technology, ports and logistic services, and on their ability to service shipping) are also changing. While European centres such as London remain attractive, Shanghai and Tokyo are in the top five and Singapore tops the list,[25] other regional centres could emerge out to 2055.

Ferries transported approximately 4.27 billion passengers in 2022,[26] an equivalent number to commercial airlines,[27] as well as 373 million vehicles.[28] Over the next three decades, this sector is likely to increase as growing populations seek new opportunities for travel. In addition, the number of recreational boats is likely to grow, as leisure pursuits expand globally. At the same time, traditional skiffs, dhows and junks are likely to retain their role in regional trade, fishing and the informal economy.

22 World Shipping Council (2023), 'The Top 50 Container Ports'.
23 Mardones, I., Royal United Services Institute for Defence and Security Studies (15 November 2022), 'Chinese Investment in Peru Set to Reshuffle Maritime Trade in South America'.
24 The Maritime Executive (3 April 2024), 'Peruvian Regulator Upsets Cosco With Ruling on Chancay Port'.
25 UN Global Compact (2023), 'The Sustainable Ocean Principles: a principles-based approach to sustainable ocean business'.
26 Interferry (2023), 'Ferry Industry Facts'.
27 IATA, Statista (June 2022), 'Number of scheduled passengers boarded by the global airline industry from 2004 to 2022'.
28 Interferry (2023), 'Ferry Industry Facts'.

Environment

Out to 2055, oceans and coastal regions will increasingly be impacted by climate change and environmental degradation, which could constrain the development of the ocean economy in various ways.[29] A 22 centimetre sea level rise, for example, could cause the loss of almost 4,000 square kilometres of agricultural land in Shanghai, while 90 centimetres would see 38% of the Mekong Delta overrun.[30] There are currently 453,000 inhabitants of the Caribbean islands who live at less than 50 centimetres above local tide lines.[31] Across the globe, one billion humans live on the coast, three billion within 100 miles of the sea and half a billion in fragile deltas, while eight of the world's ten largest cities are coastal.[32] With aquaculture, fisheries and energy infrastructure projected to occupy up to 368,000 square kilometres of littoral zones by 2055,[33] these critical activities could also increasingly be impacted by rising seas, as well as more frequent and violent storms. Island states will be particularly affected, as well as the Global South's coastal megacities, with some estimates suggesting this could prompt a migration of 17–72 million people and incur costs between US $1.4 and US $27 trillion.[34]



Observed and projected global mean sea level rise and the contributions from its major constituents

29 Organisation for Economic Co-operation and Development (OECD) (27 April 2016), *The Ocean Economy in 2030*.
30 Wembridge, R., DE&S Engineering and Science (2022), *Sea Level Rise into 2050 and 2100*, (a research paper commissioned by DCDC).
31 Ibid.
32 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
33 Ibid.
34 Ibid.

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Growing levels of maritime traffic will heighten the risk of environmentally damaging pollution accidents such as oil spills

Human impact on the oceans could have an increasingly detrimental effect on the global environment. The oceans are considered to be the world's main carbon sink, absorbing up to 50% of the carbon dioxide emitted to the atmosphere.[35] Marine life is vital for this. Mangroves, plankton, fish, coral reefs and algae are all at risk due to a number of human activities that do not take into consideration the risks posed to the maritime environment or do not have appropriate measures in place to combat those risks. The oceans are also damaged by land-based activities, such as human-made greenhouse emissions, as well as contamination by agricultural products and plastics, which mainly reach the oceans through rivers and other sources.[36] In addition, all the industries operating at sea have some risk of inflicting damage to that ecosystem.

There are currently about 50–75 trillion pieces of plastic and microplastics in the ocean and plastic generally takes between 500 and 1,000 years to degrade to microplastics. Every year, 8–10 million tonnes of plastic waste end up in the ocean, which accounts for 80% of all maritime pollution.[37] If laid out flat to the thickness of a plastic bag, this would cover an area the size of Qatar; if the trend continues, in 50 years' time, that area could be the size of France.[38]

Maritime trade and access are also likely to be increasingly affected by extreme weather events. The port of Vancouver, for example, was disrupted by flooding in 2021, leading to a 15-day closure costing US $550 million a day.[39] Heavy flooding closed Durban (responsible for 60% of South African shipments) for a week in 2022.[40] While wealthier ports such as Amsterdam, Rotterdam, Tokyo and London are already adapting with measures such as

35 Sustainability for All (2023), 'What are the Carbon Sinks?'.
36 DNV (2021), *Ocean's Future to 2050: A sectoral and regional forecast of the Blue Economy*.
37 Fava, M., UN Educational, Scientific and Cultural Organization, Intergovernmental Oceanographic Commission (9 May 2022), '*Ocean plastic pollution an overview: data and statistics*'.
38 Hussein, M. and Ali, M., Al Jazeera (8 June 2023), '*World Ocean Day: How much plastic is in our oceans?*'.
39 Zimonjic, P., CBC News (24 November 2021), 'Federal government giving $4.1M to B.C. port authority to ease supply chain chaos caused by flooding'.
40 Cele, S. and Naidoo, P., Bloomberg UK (14 April 2022), 'One of Africa's Busiest Ports Disrupted by Major Flood Damage'.

sand dunes or marshes, dykes and storm surge barriers,[41] less affluent regions are likely to struggle to develop their defences. Climate change is also having an increasing impact on major choke points. The Panama Canal suffered major delays in 2023 as drought affected its locks; at the other extreme, a 2022 report suggests that both the Panama and Suez Canals are at increasing risk from coastal inundation.[42]

Over the next three decades, the oceans will also be increasingly subject to a range of other environmental stress factors, including growing waste and pollution as human activity increases, and the loss of maritime ecosystems through climate change and overfishing. Growing levels of maritime traffic will also heighten the risk of environmentally damaging pollution accidents. Between 1970 and 2018, for example, there were an estimated 10,000 oil releases in the Niger Delta,[43] while 2,000 kilometres of the Brazilian coast was damaged by oil spillages in 2019.[44] An increasing number of desalination plants around the world, constructed to combat freshwater scarcity and reduce geopolitical tensions over water, and offshore infrastructure projects could also have a growing impact on surrounding marine environments.

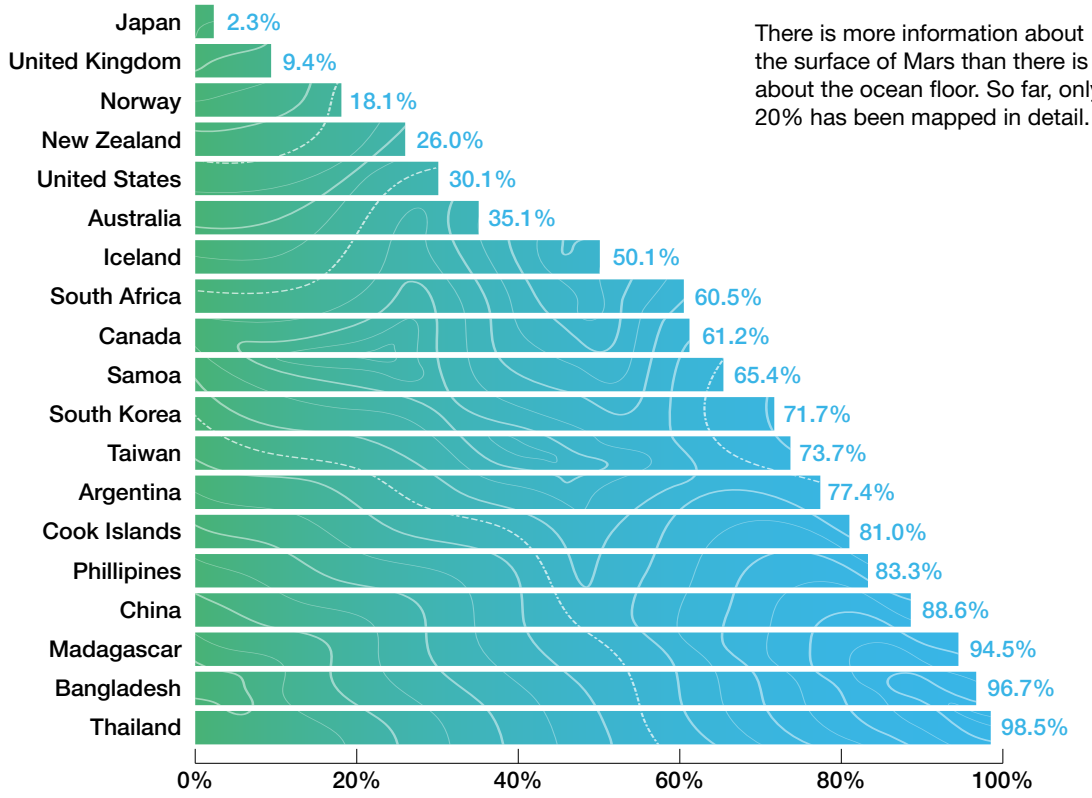
While climate change will have an increasing impact on the world's oceans and their users, shipping is also itself a major contributor, currently accounting for 3% of emissions, a figure which is likely to rise further as the requirement for transport grows.[45] The sector is increasingly responding to this trend, with the Getting to Zero Coalition, for example, seeking to develop and deploy commercially viable zero-emission vessels by 2030.[46] The Poseidon Principles have also been established to provide a framework to measure the climate priorities of shipping portfolios. The Norwegian Government Pension Fund (the largest sovereign wealth fund in the world) is actively divesting from companies found guilty of polluting the oceans.[47] In addition to these initiatives, efforts are under way to address gaps in international law, with the UN High Seas Treaty, signed in 2023 and awaiting ratification, seeking to extend environmental protections afforded under states' jurisdiction to the high seas. This will include creating marine protected areas, as well as seeking greater fairness in sharing benefits derived from the seas.[48]

Technology, infrastructure and communications

Over the next 30 years, new and emerging marine technologies could offer opportunities to address many of the world's resource, energy and environmental challenges. A rapid expansion of state-owned and commercial satellites, for example, could significantly increase understanding of the seabed, water column, weather patterns, sea ice drift, fish populations and the impacts of pollution. Such technologies are already being used by island and coastal states to monitor illegal, unreported and unregulated fishing. Increasingly widespread connectivity through low Earth orbit satellites could also transform

41 Port of Rotterdam (2024), 'Flood Risk Management: prepare for flood risks'.
42 Messenger, J., *Global Trade Review* (14 November 2022), 'Key shipping routes at risk from climate change disruption, report finds'.
43 Fr.Carmine, SouthWorld (1 January 2019), 'The Niger River: From Drought To Floods And Pollution'.
44 Phys.org (3 December 2021), 'Greek-flagged ship caused Brazil mystery 2019 oil slick: police'.
45 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
46 Global Maritime Forum (2023), 'Getting to Zero Coalition'.
47 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications*, (a research paper commissioned by DCDC).
48 UN Press Release – Secretary-General (19 June 2023), 'Note to correspondents – press release on historic agreement adopted for conservation and sustainable use of biodiversity in over two-thirds of the ocean'.

the governance of the high seas, making previously unseen activities more visible. While this could provide impetus to environmental protection and ocean governance measures, global powers may increasingly compete to offer these services, with the potential dual-purpose use of some technologies giving this an added security dimension.



Source: General Bathymetric Chart of the Oceans 2020 and National Oceanic and Atmospheric Administration

Unmapped ocean floor by selected territory as a percentage of exclusive economic zone

Advances in automation, robotics and artificial intelligence also offer huge potential. Port facilities, for example, are becoming increasingly automated, as are most modern merchant vessels and warships, a trend that could see the widespread use of uncrewed ships in coming decades. These technologies are already offering more options to explore the deeper and more hazardous reaches of the ocean, as well as for the maintenance, repair and inspection of maritime platforms. This could see a reduction in the cost of surveying and research, currently a key barrier to access. In future years, a significant expansion of sustainable aquaculture projects could also reduce land usage and emissions while meeting increasing demand for food, as could the farming of sea algae. Technologies using lava rock could also provide a chemical-free solution that reduces the cost and environmental impact of water desalination. Israel, for example, has invested in this technology and gone from severe water shortages in 2008 to now having a surplus. Israel currently obtains around 80% of its domestic water from desalination (increased from 55% in 2016); the costs have reduced significantly and are now just one-third of what they were in 1990.[49]

49 Weiss, M., *The Irish Times* (18 July 2019), 'How Israel used desalination to address its water shortage'.

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Tidal power could represent a major source of clean energy if it can be economically harnessed

Beyond the ongoing expansion of offshore wind farms, tidal and wave energy facilities could also meet an increasing portion of global energy needs in the future. Extraction of resources from continental shelves could also offer new ways to meet energy requirements. Frozen methane hydrates, for example, may be a cleaner alternative to oil or coal and are abundant in these shallower waters.[50] While profitable extraction is not yet feasible, they could become a major source of energy in the future. Emerging technologies enabling maritime green hydrogen production and carbon storage could also support the decarbonisation of the global economy. While undersea electric grid connectors are already common in Europe, efforts to connect energy-importing states with solar-rich regions are now under way, including plans to link Singapore to Indonesia[51] and the UK to Morocco.[52]

Deep-sea mining could help to address growing resource requirements out to 2055. Critical minerals on the seabed are often in concentrated nodules, theoretically making them less environmentally damaging to extract than those on land, which typically involves digging, sifting and disposal, and can also cause deforestation. Although in its early stages, deep-sea mining of minerals could therefore become a more profitable and less damaging alternative. Exploratory surveys have already started, particularly in the Pacific Ocean around hydrothermal vents, seamounts and on the abyssal plains.[53] Many of the regions identified for future seabed mining are also recognised as having vulnerable marine ecosystems, and negotiations to resolve these tensions have yet to conclude. However, irrespective of the outcome of negotiations, this could create a new frontier

50 Miller, K., et al., *Frontiers in Marine Science*, Volume 4 (10 January 2018), 'An Overview of Seabed Mining Including the Current State of Development, Environmental Impacts, and Knowledge Gaps'.
51 Reuters (8 September 2023), 'Singapore approves import of 2 GW low carbon power from Indonesia – minister'.
52 Mavrokefalidis, D., Energy Live News (4 April 2023), 'Massive Morocco-UK cable reportedly gains financial boost from Middle East'.
53 Miller, K., et al., *Frontiers in Marine Science*, Volume 4 (10 January 2018), 'An Overview of Seabed Mining Including the Current State of Development, Environmental Impacts, and Knowledge Gaps'.

for competition as commercial and state actors race to be the first to capitalise on new resources. In 2021, for example, Nauru threatened that if a mining code was not agreed, it might begin mining regardless.[54]

The International Seabed Authority has awarded 31 exploration contracts to 22 contractors since 2001

While an expansion of low Earth orbit satellites could begin to fill gaps in Internet coverage in more remote regions (including on the seas), out to 2055, fibre-optic cables are likely to remain the cheaper, higher-volume mainstay of global digital communications. This industry is therefore expected to expand considerably, particularly in the Indo-Pacific region and through programmes to improve connections in the Global South that are independent

54 Standing, G. (2022), *The Blue Commons: Rescuing the Economy of the Sea*, page 352.

of Northern Hemisphere hubs. Land-based data farms currently consume 3% of global energy,[55] a figure set to rise significantly by 2055; underwater data farms are already being developed that are far less energy intensive, quick to install and have a much lower failure rate. However, this growing network could pose an increasing number of geostrategic, policy and legal risks. With undersea cables often being privately owned by companies such as Meta and Google (which, combined, reportedly own 29% of global cables)[56] or by state-owned Chinese companies, this could lead to increasing competition to provide Internet infrastructure. Uncertainty as to who is responsible for the security of these structures in international waters could further complicate this picture.

The Humboldt Cable

The Humboldt Cable System is a 14,810 kilometre submarine cable project connecting Chile, French Polynesia and Australia, with branches for the possible connection of other countries and territories. When completed, the fibre-optic cable will have a capacity of 144 terabytes and a 25-year lifespan. This project, which is being undertaken as a partnership between Google, Desarrollo País of Chile and the Office of Posts and Telecommunications of French Polynesia, will increase the reach, reliability and resilience of the Internet by adding a trusted and secure route across the Pacific Ocean.[57]

Conflict and security

Competition in relation to the oceans is likely to increase over the next three decades as resource demand grows and the seas become more congested. At the same time, the risk of conflict between global powers is also increasing, with corresponding implications for the maritime domain.

While the US remains the only power able to sustain a permanent worldwide naval presence, many states are growing their capabilities, which will increasingly see the US' attention divided across multiple regions. For example, China's navy has already surpassed that of the US in terms of numbers[58] and, out to 2055, is expected to field increasingly advanced capabilities; Russia's navy retains advanced submarine and other capabilities. Other states are also growing their capabilities, either in opposition to the West or to hedge against an uncertain future. Winning a decisive battle on the high seas is unlikely to be an objective for many of these states, with many pursuing asymmetric strategies designed to limit access to maritime regions of national interest. However, some global powers will continue to develop ever more advanced maritime, air, cyber and space capabilities, and seek to build global alliances to limit their adversaries' maritime options. In the future, the risk of miscalculation or conflict could potentially increase. This situation may be further exacerbated if states continue to pursue activities that undermine the principles of UNCLOS, such as employing military and security capabilities to assert territorial claims and using blockades as a belligerent act.

55 Law, M., Data Centre Magazine (30 December 2022), 'Energy efficiency predictions for data centres in 2023'.
56 Seal, T., Bloomberg UK (14 March 2019), 'The Undersea Cable Network Is Booming Again, This Time Funded by Big Tech'.
57 Submarine cable networks (2024), 'Humboldt Cable'.
58 U.S. Naval Institute (11 October 2023), 'Report to Congress on Chinese Naval Modernization'.

Increasing use of the sea may result in a rise in illegal activities, which may drive the increasing use of private military and security companies

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The merging of military and other maritime levers of power is likely to increase out to 2055. While not a new phenomenon – most states own or charter merchant fleets to support their navies – the increasing use of coastguards and other maritime security capabilities to exert influence could be a growing trend. China, for example, frequently uses its coastguard to assert its claims in the South China Sea, as well as using its maritime militias and substantial fishing fleet for power projection. Its growing state-owned merchant fleet, with its potential for dual-purpose use, would also be an advantage in any future conflict in East Asia. In the future, increasing criminality and piracy on the high seas may also see a continuing growth in private military and security companies, which may take on combatant roles in times of conflict.

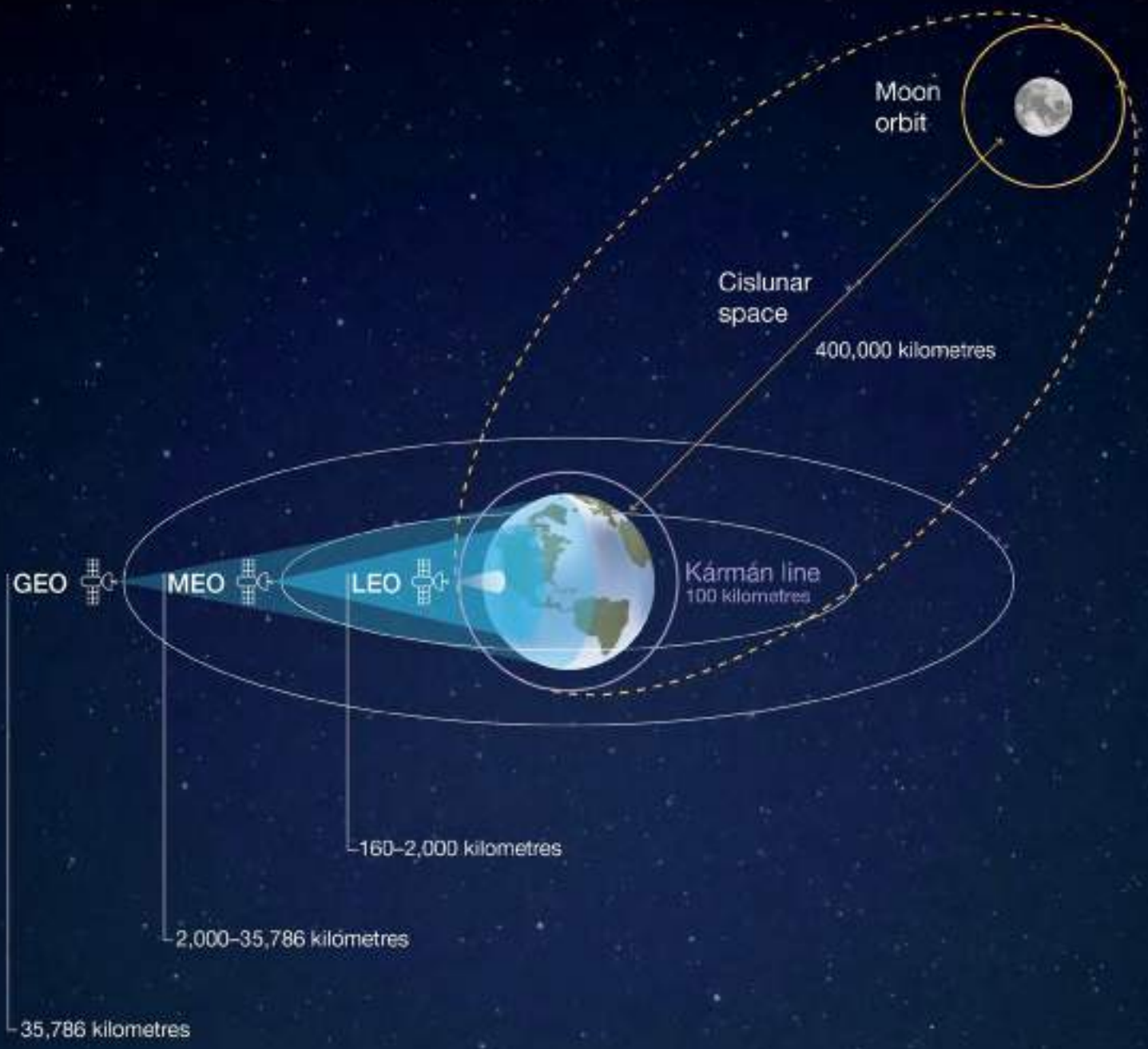
The use of the oceans for illicit and illegal behaviour seems likely to persist and could even increase. Virtually all the world's seas are already afflicted by illegal activity, from migrant and narcotics transport across the Caribbean Sea and the Mediterranean, to smuggling and piracy in the seas of Southeast Asia, and piracy and maritime crime off the coasts of West and East Africa. Given anticipated regional trends, these hotspots seem likely to endure or even intensify out to 2055. With global trade patterns likely to change significantly in the coming decades, new areas of maritime insecurity could also appear. The west coast of Latin America, Central America, the Suez Canal and the Arctic are all potential future hotspots.

The increasing importance of the ocean economy, including the emergence of new sectors, could create new security tensions in the future. An expansion of undersea infrastructure in particular could pose an increasing risk to state security and the global economy. Submarine cables, including fibre-optic telecommunications cables and power interconnectors (which transfer electricity between countries and regions enabling optimised use and storage of renewable and nuclear energy) may be potential targets for attack. Recent damage to cables in the Greenland Sea connecting the Arctic archipelago

and mainland Norway in 2022,[59] in the Baltic Sea in 2023, affecting Estonia, Finland and Sweden,[60] and in the Red Sea in 2024 all demonstrate the risk that incidents of this kind could pose to infrastructure in the future. Although these incidences could have been the result of accidental damage, natural hazards or damage from fishing vessels, the critical role of submarine cables makes them a target for sabotage – whether physical or cyber. Protecting this critical infrastructure is likely to become an increasing focus for states out to 2055.

Increasing extractive activity and a growth in renewable energy infrastructure in territorial waters and exclusive economic zones have the potential to further increase geopolitical tensions, including in already disputed areas. This could have an impact on relations between neighbouring states, and between the commercial interests of developed countries and states in the Global South. With climate change set to alter the land mass of many island states and the potential development of new floating offshore complexes to hold cities and infrastructure, fresh disputes could arise concerning jurisdiction over maritime territories. In addition, the deep oceans could become an increasing source of competition; as the demand for resources grows, disputes over existing and new claims over the seabed could arise. These developments could therefore see commercial interests and actors playing an increasing role in maritime security in future years.

59 Nilsen, T., *The Barents Observer* (9 January 2022), 'Disruption at one of two undersea cables to Svalbard'.
60 Sytas, A. and Kauranen, A., Reuters (27 October 2023), 'Three Baltic pipe and cable incidents 'are related', Estonia says'.



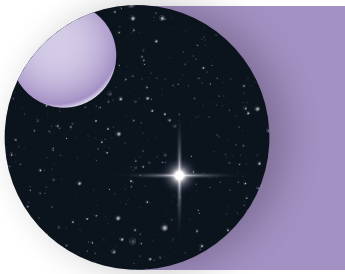
Satellite orbits

GEO geosynchronus Earth orbit

MEO medium Earth orbit

LEO low Earth orbit

Space



Current strategic context

Space is critical to modern life. From communications to navigation and from environmental monitoring to economic transactions, there are now few areas of human activity that do not rely on space technologies in some form. Space has played a central role in driving wider scientific advances, shaping attitudes towards technology and the future. It is also critical to military operations, national security, national prestige and the competition between powers.

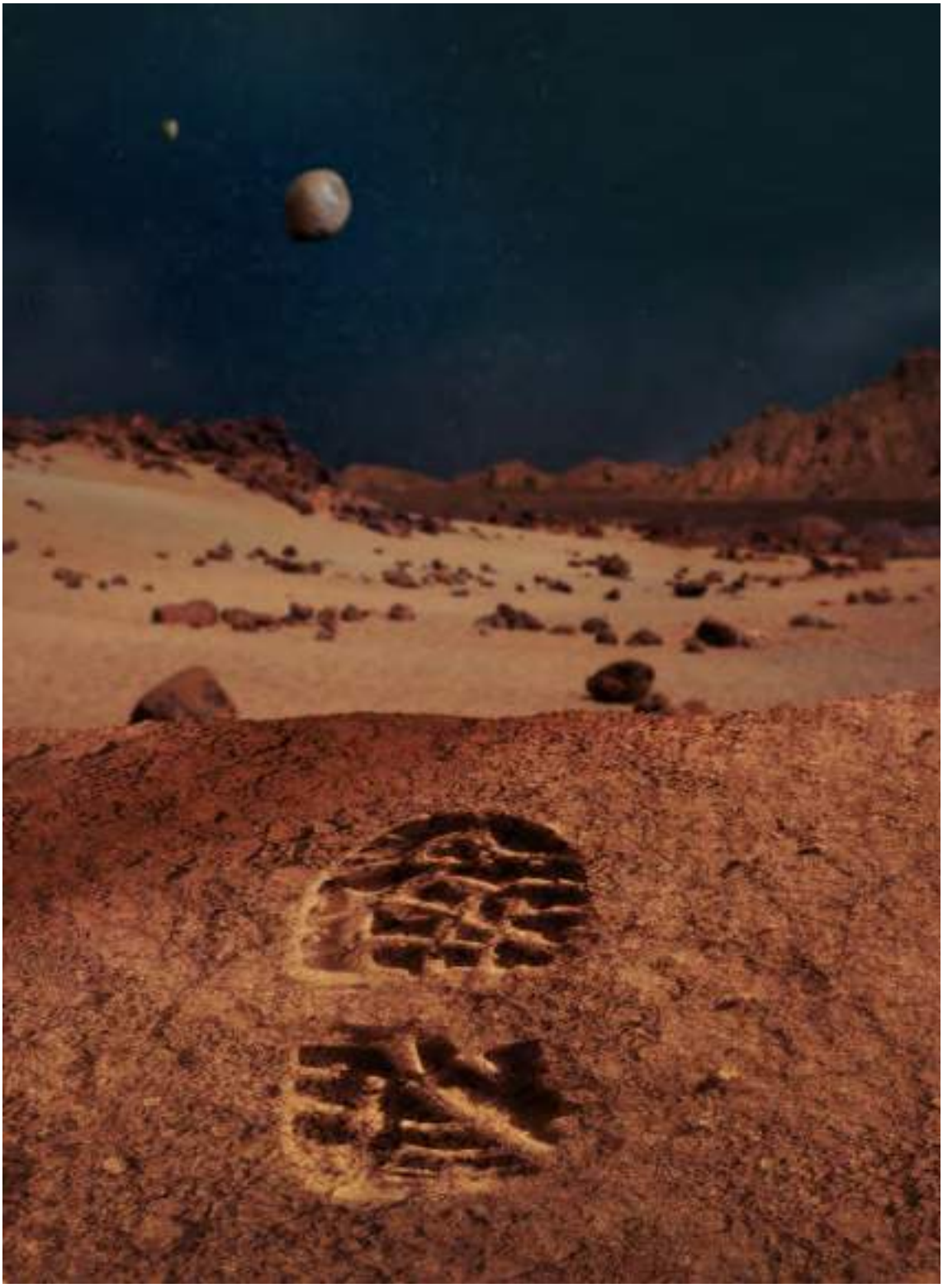
The 21st Century has seen an acceleration in the development of space technologies. Robotic systems, environmental monitoring capabilities and nanosatellite imaging are some of the more positive developments. On the other hand, the proliferation of counterspace capabilities and other dual-use technologies have the potential to lead to the increasing militarisation of space, while advances in hypersonic vehicles could increase the threat of difficult-to-counter conventional and strategic strikes. While the space domain has traditionally been considered as a shared space for the benefit of all humankind, diverging capability and budgets within and between regions mean that some could be left behind in an increasing race for dominance.

Space is becoming increasingly cluttered, with over 8,000 active and 3,000 dead satellites currently in orbit, together with 36,500 pieces of space debris larger than 10 centimetres and 130 million pieces over one millimetre.[1] This significant volume of space debris means that spacecraft, both human-crewed vehicles and robotic satellites, are increasingly having to take action to avoid damage. There is now a 1-in-10,000 risk of collision for human space flights and 1-in-1,000 risk for robotic satellites, which has seen the International Space Station having to make 25 avoidance manoeuvres since 1999.[2]

Although the increasing commercialisation of space is bringing huge benefits, it also increases risk as space becomes ever more accessible and congested. Launch costs have dropped from United States (US) $18,000 per kilogram in 2000 to as low as US $1,500 in 2023 due to more reusable launch vehicles, nanosatellites and other light payloads, off-the-shelf technologies and commercial scaling.[3] Industry placed over 1,000 spacecraft into orbit in the first six months of 2022, exceeding the number launched by governments over the past 60 years.[4]

1 European Space Agency (6 December 2023), 'Space Environment Statistics'.
2 European Space Agency (22 October 2019), 'Automating collision avoidance'.
3 Brukardt, R., *McKinsey Quarterly* (28 November 2022), 'How will the space economy change the world?'.
4 Bockel, J., NATO Parliamentary Assembly: Economic and Security Committee (17 November 2018), *The Future of the Space Industry*.

Advances in space technology have always been a stepping stone for wider innovation. The world continues to witness historic firsts, including the SpaceX vertical take-off vertical landing Falcon 9 rocket's first re-entry landing in 2015, the first powered and controlled flight on Mars (American Ingenuity) in 2021, the James Webb Space Telescope, launched the same year, capturing images showing extraordinary detail of the Milky Way, and the first landing on the lunar south pole (Indian Chandrayaan-3) in 2023. These headline-grabbing events have strongly influenced public support and interest, as well as government and investor funding, and they will continue to do so in the future.



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Key drivers of change

Technological determinism. The desire for discovery, prestige and scientific ingenuity will continue to drive progress in space exploration and technologies in the coming decades. However, although the costs of entry – particularly into low Earth orbit – are reducing, making space more accessible, it will remain a challenging environment with significant associated risks. Innovation and scientific breakthroughs, many with broader benefits on Earth, have often followed monumental failures, a pattern which is likely to continue in future years.

Space politics. Domestic and global politics, as well as the desire for international prestige, will remain key factors in space exploration. The advent of a multipolar, multistakeholder space race means that space technologies and infrastructure will be exploited to support both state and non-state actors in their strategic posturing and rivalry. Space politics and global power competition will both drive and constrain space activity, operations and law.

National security and defence. Activities in space will continue to be a critical element of national security and a fundamental part of deterrence. Increasing reliance and demands on satellites and other space assets will continue to drive the development of space-access technologies. With a number of states declaring space as an operational domain, many of the activities and research and development programmes in the space sector will be driven by national security aims and objectives.

Environmental change and resource scarcity. Climate change will be a key driver in the expansion of space activity, with space-based remote sensing playing a vital role in monitoring environmental change. Government agencies and research institutes will be heavily reliant on space-based assets to monitor the physical environment and prepare for, predict and prevent disasters. Environmental changes will drive increasing demand for weather-monitoring and Earth observation satellites. Rising demand for energy and other terrestrial resources could also see new space-based activities emerging such as asteroid mining and resource recovery.

Commercialisation and increasing access to space. As barriers to entry diminish, commercial entities and industrial actors will have an increasingly significant stake in space exploration, with commercial imperatives playing a greater role. The influx of private investment will not only drive space activity but also yield new industrial processes. Progressive innovation in reusable platforms, combined with using off-the-shelf components, will steadily drive down the cost of heavy lift launches, making space more accessible to multiple actors and even more crowded as a result.

Future key trends

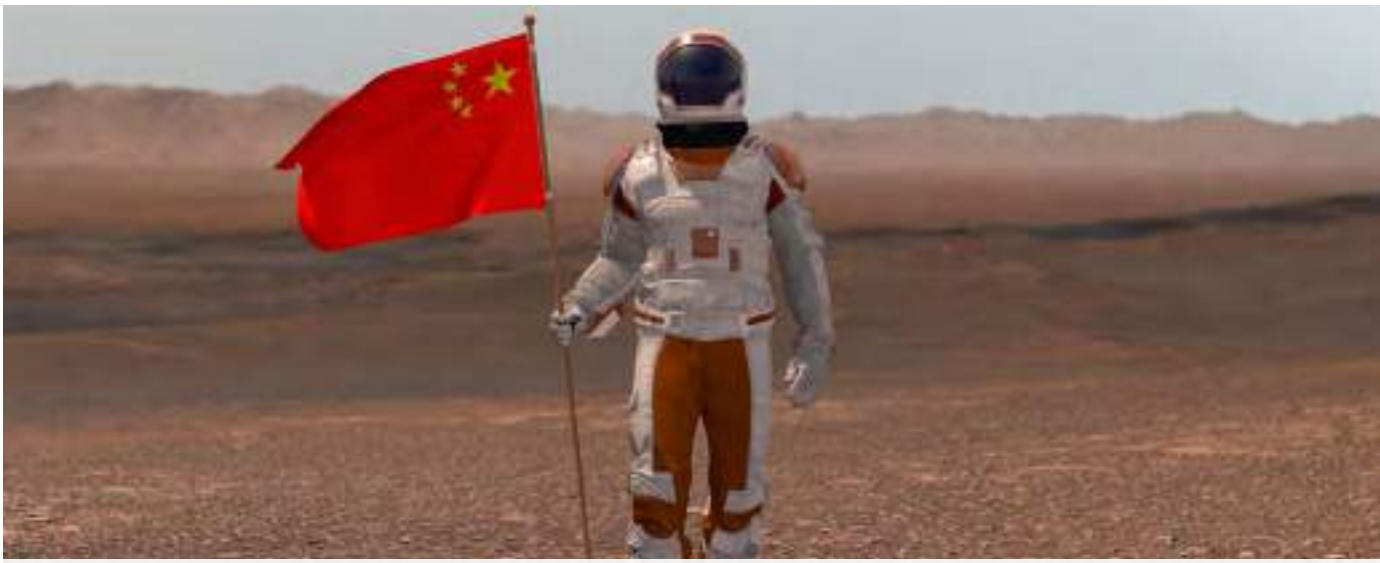
Global power competition

The space domain will remain crucial for global power competition and cooperation over the next few decades. While the post-Cold War period saw increased interstate collaboration, joint scientific projects and shared missions between the US and Russia, competition is now once again on the rise, with the number of competing actors continuing to grow. The Artemis Accords[5] and the International Lunar Research Station[6] agreement are initiatives by the US and China respectively, intended to set the rules of cooperation on the Moon and beyond. Although not mutually exclusive, the signatories to each agreement can be seen as a suggestion on where the lines of upcoming astropolitical alliances will be drawn. This is already resulting in the return of the 'action-reaction phenomenon' – where one state makes a technological accomplishment (for example, in hypersonic vehicles), which triggers a response by others; out to 2055, this trend is likely to gain momentum, with states competing to achieve technological dominance in the space domain.

The relative decline in US civil investment in space activities from the 1980s has allowed others, including China, to catch up and to some degree take a lead on some services in recent years. However, the US is reversing this trend,[7] and in the next three decades it aspires to return crewed missions to the Moon and land the first humans on Mars. It also plans to open a Lunar Gateway (in partnership with the European Space Agency, the Japan Aerospace Exploration Agency and the Canadian Space Agency), which will serve as a scientific laboratory, communications hub and base for probes, rovers and robots, as well as a short-term habitation module for astronauts. While economic and other uncertainties may see the US facing some challenges to deliver on this ambition, the country will certainly remain a dominant space actor, although it may look to increase cooperation with European, North Atlantic Treaty Organization (NATO) and Indo-Pacific allies and partners, and outsource routine activities to commercial actors to allow it to focus on high-prestige missions.

While Russia has in the past played a leading role in the International Space Station and in launch capabilities, geopolitical tensions, combined with a growing number of commercial partnering alternatives, have seen collaboration between Russia and Western states collapse. Russia has announced that it will withdraw from the International Space Station after 2028,[8] and in the future may seek to develop orbital and lunar stations with China as an alternative. This cooperation may result in greater integration between these countries' satellite navigation systems and the sharing of sensitive early-warning technology. In the longer term, adverse economic conditions could see Russia's ageing space infrastructure become increasingly obsolete, causing it to lose its first-tier status.

5 As of 1 January 2024, there are 36 signatories to the Accords, including Canada, France, Germany, Italy, Japan, the UK and the US.
6 As of 1 January 2024, there are eight signatories to the agreement, including Belarus, China, Egypt, Russia and South Africa.
7 Chatzky, A., et al., Council on Foreign Relations (23 September 2021), 'Space Exploration and U.S. Competitiveness'.
8 Garcia, M., NASA (27 April 2023), 'Partners Extend International Space Station for Benefit of Humanity'.



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There is increasing competition to reach Mars first

In recent years, China has made major investments in its space capabilities, including space traffic management, cataloguing and debris monitoring, thereby reducing its dependency on Russia. Its Earth observation capabilities have seen vast improvements, especially concerning military surveillance of the Western Pacific.[9] BeiDou, China's global navigation satellite system, is promoted as an alternative to US' Global Positioning System (GPS), with a global coverage and services in over 120 states. In the last decade, China has doubled its yearly satellite launches, placed three stations in orbit and landed a rover on the Moon and Mars. It has also achieved a first by exploring the far side of the Moon and intends to create human settlements there by 2036. China also plans to increase its number of Mars missions by 2030, and it could establish a cislunar[10] space station and put humans on Mars by 2055. However, while China is likely to be a major space actor by 2055, possible funding cuts in the face of socio-economic challenges may limit its ability to achieve these ambitions in practice.

While major powers are likely to dominate space exploration and activity over the next few decades, middle powers and commercial actors will also play an increasing role. In Europe, the European Space Agency and the UK, Germany, France and Italy will all be important space actors in the future. Out to 2055, the European Space Agency and the European Commission will continue to invest in space exploration, asteroid mining and developing next-generation global navigation and satellite communications systems. European states are also likely to form partnerships with closely aligned states such as the US, Canada, Australia, South Korea and Japan to pursue joint projects and establish common norms.

Other new and emerging space powers such as India, North Korea, Israel, Iran, Turkey and the United Arab Emirates are intensifying their space research and development activity. Some of these states will increasingly coordinate their efforts to counter any attempts on the part of more established spacefaring actors to regulate orbits or control space-access and rocket technologies. In 2023, India became the first country to successfully land a spacecraft near the south pole of the Moon and it will continue to pursue historical firsts in space, potentially placing itself as an increasingly capable space power.

9 Decker, A., Defence One (2 May 2024), 'Chinese satellites are breaking the US 'monopoly' on long-range targeting'.

10 Cislunar is defined as: 'between the Earth and the Moon'. *Concise Oxford English Dictionary*, 12th Edition.

Increasing space debris may render existing orbits largely impenetrable and overcrowded

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Some African states are already active space players; Uganda and Zimbabwe launched their first satellites in 2022, while Egypt, Algeria and Nigeria could increasingly exploit space to monitor environmental hazards and assist with mineral exploration. Latin America's space potential is also growing, with the continent offering access to both equatorial and polar orbits; several countries have established national space agencies, 11 currently own or operate satellites,[11] and Argentina and Brazil have launch sites.[12] Looking forward, both commercial entities and external state powers may find Africa and Latin America attractive bases for space-related infrastructure and access to orbits.

While governments have historically contracted the aerospace industry to provide support to publicly funded space programmes, commercial investments are now at an all-time high. Building on significant government investment, private businesses are increasingly developing their own space programmes to provide telecommunication, imagery intelligence and broadband services to governments, non-governmental organisations and private customers. Companies such as Blue Origin, Virgin Galactic and Space X have plans to move research centres and other space-related infrastructure off planet to cislunar orbits and beyond. Given the growing ambitions of the space industry and the increasing demand for space-dependent services, this trend seems likely to endure, to the extent that private ventures could increasingly dominate in some areas of activity.

As increasing space debris renders existing orbits largely impenetrable and overcrowded, there may be increased competition over Lagrange points (positions where gravitational forces allow spacecraft to 'park' with minimal fuel consumption). As spots in these critical zones become limited, tensions between competitors may increase, turning them into new battlegrounds. Space-based competition might also expand to cislunar orbits. A lack of regulation governing the use of these orbits could see a rise in tensions, as states seek to establish early dominance and prime positions. Locations for extraterrestrial infrastructure may be another area for competition between states as well as commercial actors by 2055.

11 Union of Concerned Scientists (1 May 2023), 'UCS Satellite Database'.
12 Valero, M., Slate (6 May 2021), 'Latin America's Moonshot'.

The space domain has shifted from being the exclusive preserve of a few powerful states and super-wealthy corporations to an increasingly congested, contested and complex field. As competition increases, the governance and regulation of space-based activity and exploration will come under growing pressure, with implications for the recognition and acceptance of, and support for, the 1967 Outer Space Treaty and other space conventions. While the Outer Space Treaty has been effective in prohibiting the introduction of weapons of mass destruction to outer space, the existing (and in many cases dated) frameworks lack detail on emerging or future activities, such as celestial mining, lunar infrastructure development, space tourism, the taxation of commercial gains, criminal behaviour and citizens' rights. While the requirement for a new regulatory regime is likely to grow, increased competition and unconstrained violations of existing space law may make it difficult to secure agreement on any new forms of regulation. The Outer Space Treaty may effectively be obsolete by 2055, and space governance may instead be covered by non-binding global or regional codes of conduct, agreed by a select group of actors in furtherance of their own interests. Recent years have seen some progress in this area, and work within the United Nations Committee on the Peaceful Use of Outer Space (COPUOS) led to the development of the non-binding *Guidelines for the Long-term Sustainability of Outer Space Activities* in 2019.[13]

Society

Already critical to modern life, society will become even more dependent on the space sector in the future for communications, banking, trade, navigation and transport. Innovations in space technology will continue to have wider terrestrial benefits, including in the field of health care. For example, components from future telescopes and automated landers could be applied to advanced and remote medical treatments, including microsurgery. This could allow remote communities access to complicated medical procedures, especially operations involving complex organs such as the eyes, the brain and the central nervous system. By 2055, society may also be funding research on human reproduction in space, with potential wider benefits to society.[14]

How societies use and think about space will also change. An increasing number of actors will have a voice in space activity by 2055, resulting in what might be considered as the increasing 'democratisation' of space. A growth in space activity will drive an increasing requirement for related skills, notably in science, technology, engineering and mathematics. Societal dependence on space and the emergence of new ideas linked to space exploration will yield new educational opportunities, which may see the development of new academic disciplines. By 2055, space-related employment in fields such as medicine, sociology, psychology, physiology, food, law, platform design, construction and repair and asteroid mining could be more commonplace. However, while understanding of life on Earth will be greatly enhanced by commercial satellite imagery and space-based surveillance, out to 2055, developments in these fields may result in increasing concerns over privacy.

While space tourism remains primarily for the world's wealthiest individuals at present, over the next 30 years, cislunar stays and long-haul flights via space could be enjoyed by far greater numbers of people. By 2055, the world could see the first signs of permanent

13 United Nations Office for Outer Space Affairs (2019), *Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space*.
14 Watkins, A., *Physiology News Magazine*, Issue 117 (Winter 2020), 'Sex in Space: Our final reproductive frontier', page 14.

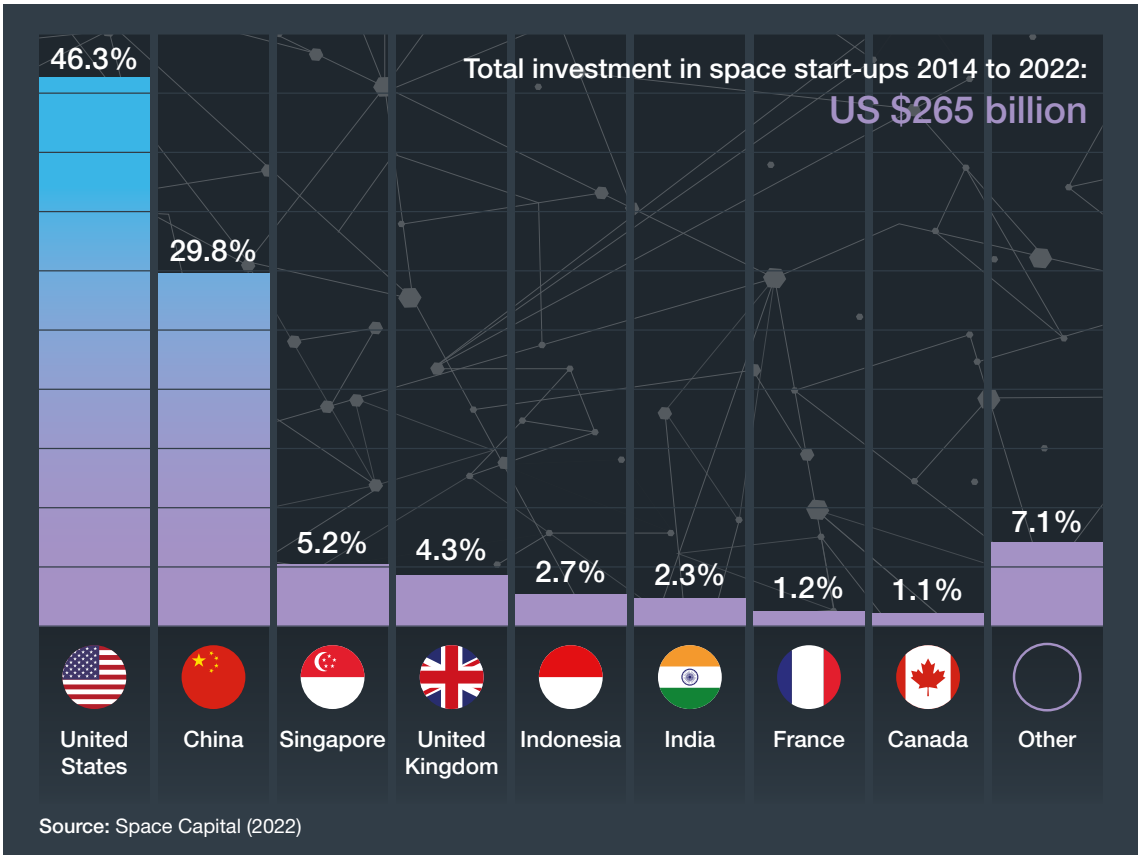
off-planet settlement and long-duration crewed flights to asteroids, the Moon and Mars, requiring substantial resources at these outposts. While self-contained spacecraft will remain necessary in the medium to long term, technological developments and the ability to access or manufacture resources at the outpost are likely to reduce dependence on supplies from Earth over time.

Permanent human settlement in space will only be possible if humans overcome a range of biological and physiological barriers. For example, prolonged exposure to microgravity and radiation are known risks for humans in space. Whilst space suits and spacecraft can offer some protection, ionising radiation and higher energy cosmic rays can damage brain cells, cause cancer and even mutate DNA.[15] Techniques such as immunotherapy could mitigate these risks but are as yet unproven. Living in an isolated environment could also have adverse neurocognitive impacts, and those participating in long-duration missions will require mental health support. Human augmentation, including breakthroughs in areas such as brain-computer interfaces[16] and human genome editing (such as CRISPR/Cas9), could increase resilience to the risks involved, but the effects are yet to be proven.

Economy

The global space economy is now worth around US $500 billion, 55% higher than a decade ago.[17] Current trends suggest that this could triple to around US $1.5 trillion by 2030 and over US $3 trillion by 2055.[18] Public markets as a source of funding will grow; in parallel, the number of private investors and influx of private capital will drive space activity and yield new industrial processes. The future space economy will increasingly be dominated by the private sector, with states concentrating their efforts on prestige missions and activities critical to national security. Private companies and institutions already own the majority of satellites, while start-ups receive and invest more than US $21 billion in space ventures every year, a figure which is likely to grow in the coming decades.[19] As a result, governments will increasingly work alongside the private sector in their space-based activities. Joint research through public-private partnerships, for example, will enable advances in vehicle design, heat-shield fabrication and satellite manufacture, with a wide array of applications in the upstream and downstream markets. A more symbiotic relationship between governments and the space industry will begin to evolve, with an increasing number of governments incorporating private sector space capabilities into their national security strategies by 2055.

15 Baker, G. and Burchell, M., Defence Science and Technology Laboratory (2022), *The future of Space in 2055: Social, psychological and biological trends, drivers and implications – a literature review* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
16 U.S. Government Accountability Office (8 September 2022), 'Science & Tech Spotlight: Brain-Computer Interfaces'.
17 McKinsey & Company (19 January 2023), 'A giant leap for the space industry'.
18 di Concini, A. and Toth, J., European Investment Bank (2019), *The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures*.
19 Sriram, A. and Singh, J., Reuters (11 April 2024), 'Space startups see funding surge as government spending remains high, report says'.



Distribution of investment in private space companies between 2014 and 2022, by country

Trends in start-up ventures have enormous potential to trigger advances in nanosatellites, space communication systems, electric propulsion systems and Internet solutions. Satellite capture, collection, disposal and recycling services are likely to yield new opportunities for private venture by 2055. While the growth in space markets could substantially impact the global economy, however, countries with less sophisticated space programmes may struggle to remain competitive in the future.

The cost of satellite and rocket launches will continue to reduce over the coming decades. A combination of changes will make this possible: adopting consumer-centric approaches, new rocket engine designs, reduced material costs and streamlining traditional aerospace business structures, following the example of SpaceX and Blue Origin. In addition, technological advances may result in new solutions beyond those currently imagined. Based on current trends, it is very likely that launch costs will fall to around US $1,000 per kilogram within the next decade and could be orders of magnitude cheaper in three decades.[20] As a result, satellite and rocket technology will be even more accessible to new actors. Trends in cost reduction suggest that the wealthiest of citizens and commercial entities could be able to launch small rockets into space for as little as a few hundred US dollars by 2055.

20 Roberts, T., Center for Strategic and International Studies (1 September 2022), 'Space Launch to Low Earth Orbit: How Much Does It Cost?'.

Cislunar tourism may help to drive the infrastructure and technology development needed for deeper human exploration of space

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In the longer term, cislunar tourism may act as a stepping stone for space colonisation and human settlement, with corresponding economic benefits. Long-haul space tourism and the development of cislunar hotels could become a reality that will increasingly appeal to broader society, who may begin to view space as an extension of the terrestrial domain.

Environment

Space technologies will play a vital role in monitoring environmental change over the next 30 years. As climate change accelerates, weather patterns will become less predictable and more erratic, making space-based observations ever more important to monitoring and disaster prevention. Space-based technology will increasingly be used to monitor deforestation and changes in air quality, as well as developments in the maritime environment and polar regions. Satellite technology will enable the tracking of weather patterns, as well as the prediction of droughts and flooding by using artificial intelligence algorithms. By 2055, therefore, space-based technology could constitute a primary tool in understanding climate change.

Space-based technology will begin to play an increasingly significant role in agricultural management and production. With the amount of global arable land steadily decreasing, farmers increasingly rely on remote sensing satellites to monitor drought, crop development, productivity and soil conditions, potentially bringing substantial benefit to rural populations and developing economies. In the future, space technologies could also help to tackle water scarcity, with hyperspectral satellites being used to identify drinkable water and local geological changes, as well as alerting populations to water pollution.[21]

Increasingly frequent travel into space, as well as the re-entry of boosters and decommissioned satellites, will release huge amounts of waste and particles into the Earth's upper atmosphere and is likely to have an impact on the Earth's climate, the

21 Thomasy, H., Eos (6 December 2021), 'A New Technique Could Identify Algae from Space'.

extent of which is currently unknown.[22] The development of future space stations, satellite mega-constellations, fuel depots and large-scale manufacturing facilities will require significant energy resources; the expansion of spaceports and other terrestrial infrastructure could also increase the level of the Earth's carbon emissions. However, the precise environmental impact will depend on the space industry's ability to develop and adopt sustainable solutions and renewable energy sources, which currently remains uncertain.

Space debris could also have its own environmental as well as economic and geostrategic impacts. Access to low and middle Earth orbits could become increasingly difficult, resulting in the loss of capabilities critical to the global economy, communications and environmental monitoring. Space debris may increasingly be viewed as a crucial issue for governments to address, resulting in growing investment in debris removal technologies to mitigate the effects of the so-called 'Kessler Syndrome' (where collisions between debris in a chain-effect-like development leads to an exponential increase of debris in orbit around the Earth).

As demand increases, the mining of celestial bodies and extraction of critical minerals may develop as a possible alternative to environmentally destructive extractive activity on Earth. The asteroid belt between Jupiter and Mars, for example, has unquantified reserves of critical and precious minerals such as gold, iron, nickel, cobalt and platinum. The lunar surface is also known to contain significant reserves of the rare helium-3 isotope, used in the production of nuclear energy. In the future, these resources could be extracted, harvested and recovered for use in space and on Earth. While current cost structures and the technical difficulties of extraction would not justify space mining in the near term,[23] resource scarcity on Earth, combined with climate change and environmental concerns, could see rising investment in new technologies to drive costs down in the future.

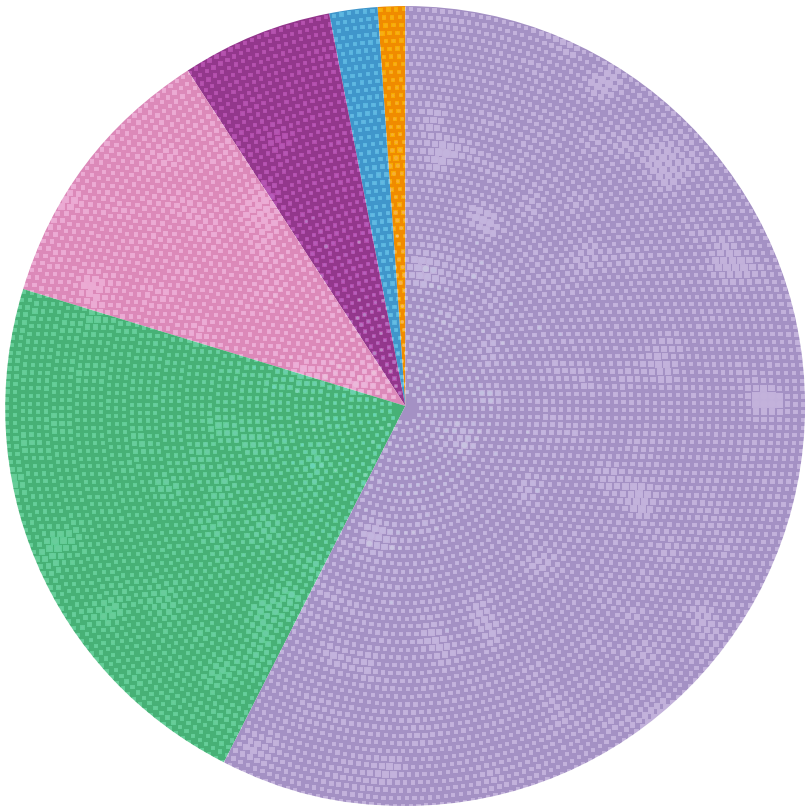
Technology, infrastructure and communications

Over the next three decades, it is likely that rapid advances in wider science and technology will continue to promote space as an environment for human endeavour. Technologies that are likely to advance at a transformative pace and reduce barriers to entry include satellite imagery, miniaturisation (nanosatellites), microgravity additive manufacturing (3D printing), reusable vehicles, robotics and automation, data transfer, broadband Internet and artificial intelligence.

By 2055, developments in satellite technology could result in the automation of a broad range of terrestrial activities. Traffic management, smart cities and transport are already benefiting from using space technologies; going forward, increases in spatial resolution and geolocation services will drive significant innovations in transport, including in self-driving capabilities and vehicle-to-vehicle communications. Commercial aviation and maritime vessels will be fully integrated with satellite communications and positioning, navigation and timing systems, embedded in advanced satellite constellations. Satellite imagery will also help state and global authorities to exert increasing oversight and control of remote or otherwise inaccessible territory and shared spaces, with numerous applications, from combatting illegal, unreported and unregulated fishing and piracy to monitoring illegal deforestation, migration and the production and smuggling of illicit substances.

22 Sirieys, E., et al., MIT Science Policy Review (29 August 2022), 'Space sustainability isn't just about space debris: On the atmospheric impact of space launches'.
23 Bockel, J., NATO Parliamentary Assembly: Economic and Security Committee (17 November 2018), *The Future of the Space Industry*.

While undersea and cross-land fibre-optic cables currently enable the majority (over 95%)[24] of Internet traffic and are likely to remain the mainstay of global digital communications, in the coming decades space-based broadband services will play an increasing role, especially during periods of conflict and in areas with underdeveloped infrastructure. Mega-constellations, comprising thousands of satellites, may provide more people – particularly those in poor and rural areas – with affordable access to the Internet. The most remote geographical areas will also become better connected, transforming their future socio-economic and environmental trajectories.



57% Starlink
22% Communication
11% Remote sensing
6% Research and development
2% Positioning, navigation and timing
1% Meteorology

Source: Westman, J., et al., Swedish Defence Research Agency (2023), *Global Space Trends 2023*

Percentage of active satellites in orbit by usage type as of October 2023

In the future, alongside ongoing research programmes on Earth, research in space could also support developments in health care and drive pioneering biomedical treatments. Biofabrication (the production of complex biological matter from raw materials such as living cells and molecules), 4D bioprinting[25] and tissue engineering technologies are fast-developing areas with significant potential, particularly given the global shortage of suitable organs for transplantation. While the extent to which these technology trends might have advanced by 2055 may be uncertain, experiments on the International Space Station show that human tissue growth in space could be feasible in the coming decades.

24 Sherman, J., Atlantic Council (13 September 2021), *Cyber defense across the ocean floor: The geopolitics of submarine cable security*.
25 Ashammakhi, N., et al., *Biotechnology Journal*, Volume 13 (December 2018), 'Advances and future perspectives in 4D bioprinting'.

Bio-ink and tissue growth in space

In 2019, NASA developed living tissue using a modular 3D printer and bio-ink technology. The experiment took place in the BioFabrication Facility on the International Space Station.[26] The facility, which is funded by the American companies Techshot and NScrypt, is designed to print human cells into organ-shaped tissues, the controlled environment on board the International Space Station providing optimum conditions for research of this kind. Two American companies, Techshot and Axiom Space, have since signed an agreement to install the first commercial 3D bioprinter on the International Space Station. More recently, NASA successfully conducted its first BioFabrication Facility-Meniscus investigation bioprinting a human knee meniscus in orbit.[27]

While the convergence of these technologies will become increasingly central to terrestrial human activity, they will also support missions to cislunar orbits and beyond by 2055. For example, advances in mechanical and electronic miniaturisation, quantum computing, sensor technology and satellite communications will radically reduce the size, power consumption and weight of modular satellites, while also making them more capable. In the coming decades, improvements in radar, light detection and ranging (LiDAR), optics, machine visions, cadence and spatial resolution will transform satellite imagery and spectrometry of the Earth, while also supporting future deep-field telescopes for the observation of other galaxies.

Additive manufacturing (3D and 4D printing) may be a key enabler for space-based exploration and activity by 2055. Advances in microgravity additive manufacturing could enable the rapid printing of mechanical components and tools in zero-gravity conditions. In the future, space explorers may leverage additive manufacturing to build and repair infrastructure on the surfaces of the Moon and Mars. Trends in vacuum-based additive manufacturing (polymers, composites and metals) appear particularly promising and might offer solutions for energy storage. Robots could also play a pivotal role in facilitating space exploration, with robotic manipulators and space docks being deployed for on-orbit inspection, repair, repurposing, maintenance, refuelling and assembly.

These same technologies may also help to facilitate breakthroughs in space habitation. At present, the practical barriers to prolonged life in deep space are considerable; unless carried with the spacecraft, and therefore in limited supply, everything required to sustain human life – oxygen, water and food – is subject to uncertain availability and/or unproven technologies. In the future, however, pioneering expeditions may be able to extract water from the Moon's surface to sustain long-term space habitation and missions,[28] while additive manufacturing will enable food printing. By 2055, early manifestations of in-situ agriculture, including the growth of biochemically altered vegetation, may be possible using hydroponic gardening techniques. Explorers could also use specialist excavators to extract water from the Moon, Mars and beyond to meet water and oxygen needs.

26 Boling, R., International Space Station National Laboratory (13 August 2019), '3D Printer for Human Tissue Now Available for Research Onboard the ISS National Laboratory'.
27 Space Station Research Integration Office, NASA (20 December 2023), '3D Bioprinting'.
28 NASA (16 July 2023), 'Using Space-Based Resources for Deep Space Exploration'.

The next 30 years could see breakthroughs in engine and propulsion technologies

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Breakthroughs in engine and propulsion technologies will be key to determining the rate and depth of future space exploration. Future decades may see new developments in horizontal take-off and landing capabilities, single-stage-to-orbit systems, kinetic energy space launch systems (such as SpinLaunch), planetary landers and laser-powered nanocraft, solar sails and electric and electromagnetic propulsion systems brought into operation.

While the majority of satellites in Earth orbit will continue to use solar panels for energy generation, advances in nuclear power could also greatly enhance future space travel capabilities. Advanced nuclear technology such as small and micro modular reactors are likely to see increased use over the next three decades,[29] and nuclear fusion research will advance further, perhaps to the point of commercialisation. China already has plans to build nuclear-powered shuttles and send them into orbit as early as 2040. This could halve the time required to reach Mars, effectively making human habitation in space a real possibility. Nuclear energy could not only act as an enabler for clean energy use at outposts, but also allow for the operation of high energy power stations on the Moon and Mars.

As space becomes increasingly commercialised, the requirements for physical and digital infrastructure will grow exponentially, expanding beyond low, medium and high Earth orbits. The number of landing and recovery sites on the Earth, Moon and Mars are likely to expand, with sea-based spaceports potentially becoming increasingly widespread by 2055.

Conflict and security

Space capabilities already form the backbone of multi-domain operations for some states and will increasingly act as a formidable force multiplier. The current shift from dependence on a few assets in higher orbits (geosynchronous Earth orbit and medium Earth orbit) to an increasing number of constellations in low Earth orbit marks a paradigm shift in the use of the space domain for military purposes. This could see to extraterrestrial infrastructure being established to support and protect future warfighting capabilities. Military satellite designs could incorporate self-defence capabilities, while co-orbital missile defence systems may emerge by 2055. Although there is no possibility for immediate or near-term deployment of these systems, in the long term, orbital interceptors could be designated to protect and defend military satellite constellations against ground-based anti-satellite systems, and a space-based interceptor could emerge as a novel counter to hypersonic glide vehicles.

29 Ball, P., *Scientific American* (1 June 2023), 'What Is the Future of Fusion Energy?'.

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Satellite-based capabilities may provide significant strategic advantage in future conflicts

Out to 2055, traditional powers will see their advantage in space erode as emerging powers such as China seek to boost their capabilities in the field of space technology. In the coming decades, for example, China is likely to use its space capabilities to enable it to extend its advanced intelligence, surveillance and reconnaissance, and positioning, navigation and timing capabilities; it may also deploy a new oceanographic satellite,[30] master space debris mitigation and docking techniques, and field sophisticated space tug capabilities.[31] By 2030, China is likely to field directed energy weapon capabilities designed to target non-optical satellite structures. Those space-based capabilities will include kinetic-kill missiles, orbiting space robots and ground-based lasers.[32]

Despite Russia's technological setbacks and funding shortfalls, nuclear deterrence remains central to its standing as a global power. This includes contingent access to space-based capabilities, and the Russian armed forces maintain an ageing fleet of satellites providing early warning, radar observation and electro-optical imagery. Russia may be able to field lasers and higher power systems capable of targeting both electro-optical intelligence, surveillance and reconnaissance and satellite infrastructure in the coming decades. Russia aims to increase its investment in mobile missile systems, including the potential use of anti-satellite capabilities and on-orbit vehicles to target military assets. These capabilities will allow Russia to target vital links between ground and space capabilities and contest the electromagnetic spectrum.

Out to 2055, these developments will inevitably trigger a response not only on the part of the West but also other emerging powers. NATO and its member states now treat space as an operational domain where offensive and defensive operations might take place. Other partners are following suit, while nuclear-capable powers like India and proliferators such as North Korea are also emphasising orbital launch and kinetic physical attack capabilities as part of their nuclear programmes. Taken together, these developments are likely to increase instability in the international system, exacerbating the risk of miscalculation and unintended escalation.

30 Stokes, M., et al., U.S.-China Economic and Security Review Commission (30 March 2020), *China's Space and Counterspace Capabilities and Activities*.
31 Defense Intelligence Agency (2022), *2022 Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion*.
32 Ibid.

Increasing weaponisation of space and development of anti-satellite and directed energy weapons will create legal and ethical dilemmas

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Improvements in miniaturisation, hypersonic aerodynamics, engine fuel efficiency, precision guidance and payload capacity will make it more challenging to control proliferation-sensitive technology in the future. Equally, space-based assets may challenge the ability to conceal military capabilities, with wider implications for operations and deterrence. This could trigger further rounds of proliferation and potentially lead to another arms race.

Space weaponisation: a definitional problem

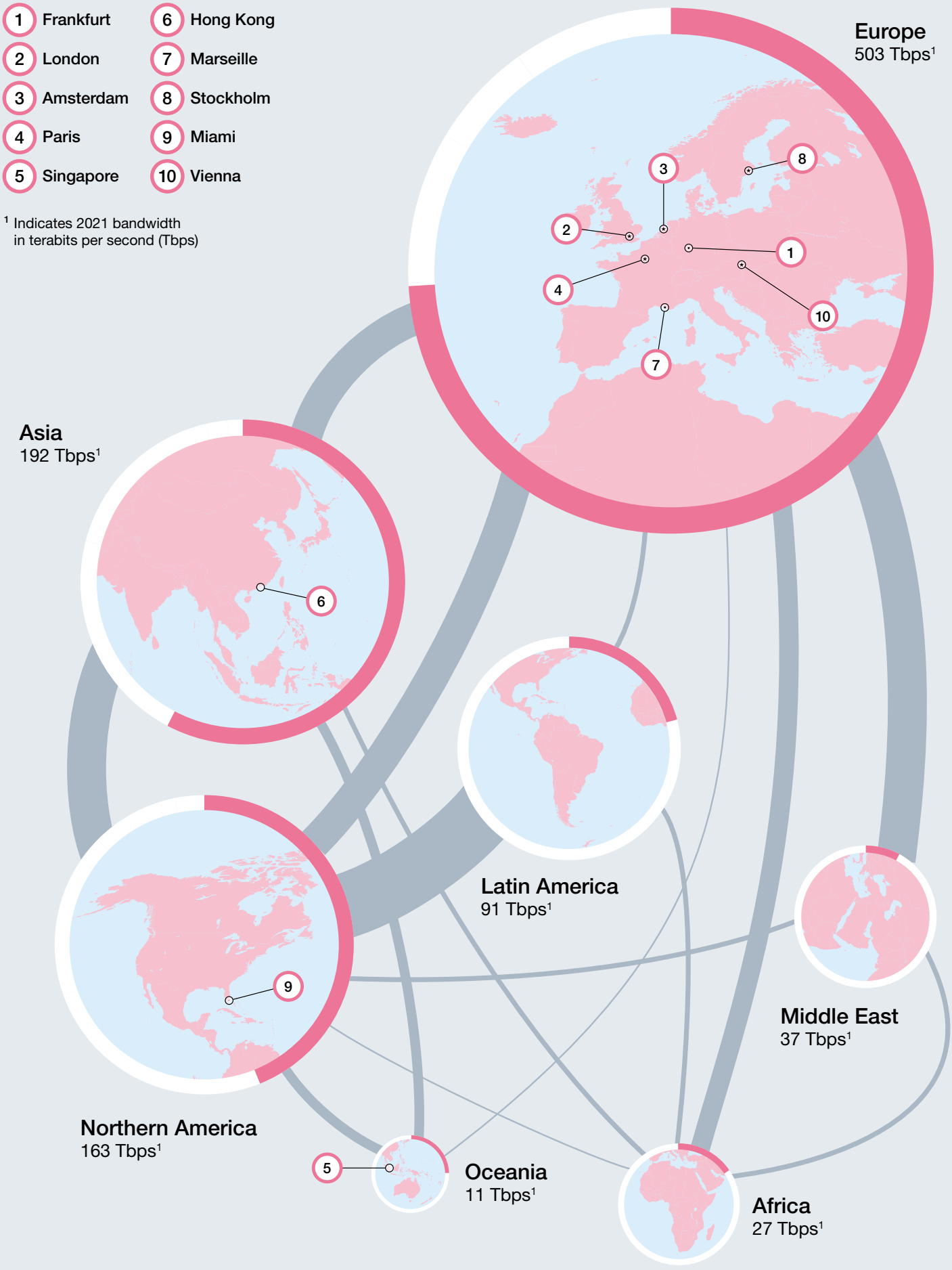
The Outer Space Treaty 1967 (one of five United Nations Treaties on outer space) prohibits the placement of nuclear weapons and other weapons of mass destruction (chemical and biological weapons) in orbit around the Earth, and the installation of those weapons on celestial bodies or any other stationing of them in outer space. However, international space law does not prohibit the deployment of conventional weapons in outer space. Opinions differ as to what constitutes a 'space weapon'; satellite navigation, for example, is both a civilian and military tool. The advent of dual-use capabilities and systems further complicates any enforcement of the Outer Space Treaty, as the Treaty does not clarify whether a space weapon must be based in space, or if its primary purpose must be to inflict physical damage.

While the current focus is on Earth orbital capabilities, warfighting considerations are increasingly expanding to include cislunar options. This would allow forces greater freedom of access and manoeuvrability to position assets, including deep space situational awareness capabilities, data relay satellites and other beyond-line-of-sight satellite communications, to provide more accurate targeting data.

Over the next 30 years, developments in commercial space technologies will increasingly drive the global defence and security agenda, as well as responding to it. This includes not only the increased outsourcing of many space services such as telecommunications and imagery intelligence, but also commercial innovations creating an increasingly rapid and far-reaching effect on operations.

While private citizens will get easier and cheaper access to space, a lack of robust governance mechanisms to regulate space-based activity could result in a growing range of cybersecurity and national security risks. State and non-state actors will increasingly be able to conduct cyberattacks against critical satellite services, disrupting economic and other essential services. High-powered microwave weapons could corrupt data and damage the electrical circuits and processors of both civil and military satellites. Moreover, attacks of this sort may be exceedingly difficult to attribute.

Cross-border Internet bandwidth and top international hubs



The size of each circle is proportional to the total cross-border Internet bandwidth connected to that region. The pink outer segment represents the proportion of bandwidth connected within that region. The grey lines represent the connected bandwidth between regions.

Source: TeleGeography: Global Internet Map 2022

Cyberspace

Current strategic context

Cyberspace[1] has become central to human life in almost every corner of the world. Today it forms a fundamental enabler in almost every human activity, impacting the way in which societies organise and communicate, how economies function, and how scientists study the natural environment. In addition to this, its criticality has seen it take on a growing security dimension, with the cyber and electromagnetic domain[2] being the only entirely artificial military operational domain.

Within a little over three decades, the Internet has evolved from static systems (Web 1.0) to an interoperable, user-friendly environment characterised by user-generated content and interaction (Web 2.0).[3] This ongoing evolution will bring yet further developments – in particular, enabling new forms of collaboration between humans and machines. Development cycles have become so fast that hardware is either obsolete, or about to become so, by the time it is introduced to market. As states and businesses increasingly compete amongst themselves for technological advantage, these development cycles, particularly those for software, are likely to become even faster and shorter in the future.

The data held in cyberspace is becoming increasingly important socially, economically and geopolitically. At the same time, the rate at which data is generated continues to grow exponentially, and for the foreseeable future there will be more data than processing power to analyse it. As a result, the future will not be about access to data, but about how to interpret vast amounts of information, and the ability to extract the critical details from an increasing wealth of data will define success.

With regularly updated cyber strategies that have been in place for several decades and a dominant position in the digital economy, the United States (US) is still considered the primary cyber power;[4] however, it is under increasing challenge from China, which has now emerged as a credible and highly capable cyber actor.[5] Recent years have also seen multinational corporations outpacing most states with their expertise in cyber technologies. A handful of US-based global technology companies dominate the international market, with Asian firms in second place and European firms in third. Such is the strength of these corporate actors that they effectively hold a quasi-monopoly over the global physical and virtual infrastructure that forms the core of an ever-expanding cyber universe.

1 Cyberspace is defined as: 'the global environment consisting of all interconnected communication, information technology and other electronic systems, networks and their data, including those which are separated or independent, which process, store or transmit data.' Development, Concepts and Doctrine Centre (DCDC) (October 2022), *Cyber Primer*, 3rd Edition, page 1.

2 DCDC (November 2022), Joint Doctrine Publication 0-01, *UK Defence Doctrine*, 6th Edition, page 42.

3 Nath, K., et al., IEEE, 2014 International Conference on Reliability Optimization and Information Technology (ICROIT) (February 2014), *Web 1.0 to Web 3.0 - Evolution of the Web and its various challenges*, pages 86–89.

4 International Institute for Strategic Studies (IISS) (28 June 2021), *Cyber Capabilities and National Power: A Net Assessment*.

5 Torreblanca, J., European Council on Foreign Relations (December 2021), *The Power Atlas: Seven battlegrounds of a networked world*, 'Technology'.

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Key drivers of change

Persistent competition for the technological edge. While advances in processing and data storage technology will set the pace for the expansion of cyberspace, developments in advanced software, incorporating features such as machine learning and artificial intelligence, will extend the possibilities for its use. As quantum and novel computing becomes more widely available, these have the power to change the direction in which cyberspace develops. Those states and corporate entities that take the lead on technology advances of this kind will be at a growing advantage in being able to determine the future character of cyberspace, as well as having a fundamental influence over its governance and control.

Increasing public–private collaboration. The growing economic importance of cyberspace, its significance for modern societies and its relevance as an arena for geopolitical competition will further blur the boundaries between state and non-state actors. Private companies will increasingly hold de facto power through their control of much of the virtual and physical infrastructure and their ownership of the technological edge. As a result, states will increasingly look to work with the business sector as a means to secure technological advantage, which in turn will further boost the influence of corporate entities.

The growing value of data. Out to 2055, the volume of data generated will increase significantly, and its use will become increasingly important to public and private sector decision-making. The software used to analyse this growing amount of data will also become more sophisticated, not only allowing more information to be collected and analysed but also enabling more accurate and relevant deductions to be made.

A powerful and expanding network. As a growing number of people obtain access to cyberspace, the number of connected devices per person will increase, as will the number of independent devices that are linked to the Internet. Data and data processing will increasingly move to data centres offering cloud-based services, which will become much more important in the cyberspace landscape. New technological developments will enable faster transmission speeds and provide new ways to connect devices to the Internet, even in the remotest areas.

The human dimension of cyberspace. Beyond the technical aspects determining future developments, human aspirations and desires will determine the future characteristics, use and design of cyberspace. However, the growing capability of governments to counter attacks on cyber systems may see criminals increasingly targeting individual users instead, viewing them as softer targets.

Future key trends

Global power competition

Leadership of the virtual world will be a key element of global power competition over the coming decades. Out to 2055, cyber capabilities and cyber superiority could shift the balance of power between states, and between states and other actors.

Having laid the foundations of the Internet, based on a concept developed by Sir Tim Berners-Lee, the US still has a significant advantage and power to determine the future evolution and use of cyberspace. Global demand for US information and communications technology has led to unprecedented commercial success, allowing US companies such as Apple, Microsoft and Alphabet (Google) to invest heavily in research and development. Combined with the significant number of US universities in the Times Higher Education Global 200 List, this provides the basis for a national culture of technical expertise and innovation-led investment.[6]

However, a rising number of states and multinational corporations are challenging US dominance. A number of middle powers, including South Korea, Japan and countries in northern Europe, have seen improvements in their capabilities and technical sophistication in developing and using cutting-edge technologies. Several other states are experiencing rapid booms in technology start-ups and innovation through high levels of research and development investment, despite currently being behind other countries in terms of smartphone penetration and Internet usage. Israel is one example of this, which has seen it achieve significant growth in both its private and public technology sectors in recent years.[7] China is pushing hard to close the technological gap with the US, and the next 30 years may see increasing competition between these two powers in the field of cyber technology, including over global cyber governance. Depending on how US–China relations evolve in the future, this may have major ramifications for access to, and control over, activities within cyberspace at the global level.

In the future, corporate actors are increasingly likely to outpace most states in the field of cyber technology, maintaining their intellectual lead through their economic power and de facto control over cyberspace users and systems.[8] The ability of governments to access and monitor data signals and collect information will be increasingly dependent on these corporate entities. As a result, states around the world will seek closer ties with the business sector, thereby increasing the influence of non-state actors. The character of this convergence will continue to depend significantly on the ideological and legal framework in which it takes place. In liberal democracies, cooperation between the public and private sector may take place on a relatively equal footing; in authoritarian countries, the state may exercise a higher degree of coercion.

6 IISS (28 June 2021), *Cyber Capabilities and National Power: A Net Assessment*, page 19.
7 Getzoff, M., Global Finance (1 December 2023), 'Most Technologically Advanced Countries In The World 2023'.
8 Blondin, C. (2022), *Governance in the Cyberspace out to 2055*, page 4 (a research paper commissioned by DCDC).

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The character of relations between states and the private sector will be determined by ideological and legal frameworks

Approaches towards the technical underpinnings and future governance structures of the virtual world are likely to continue to reflect the competing ideological standpoints of today's great powers. While some governments will continue to favour state control of the domestic cyberspace and the data held within it, others will advocate for a multi-stakeholder approach, and will press for market- and citizen-driven governance structures. However, while uncertainty and disagreement over the structure and governance of the Internet could result in the development of a 'splinternet' at some point over the next 30 years,[9] there are suggestions that today's global powers are too embedded in the digital economy for a fragmented structure that does not allow full international interoperability.[10]

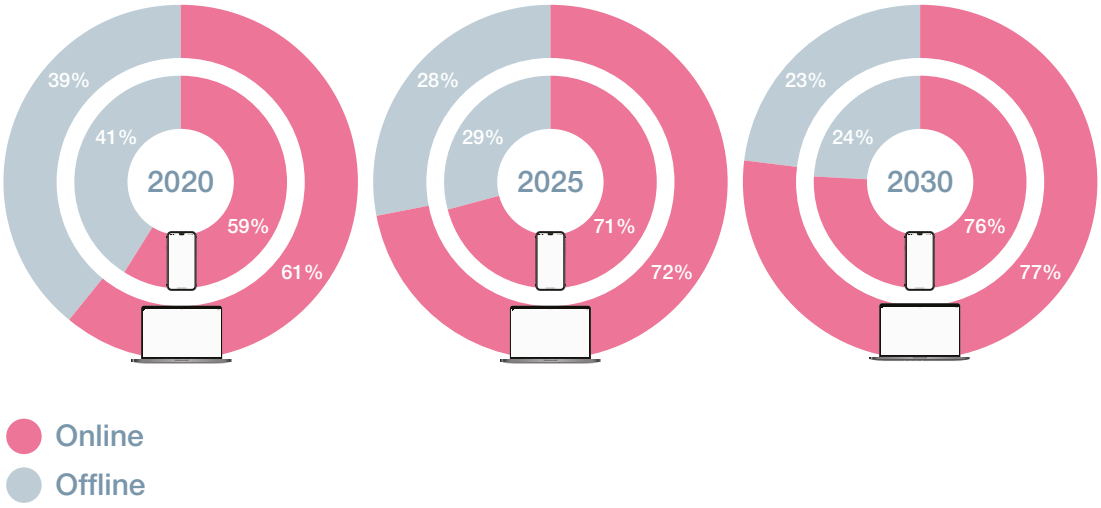
In the future, the ability of governments and businesses to make decisions will depend even more fundamentally on their access to data, and the quality of their decisions will be determined by their ability to make sense of the information they access. The physical and digital protection of data centres will consequently become more critical. This was seen in the war in Ukraine, where the Ukrainian government was faced with the decision to move sensitive information to data centres in third-party countries such as Poland, France or Estonia, outside its sovereign borders.[11] Technological advances will make it possible to exploit and combine data sets in more sophisticated ways, and while some actors may be constrained by ethical and legal considerations, others will be less influenced by these.[12]

9 Hoffman, S., et al., *Journal of Cyber Policy*, Volume 5, Issue 2 (29 August 2020), 'Standardising the splinternet: how China's technical standards could fragment the internet', pages 239–264.
10 Pohle, J. and Voelsen, D., *Policy & Internet*, Volume 14, Issue 1 (21 March 2022), 'Centrality and power. The struggle over the techno-political configuration of the Internet and the global digital order', pages 13–27.
11 Stupp, C., *The Wall Street Journal* (14 June 2022), 'Ukraine Has Begun Moving Sensitive Data Outside Its Borders'; Satter, R. and Pearson, J., Reuters (9 March 2022), 'Exclusive: Ukraine prepares potential move of sensitive data to another country – official'.
12 Baker, G. and Burchell, M., Defence Science and Technology Laboratory (Dstl) (2022), *The future of Space in 2055: Social, psychological and biological trends, drivers and implications – a literature review* (a research paper commissioned by DCDC).

Society

In January 2024, approximately 66% of the world's population had access to cyberspace,[13] an increase of 13% from 2018. By 2030, nearly four out of five people worldwide are expected to be online, mostly using mobile devices.[14] However, global Internet access remains unevenly distributed. With 1.2 billion Internet users, East Asia accounts for the highest number of users globally.[15] Africa, despite having the fastest growing online population, lags behind other regions in terms of digital connectivity,[16] not least as 50% of fixed broadband users in Africa have slow Internet connections (less than 10 megabits per seconds).[17] While Internet access is currently unevenly distributed between regions, there is also a general urban–rural divide, with the percentage of users in urban areas being 82% compared with 46% in rural areas.[18]

However, an increasing number of people will have access to cyberspace by 2055, with technology advances enabling faster transmission speeds and providing new ways to connect to the Internet, even in the remotest areas. The number of connected devices per person will increase, as will the number of independent devices connected through the Internet of things.



Source: Statista (2021), 'Digital Economy Compass, 2021'

By 2030, almost four out of five people worldwide will be Internet users

Human curiosity and the desire for social interaction will continue to play a dominant role in shaping the future of cyberspace. Globally, the average amount of time that an individual spends online is now more than six hours per day,[19] with information searches and social interaction the two most popular uses of that time. Over the next three decades, new forms of digital identity and communities are likely to come into existence,

13 Kemp, S., DataReportal (31 January 2024), *Digital 2024: Global Overview Report*, page 10.
14 Statista (November 2021), *Digital Economy Compass 2021*, page 21.
15 Statista (June 2022), 'Number of internet users worldwide as of 2022, by region (in millions)'.
16 Kemp, S., DataReportal (31 January 2024), *Digital 2024: Global Overview Report*, page 36.
17 Statista (November 2021), *Digital Economy Compass 2021*, page 12.
18 International Telecommunication Union (2022), 'Internet use in urban and rural areas'.
19 Kemp, S., DataReportal (31 January 2024), *Digital 2024: Global Overview Report*, page 58.

potentially developing into extended realities, which allow people to engage with content in cyberspace in a more realistic and interactive way. Virtual services could be delivered as part of an immersive version of the Internet, with sensors enabling technology to dynamically modify the human environment in both public and private spaces.

What this future virtual world will look like in practice remains uncertain, as do the data structures and protocols that will underpin it. A more immersive, interactive and communal platform, where people can create avatars to represent themselves, buy and sell virtual property, and interact with other users in real time, seems entirely plausible.[20] Whatever the outcome, it is likely that future users will be increasingly aware of the economic value of their online activity and will look to exert greater control over the monetisation of their personal data as well as over their ownership of digital goods.[21]

The next Internet: Web 3.0 versus Web3

In parallel with advances in other areas of technology, the Internet is constantly evolving and changing. The term Web 3.0 was coined in 2006 to describe the vision of a more intelligent and connected web, where machines understand the meaning of data and users can interact with it in a more natural and intuitive way. In 2022, Morehouse College in the US created a digital twin of its chemistry laboratory, allowing students to conduct experiments as if they were there in person.[22] Around nine years after the term Web 3.0 emerged, Web3 came into use to describe a decentralised version of the Internet based on blockchain technology. It envisages a redistribution of authority to users, giving them more control over their personal data and greater ownership of their digital assets. In November 2022, J.P. Morgan conducted the first live trade on a public blockchain, which involved tokenised Singapore dollars and Japanese yen deposits.[23] Despite the considerable uncertainties surrounding Web 3.0 and Web3, the technology underpinning the developments, such as immersive reality and smart contract technologies, has gained significant traction and the number of job opportunities has increased.

In parallel with increasing human access to cyberspace, the Internet of things has emerged in recent years as the most prominent link between the physical and virtual worlds. In 2019, the number of devices connected to the Internet of things totalled 10 billion; this number is expected to triple by 2025, with the potential for further growth thereafter.[24] Over the coming decades, the Internet of things will continue to transform the way we live and connect, with machine-to-machine communication likely to become a dominant feature of cyberspace.[25] Emerging Internet of things applications will be brought to life through intuitive human-machine interactions, allowing people to interact in real

20 Minevich, M., *Forbes* (17 June 2022), 'The Metaverse And Web3 Creating Value In The Future Digital Economy'.
21 Chui, M., et al., McKinsey Digital (20 July 2023), *McKinsey Technology Trends Outlook 2023*.
22 Clegg, N., Medium (12 April 2023), 'How the Metaverse can Transform Education'.
23 Lindrea, B., Cointelegraph (3 November 2022), 'JPMorgan executes first DeFi trade on public blockchain'.
24 IoT Analytics, Statista (November 2020), 'Internet of Things (IoT) and non-IoT active device connections worldwide from 2010 to 2025 (in billions)'.
25 DCDC (October 2022), *Cyber Primer*, 3rd Edition, page 5.

time over great distances – both with each other and with machines – and to have similar sensory experiences to those that they experience in real life. How best to implement this remains a challenge at present: it will require trust in artificial intelligence systems, which is currently lacking. However, if trust in human-machine interactions can be sufficiently established, humans and machines will be able to work much more closely together, interfacing through human augmentation systems,[26] opening new possibilities for remote learning, surgery and the repair of equipment.[27]

Out to 2055, Internet of things technologies will be the basis not only for smart homes but also for smart cities. While this will create significant improvements in many aspects of everyday life, it will also give rise to new risks and vulnerabilities, with potentially significant implications for privacy, security and safety.[28] With around 30% of the world's connected Internet of things devices, China is likely to continue to account for the largest number of Internet of things connections out to 2030, followed by North America and Europe with around 20% each.[29]

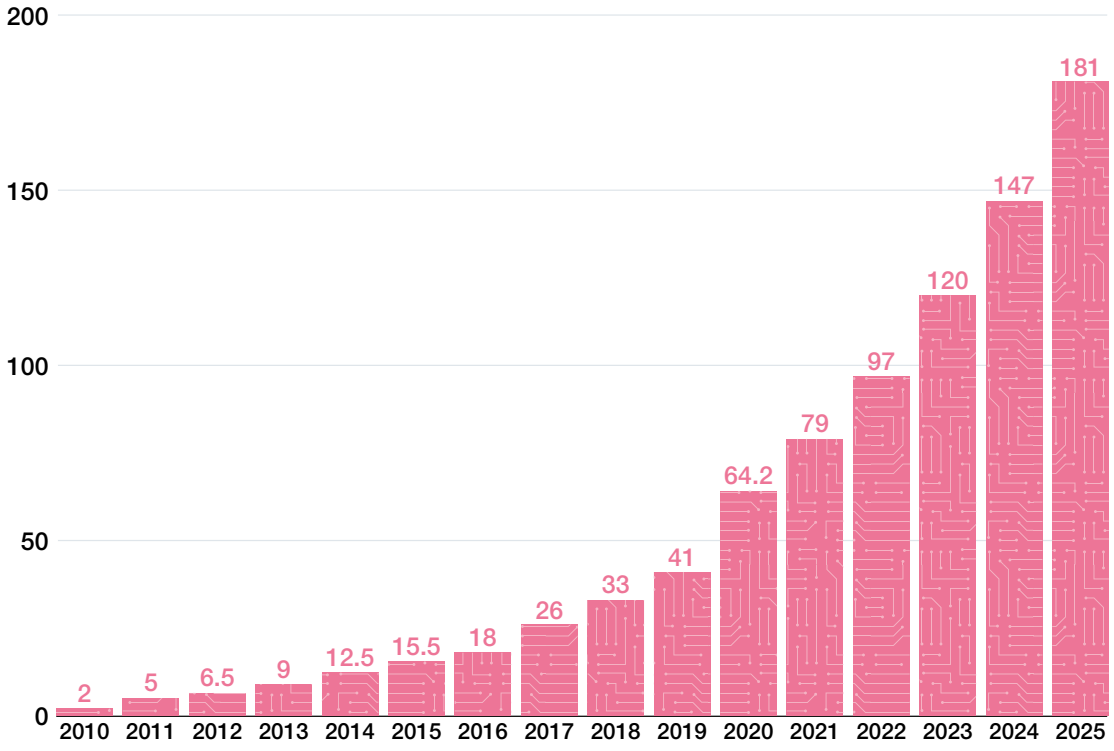
Economy

Global economic dependency on cyberspace and digital systems has grown exponentially since the 1990s. In 2021, e-commerce accounted for almost 19% of global retail sales; this is expected to grow to nearly a quarter of sales by 2026.[30] The growth of the financial technology sector is challenging traditional banks, with a range of digital products such as PayPal's cryptocurrency trading, Robinhood's neobroker services and a host of new exchange-traded fund investment options now on offer. While the nature of digital products and services, as well as the infrastructure that underpins them, will change over the coming decades, many, if not all, industries are expected to benefit significantly in the future from emerging information and communications technologies. Examples include the Internet of things, robotics, the sixth generation of wireless technology (6G), quantum computing and distributed ledger technologies such as blockchain.[31]

Spending on digital transformation has already risen to significant levels and is expected to reach US $3.9 trillion in 2027, more than double the level it was in 2022.[32] The global economy, as well as societies around the world, will be increasingly dependent on an uninterrupted physical and virtual cyber infrastructure. However, with 'big tech' companies increasingly dominating rankings of the world's most valuable enterprises, an expanding cyberspace is paradoxically likely to see a concentration of services ('platformisation'), leading potentially to the creation of sub-cyberspaces in the future. Of the seven leading big tech companies, five (Alphabet (Google), Apple, Amazon, Meta (Facebook) and Microsoft) have their headquarters in the US, with two other giants (Alibaba and Tencent) having their headquarters in China.[33]

26 Baker, G. and Burchell, M., Dstl (2022), *The future of the information environment out to 2055 – trends, drivers and implications: a literature summary* (a research paper commissioned by DCDC).
27 Ericsson (19 January 2023), 'Future IoT'.
28 Liu, X., et al., *IEEE Access*, Volume 7 (4 June 2019), 'Secure Internet of Things (IoT)-Based Smart-World Critical Infrastructures: Survey, Case Study and Research Opportunities', pages 79523–79544.
29 Transforma Insights (July 2022), 'Current IoT Forecast Highlights'.
30 Cramer-Flood, E., eMarketer (27 February 2024), 'Worldwide Retail Ecommerce Forecast 2024: Steadiness and Stability Replaces High Highs and Low Lows'.
31 Statista (November 2021), *Digital Economy Compass 2021*, page 3.
32 Needham, M., International Data Corporation (November 2023), 'Worldwide Digital Transformation Spending Forecast to Continue Its Double-Digit Growth Trajectory, According to IDC Spending Guide'.
33 Fernandez, R., et al., SOMO (17 December 2020), 'The financialisation of Big Tech'.

As spending on digital transformation increases, the correlation between technology, innovation and value creation will become even stronger. Large technology companies with existing access to vast amounts of data will have a significant advantage, being able to use this information to train their algorithms and improve the quality of their product or service in future. In contrast, those who do not have access to a similar quantity and quality of data risk being left behind. The value and revenue of the global big data market is expected to more than double over the next decade,[34] increasing the volume of data collected and analysed while improving its accuracy and relevance. From data on their customers and consumer habits to information about the health of a product in service or the performance of a robot on the assembly line, companies will be increasingly data-driven, maximising the exploitation of information for commercial gain.



Source: International Data Corporation and Statista (2021)

Volume of data/information created, captured, copied and consumed worldwide in zettabytes,[35] from 2010 to 2020 and out to 2025

As cyberspace and its infrastructure become ever more crucial to modern societies and economies, big tech organisations will increasingly act as gatekeepers for digital, or even digitally augmented, social exchange. Out to 2055, this could result in technology firms, both state-owned and private, exerting increasing influence over how individuals understand the world around them.[36]

34 SiliconANGLE, Statista (9 March 2018), 'Big data market size revenue forecast worldwide from 2011 to 2027 (in billion U.S. dollars)'.

35 One zettabyte is equivalent to 10^{21} bytes or one billion terabytes.

36 Baker, G. and Burchell, M., Dstl (2022), *The future of Space in 2055: Social, psychological and biological trends, drivers and implications – a literature review* (a research paper commissioned by DCDC).

The growing dependence on cyberspace is increasing the demand for electricity due to a growing number of data centres and cloud-based services

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Environment

Cyberspace will play an increasing role in addressing the effects of climate change, as well as contributing to its causes. Already it is helping to mitigate harmful impacts through the use of modern technologies, facilitating information dissemination, data analysis and sustainable practices. Advanced data analytics and increasing computing power will enable the analysis and processing of growing volumes of data on the changing climate, and support the development of models capable of simulating the Earth's climate system.[37] In addition, the interconnectivity that cyberspace brings will continue to change how and where we work. Smart power grids and energy management technology will change electricity distribution, making it more flexible and efficient,[38] and cities will become smarter, enabled by a network of sensors and the Internet of things.[39] Through various applications, automation systems, advanced monitoring and dynamic pricing, carbon emissions and water consumption in cities could be reduced by 15%. Early detection of leaks in water pipes could reduce wastage by up to 25%.[40]

However, while cyberspace will serve as an important enabler for climate change interventions, growing dependence on cyberspace is increasing the demand for electricity through a rise in the number of data centres and cloud-based services. Commercial data centres currently consume approximately 1–1.5% of global electricity use[41] and are responsible for 1–2% of greenhouse gas emissions.[42] Despite any efficiency gains in

37 The Royal Society, Climate Change: Science and Solutions (June 2021), *Next generation climate models: a step change for net zero and climate adaptation*; Levey, S. (14 January 2020), 'Thanks to clouds, new climate simulations predict more warming than predecessors'.
38 Butt, O.M., et al., *Ain Shams Engineering Journal*, Volume 12, Issue 1 (March 2021), 'Recent advancement in smart grid technology: Future prospects in the electrical power network', pages 687–695.
39 Sarakar, A.N., *The Smart City Journal*, 'Smart Cities: A Futuristic Vision'.
40 Woetzel, L., et al., McKinsey Global Institute (5 June 2018), *Smart cities: Digital solutions for a more livable future*.
41 Kamiya, G. and Kvarnström, O., International Energy Agency (20 December 2019), 'Data centres and energy – from global headlines to local headaches?'.
42 NowVertical (11 September 2022), 'The Impact Of Data Centers On Global Carbon Emissions & How Removing ROT Data Can Help Reduce It'.

overall global electricity consumption, there is growing concern about the ability of local power grids to support the massive new energy demands of hyperscale data centres with their vast data processing and storage needs, such as those operated by Alphabet (Google), Microsoft and Amazon.[43] Over the next three decades, locations with access to large amounts of renewable energy are likely to become especially attractive to investors in cyber infrastructure, with sites having been built in Mexico and Saudi Arabia in recent years. Innovations such as underwater or deep-sea data centres may also become increasingly common as operators seek to reduce energy requirements.[44]

Location for data centres

Three priorities have so far been important factors in determining the location of data centres: proximity to demand, risk from environmental hazards and regulatory practice. In the future, however, security and energy requirements will also become important considerations when choosing a location for these centres. In terms of energy, the difficulty with data centres is that they require large amounts of energy for power and cooling.[45] The growing need for energy efficient infrastructure and the increasing dependence on renewable energy sources such as solar, wind, hydro and geothermal will therefore drive the global green data centre market at least in the coming decade.[46] A way to reduce the energy required for cooling is motivating leading technology companies such as Microsoft, Amazon Web Services and Beijing Highlander Digital Technology to experiment with underwater data centres as an alternative to land-based locations.[47]

In the era of digital transformation, the physical infrastructure of cyberspace will increasingly rely on the availability of critical materials such as copper, lithium, nickel, cobalt and rare earth elements for its maintenance, innovation and expansion. By 2050, driven in part by net-zero ambitions, demand for copper is expected to double,[48] while that for lithium is expected to more than triple.[49] This growing demand and the concentration of resources in a limited number of locations is likely to create a supply gap, which could have long-term implications for the global economy and wider security. With China currently having the largest capacity to process critical minerals and dominating global supply, this represents a significant dependency and highlights the potential impact on Western countries of the growing tensions between the US and China.[50]

43 Kamiya, G. and Kvarnström, O., International Energy Agency (20 December 2019), 'Data centres and energy – from global headlines to local headaches?'.
44 Baker, G. and Burchell, M., Dstl (2022), *The future of Space in 2055: Social, psychological and biological trends, drivers and implications – a literature review* (a research paper commissioned by DCDC).
45 Ibid.
46 Fortune Business Insights (April 2024), 'Green Data Center Market Size, Share & Industry Analysis, By Component, By User, and Regional Forecast 2024 – 2032'.
47 Zhang, M., Dgtl Infra (23 January 2024), 'Underwater Data Centers: Servers Beneath the Surface'.
48 S&P Global (July 2022), *The Future of Copper: Will the looming supply gap short-circuit the energy transition?*
49 Scheyder, E., Reuters (22 June 2022), 'Lithium producers warn global supplies may not meet electric vehicle demand'.
50 Reuters (27 June 2019), 'U.S. dependence on China's rare earth: Trade war vulnerability'.

The integration of artificial intelligence into software today is a novelty – in the future it is likely to be the norm

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Technology, infrastructure and communications

The physical infrastructure and technologies that interconnect to create cyberspace are likely to undergo a phased but possibly revolutionary change over the coming decades. Connectivity speeds will improve as a range of different technologies increasingly work together to create a seamless and interconnected web for uninterrupted access. New generations of wireless technologies may fundamentally change the way people access the Internet,[51] with 6G expected in the second half of the 2030s. One hundred times faster than current connections and with speeds potentially measured in terabytes per second, 6G will enable near-instantaneous connectivity.

Currently, undersea cables carry over 95% of the world's Internet traffic,[52] and the submarine cable market is expected to continue to grow by 5–6% per year until 2030.[53] However, while these cables will become an increasingly critical element in states' digital power due to their vital role in data transmission, out to 2055 they will increasingly be complemented by a mix of other technologies, including satellite broadband. While only 3.75 million of 1.2 billion broadband subscriptions are satellite-based today,[54] as more satellites are placed in low Earth orbit and the number of subscriptions increases, prices will fall and these services will become more accessible.

51 Clancy, C., MITRE (3 January 2020), '5G and the Front Lines of the U.S.-China Great Power Competition'.
52 Siebold, S., Reuters (3 May 2023), 'NATO says Moscow may sabotage undersea cables as part of war on Ukraine'.
53 Grand View Research (2020), 'Submarine Cable Market Size, Share & Trends Analysis Report, By Application, By Voltage, By End-user, By Offerings, By Component, By Region, And Segment Forecasts, 2023 – 2030'.
54 Zandt, F., Statista (17 August 2021), '50 Percent Of Rural America Without Internet Access'.

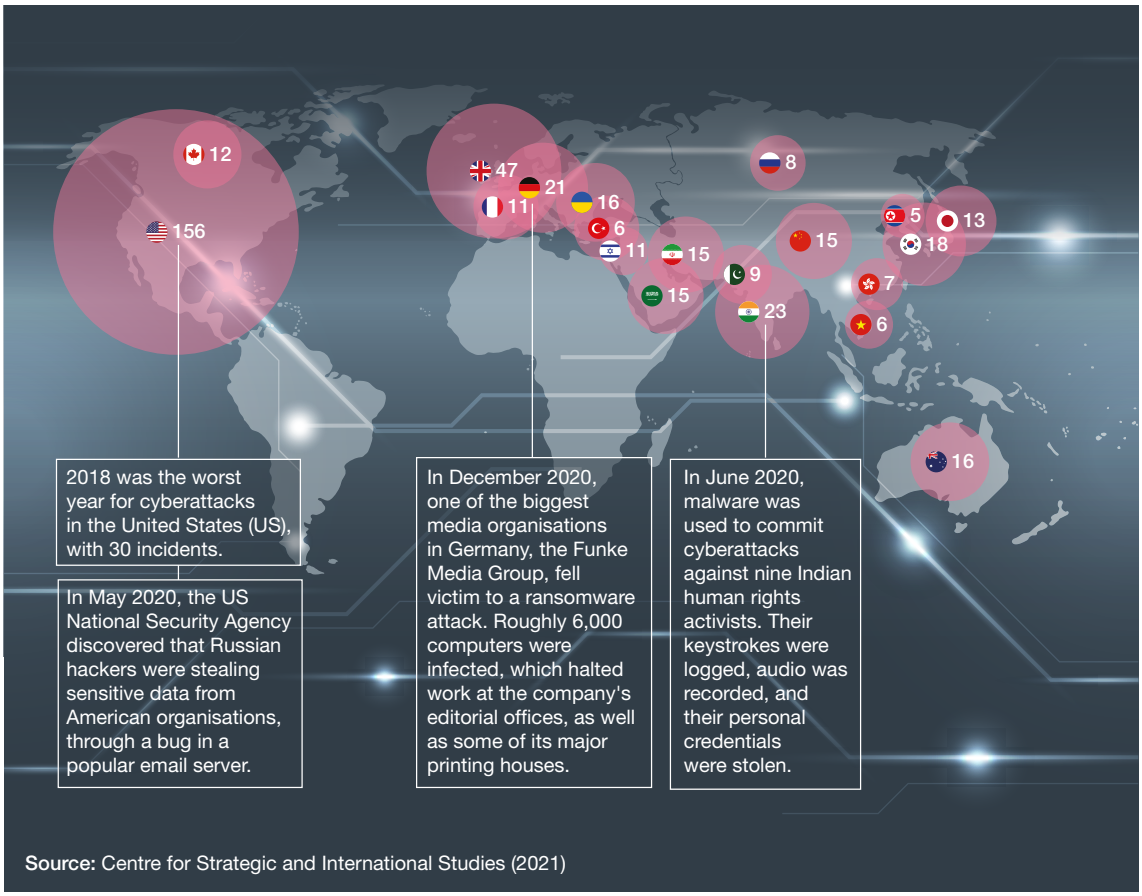
Out to 2055, advances in hardware technology will continue to revolutionise the computing and data storage landscape. As complementary metal-oxide-semiconductor technology reaches its physical limits, researchers are turning to novel computing technologies, which have promising outlooks over the next 30 years.[55] The possibilities are vast, and if successfully developed have the potential to transform the entire field of computing. However, the dependencies that exist with today's technologies are likely to remain, at least in part. For the near-term future, semiconductor technology will continue to provide computing power and data storage capacity[56] and underpin parts of the cyberspace infrastructure. As a result, semiconductors will remain essential components of computing, and their supply will continue to be a critical dependency for states and businesses. Over the past few decades, semiconductor manufacturing capacity in the US and Europe has been shrinking, while Taiwan and South Korea's shares in global leading-edge semiconductor manufacturing capacity are expected to grow to 59% and 19% respectively by the end of this decade.[57]

Alongside advances in hardware, the accessibility and capabilities of advanced software, incorporating machine learning and artificial intelligence features, will expand the possibilities for harnessing cyberspace. In the future, it is expected that artificial intelligence and machine learning will be fundamental components of many software applications, becoming indispensable for any interaction with data.[58] The deployment of artificial intelligence is still limited,[59] and the vision of artificial general intelligence remains at a very early stage. Nevertheless, it is likely that future years will see the increasing use of artificial intelligence agents to assist and augment human activity.

Conflict and security

Over the next 30 years, the increasing interconnectedness of cyberspace, with its multiple nodes and networks, will provide numerous opportunities for malicious actors to access, disrupt and exploit online activity. By 2028, the global cost of cybercrime is estimated to rise from US $0.86 trillion in 2018 to US $13.82 trillion;[60] however, this does not capture the full range of economic losses, such as reputational damage or loss of shareholder value.[61] Cybercrime is exposing a growing number of organisational and national vulnerabilities, and the tools for such attacks are becoming more accessible and affordable. As most cyberattacks targeting individual citizens are of a low level of sophistication, the growing availability of cybercrime tools online and via the dark web will present a growing concern. In addition, the proliferation of 'cybercrime-as-a-service' is increasingly enabling those without hacking or deeper technical skills to become involved in cybercrime. 'Hacktivism' is increasingly being used as a tool of both state and non-state cyber operatives.

55 Crick, J. and Burchell, M., Dstl (2023), *Technological Advances in the Information Technology Sector out to 2055* (a research paper commissioned by DCDC).
56 Heaven, D., BBC, 'Made on Earth: The humble mineral that transformed the world'.
57 Kearney (23 February 2022), *Europe's urgent need to invest in a leading-edge semiconductor ecosystem*, page 6.
58 Pickett, S., Software Development UK (29 June 2021), 'Future trends in the world of software development'.
59 Rimol, M., Gartner (22 November 2021), 'Gartner Forecasts Worldwide Artificial Intelligence Software Market to Reach $62 Billion in 2022'.
60 Statista (14 September 2023), 'Estimated cost of cybercrime worldwide 2017–2028 (in trillion U.S. dollars)'.
61 IISS (28 June 2021), *Cyber Capabilities and National Power: A Net Assessment*.



Various countries around the world have suffered significant cyberattacks

In the future there will be persistent engagement in cyberspace between actors at both the state and non-state level, in which those who rely purely on defensive rather than offensive capabilities will find themselves at a disadvantage.[62] States are likely to collaborate with allies and partners to strengthen their cyber defences, as well as leveraging the technical expertise of the business sector. This growing partnership between the public and private sectors will be crucial in countering cyber threats and staying ahead of the evolving tactics of hostile actors.[63]

Future years may see more complex forms of encryption being developed, such as homomorphic encryption (which allows data to be processed without being decrypted)[64] and quantum encryption, which will help in the fight against cyberattacks.[65] A number of applications are being explored for quantum technology, such as the use of quantum keys, which can be shared to decrypt data, and quantum teleportation to avoid the need to transmit traditionally encrypted information.[66] Along with companies such as Alphabet (Google), states such as China have invested heavily in quantum computing.[67] However, with the advent of advanced technologies it is likely that there will be a

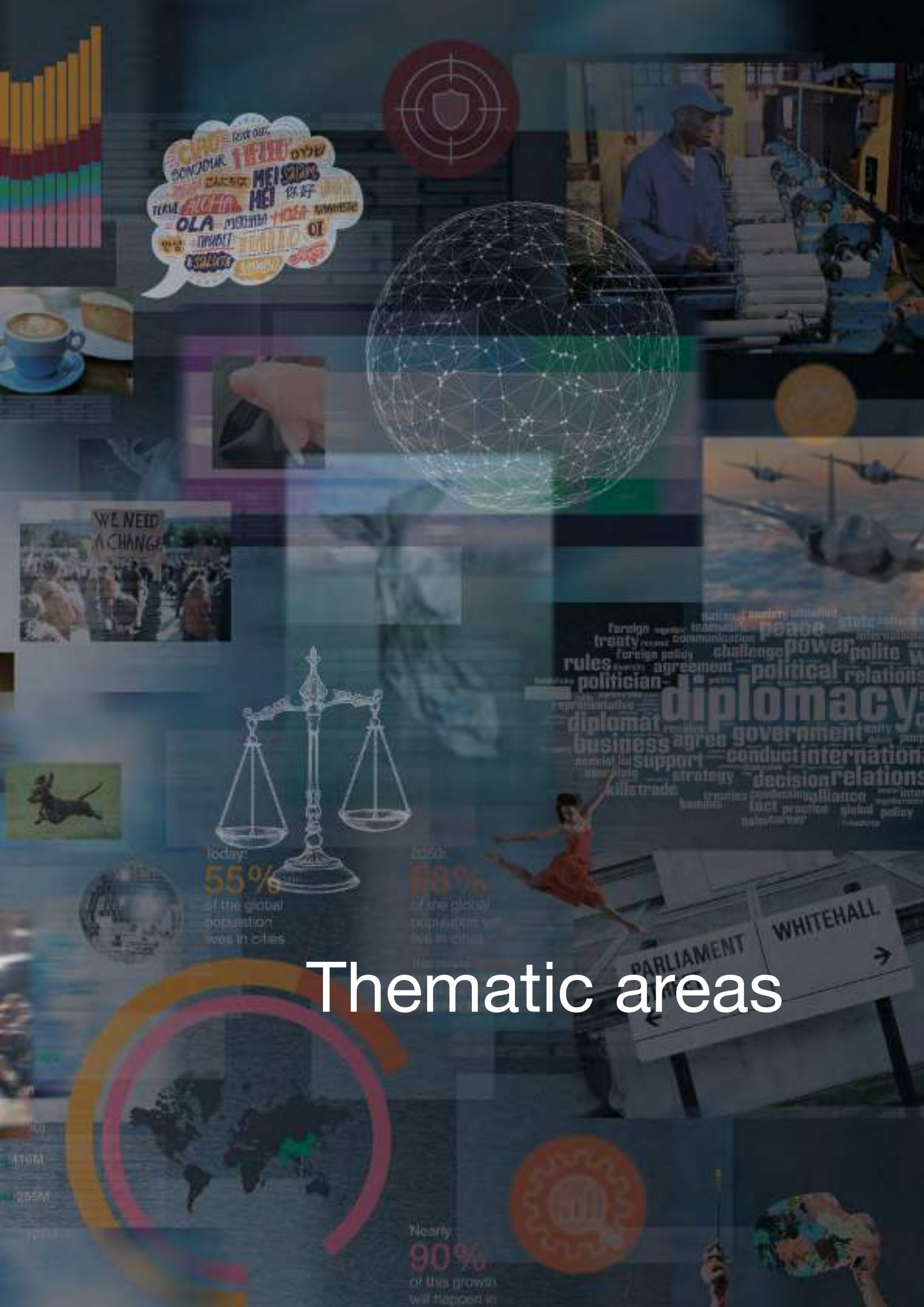
62 Fischerkeller, M., et al. (2022), *Cyber Persistence Theory: Redefining National Security in Cyberspace*.
63 Eoyang, M., DEFCON Conference (2023), 'There Are No Mushroom Clouds in Cyberwar'.
64 Acar, A., *ACM Computing Surveys*, Volume 51, Issue 4 (25 July 2018), 'A Survey on Homomorphic Encryption Schemes: Theory and Implementation', pages 1–35.
65 Crick, J. and Burchell, M., Dstl (2023), *Technological Advances in the Information Technology Sector out to 2055* (a research paper commissioned by DCDC).
66 Giles, M., *MIT Technology Review* (14 February 2019), 'Explainer: What is quantum communication?'.
67 Dstl (7 July 2020), *Quantum Information Processing Landscape 2020: Prospects for UK Defence and Security*.

sudden leap in the performance of decryption technology. This could pose a significant risk to defence, police and security services in areas such as autonomy, logistics and secure communications.[68]

Cyberspace will provide states with an increasing range of intelligence and defence options, from cyber espionage to cyber influence and cyber sabotage operations. Over the past two decades, state-backed cyber operations have become a permanent feature of cyberspace, with incidents taking place every second. Some states, such as Russia and Iran, are likely to continue to tolerate the activities of 'patriotic hackers' or cybercriminals, seeing them as contributing to their political and geopolitical objectives.[69] Not only will this blur the lines between these states and criminals, but it is also likely that the use of cyberspace as an asymmetric capability will shift as more states develop offensive capabilities. Since only a few states have the capability for large-scale (and precise) cyber operations, the next three decades are likely to see a trend towards low-level cyber sabotage and influence operations. However, while the world has yet to experience a cyber operation resulting in large-scale death or destruction, the future use of offensive cyber actions (with insufficient technical precision) may well result in significant collateral damage, potentially on a scale almost impossible to calculate, for the public and private sector.

Out to 2055, the ability to differentiate between internal and external security threats will become increasingly difficult in a hyperconnected cyberspace-enabled world. While some states have already recognised and responded to this fact, others are still in the process of understanding how this will impact their security requirements and capabilities. In a world where cyberspace could become one of the main areas for great power confrontation, a decision as to whether the perpetrator of a threat is a criminal (and hence subject to criminal jurisdiction, domestic or international) or a state-sponsored actor will rarely be possible to make in the early stages of a cyberattack.

68 Dstl (7 July 2020), *Quantum Information Processing Landscape 2020: Prospects for UK Defence and Security*.
69 IISS (28 June 2021), *Cyber Capabilities and National Power: A Net Assessment*, page 6.



Thematic areas

Society

Overview

A number of the world's societies will pass their demographic inflection points over the next three decades. Many developed countries have either reached, or are on the verge of reaching, peak population, posing significant challenges for their economic growth models. A combination of policies will be necessary to help mitigate these issues, including potentially automation, family planning and changes to the retirement age. In contrast, a number of the world's developing countries will continue to experience population growth into the second half of the century; while this offers significant economic potential, it also presents challenges for regions with weak governance and shortfalls in education and service provision. Developed countries with shrinking workforces may increasingly compete for labour from the developing world, potentially creating tensions at both the global and the domestic level if not carefully managed. Although societies will generally become richer over time, poverty will endure in some parts of the world; as a result, inequality will increase both within and between states.

The world is continuing to urbanise, with the proportion of the global population living in towns and cities set to increase further. While this increasing urbanisation should bring economic and societal benefits, the rapid expansion of informal housing in some regions will pose health, social and security risks, not least as these cities are often most vulnerable to the effects of climate change and other forms of environmental degradation. Many states will invest in smart city technologies or other urban planning measures aimed at modernisation; however, integrating these new technologies into existing infrastructure will remain a challenge in some parts of the world. Out to 2055, a number of major cities will emerge as centres of economic and political power in their own right, a trend that could present an increasing challenge to governments.

At the global level, health trends are generally improving; however, the rate of improvement will continue to vary, exacerbating the gap between rich and poor both within and between states. Non-communicable diseases will place an increasing burden on both developing and developed countries, while communicable diseases will continue to present a challenge across the globe. Urbanisation, environmental change and other factors make future pandemics likely and increasing antibiotic resistance could see a resurgence in communicable disease. Mental health conditions will continue to affect a significant proportion of the population, although awareness and treatments are likely to improve over time. Ageing populations mean that an increasing number of individuals will require social care for longer periods. At the same time, many elderly people will remain active, possibly supported by technology advances, which may change perceptions of what it means to be old. Traditional medicine will remain highly valued in many global regions, while trust in modern medicine may decline in some sectors.

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Culture and religion remain powerful sources of identity, uniting communities and providing leaders a means of generating powerful influence

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The number of middle class individuals will continue to grow, particularly in the Indo-Pacific region, leading to higher expectations regarding lifestyle, resources, and personal and national status. While standards of education provision should increase across the globe, the gap between rich and poor countries and between different sectors of society may widen. Changing working patterns will also lead to new learning and skills requirements and those countries that are able to take a flexible and agile approach to education provision will see themselves well placed to become drivers of global innovation.

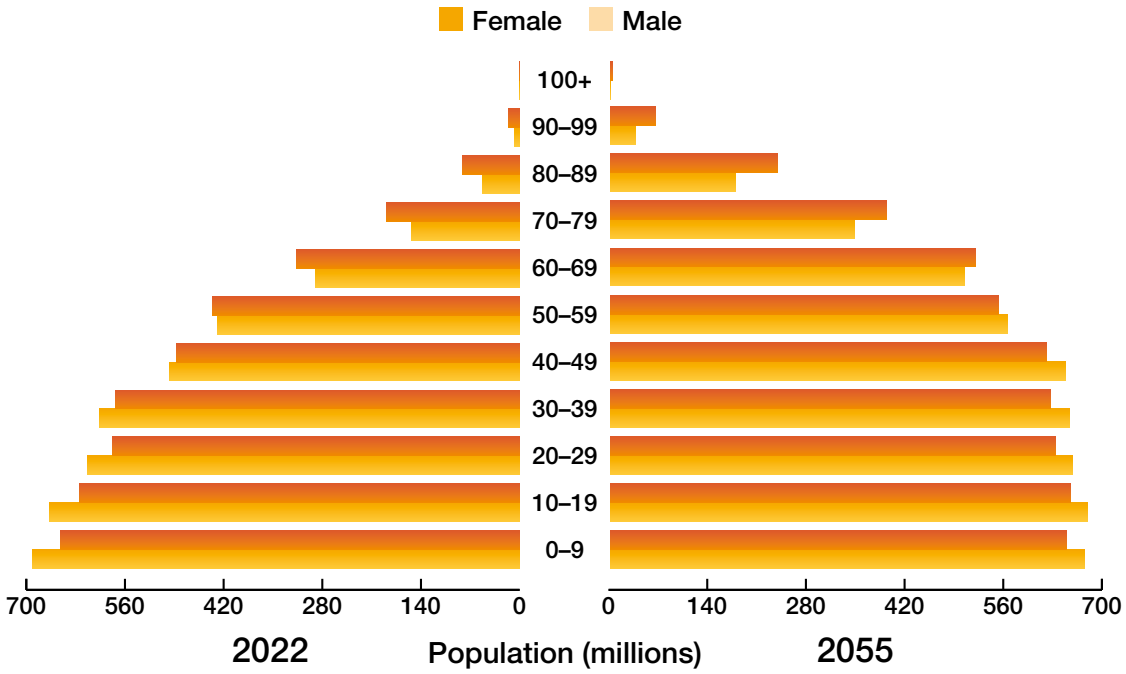
History, culture and religion will remain important sources of identity, driving social cohesion within communities but also tensions between opposing groups. National identity may play an increasing role, and in some cases will be leveraged by leaders to cohere and align populations, as well as mobilising them against opponents. The diversity and composition of family units will continue to evolve, with implications for social norms and values. At the same time, an increasing range of factors will influence an individual's sense of personal identity, potentially leading to the emergence of new political and social movements, which in the future may present a growing challenge to governments.

Out to 2055, the world is likely to become both more and less tolerant, with a growth in empathy in some quarters at the same time as polarisation and antipathy increases in others. Continuing increases in Internet access and social media use could fuel this phenomenon, while creating new sources of political and social influence. The crowded information environment may also serve to undermine trust in institutions and the veracity and relevance of facts; in some cases, this could lead to the creation of silos where actors deliberately seek to segment themselves from a global Internet. Film, music, the arts and participation in sport and online gaming will continue to play an important role in shaping shared values, a sense of community and as a vehicle for individual empowerment.

Demography

Changing population trends. Although populations have been increasing across the globe for most of human history, demographic trends are likely to reverse in many of the world's countries. Japan, South Korea, China, Russia and much of Europe have either already reached or will reach peak population over the next three decades, with numbers expected to decline thereafter.[1] This demographic shift is already leading to a reduction in the ratio of working age people to dependants in many countries, and in the future this will place increasing pressure on state health, welfare and pension systems.

In contrast, populations in Africa, South Asia and parts of Southeast Asia and Oceania will continue to grow,[2] making these regions potential focal points for manufacturing productivity and economic growth. For example, Africa's population is projected to almost double to over 2.6 billion by 2055.[3] However, the ability of governments to capitalise on the opportunities presented by their young working age populations will depend on levels of state capacity and service provision, including the need to provide education and meaningful employment opportunities for these young people. In some cases, these regions will become an increasingly important source of workers for more developed economies, thereby limiting their own domestic economic growth.



Source: United Nations Population Division (2022)

Population statistics prediction for the world by age range

Ageing populations. Due in part to the slowdown in population growth in many countries, the proportion of the global population aged over 65 is growing rapidly, from 372 million in 1995 to over 750 million today. Projections suggest that it will reach 850 million by 2055

1 United Nations (UN), Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
2 Ibid.
3 Ibid.

and surge past 1.4 billion by 2100.[4] By the middle of the century, 25% of the total population of the world's high-income countries will be over 65, more than three times the proportion in 1950.[5] However, low- and middle-income countries will experience the most significant change, accounting for two-thirds of the global population aged over 60 years by the middle of the century. Contributing to this is the fact that life expectancy has seen a significant increase worldwide, with an average rise of around 2.5 years per decade.[6] The number of people aged over 80 is expected to triple by the middle of the century, reaching 426 million.[7] However, while life expectancy will continue to improve in the world's developing states, it may begin to plateau in developed countries. Although the quality of life in these older years may be enhanced as technology and data sciences offer an improved understanding of how and why our bodies change, the ability to benefit from medical advances will almost certainly be unevenly distributed, and social attitudes towards older citizens will continue to vary across regions.

Japan leads the way in the global demographic transition

Currently at the forefront of the global demographic transition, Japan provides a glimpse into the demographic shifts that other countries will face in the future. Today, 28% of its population is over 65, up from 5% in 1950; this is expected to grow to 38% by 2055.[8] Moreover, in the same period, Japan's current population of 127 million will shrink by nearly 20%.[9] For the Japanese workforce, this will result in fewer and older workers, which will have implications for growth, productivity and consumption. A study by the International Monetary Fund in 2018 estimates that Japan's economic growth will decline by an average of 0.8% each year out to 2060 due to demographics alone.[10]

Declining workforces. Out to 2055, a decline in the size of the working age population will present a significant challenge to governments, which may be forced to confront uncomfortable policy choices to adapt. The ability to address the consequences of a declining workforce will be a crucial determinant of future economic competitiveness for all states. For some, the issue will arise earlier than others; China, for example, (which has a population three times that of the United States (US)), is projected to experience a workforce decline of over 25% in absolute terms by 2055, while the US is expected to see a growth of more than 6% during the same period.[11] To combat population declines, a combination of strategies will be necessary, including the need to embrace automation and other enabling technologies and, in some cases, to adopt more flexible migration policies. As countries vie to entice skilled talent from abroad, the ability to attract migrants may become an increasing source of geopolitical competition, as well as potentially causing an increase in tensions at the domestic level if not carefully managed.

4 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
5 *The Economist* (21 December 2021), 'The true costs of ageing'.
6 Kontis, V., et al., *The Lancet*, Volume 329, Issue 10076 (22 February 2017), 'Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble', pages 1323–1335.
7 World Health Organization (1 October 2022), 'Ageing and health'.
8 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.
9 Ibid.
10 Colacelli, M. and Corugedo, E.F., International Monetary Fund (28 November 2018), 'Macroeconomic effects of Japan's demographics: can structural reforms reverse them?'.
11 UN, Department of Economic and Social Affairs (2022), 'World Population Prospects 2022'.

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Since the COVID-19 pandemic, levels of poverty have surged, including in wealthy countries such as the United States

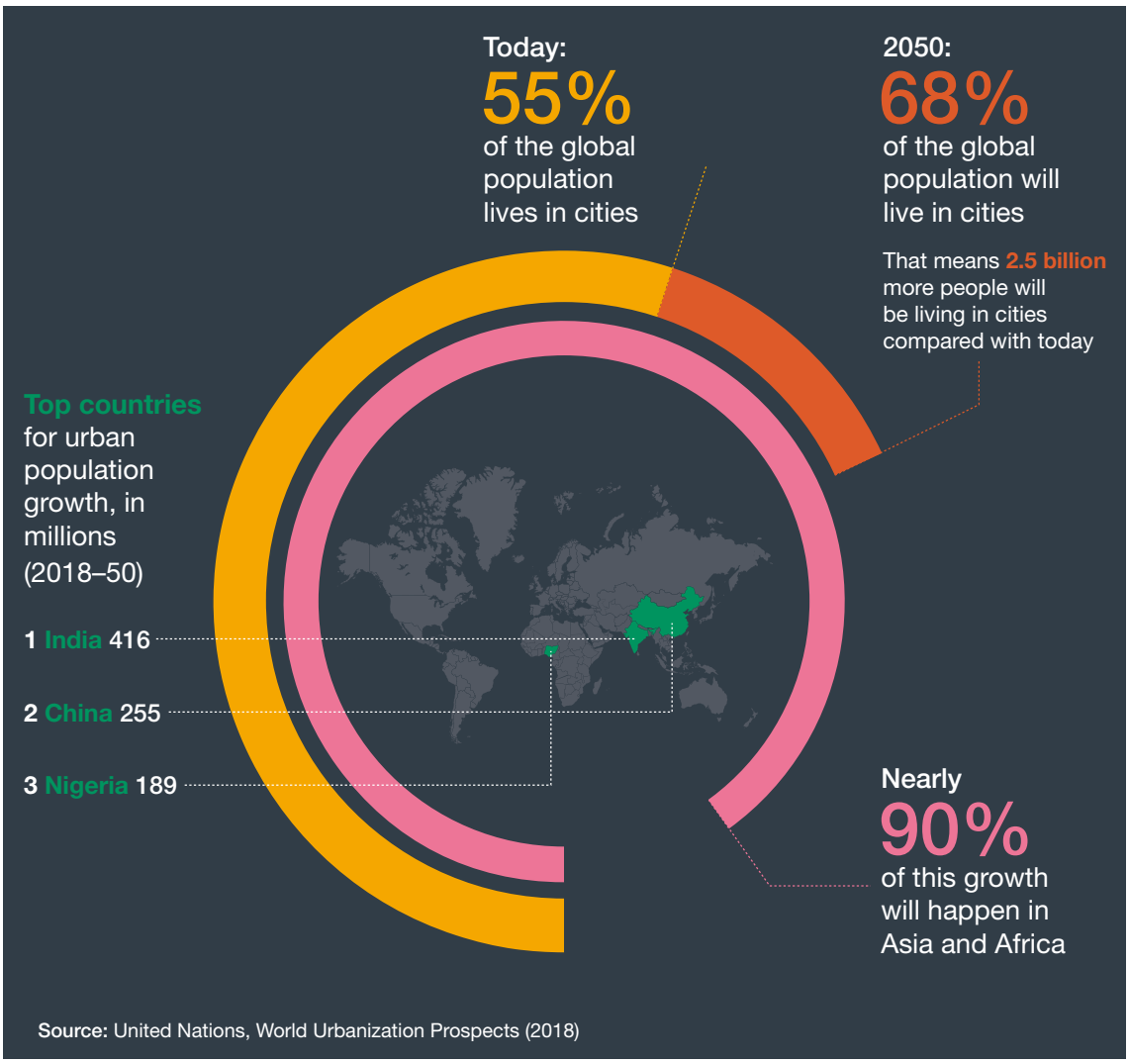
The reality of an ageing population will cause governments in some countries to consider increases in the state retirement age to extend the working life; however, this will depend on changes in health and health care, as well as technology advances to enable older workers to remain actively engaged in the workforce for a longer period of time. Countries with well-developed service sectors, which may provide more opportunities for older workers, are likely to be better equipped to take advantage of this option. In other cases, countries may seek to adjust their family planning policies to boost birth rates, while elsewhere social change may be required to improve rates of female representation in the workforce.

Poverty and inequality. Prior to the COVID-19 pandemic the world had been making significant strides in poverty reduction, with the poverty rate dropping from around 40% of the global population in 1990 to approximately 8% in 2019. Over a billion people managed to escape extreme poverty during this period.[12] However, the pandemic has dealt a severe blow to poverty reduction efforts, causing a slowdown and even a reversal in improvements in some regions, with 120 million people pushed into extreme poverty as a result of lockdowns and other economic impacts.[13] While the extent to which these setbacks can be overcome (and how quickly) remains uncertain, future attempts to alleviate poverty will remain vulnerable to various factors, including slowdowns in global economic growth, conflict and insecurity, and the concentration of poverty in remote and inaccessible areas.[14] At the same time, while absolute poverty will endure in some parts of the world at least, incomes elsewhere will continue to grow, exacerbating levels of socio-economic inequality. Amidst the hardship experienced by many global citizens, some others have increased their wealth; for example, 131 billionaires more than doubled their wealth during the pandemic.[15]

12 World Bank (5 October 2022), 'COVID-19 dealt a historic blow to poverty reduction. Fiscal policy can help repair the damage'.
13 Ferreira, F.H.G., International Monetary Fund (Summer 2021), 'Inequality in the time of COVID-19'.
14 World Bank (5 October 2022), 'COVID-19 dealt a historic blow to poverty reduction. Fiscal policy can help repair the damage'.
15 Jha, S., Al Jazeera (22 December 2022), 'Why do the rich get richer – even during global crises?'.

Human habitats

Urbanised societies. Over the past two centuries, the world has been steadily urbanising. This trend is expected to persist out to 2055, although the rate may slow as countries reach saturation points. At present, approximately 55% of the world's population resides in urban centres; over the next few decades, the urban population may more than double to approximately 6.7 billion, meaning that by the middle of the century 68% of the world's population will be living in towns and cities.[16] However, these figures will continue to conceal disparities both within and between regions. In Kuwait, for instance, an estimated 99% of the population already live in urban areas,[17] whereas in Yemen the urban population represents only 39% of the country's total.[18]



Long-term urbanisation change out to 2050

16 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.
17 Ibid.
18 Ibid.

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Future developments may see cities becoming significantly more sustainable

Urbanisation will act as a spur to economic growth in many parts of the world over the next 30 years, boosting incomes and providing new employment and education opportunities for many. The concentration of people in urban areas will lead to improvements in the provision of essential services such as clean water, sanitation and energy, resulting in a rise in living standards and levels of economic and social development. However, in other places, planning and investment will fail to keep up with the influx of people to urban areas, leading to an increase in informal housing settlements. While the overall global trend shows a decline in the number of people living in slum conditions, these settlements are likely to remain an enduring feature across much of Africa and in certain countries in Asia and Latin America, exacerbating inequalities within and between countries.

Future cities. The challenges posed by rapid urbanisation will lead to a continued focus on reshaping the conventional city model, including the adoption of 'smart city' technologies to enhance urban efficiency, safety and security. In 2023, the top 15 smart cities (in terms of transportation, infrastructure, energy, lighting, city management, technology and urban connectivity) were: Zürich (Switzerland), Oslo (Norway), Canberra (Australia), Copenhagen (Denmark), Lausanne (Switzerland), London (UK), Singapore, Helsinki (Finland), Geneva (Switzerland), Stockholm (Sweden), Hamburg (Germany), Beijing (China), Abu Dhabi (United Arab Emirates), Prague (Czechia) and Amsterdam (Netherlands).[19] Over the next 30 years, it is likely that other cities, including a number in developing states, will increasingly adopt similar technologies. Future developments may also see cities becoming significantly more environmentally friendly, exemplified by Hong Kong's Smart City Blueprint, which outlines 130 'green' initiatives, from pollution monitoring using remote sensors to smart recycling systems.[20] While beneficial in many respects, the increasing use of surveillance technology in smart city management and urban security provision may be exploited by governments in some countries, enabling them to exert increased control and surveillance over their populations.

19 IMD/World Competitiveness Center (2023), *IMD Smart City Index Report 2023*.
20 Cheng, I., Earth.org (28 April 2021), 'The Importance of Smart Cities in the Fight Against Climate Change'.

Alongside this, other initiatives will seek to transform cities from being consumers to producers of essential resources by implementing urban farming and green energy projects aimed at increasing levels of self-sufficiency and minimising environmental impact. For example, vertical and indoor farming are both concepts that are being explored to enable the mass production of food in urban centres, and by 2055 these techniques may be adopted more widely.[21] Despite these efforts, however, it is likely that reliance on the import of food from rural areas will continue.

Indonesia's green, smart city

Indonesia's new capital Nusantara is planned to be a green, smart city where no resident lives more than a 10 minute commute by walk or bicycle from their workplace, and aims to be completely powered by renewable energy. Nestled in the remote forests of Kalimantan, the Indonesian government hopes to use this project to secure significant private investment, rebalance inequalities in regional development and drive Indonesia's economic growth.

While ambitious smart city projects have the potential to introduce new models of urban living, in most cases city planners will be faced with the need to integrate new technologies into existing, often ageing and inadequate infrastructure, presenting a complex and costly challenge. In this context, smaller cities and developing countries have a unique opportunity to leap forward by adopting next-generation technology during their modernisation processes, following the example of Estonia's visionary uptake of digital infrastructure at the end of the Cold War. New urban centres such as The Line in Saudi Arabia, which embrace smart planning from the beginning of the project, can avoid the challenge of having to develop or retrofit an existing urban site, although these developments come at significant cost.

New patterns of urbanisation. The COVID-19 pandemic triggered a significant shift in living arrangements in some Western societies, with many individuals moving away from large cities and using the possibilities afforded by new technologies and improved levels of digital connectivity to enable remote working. This trend did not necessarily lead to a permanent move to rural areas; instead, many people moved to smaller urban settlements, and some have since returned to cities, meaning that for now the long-term implications remain uncertain. Nevertheless, out to 2055, trends in telecommuting, improvements in transport and digital connectivity, and new ways of interacting through cyberspace may contribute to the gradual depopulation of large city centres. When added to the pressures of climate change and natural disasters, this could lead to the reconfiguration of urban living patterns, giving rise to new conurbations made up of multiple connected urban hubs or the construction of new satellite cities outside the main municipalities. In the long term, however, these trends are unlikely to reverse the general trend of urbanisation, with the global proportion of urban inhabitants continuing to increase overall. Moreover, even with increasing automation, remote working will only be feasible for certain economic sectors, and those in low-paid service jobs and certain key roles, including nursing and policing, will remain tied to a physical workplace, without the same degree of choice and flexibility in living arrangements.

21 Caughill, P., Futurism (17 January 2018), 'Urban Farming Is the Future of Agriculture'.

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The number of cities exposed to extreme temperatures will nearly triple

Cities as centres of power. Out to 2055, the power and influence of urban centres is likely to increase, with some major global cities developing an increasing voice on the world stage. Urbanisation has already transformed certain cities such as London, New York and Shanghai into influential economic powerhouses, and over the next 30 years emerging centres such as Chicago, Seoul and Boston will grow in influence, partly enabled by their expanding financial prowess. The wealth of these centres and the increasing concentration of populations in urban centres has resulted in a growing political role for cities; this is particularly evident in Africa and Latin America, where single cities such as Lagos and São Paulo, which generates almost a third of Brazil's gross domestic product (GDP), are becoming key centres of power. In the future this may lead to domestic power struggles as cities increasingly vie for influence with state governments. However, this concentration of wealth and power can also make cities vulnerable to exploitation by malicious actors, for example, through large-scale cyberattacks, physical terrorist attacks or through a rise in gang violence and criminality.

Environmental impacts. Climate change, environmental disasters and rising levels of pollution will have an increasing impact on urban areas over the coming decades. Coastal cities are becoming more vulnerable to rising sea levels and severe weather events; by the middle of the century, over 800 million people will be living in cities at risk of coastal flooding and storm surges.[22] At the same time, the number of cities exposed to extreme temperatures will nearly triple.[23] Out to 2055, natural disasters affecting densely populated areas will result in population displacement and significant economic losses due to infrastructure damage and reduced productivity. Elsewhere, pollution and environmental degradation will increasingly compromise infrastructure, health, livelihoods and possibly the viability of certain cities. Developing countries are particularly at risk, although mitigation and adaptation strategies – such as the relocation of Indonesia's administrative capital from Jakarta to Nusantara[24] – may offer some solutions.

22 C40 Cities, UCCRN Technical Report (February 2018), *The Future We Don't Want*.
23 Ibid.
24 Beech, H., *The New York Times* (16 May 2023), 'Welcome to Nusantara'.

Colonisation of the shared spaces. In the coming decades, migration may extend into areas beyond the jurisdiction of state governments, with more people working and living in the shared spaces such as the oceans, space and cyberspace. This will pose new global governance challenges regarding applicable laws and norms for those living outside national borders, as well as challenging traditional definitions of citizenship and sovereignty. Societal understanding of what constitutes strategically significant resources might change; currently hard-to-reach natural resources will become increasingly accessible, but also what is valued as a resource, for example, by 'inhabitants' of cyberspace, will bring new dimensions to resource competition. This could lead to tensions between states and between state governments and corporate entities, with potential implications for regional security.

Life on Mars

The coming decades are likely to see an increase in the volume and duration of human space travel. If ambitions for lunar and even Martian outposts are realised, human society will need to adapt to these new environments. Long-duration missions on extraterrestrial surfaces will require significant in-situ health care to mitigate radiation and microgravity effects, and long-term disconnectedness may see a requirement for specific mental health support. As space tourism increases the exposure of (albeit wealthy) citizens to life in space, it is possible that by 2055 a 'spacefaring culture' may develop, with possible impacts on terrestrial cultures through the introduction of new vocabulary, fashion, norms and even laws.[25]

Health

Non-communicable diseases. The burden of non-communicable diseases on the human population will rise substantially over the next 30 years. At present, non-communicable diseases cause approximately 41 million deaths each year, equivalent to 74% of all worldwide deaths.[26] Cardiovascular diseases account for the most non-communicable disease deaths, with a figure of 17.9 million deaths annually. This is followed by cancers (9.3 million), respiratory diseases (4.1 million) and diabetes (1.5 million). In all continents except Africa, the number of deaths from non-communicable diseases now exceeds the total number of deaths from communicable, maternal, perinatal and nutritional conditions;[27] but even in Africa the number of deaths is growing, effectively meaning that out to 2055 the continent will face a double burden of communicable and non-communicable diseases. However, an estimated 80% of non-communicable diseases are deemed preventable through changes to modifiable risk factors such as smoking, unhealthy diets, physical inactivity and air pollution; by 2055 this, together with advances in treatment and data science, may mean that the impact of non-communicable diseases may be starting to reduce in some parts of the world.[28]

25 Harris, P., National Space Society (January 1986), 'The Influence of Culture on Space Developments'.
26 World Health Organization (16 September 2023), 'Noncommunicable diseases'.
27 Wang, Y. and Wang, J., *BMC Public Health*, Volume 20, Issue 822 (1 June 2020), 'Modelling and prediction of global non-communicable diseases'.
28 NCD Alliance (2022), 'Noncommunicable diseases'.

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Rising urbanisation and antimicrobial resistance could reverse decades of reductions in communicable disease and increase pressure on health care systems

Communicable diseases. Communicable diseases will continue to have an impact on societies and place a burden on state health care services. The COVID-19 pandemic brought into sharp focus the catastrophic consequences of widespread and uncontrolled communicable disease outbreaks, and the effect that increasing global connectivity and movement of people can have on disease spread. Prior to this, medical advances, improved access to health care, and improvements in sanitation and living standards had led to a general reduction in the incidence of communicable diseases over the past two decades.[29] However, rapid urbanisation in low- and middle-income countries, alongside overcrowded, low-quality living conditions and increased encroachment into animal habitats, has created new opportunities for novel and latent infectious disease outbreaks.[30]

Out to 2055, changes in land use, deforestation and global climate change may result in shifting distributions of existing diseases, as well as the spread of new pathogens and zoonotic diseases (infectious diseases caused by a pathogen that can jump from an animal to a human and vice versa). Antimicrobial resistance poses another growing concern; this is currently responsible for 1.2 million deaths annually, with a further 5 million deaths linked to associated infections and secondary effects,[31] surpassing the combined death toll of HIV/AIDS and Malaria.[32] The success of research programmes currently seeking to address the challenge of antimicrobial resistance in the global food chain will be key to determining the effectiveness of antimicrobials in the future. If left unchecked, antimicrobial resistance across the environment–food–health spectrum could reverse many of the health benefits accrued through previous medical advances.

29 Baker, R.E., et al., *Nature Reviews Microbiology*, Volume 20 (April 2022), 'Infectious disease in an era of global change', pages 193–205.
30 Ibid, pages 193–205.
31 Antimicrobial Resistance Collaborators, *The Lancet*, Volume 399, Issue 10325 (12 February 2022), 'Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis', pages 629–655.
32 University of Oxford (20 January 2022), 'An estimated 1.2 million people died in 2019 from antibiotic-resistant bacterial infections'.

Zoonotic diseases

Africa experienced a 63% increase in zoonotic diseases such as monkeypox and West African Ebola in the 2012–22 period compared with 2001–11. While some of this might be explained by enhanced monitoring programmes, the rapid expansion of urban centres and transport links is thought to be a key driver in the spread of these diseases.[33] Zoonotic diseases are growing fastest in the Democratic Republic of the Congo and Nigeria, which together will account for almost a third of Africa's urban population growth by the middle of the century.[34]

The COVID-19 pandemic highlighted a number of gaps in global preparedness for disease outbreak, which are likely to have contributed to millions of preventable deaths. In light of this, equally important alongside technology-focused efforts to combat infectious diseases will be collaborative responses by governments, pharmaceutical companies and multinational organisations to improve resilience against future outbreaks. This could include implementing new public health strategies and efforts to counter public misinformation and disinformation. The COVID-19 pandemic demonstrated a successful example of collaboration in the field of vaccine development, with states and pharmaceutical companies working together to rapidly design, mass produce and distribute an effective vaccine against the virus. However, the ability to implement lessons from the COVID-19 pandemic experience and boost resilience to disease outbreaks will not be universal, and some state and non-state actors are likely to revert back to previous poor practices.

Advanced and bespoke medicine. Telehealth, medical robotics and vaccination research have all seen significant progress in recent years, promising improved health care delivery and therapies in the future.[35] Going forward, artificial intelligence will play a crucial role in analysing the vast amounts of data generated. At an individual level, rich data from diagnostic techniques such as magnetic resonance imaging (MRI) and pathology may support personalised preventative monitoring and treatment strategies intended to avoid the onset of chronic and serious disease. Many of today's common diseases may become treatable or even curable as a result of these developments. 3D bioprinting holds great promise for enhancing skin, bone and possibly even organ transplants by 2055. At the societal level, data analytics might yield more effective public health policies.

Changing lifestyles. Out to 2055, lifestyle choices will have an increasing influence on global health trends. The global fitness industry is expanding rapidly, growing to US $96.7 billion in 2022, with the potential to reach US $131.9 billion by 2028.[36] This rise is driven by an increasing interest in health and aesthetics – particularly on the part of young people – including a greater focus on diet, and the individual and collective use of technology to monitor bodily functions and activity. The emergence of 'functional foods' tailored to individual needs may counter the trend towards unhealthy diets that are high in fat and sugar.

33 World Health Organization (14 July 2022), 'In Africa, 63% jump in diseases spread from animals to people seen in last decade'.
34 UN, Department of Economic and Social Affairs, Population Division (2018), *World Urbanization Prospects: The 2018 Revision*.
35 Clipper, B., *Nurse Leader*, Volume 18, Issue 5 (October 2020), 'The Influence of the COVID-19 Pandemic on Technology: Adoption in Health Care', pages 500–503; Busby, M., *The Guardian* (20 February 2022), 'How Covid changed medicine for the future',
36 Tagliaferro, L., Future Fit (2022), 'Why is the fitness industry worth £90 billion and is about to skyrocket to £115bn'.

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Fentanyl overdose deaths have risen 29-fold in the United States in the past decade

Behavioural science may reveal a way to develop policies to drive healthy behaviours across a population. However, this greater interest in healthy living is far from being a universal trend, and obesity rates continue to grow in some countries and sectors of society.[37] In some cases this is due to rising incomes and the increasing availability of processed foods, whereas in others, it is due to limited choices forcing people into unhealthy eating habits. At the other end of the scale, hunger and malnutrition will continue to be a problem in many parts of the world, exacerbated in some regions by the effect of climate change and extreme weather events on food availability. Looking forward, it is likely that external influences such as resource availability, food prices, regulatory policies and education will continue to dictate how easy, affordable and attractive it is to maintain a healthy lifestyle.

Narcotics. Illegal drug use saw a global increase of 23% between 2011 and 2021, affecting an estimated 296 million people.[38] Drug disorders have also seen a significant rise, with an estimated 39.5 million people affected, representing a 45% increase during the same period. Cannabis remains the most commonly used drug (219 million people), but the rapid spread of synthetic drugs such as fentanyl is gaining increasing attention. In the US alone, fentanyl overdose deaths have risen 29-fold in the past decade, and now account for over half of all overdose deaths.[39]

Although fentanyl is primarily the scourge of high-income societies, developing countries have experienced a more rapid increase in drug use than developed states in recent years.[40] In addition, younger people are particularly vulnerable to drug misuse; for example, 70% of people receiving drug treatment in Africa are under 35. This may have particular implications for countries experiencing a continued growth in youth populations.[41] Addressing the deep-rooted causes of drug misuse, such as narco-smuggling, unequal access to health care and treatment programmes, and uneven levels of social and economic development, will be crucial to prevent this trend from intensifying out to 2055.

37 World Health Organization (1 March 2024), 'Obesity and overweight'.
38 UN, Office on Drugs and Crime (2023), *World Drug Report 2023*.
39 Volkow, N., *World Psychiatry*, Volume 20, Issue 2 (June 2021), 'The epidemic of fentanyl misuse and overdoses: challenges and strategies', pages 195–196.
40 O'Dowd, A., *British Medical Journal* (30 June 2020), 'Drug misuse rose 30% in the past decade and covid-19 could worsen situation, UN report warns'.
41 UN, Office on Drugs and Crime (2023), *World Drug Report 2023*.

Traditional medicine remains more trusted in some regions, while disinformation is degrading trust in modern medicine and driving some people to seek alternative practices

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Mental health. Globally, an estimated 970 million people suffer from a mental health disorder each year, which is 1 in every 8 people.[42] Approximately 20% of children and adolescents worldwide have a mental health condition.[43] Suicide is a major concern, with approximately 703,000 people worldwide taking their own lives annually.[44] Low- and middle-income countries contribute the highest proportion, around three-quarters of global suicides.[45] Looking forward, mental health will remain a key concern across the globe, driven in part by pressures resulting from lives increasingly spent online. The mounting cost of medical interventions may see more preventative approaches, which could increasingly be delivered virtually (including stress management and addiction treatment), becoming an integral part of health care in both developed and developing countries. Although the stigma associated with mental health disorders is likely to endure in some regions, this could decrease over time as mental health issues become more widely understood.

The impact of the Internet and social media use on adolescent development is a key area of uncertainty that will gain even more attention in coming years. Studies indicate a connection between higher rates of Internet usage and poor mental health, as well as an increased dependence on the digital realm.[46] Moreover, there are suggestions that prolonged exposure to the digital world might be altering cognitive abilities, including attentional capacity, memory processes and social cognition.[47] This could have significant implications for the future of mental health therapies.

Increasing life expectancy. Increasing life expectancy will present both opportunities and challenges for governments. For example, greater longevity will not necessarily translate into healthier or more active lives. The average 'health span' (the length of time for which a person is healthy) is currently 63 years, significantly shorter than the average

42 World Health Organization (8 June 2022), 'Mental disorders'.
43 World Health Organization (2022), 'Mental Health'.
44 World Health Organization (28 August 2023), 'Suicide'.
45 World Health Organization (2019), *Suicide worldwide in 2019*.
46 Karim, F., et al., *Cureus*, Volume 12, Issue 6 (15 June 2020), 'Social Media Use and Its Connection to Mental Health: A Systematic Review'.
47 Sina, E., et al., Nature, *Scientific Reports*, Volume 13 (1 November 2023), 'Digital media exposure and cognitive functioning in European children and adolescents of the I.Family study'.

life expectancy of 79 years.[48] As the global proportion of people aged 65 years and older increases, this could see governments faced with a significant rise in health care costs.[49] For example, a study in the US found that between 1996 and 2013 population ageing resulted in a 12% increase in health care costs.[50]

A key influence on future health span and ageing will be dementia. By the middle of the century, it is estimated that the global number of adults living with dementia will triple to 153 million, up from 57 million in 2019,[51] although trends will vary by region. Women, who currently make up two-thirds of all cases, are likely to be disproportionately affected.[52] Medical advances (including biotechnology breakthroughs) may in the future help to prevent or delay the onset of dementia and other non-communicable diseases affecting elderly populations. This, alongside other developments such as changes in nutrition, lifestyles and public health, could cause a shift in attitudes towards age and the elderly, creating expectations that people will live healthier as well as longer lives, with capacity and productivity being regarded as more relevant guides than age. However, wealth, through-life health and luck will still play central roles in how well people age, resulting in enduring inequalities both between and within countries. Ageing populations mean that care for the elderly will remain a growing requirement across the world.

Traditional and alternative medicine. Out to 2055, the significance of traditional and alternative medical practices will continue to be valued across the globe. Traditional Chinese medicine, for instance, is already a substantial market, estimated at US $18.8 billion in 2021 and projected to reach US $50.3 billion by 2030.[53] Similarly, around 200 million people worldwide regularly use homeopathic treatments.[54] While the popularity of homeopathy and other forms of alternative medicine has not fluctuated significantly in recent years,[55] regional differences are noticeable; in India, for example, 100 million people rely solely on homeopathy for their health care.[56] The trade in herbal medicine is also flourishing with an increase of approximately 15% each year; an estimated 60% of the world's population rely on these forms of treatment, particularly in developing countries where access to modern medical practitioners is limited.[57] Despite innovations in modern medicine, traditional alternatives will continue to be a preferred option in many regions due to their affordability, accessibility and cultural acceptance, especially in low- and middle-income countries where modern medicines may be less available.[58] Elsewhere, interest in alternative forms of medicine may grow due to a decline in trust in more modern techniques, including as a result of online misinformation and disinformation campaigns.

48 Deloitte Insights, Deloitte Center for Health Solutions (2019), *The Future of Aging: What impact might the expansion of health span have on society?*
49 Scott, A., International Monetary Fund (2 March 2020), *The Long, Good Life*.
50 Dieleman, J.L., et al., *JAMA*, Volume 318, Issue 17 (7 November 2017), 'Factors associated with increases in US health care spending, 1996-2013', pages 1668–1678.
51 GBD 2019 Dementia Forecasting Collaborators, *The Lancet Public Health*, Volume 7, Issue 2 (February 2022), 'Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019', pages E105–E125.
52 Beam, C.R., et al., *Journal of Alzheimer's Disease*, Volume 64, Issue 4 (24 July 2018), 'Differences between women and men in incidence rates of dementia and Alzheimer's disease', pages 1077–1083.
53 Emergen Research (December 2022), *Traditional Chinese Medicine Market, By Therapy Type, By Disease Time, By Region Forecast To 2030*.
54 Homeopathy Research Institute (2017), 'Homeopathy use around the world'.
55 Relton, C., et al., *Homeopathy*, Volume 106, Issue 2 (May 2017), 'Prevalence of homeopathy use by the general population worldwide: a systematic review', pages 69–78.
56 Chameleon Pharma Consulting Group (2020), 'The Indian Homeopathic market – an orchestra of growth'.
57 Khan, A.S.A., et al. (2018), *New Look to Phytomedicine: Advancements in Herbal Products as Novel Drug Leads*, 'Chapter 1 – 'Herbal medicine: Current trends and future prospects'.
58 Oyebode, O., et al., *Health Policy and Planning*, Volume 31, Issue 8 (31 October 2016), 'Use of traditional medicine in middle-income countries: a WHO–SAGE study', pages 984–991.

Improving health and rising inequalities. Despite overall improvements in health over recent decades – including dramatic reductions in global child mortality levels and the eradication of diseases such as smallpox – stark inequalities will continue to endure between different regions and sectors of society. For example, studies suggest that the wealthiest people in society can expect to live an additional eight to nine years free from disability compared with people in the poorest groups.[59] Globally, children from the poorest 20% of households face higher mortality rates and are nearly twice as likely to die before the age of five as children from the richest 20%.[60] Around 400 million people worldwide still lack access to essential health services,[61] with an estimated 5.7 million dying every year in developing countries as a result.[62] Communicable, maternal, neonatal and nutritional diseases cause approximately 10 million deaths each year globally, disproportionately affecting the world's poorest economies;[63] for example, developing countries account for 99% of maternal deaths annually.[64] The absence of cutting-edge treatments and general deficiencies in health care provision mean that survival rates for non-communicable diseases are lowest in low- and middle-income countries, with non-communicable diseases accounting for 77% of all deaths occurring in these parts of the world. Taken together, these factors suggest that health inequalities are likely to endure and, in some cases, may increase, with the world's poorest regions and communities being disproportionately impacted.

Purpose and lifestyle

The expanding global middle class. Despite recent setbacks, the overall trend of a growth in wealth is expected to resume, resulting in an increase in the size of the global middle class population.[65] The Indo-Pacific region will continue to be home to the largest number of middle class people, growing to 65% of the world's total by the end of the decade;[66] elsewhere, Africa, Southwest Asia and Latin America will also see significant increases in their middle class populations.[67] This expansion will bring about lifestyle improvements associated with increased wealth, as well as a rise in educational standards and shifts in consumption patterns. The growth of the middle class population at the global level could redefine the notion of middle class status entirely, which may vary according to regional biases and perceptions. While an expanding middle class will bring substantial economic and social changes, poverty will continue to endure in some parts of the world, leading to growing inequalities between rich and poor populations.

59 Zaninotto, P., et al., *The Journals of Gerontology*, Volume 75, Issue 5 (May 2020), '*Socioeconomic inequalities in disability-free life expectancy in older people from England and the United States: A cross-national population-based study*', pages 906–913.
60 World Health Organization (22 February 2018), 'Health inequities and their causes'.
61 Ghebreyesus, T.A., *The Lancet: Global Health*, Volume 5, Issue 9 (17 July 2017), 'All roads lead to universal health coverage', pages E839–E840.
62 Goldschmidt, G. and Pate, M.A., World Economic Forum (25 November 2019), 'Every year nearly 6 million people die in developing countries from low quality healthcare – this is how we help them'.
63 *The Lancet*, Volume 396 (17 October 2020), 'Communicable, maternal, neonatal, and nutritional diseases–Level 1 cause'.
64 Girum, T. and Wasie, A., *Maternal Health, Neonatology and Perinatology*, Volume 3, Issue 19 (7 November 2017), 'Correlates of maternal mortality in developing countries: an ecological study in 82 countries'.
65 Fengler, W. and Kharas, H., Brookings Institution (20 May 2021), 'A long-term view of COVID-19's impact on the rise of the global consumer class'.
66 Bouw, M., Cushman & Wakefield (16 December 2020), 'Asia Pacific on the rise'.
67 Kharas, H., Brookings Institution, Global Economy & Development Working Paper 100 (February 2017), *The unprecedented expansion of the global middle class: an update*.

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If it becomes affordable, global satellite-enabled Internet could bring quality education to many historically deprived regions

Education. Over the next three decades, improvements in infrastructure, including the increasing prevalence of satellite-enabled Internet, will increase the availability of quality education, which could be an important driver of global economic growth. Levels of educational attainment are improving across the world, with the number of people without formal education forecast to decline from 729 million in 2020 to 421 million by 2055.[68] However, educational inequalities will persist, with the rural poor and female populations in some parts of the world being particularly affected by a lack of access to education. Standards will continue to vary across the globe, and the gap between developed and developing countries may widen.

As automation and other developments change the character of employment over the next 30 years, countries will need to maintain flexible and adaptive approaches to education to retain or gain economic advantage. While Europe and the US have historically been among the leaders in educational provision, both in terms of educational standards and numbers of tertiary graduates, they will face a growing challenge from the Indo-Pacific region; in particular, China and India are making advances in the subjects of science, technology, engineering and mathematics. However, for this to translate into economic advantage, these countries will need to ensure that they provide sufficient numbers of rewarding and well-paid employment opportunities for their graduates; this could lessen the risk of brain drain as corporations seek to attract skilled labour from Asia to fill roles in Europe and the US.

In the future, society's dependence on space and increasing interest in space exploration may lead to new educational opportunities and the emergence of new academic disciplines. By 2055, young people could be attracted by new space-related occupational fields, including space psychology and physiology, space architecture and construction, space medicine, asteroid mining, food engineering, spaceport traffic control and on-orbit refuelling.[69]

68 Roser, M., et al., Our World in Data (2016), 'Global Education'.
69 The Space Report: Space Foundation, 'Industry Insight: Space Jobs of the Future'.

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Skill sets that allow organisations to extract the maximum benefit from new technologies will be in high demand

A changing workforce. While the growing use of automation will not see employment decline in all sectors, it will see workers required to perform new tasks, and as a result will see a change in the skills requirement for many roles.[70] As machines become increasingly intelligent and enabled by more sophisticated computing techniques, they will more commonly be considered as a partner rather than a tool, with expanding utility across a broader range of roles.[71] In those countries that already have access to sophisticated technologies, the demand for highly skilled workers has increased, while the demand for less educated workers with lower skills has decreased.[72] While the speed of the transition will inevitably vary across countries and regions, many workers will be faced with the prospect of stagnating wages and widening income inequality over the next few decades.[73] From a societal perspective, individuals with skill sets that complement the growing use of automation will be more likely to benefit as a result of the transition.[74] Equally, regions with education systems that are able to adapt more readily to the requirements of automation and support a changing workforce will profit the most, not least by attracting migrants in search of rewarding opportunities that may not be available in their home countries.

As population peaks and productivity demands place increasing pressure on economies, some countries may see a rise in female participation in the workforce, leading in time to an increase in gender equality more generally. However, regional disparities will remain, with women continuing to be under-represented in the workforce in many countries as a result of enduring cultural norms or systemic issues.

70 Manyika, J., et al., McKinsey Global Institute (12 January 2017), 'A future that works: Automation, employment, and productivity'.
71 Konaev, M. and Chahal, H., Brookings Institution (18 February 2021), 'Building trust in human-machine teams'.
72 Schwab, K., World Economic Forum (14 January 2016), 'The Fourth Industrial Revolution: what it means, how to respond'.
73 Schlogl, L. and Summer, A. (2020), *Disrupted development and the future of inequality in the age of automation*, 'Chapter 5 – Automation and structural transformation in developing countries', pages 51–78.
74 Holzer, H.J., Brookings Institution (19 January 2022), 'Understanding the impact of automation on workers, jobs and wages'.

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Demographic drivers will result in an overall growth in global religious following, reinforcing its prominence as an element of identity and values

Enduring inequalities. Although societies in general will become wealthier, inequalities in wealth and power are expected to persist or even increase at both national and international levels. Poverty will endure in some regions, exacerbating levels of socio-economic inequality and leading to persistent inequalities in other areas of life. Out to 2055, increasing awareness of inequalities in income, education and employment opportunities, which in turn lead to inequalities in health care and living conditions, may drive unrest and instability in some societies.

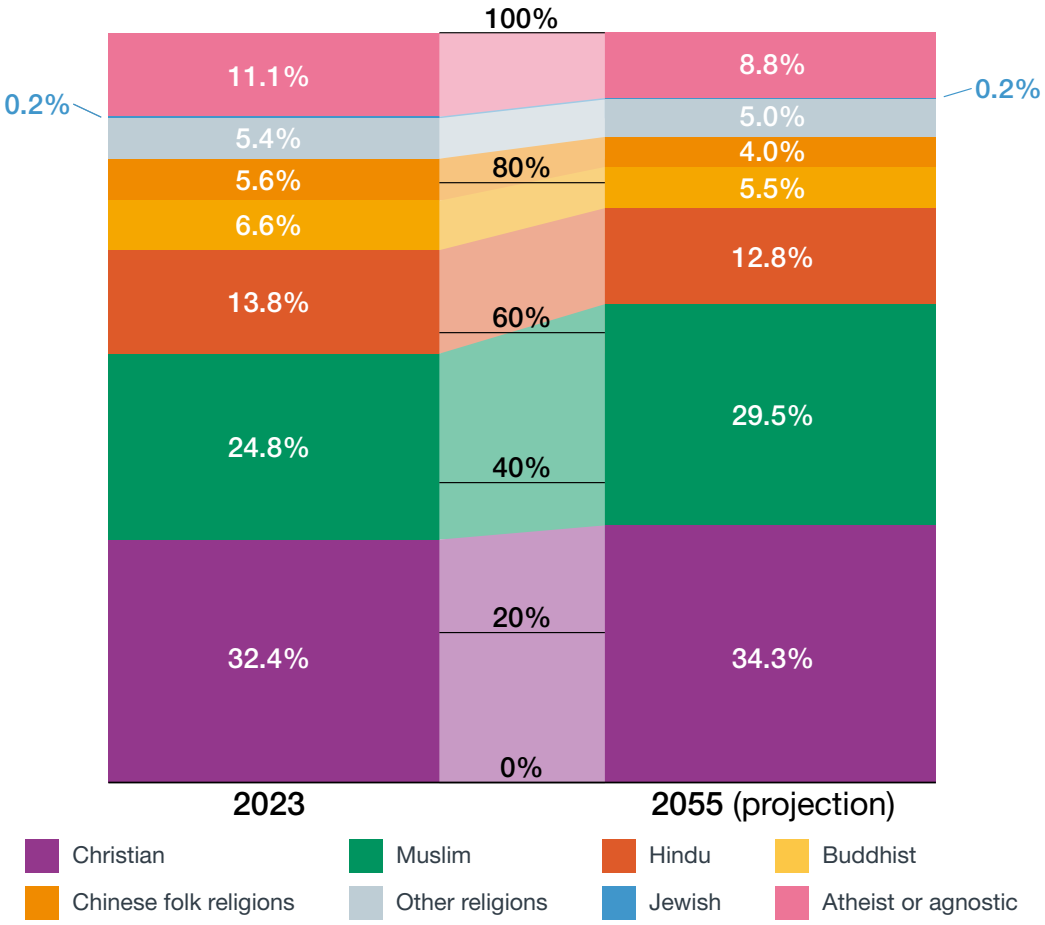
Identity and values

Culture and identity. Despite the impact of decades of globalisation, it is clear that factors such as a society's history, culture and religious, national and ethnic composition will continue to have a significant influence on domestic and international affairs, as well as individual values and beliefs. The idea of universal values, once championed, now faces suspicion from some quarters, even though it remains attractive to many. The world may see renewed competition over alternative systems of governance and social and economic development models, which may potentially exacerbate future crises.

Religion. Religion will remain a significant influence and identity marker for many of the world's societies. Around 89% of the global population has an affinity with a religious group, and this is projected to rise slightly to 91% by 2055.[75] Christianity remains the largest faith group (2.6 billion people), followed by Islam (2 billion), Hinduism (1.1 billion), Buddhism (535 million) and Chinese folk religions (454 million).[76] However, the number of adherents to the Islamic faith is anticipated to see a 46% increase by 2055, largely as a result of high birth rates among the Muslim population, bringing it closer to parity with the world's Christian population. Many religions, including Buddhism, are expected to decline as a percentage of population, but only Chinese folk-religionists are likely to decline in actual numbers during this period.[77] Approximately 900 million people worldwide identify as

75 Institute on Culture, Religion and World Affairs, Boston University, 'World Religion Database'.
76 Ibid.
77 Ibid.

non-religious or hold atheist beliefs; this proportion is expected to decline from 11% of the global population in 2015 to 9% by 2055.[78] At the same time, new interpretations of world faiths, influenced by modern cultures and ideals, are emerging. Out to 2055, this may result in increasing diversity within religious groups, and potentially new sub-groupings. While the vast majority of religious followers will continue to live peacefully in the pursuit of their religious beliefs, no faith is immune to manipulation for political or malign purposes, and the threat from people acting with malice in the name of religion will remain.



Source: World Religion Database (2023)

World's largest religions between 2023 and 2055

National identity. Despite the rise in global connectivity and increasing exposure to other cultures through travel and other forms of social interaction, an individual's nationality will remain an important identity marker, albeit with variations across different countries. Older people are more likely to view birthplace as being an important factor in national identity, while majorities in many countries believe that being able to speak the dominant language is very important.[79] The political exploitation of national identity is likely to remain prevalent in autocratic states such as Russia and China, as well as being a prominent feature of politics in Southwest Asia, Africa, Latin America and an increasing number of Western countries.[80] Out to 2055, leaders may increasingly play on national identity, sometimes intertwined with culture and religion, to mobilise populations and boost support, at the same time risking the exacerbation of tensions with others outside the national group.

78 Institute on Culture, Religion and World Affairs, Boston University, 'World Religion Database'.
79 Stokes, B., Pew Research Center (1 February 2017). 'What It Takes to Be Truly 'One Of Us''.
80 Ibid.

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Unexpected events may galvanise increasingly diverse identity markers in globally connected societies, potentially leading to movements that challenge state stability or drive global change

Family. In many parts of the world the nature and construct of families is undergoing a gradual change, which out to 2055 will inevitably have implications for social structures generally. Marriage rates have been declining globally since the early 1970s,[81] and the number of non-marital childbearing families has grown substantially over the last three decades,[82] indicating shifts in family dynamics. In addition, the age at which people marry and have children is increasing,[83] birth rates are declining and a rising number of people are living alone or choosing not to have children.[84] While same-sex marriages make up no more than 3.4% of all marriages in the countries where they are legal, rates for same-sex marriages and civil partnerships may rise over time, and out to 2055 there is likely to be an increase in the number of countries recognising same-sex unions.[85] However, traditional and more conservative attitudes toward family structures will persist in many cultures and regions, potentially resulting in greater divergence between different global societies.

Individual identity and social movements. In the future, personal identity may become more complex as humans are increasingly exposed to new values and ideas alongside the traditional influences of religion, culture, nation and family. A range of diverse factors such as employment, environment, income group, social media usage, gender identification, sexual orientation, self-identification and even human augmentation will increasingly be brought into the mix, shaping individual identities and values in new and complex ways. Sudden events, for example, conflict, terror attacks, economic or environmental crises or the introduction of new laws, may serve to reinforce certain identity markers, giving rise to new social and political movements and hardening divisions between groups. While strong states will be able to absorb these movements, in some other states, popular pressure will lead to tension and potentially radical changes within society.

81 Berrington, A. and Vitali, A., World Economic Forum (12 May 2016), 'What will the family of the future look like?'.
82 Schnor, C. and Jalovaara, M., *Acta Sociologica*, Volume 63, Issue 4 (14 November 2019), 'The increase in non-marital childbearing and its link to educational expansion', pages 400–421.
83 Ortiz-Ospina, E. and Roser, M., Our World in Data (25 July 2020), 'Marriages and Divorces'.
84 Saner, E., *The Guardian* (31 December 2019), 'The family in 2050: artificial wombs, robot carers and the rise of single fathers by choice'.
85 Desilver, D., Pew Research Center (13 June 2023), 'In places where same-sex marriages are legal, how many married same-sex couples are there?'.

Sport continues to be a powerful force in society, and it is increasingly providing a global platform to shape attitudes and values

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Exposure to a range of cultures, values and ideas has the potential to increase tolerance and unlock the benefits of diversity, although intolerance between societal groups appears to be increasing in many parts of the world. New ideals are being seen as a challenge to established historical, cultural and religious norms, and in recent years some Western societies have seen the emergence of increasingly irreconcilable positions on a range of issues from abortion to immigration. As the increasing prevalence of social media provides new platforms through which different groups are able to express their views and see them reinforced by others, this may see an increase in polarisation and tensions between groups, with implications for political stability.

The virtual space. The Internet's ability to connect individuals globally will continue to transform our understanding of identity and values out to 2055. With increases in Internet access, social media is already becoming the dominant source of information, with 4.9 billion users expected to grow to 5.85 billion by 2027.[86] The congested social media landscape will increasingly encourage people to use provocative content to make sure they are heard, challenging the truth and making fact-checking difficult. Weak governance of the online world could contribute to a growing global trust deficit, providing an ideal environment for misinformation and disinformation to flourish. Human and algorithmic biases will serve to deepen societal polarisation, resulting in the formation of echo chambers. New platforms will result in governments facing increasing challenges from external sources, both state and non-state, including super-empowered individuals who in some cases may seek to use these online tools to galvanise support for new ideas and political movements. On the other hand, some governments may seek to develop national digital ecosystems or 'splinternets' as a way to mitigate this challenge.

86 Wong, B., *Forbes* (18 May 2023), 'Top social media statistics and trends of 2024'.

Film, music and the arts. Societies and individuals will continue to be influenced by the creative arts, particularly in more liberal societies with greater freedoms and volume of digestible media. Advances in technology will make for more realistic and immersive experiences, and artificial intelligence is likely to be increasingly used to generate content tailored towards an individual's preferences, character and values.[87] Digital art forms, such as virtual reality installations and interactive multimedia experiences, could become more commonplace,[88] with many of these hosted in virtual spaces that can be accessed from anywhere in the world. Whilst these forms of media will in some cases reinforce views and standpoints within like-minded communities, the opposite is equally possible, and individuals could be increasingly exposed to alternative perspectives as these become more accessible, with implications for political and social allegiances.

Sport. Sport will continue to be important both for physical activity and as a social pastime that brings together like-minded individuals with a shared interest. Sport can drive positive change, offering individuals the opportunity for greater self-empowerment while also breaking down gender, class, religious and ethnic barriers. However, the opposite is equally possible, and it can instead bring to the surface divisions and injustices, such as misogyny, racism and other forms of prejudice and discrimination. Notwithstanding this, in recent years a number of highly publicised cases relating to misogyny, racism, gender inequality and sexual impropriety in sport have led to widespread protests, changing social norms and even leading to legislative action. It is likely that this trend will continue out to 2055, with sport playing a central role in shaping individual attitudes as well as social norms and values.

87 Mykhaylyuk, Y., Global Logic (2023), 'AI is the Future of Media'.
88 Artdex (2023), 'How Technology is Changing the Art World'.

Economy

Overview

Economic fortunes have always fluctuated over time. However, recent shocks and continuing geopolitical tensions have resulted in an increase in economic uncertainty and volatility in the past few years, meaning that assessments regarding the future economic trajectory of states, regions and the world as a whole are now more complex than ever. The perceived wisdom that particular economies will ascend or decline is now increasingly under challenge, and the continuing rise of new emerging economies could see global economic power becoming more diffuse in the future.

Whether the global economy will rebound from recent setbacks or whether growth will continue to slow remains uncertain. Although new forms of technological innovation could provide a catalyst for growth in the future, currently high levels of public debt in many countries will have an impact on economies in the short to medium term at least. While the global economy still remains highly interconnected, a widespread return to protectionism in future years may see a decline in levels of global trade. At the same time, environmental concerns and the drive for sustainability may result in alternative measures of economic success rather than traditional growth-driven models.

Services will play an increasing role in the global economy, although manufacturing activity will continue to be significant in some countries and the next 30 years may see the rise of new leaders in that sector. Additive manufacturing (3D printing) will play an increasingly important role in the production of goods, although it is unlikely to displace mass manufacturing and automation for the bulk of products. Information technology (IT) services will increase in value, while e-commerce will play a more prominent role. Increasing personalisation of services and products will be expected in most developed economies, which at the same time may also see the emergence of more environmentally and socially conscious approaches to consumption.

The financial technology (FinTech) sector will see the emergence of new players and ways of doing business, although traditional banks are likely to remain important. Cashless payment will expand in the coming decades; however, cash will remain vital for the billions of people living and working in poorer regions and in particular those employed in the informal sector. The use of cryptocurrencies may continue to grow, although caution is increasing due to market volatility and immature regulatory frameworks. Some governments have already banned them entirely, and others could follow, while some other governments are developing state-backed digital currencies as an alternative to unregulated cryptocurrencies. While the United States (US) dollar is likely to remain the dominant reserve currency out to 2055, other currencies will play an increasing role and offer a viable alternative.

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Regions with a growing young workforce may become new hubs for manufacturing and service provision

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While many Western countries and East Asian states are already experiencing the effects of an ageing and shrinking workforce, some emerging economies could enjoy the benefits of a significant youth bulge, becoming new centres for global manufacturing and service provision. However, this will depend on their ability to provide the education, skills, training and employment opportunities needed to capitalise on this potential, and a failure to do so may lead to a rise in levels of international migration. Automation and artificial intelligence could compensate for a declining workforce in some regions and lead to the creation of new jobs in certain sectors, but could also disrupt existing employment patterns in others.

The desire to secure access to resources will continue to have a major influence on geopolitical relations, while also driving new efforts to diversify supply chains. Information, including personal data, will become an increasingly vital global resource.

While globalisation has driven increased levels of trade between countries in recent decades, patterns of trade are changing and will continue to do so out to 2055. Although servitisation is likely to see an increasing volume of trade in services, the movement of physical resources and goods will remain important. Despite the development of new technologies to service 'last mile' transport, the bulk movement of goods and resources by sea, land and air will continue to be a vital part of global trade.

The next three decades are likely to see increasing competition over the control of global and regional organisations and international standard setting. Western liberal economic ideals are increasingly being questioned by emerging powers; in the future, this may lead to increasing divergence in approaches to economic governance, further encouraging a trend towards regionalism. Collaboration on global science and technology may become increasingly limited as countries seek to protect the intellectual property that could allow them to lead the next wave of global innovation and economic growth. States will step up their attempts to de-risk critical supply chains and other vulnerabilities, although market forces will continue to play a dominant role in practice.

Over the next three decades, global powers may increasingly exploit their control over global financial systems and domestic legislation to influence and constrain others. Rising US–China tensions have been at the centre of this development, although other

powers are also adopting similar approaches. The use of economic levers as a tool of global power competition is likely to increase, ranging from debt entrapment through to de-risking activity, and in more extreme scenarios the use of sanctions, blockades and even attacks on critical infrastructure. Advances in artificial intelligence, FinTech and quantum technologies, as well as increasing reliance on digital infrastructure and data, could further expand the range of levers employed by states in the future. While in some instances such developments may help to avoid direct confrontation between states, in other cases they may trigger an escalation in tensions.

The global economy

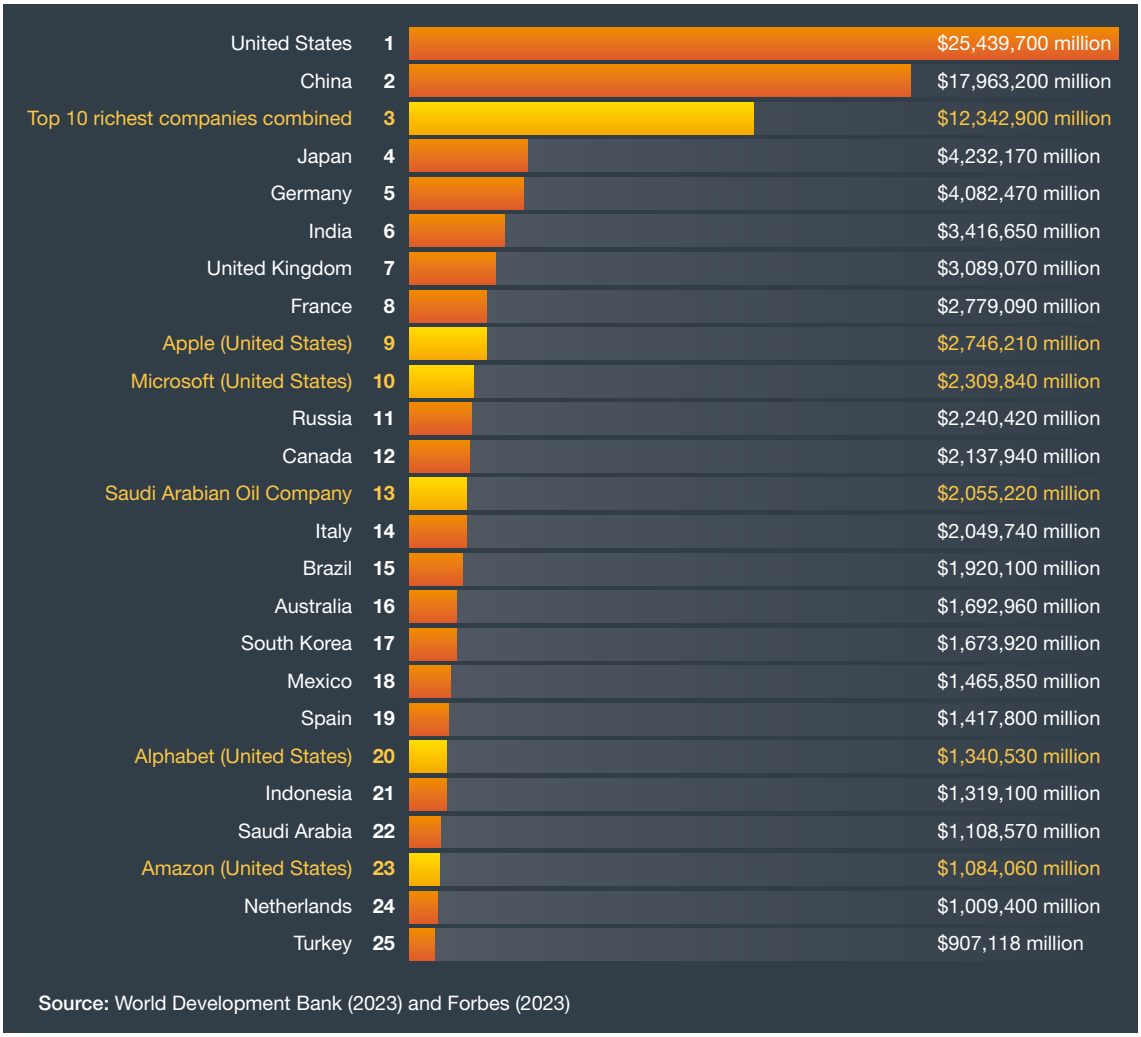
Uncertain outlook. The art and science of economic forecasting will remain highly complex and beset with difficulties out to 2055. Global economic performance will continue to be subject to shocks and uncertainties, and will be affected by a multitude of factors, including macro-economic trends, consumer demand, resource availability, trade flows and the actions of powerful states, firms and individuals. A succession of shocks in recent years, as well as ongoing geopolitical tensions (not least wars in Ukraine and Southwest Asia) have all contributed to an increase in volatility and uncertainty, which is likely to endure in the short term at least. While global gross domestic product (GDP) per capita has grown steadily at an average of around 1.8% since the Organisation for Economic Co-operation and Development's records began in 1961,[1] continued growth at this rate out to 2055 now looks increasingly uncertain.

With Asia's early phase of rapid economic expansion now behind the region's powerhouses, and continuing uncertainty about future growth levels in Africa and other regions approaching favourable ratios of working age people to dependants, the global economy could be faced with a slowdown of uncertain duration. Recent events have seen the costs of some key resources, including food and energy supplies, rising rapidly, fuelling inflation.[2] While this may be a short-lived development, it is also possible that the global economy will undergo a longer period of stagnation and turbulence. On the other hand, a new economic cycle, driven by emerging technologies and industries, could see global growth given fresh impetus prior to 2055.

Diffusion of economic power and influence. Increased economic volatility is likely to have an impact on global GDP rankings out to 2055. While the Group of Seven (G7) (Canada, France, Germany, Italy, Japan, the UK and the US) was responsible for 31% of global GDP in 2020, the Emerging Seven (E7) economies (Brazil, China, India, Indonesia, Mexico, Russia and Turkey) are likely to become increasingly influential, and by the middle of the century may have increased their share of global GDP to 50%.[3] The gradual diffusion of economic power between countries is reinforced by the increasing number of multinational corporations that have gained financial resources equivalent to those of a middle power state. Most of these are technology firms that can amplify their economic resources with their increasing control of technical infrastructure and know-how, which may give them significant influence in the global activities that rely on their systems. This creates a complex dynamic where states are seeking to influence corporations via regulation and policy, but without discouraging investment through heavy-handed legislation.

1 World Bank (2022), 'GDP per capita growth (annual %)'.
2 Holland, B., et al., Bloomberg UK (25 February 2022), 'How War in Ukraine Threatens the World's Economic Recovery'.
3 PricewaterhouseCoopers (PwC) (2017), 'Shift of global economic power to emerging economies set to continue in long run, with India, Indonesia and Vietnam among star performers'.

The extent of this diffusion of economic power will depend on how emerging countries, and the businesses that form the basis of their economies, overcome a range of pressures. China's previously high levels of growth have slowed recently, due to increasing demographic, social and environmental challenges, alongside rising levels of debt in state and private companies and an ongoing real estate crisis.[4] Some forecasts even suggest that China's growth could flatline by 2035, long before its 2049 milestone for full development.[5] The future performance of the Russian economy continues to be beset by high levels of uncertainty following its 2022 invasion of Ukraine, the imposition of sanctions by Western countries and decisions on the part of corporate actors to withdraw from the Russian market. At the same time, a number of middle- and lower-income countries in the Indo-Pacific region have demonstrated continued strong per capita growth. India and Indonesia, for example, are likely to see the importance of their business sectors and markets increase in coming decades. India could potentially overtake the US' GDP in purchasing power parity by the middle of the century and the eurozone by the mid-2030s, if growth continues on current trends.[6] For corporations, it is unclear whether the vast market capitalisation of technology companies, especially artificial intelligence companies, is durable or merely a bubble.



Country nominal GDP (in 2022) compared with the market capitalisation of multinational corporations (in 2023)

4 Topaloff, L.K., *The Diplomat* (4 March 2020), 'Is COVID-19 China's 'Chernobyl Moment'?'.
5 Rajah, R. and Leng, A., Lowy Institute (14 March 2022), 'Revising down the rise of China'.
6 Organisation for Economic Co-operation and Development (2024), 'Real GDP long-term forecast'.

Rising public debt. Government debt has increased in many countries over recent years, accelerated by the COVID-19 pandemic. Public debt in advanced economies rose from 70% of GDP in 2007 to 124% in 2020, and in low-income countries it reached levels not seen since the early 2000s.[7] Increasing public debt will place a major burden on future generations, limiting public spending options and presenting future governments with difficult choices. Government spending, including defence and security budgets, may come under increasing pressure. In extreme cases, countries with high levels of debt and poor economic performance could even face bankruptcy.

Public debt

The accumulation of government debt is largely due to two major economic crises – first the global financial crisis and then the COVID-19 pandemic. Since the pandemic, governments around the world have borrowed to compensate for the economic impact of the disease. This has resulted in 25 countries, including the US and China, having a total debt of over 300% of GDP.[8] At the end of 2021, public debt accounted for almost 40% of total global debt, the highest share since the mid-1960s. Since then, the war in Ukraine has seen the price of natural gas and oil rise enormously, providing a further shock to global economies. Regardless of the future direction this will take,[9] it is likely that states around the world will have to take on additional debt in the short term to support their economies, as households are already spending an ever-larger amount of their incomes on fuel and heating and therefore have less money available for other goods and services.

A return to protectionism. Over the next few decades, increasing geostrategic tensions over trade, intellectual property rights and the security implications of technology transfers and supply chains may see a decline in commitment to economic globalisation. Although the global economy remains highly interconnected, protectionist practices already appear to be on the rise. While the current focus for states is on ensuring that they have reliable access to energy and critical minerals, components and technologies, an expansion of such measures to other sectors could have significant implications out to 2055. In the future, international economic and industrial relations could be characterised by competition rather than cooperation as an increasing number of states pursue strategies to safeguard their economic and security interests.[10]

The economics of climate change. Climate change and other environmental issues could also see a reshaping of the global economy over the next three decades. For example, it has been estimated that climate change could cost Indo-Pacific region economies US $96 trillion, Europe US $10 trillion and the US, US $14.5 trillion by 2070.[11] While many national pledges fall short of the targets that climate scientists believe are required to avoid the more challenging scenarios, the green energy sector is growing,

7 Gaspar, V., et al., International Monetary Fund (15 December 2021), 'Global Debt Reaches a Record $226 Trillion'.
8 *Financial Times* (2 January 2022), 'Ten economic trends that could define 2022'.
9 Holland, B., et al., Bloomberg UK (25 February 2022), 'How War in Ukraine Threatens the World's Economic Recovery'.
10 Soong, J.J., *The Chinese Economy*, Volume 56, Issue 4 (17 November 2022), 'The Political Economy of Asian States and Their Development Strategies under USA-China Power Rivalry: Conducting Hedging Strategy on Triangular Relation and Operation', pages 245–255.
11 Deloitte (May 2022), *The turning point: A Global Summary*.

suggesting that renewable sources could begin to take an increasingly dominant share of the energy industry overall. Although US, Spanish, Danish, Chinese and Canadian firms currently dominate renewables production, other players are likely to emerge prior to 2055, potentially driving improvements in economic growth levels in unexpected quarters. However, there remains a demand for fossil fuels, which are not expected to peak until later this decade at the earliest,[12] and therefore major fossil fuel-exporting economies are likely to see a continued market for their products in the short to medium term at least.[13]

Goods and services

Balance of goods and services. The balance of global economic activity between different sectors is likely to continue to change in the coming decades. The service sector is already the biggest source of employment and holds the highest value in GDP terms, ahead of commodity extraction and manufacturing, and is likely to continue to grow out to 2055.[14] In particular, health care, IT services and transport (particularly in Asia) are all expected to show significant growth.

Manufacturing. The future of the manufacturing sector will be influenced by a range of factors, including technological advances, shifting value chains and changes in consumer behaviour over the next 30 years. These trends, in combination with other factors such as the cost and availability of skilled labour, access to capital and openness to trade, will influence where manufacturing is located in the future. At present, China is the world's largest manufacturer, a position which it has held for over a decade, with a 28.7% share of global manufacturing in 2019, ahead of the US at 16.8%.[15] Out to 2055, a number of middle-income countries on different continents may try to boost growth by becoming export-driven production hubs, although major commodity exporters may struggle to break their reliance on commodity extraction due to vested interests.

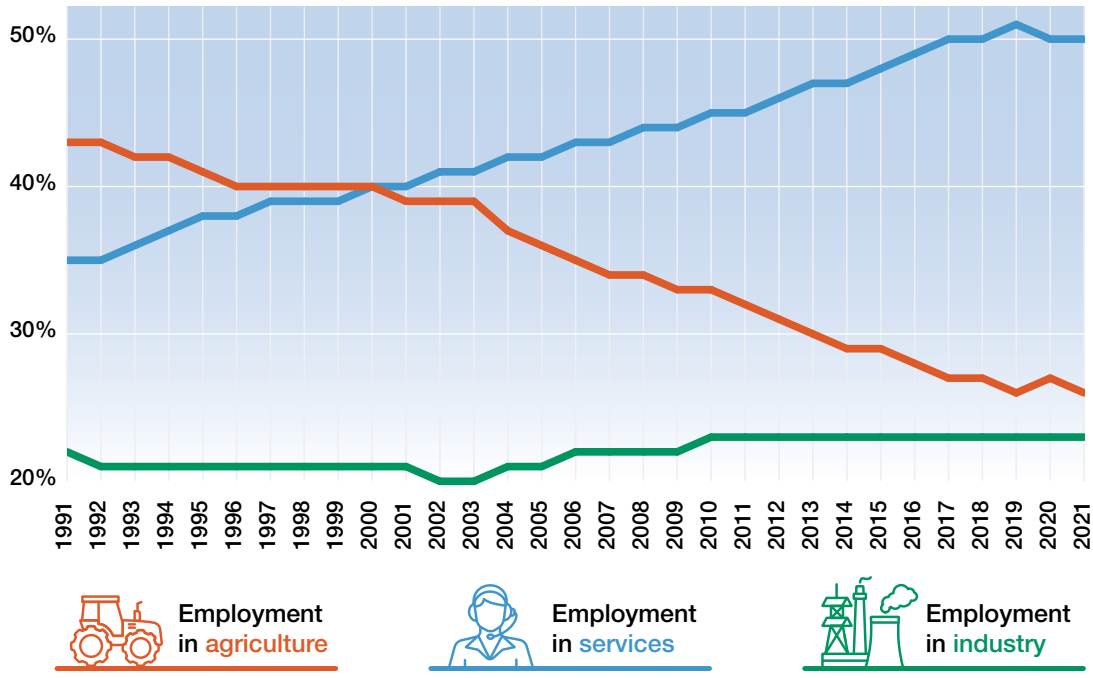
Over the next three decades, continuing moves by traditional manufacturing economies to relocate their production to cheaper locations will drive the emergence of new global manufacturing hubs. At the same time, high-tech manufacturing processes, including automation and additive manufacturing, may see the production of certain goods shifting closer to the customer in the developed world. Although it could potentially play an increasing role across a range of sectors, the extent to which additive manufacturing will surpass mass production in practice remains to be seen. Even if it drives an increase in the onshoring of manufacturing activity in developed states, additive manufacturing will continue to rely on imports of raw materials and other inputs, and hence will remain dependent on global trade dynamics. Nevertheless, the way in which goods are sold in the future is likely to evolve, shifting in part from e-commerce to file or blueprint trading, increasing the importance of intellectual property rights and data ownership.[16] As a result, additive manufacturing could create a range of challenges in the areas of standardisation and intellectual property, potentially leading to an increasing demand for intellectual property rights protection and other legal services. In 2022, manufacturing became the

12 International Energy Agency (October 2023), *World Energy Outlook 2023*, pages 26–30.
13 Ross, J., Visual Capitalist, Advisor Channel (29 July 2021), 'The 5 Fastest Growing Industries of the Next Decade'.
14 Investopia (29 March 2022), 'Service Sector: Place in Economy, Definition and Examples'.
15 Richter, F., Statista (4 May 2021), 'China Is the World's Manufacturing Superpower'.
16 Jiang, R., et al., *Technological Forecasting and Social Change*, Volume 117 (April 2017), 'Predicting the future of additive manufacturing: A Delphi study on economic and societal implications of 3D printing for 2030', pages 84–97.

most targeted sector for cyberattacks, overtaking the financial and insurance sectors; this trend is likely to continue as additive manufacturing and automation technologies evolve.[17]

Services. Over the past three decades, the service sector has seen more rapid growth than the manufacturing sector, initially in developed countries but increasingly in many developing economies as well.[18] Analysis by the World Bank shows that much of the expansion in employment in low- and middle-income countries in recent years has been in the low-skills service sector, particularly in the informal economy in which women often play a major role.[19]

Out to 2055, increasing global digital connectivity could see an expansion of the service sector in many countries and a boost to global service exports, potentially transforming a number of the world's economies. In 2017, for example, IT, professional, scientific and technical services accounted for more than half of all service exports in Costa Rica, Ghana, India, Pakistan and the Philippines.[20] China's service sector is also rapidly expanding, due in part to its growing domestic consumer class; looking forward, the intention of the Chinese government is to grow the level of services in the country to 70–80% of GDP, placing it on a par with advanced economies.[21] However, this will depend on future government policy towards China's globally dominant manufacturing sector, which is a strategic asset that China may choose to protect.[22]



Source: World Bank, World Development Indicators (2023)

Employment by sector as a percentage of the population

17 IBM Corporation (February 2022), *X-Force Threat Intelligence Index 2022*.
18 World Bank, China Economic Update – December 2021 (22 December 2021), *Rebalancing Act: From Recovery to High-Quality Growth*.
19 World Bank (15 September 2021), *At Your Service? The Promise of Services-Led Development*.
20 Gill, I., World Bank Blogs (27 September 2021), 'At your service? Developing economies bet on service industries for growth'.
21 Hsu, S., *Forbes* (21 February 2017), 'China Takes Another Step Towards A Service Economy'.
22 *The Economist* (14 August 2021), 'China's future economic potential hinges on its productivity'.

New technologies enable customers to visualise goods in their homes before they commit to buy

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Information technology as a service. The IT industry is expected to continue to grow significantly in coming decades, with the recent increase in remote working and e-commerce helping to drive an acceleration of this trend. This growth will manifest itself not only in developed economies, but also in developing countries such as Indonesia, Malaysia, the Philippines, Thailand and Vietnam, which alongside Singapore are quickly emerging as the next 'digital giants'.[23] This will be driven largely by the growing number of Internet users in Southeast Asia, which is expected to rise from 392 million in 2018 to 662 million by 2029.[24] Out to 2055, further advances in communications technology will also support innovation and new forms of value creation in the IT sector, as demonstrated by the popularity of subscription-based streaming platforms. While US and Chinese businesses currently dominate the platform, infrastructure and software-as-a-service sectors by a wide margin, and they are likely to maintain their positions in the short to medium term at least, the UK, Japan, Germany, India and Brazil also perform strongly in these areas, and may improve their position further in future.

Traditional and e-commerce. Technology will continue to revolutionise the way in which consumers access goods and services out to 2055. Although there has been a slight dip in online spending since the height of the COVID-19 pandemic, levels remain higher than previous figures in about half of all states, from large emerging economies such as Brazil and India to middle-income countries such as Bahrain and Jamaica. Much of this growth is associated with millennials, with this age group being more familiar with online shopping.[25] Over the next 30 years, it is likely that the shopping experience will increasingly begin and end online, with consumers across the world using the Internet to access product information and reviews before making an online purchase. Augmented

23 Vyas, R.K., *Forbes* (17 May 2022), '3 Reasons Southeast Asia Is A Hot Market For Tech Startups'.
24 Statista (25 July 2023), 'Number of internet users in Southeast Asia from 2014 to 2029 (in millions)'.
25 Gapper, J., *Financial Times* (6 June 2018), 'How millennials became the world's most powerful consumers'.

reality is already helping consumers choose products, allowing them to try on clothing or position furnishings in their home without needing to visit a physical retail outlet. This level of functionality and convenience has seen many turn away from physical shops. In the future, businesses may increasingly have to fuse their physical and digital offer to remain attractive; total e-commerce revenue is projected to increase to US $5.56 trillion by 2027, from US $1.47 trillion in 2017.[26] China is the biggest e-commerce market and is likely to retain its lead out to 2055, followed by Southeast Asia, fuelled by growing consumer markets and a rise in digital connectivity in the region.[27]

The future of online shopping

Virtual reality glasses are becoming more widely available, and as more and more people adopt this technology, the manufacturing cost per unit is likely to fall. A survey conducted by PricewaterhouseCoopers (PwC) in 2022 found that around a third of virtual reality users have already made purchases using the technology. China, India and Qatar are the markets where shopping with virtual reality is most popular. Retailers are being encouraged to respond to the increasing popularity of virtual reality, with luxury goods being the most popular markets for the use of these tools. Customers shopping at Hugo Boss, for example, can now create personalised avatars to try on clothes without getting off the couch. At the same time, there is increasing use of augmented reality technology when shopping, which enables customers to place furniture in their living rooms, for example, by superimposing a digital projection onto the real world.[28]

Customisation and personal data. Data analytics and other enabling technologies mean that out to 2055 goods and services will increasingly be delivered in a more customised and personalised way. While delivery companies were at the forefront of this trend, other sectors are now adopting similar approaches. Looking forward, this development is expected to expand further; for example, insurance policies may increasingly be tailored according to location, lifestyle choices, monitored health risk and other person-centred factors.[29] The flexibility afforded by automation and other manufacturing technologies will increasingly enable individually tailored products to be created, supported by continuous monitoring, servicing and upgrade packages. In the coming decades, as data becomes ever more accessible, this trend is likely to accelerate further. For producers, this may lead to a growth in customer loyalty and create a more stable revenue stream, as well as providing a wealth of information that may be used to improve products in the future. This model will depend on customers being willing to share large quantities of personal information in exchange for the benefits afforded by tailored goods and services. However, it appears that younger generations who were born or brought up during the age of digital technology increasingly appear to value personalisation over data privacy, which should see this becoming a growing trend in future years.[30]

26 Statista (2023), 'eCommerce – Worldwide'.
27 Statista (2021), 'eCommerce report 2021'.
28 Read, S., Web Economic Forum (23 August 2022), 'How many consumers are shopping in virtual reality and what can it offer them?'.
29 Pathak, R., Analytics Steps (9 January 2021), '7 Uses of Big data in the insurance industry'.
30 Williams, R., Marketing Dive (4 June 2019), 'Study: Gen Z opts for personalized interactive content over privacy'.

Consumers are increasingly making purchase decisions based on environmental and social justice criteria, forcing firms to be transparent about their supply chains

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Socially conscious consumption. The trend towards socially conscious consumption is expected to grow over the next few decades. Concerns over climate change, environmental protection and the rights of workers will increasingly feature in purchase decisions, forcing firms to understand their supply chains more intimately. For example, the next three decades may see an increasing backlash against the environmental impact of fashion production, which is estimated to be responsible for 10% of global carbon emissions and is the second largest industry in terms of water consumption.[31] This, together with concerns over the treatment of workers in some parts of the 'fast fashion' industry, may see consumers thinking more carefully about their purchase choices, as well as increasingly choosing to rent clothes or buy second hand. The global impact of this trend, however, will depend on a range of factors, including the availability and affordability of sustainable alternatives, as well as the effect of public policy interventions. In addition, governance factors may also limit consumer choice. In China, for example, while consumers are increasingly concerned about water and air pollution, contamination of the food chain and other environmental issues, it is sometimes difficult to mobilise pressure for change given state control of social media.

Servitisation. Out to 2055, the potential increase in servitisation (where consumers pay for a service or hire an item rather than buying the product) may result in closer integration of goods and services. Servitisation could increasingly be seen as a sustainable consumer choice, helping to reduce entry costs for individual consumers as well as reducing environmental impacts.[32] Climate change and other environmental pressures could see the increasing adoption of circular economies in some sectors, with a shift in focus towards sharing, leasing, reusing, repairing, refurbishing and recycling rather than the production of new goods.[33]

Health care. The health care and biotechnology industries will constitute an increasingly important share of the global economy out to 2055. Health care is already one of the

31 Maiti, R., Earth.org (5 January 2024), 'Fast Fashion and Its Environmental Impact'.
32 Karamitsos, D., et al., World Economic Forum (20 November 2020), 'What is servitization, and how can it help save the planet?'.
33 European Parliament (24 May 2023), 'Circular economy: definition, importance and benefits'.

fastest growing sectors in the US, for example, due to its ageing population and increasing life expectancy and incidence of chronic conditions.[34] Over the last two decades alone, global spending on health has more than doubled in real terms, reaching US $8.5 trillion in 2019, or 9.8% of global GDP.[35] While the US' share of the global health care market is expected to decline from 41% in 2018 to 35% by the end of this decade, the share in China and Japan is forecast to rise from 9% to 16% and from 5% to 7% respectively.[36] By the middle of the century, this is expected to equate to a global average health spend of US $1,515 per person per year, rising from US $1,129 in 2019.[37] However, funds will not be applied equally; despite global health spending doubling over the last two decades, low-income countries account for only 20% of the total,[38] a disparity which is expected to continue and potentially grow.[39] As a consequence, there is the potential in the future for increasing health inequalities both within and between states, as well as a rise in 'health tourism' from rich to poor countries.[40]

The global biotechnology market was estimated to be worth US $1.37 trillion in 2022, with the US accounting for the largest share at 58.8%, significantly ahead of their nearest competitors, China (11.3%) and Denmark (6.9%).[41] Current forecasts suggest that the biotechnology market could increase by a compound annual growth rate of 13.96% out to 2030, with the Asia-Pacific region expected to grow at the fastest rate.[42] Out to 2055, reducing costs in artificial intelligence and data analytics are likely to cause a further expansion in the potential applications of biotechnology, driving economic growth in states that are active in this sector.

Finance

Financial technology. Out to 2055, technology innovation will continue to drive significant change in the global financial sector. Developments in artificial intelligence, blockchain, cloud computing and big data analytics are all creating new innovations in the FinTech field, including new forms of payment services and the automation of financial advice. Algorithmic trading is already beginning to constitute a growing share of all international trading, estimated to account for 60–75% of trading volume in European, US and Asian financial markets in 2021;[43] this is expected to grow by 10.5% between 2022 and 2027.[44] Financial institutions view FinTech start-ups as a major part of the digital future, and invested US $239 billion in FinTech and digital innovation in 2021.[45] Looking forward, a growth in artificial intelligence and machine learning capabilities will result in these tools exerting increasing influence on the stock market, not only in terms of the amount of trade conducted, but also as a tool to detect (and in some cases create) malicious financial transactions.

34 St.Onge, T., U.S. Census Bureau (December 2020), *Snapshot of Service Industries: 2020*.
35 World Health Organization (15 December 2021), *Global expenditure on health: Public spending on the rise?*
36 Grifols (5 June 2019), 'Global Health Expenditure'.
37 IHME, Statista (22 September 2021), 'Global health spending per capita in 2019 and projection for 2050 (in U.S. dollars)'.
38 World Health Organization (15 December 2021), *Global expenditure on health: Public spending on the rise?*
39 Global Burden of Disease Health Financing Collaborator Network, *The Lancet*, Volume 389, Issue 10083 (19 April 2017), 'Future and potential spending on health 2015-2040: development assistance for health, and government, prepaid private, and out-of-pocket health spending in 184 countries', pages 2005–2030.
40 World Bank (15 September 2021), *At Your Service? The Promise of Services-Led Development*.
41 Mikulic, M., Statista (2023), 'Value share of the biotech sector worldwide as of 2021, by country'.
42 Grand View Research (2022), *Biotechnology Market Size, Share & Trend Analysis By Technology, By Application, By Region, And Segement Forecasts, 2024–2030*, 'Report Summary'.
43 World Bank (23 April 2019), *Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes*.
44 Adrian, T. and Mancini-Griffoli, T., International Monetary Fund (June 2021), 'A New Era of Digital Money'.
45 KMPG (2019), *Forging the future: How financial institutions are embracing fintech to evolve and grow*.

The use of cryptocurrencies and associated technologies may become increasingly widespread by 2055

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Banking and credit provision. Notwithstanding these technological innovations, the requirement to provide capital, payment services and public and private credit will continue, as will generating profit from these activities. However, the organisations that provide such services, and the way in which they provide them, could see significant changes out to 2055. Physical retail banking is already decreasing in many parts of the world, with many institutions moving increasingly towards online and call centre models. In addition, many of the services traditionally provided by banks, such as bank accounts or wallets, payments and lending, are increasingly being offered by alternative providers, including some in the retail industry.[46] However, banking remains heavily regulated, which favours established institutions that often have significant resources, allowing them to outlast or even buy up new competitors.[47] Of the 400 or so neobanks (online-only banks) identified around the world in 2022, only a few remain profitable,[48] and these are largely in regions where the established banks are weak, such as in Latin America and South Asia.[49]

The next three decades will see the continued operation of market-based finance entities (credit providers that do not operate as banks), which range from pawn shops and microloan organisations in developing countries to hedge funds for large-scale business credit. New forms of shadow banking may emerge over the next 30 years as a result of financial innovation, and some existing forms have the potential to expand their activities further due to societal changes or technological developments. However, technology and systems pitched at younger generations may not have the same appeal to the over 65s, the fastest growing demographic in most advanced economies and in some cases

46 Townsend, Z., McKinsey & Company (1 March 2021), 'What the embedded-finance and banking-as-a-service trends mean for financial services'.
47 Cornish, P., et al., Cityforum (2022), *Future of Finance for the GST7* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
48 Stegmeier, C. and Verburg, M., Simon Kuchler & Partners (May 2022), *The Future of Neobanking – How can Neobanks unlock profitable growth?*, page 18.
49 Cornish, P., et al., Cityforum (2022), *Future of Finance for the GST7* (a research paper commissioned by DCDC).

the one with the most disposable income. A mix of traditional and technology-enabled systems therefore seems likely going forward, and financial regulation will need to evolve to match this changing landscape.

Cash and cashless payments. The last decade has seen a steady decline in payments by cash or cheque and an increase in electronic transactions, a trend which is likely to continue. While emerging Asian economies lead the cashless revolution – with an estimated growth in electronic payments from US $96.2 billion in 2017 to US $352.8 billion in 2022[50] – the COVID-19 pandemic has accelerated this trend worldwide. Electronic payment infrastructure is increasing significantly around the globe and the volumes of payment are growing faster than cash transactions.[51] Digital commerce and mobile point-of-sale payments are expected to reach US $14,620 billion of global transactions in 2027, a growth rate of nearly 15.9% per year.[52] Nevertheless, cash will remain fundamental to the estimated 2 billion global citizens without access to a bank account.[53]

Cryptocurrency and central bank digital currencies. The use of cryptocurrencies and associated technologies such as blockchain and distributed ledgers, which enable secure direct payments outside the purview of state-backed currencies or banks, may become increasingly widespread by 2055. Since 2013, over 81 million 'wallets' for the purchase of Bitcoins have been issued,[54] and there are currently an estimated 9,000 different cryptocurrencies available worldwide.[55] Initially viewed as a niche alternative to traditional currencies, these technologies are increasingly being adopted into the mainstream, and over the next three decades may become a familiar part of everyday life. For example, cryptocurrency-linked funds were issued through the New York Stock Exchange in 2021,[56] MasterCard now allows partners to buy, sell and hold cryptocurrencies, and PayPal, Tesla and Amazon all accept them.[57]

However, cryptocurrencies have proved highly volatile and despite efforts to stabilise them by backing with tangible assets such as gold[58] or 'tethering' them to a traditional currency, there is increasing concern about the risk they pose. In addition, state governments are increasingly recognising that the widespread use of cryptocurrencies could impact on tax revenues, as well as enabling illicit activities and the evasion of sanctions; China has already banned them.[59] Despite that, and with the growing interest in digital currencies, an increasing number of countries are developing alternative central bank digital currencies, which seek to combine the benefits of a digital asset with the stability of state-controlled mechanisms. There could be 15 retail and nine wholesale central bank digital currencies publicly circulating in 2030.[60] However, it is currently unclear whether central bank digital currencies will be seen as a more attractive alternative to cryptocurrencies or whether they will attract greater interest as people gain a better understanding of them.

50 Roper, W., Statista (24 January 2020), 'Asia Leading the Cashless Revolution'.
51 PwC (7 May 2021), 'Navigating the payments matrix: Payments 2025 & beyond'.
52 Statista (2023), *In-depth Report: FinTech 2023*.
53 G4S Cash Solutions (2018), *World Cash Report 2018*, page 27.
54 Thakur, A. and Verma, R., 4th International Conference on Advanced Research in Management, Business and Finance (March 2022), 'An Empirical Three Phase Analysis of Crypto Market'.
55 Bullhound, GP., et al., Statista (9 January 2024), 'Number of cryptocurrencies worldwide from 2013 to January 2024'.
56 Thune, K., Seeking Alpha (28 April 2023), 'Bitcoin ETF (BITO): What It Is & How It Works'.
57 Walsh, D., EuroNews (12 April 2021), 'Paying with Bitcoin: These are the new major companies that accept crypto as payment'.
58 *The Economist* (20 October 2018), 'A new form of cryptocurrency promises to defy financial gravity'.
59 Shin, F., World Economic Forum (31 January 2022), 'What's behind China's cryptocurrency ban?'.
60 Kosse, A. and Mattei, I., Bank for International Settlements (10 July 2023), 'Making headway – Results of the 2022 BIS survey on central bank digital currencies and crypto'.

The changing economic landscape is seeing new regional centres emerge, such as Chicago

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The cost of cybercrime. Cryptocurrencies and other digital currencies also have the potential to increase the risk of cybercrime, the cost of which is expected to increase from US $0.86 trillion in 2018 (already about 1% of global GDP) to US $13.82 trillion by 2028.[61] Although the capacity to enforce and manage cybersecurity using technologies such as artificial intelligence will continue to evolve, malicious actors are equally able to exploit these technologies themselves, and out to 2055 may increasingly do so.[62] The advent of quantum computing could also render cryptocurrency and digital currency security features ineffective.

Reserve currencies. Reserve currencies will continue to be a valuable source of global influence for the state that issues them, reducing borrowing costs, exchange rate risk and the cost of transactions, as well as providing a valuable tool for states to impose sanctions and embargoes. Although the use of the US dollar dropped from 70% of foreign exchange reserves at the beginning of the century to 60% by 2019,[63] it remains by far the largest single reserve currency, ahead of the euro (20%) and Chinese renminbi (3%).[64] However, Chinese swap agreements with other countries are growing and are likely to continue to do so out to 2055; this, together with the development of the digital renminbi, could see the renminbi increase in importance as a reserve currency.[65] While many countries view the US dollar's dominance as providing the US with unfair leverage, their willingness to move away from current arrangements in practice remains uncertain. Nevertheless, what is clear is that the US dollar may increasingly share influence with other currencies, even if it is not surpassed.

61 Statista (15 November 2023), 'Estimated cost of cybercrime worldwide 2017-2028 (in trillion U.S. dollars)'.
62 European Union Agency for Law Enforcement Cooperation (EUROPOL) (6 December 2021), *Malicious Uses and Abuses of Artificial Intelligence*.
63 Richter, F., Statista (1 August 2019), 'The U.S. Dollar Still Dominates Global Reserves'.
64 Siripurapu, A. and Berman, N., Council on Foreign Relations (2023), 'The Dollar: The World's Reserve Currency'.
65 Shatz, H.J. and Chandler, N., RAND Corporation (11 May 2020), *Global Economic Trends and the Future of Warfare: The Changing Global Environment and Its Implications for the U.S. Air Force*.

Rising geopolitical competition will also influence reserve currency holdings, as these provide states with a buffer against geostrategic shocks. While Russia attempted to deleverage itself from the US dollar after sanctions were applied in 2014, the number and range of countries that responded when fresh sanctions were applied in 2022 left it with few alternative options. China continues to build up foreign exchange reserves which, at around US $3,204 billion in 2023, are the largest of any country in the world.[66]

Financial centres. The changing economic landscape could see new regional centres emerge alongside existing financial hubs such as New York, London, Singapore and Hong Kong, in some cases even potentially replacing them. Chicago, Seoul and Boston have all recently entered the list of the top ten global financial centres, for example, replacing Paris, Shenzhen and Beijing. In the next 30 years, some Gulf countries could expand their existing regional role, while rapid pull-through of technologies and young populations may enable countries such as Indonesia, Brazil, Chile, Argentina, South Africa and Morocco to establish financial centres with global reach by 2055.[67]

Financial instability and shocks. Where transitions are poorly managed or outpace attempts at regulation, future changes to financial instruments and markets may give rise to instability at the regional or global level. Shifting dynamics in other sectors such as those associated with adopting green technologies or artificial intelligence could also prove highly disruptive to global financial markets. The future failure of major financial institutions also presents a continued concern for the global economy. As recent upheavals have demonstrated, some global shocks could prove beyond the ability of the financial sector to manage without significant state intervention.

Labour, resources and capital

The changing workforce. Changing demographics, education levels and other societal factors, together with advances in technology, will all have an impact on labour requirements and supply out to 2055. Over the coming decades, countries with ageing populations could experience a reduction in the size of the workforce, potentially leading to labour shortages in certain sectors. In addition, in some regions, the post-pandemic tendency towards 'quiet quitting' or 'tang ping' (Chinese for lying flat) has attracted attention, describing how an increasing number of workers are only fulfilling the minimum requirements in their jobs. While the phenomenon itself is not new, the way it is being handled by employers could suggest a changing working environment in the future.[68] Automation could help to offset these challenges, but it will depend on highly skilled labour for its implementation.

The rate at which technological, societal and economic changes increase the demand for certain skills, and reduce the need for others, could lead to unemployment in some sectors and a lack of specialist labour elsewhere, particularly in countries where educational systems are unable to adapt to the new requirements. Countries that are able to take a flexible and adaptive approach and educate their workforce for the new working environment may realise considerable economic (and therefore strategic) advantage as a result of this.

66 Bloomberg UK (2023), 'China Monthly Foreign Exchange Reserves'.
67 Cornish, P., et al., Cityforum (2022), *Future of Finance for the GST7* (a research paper commissioned by DCDC).
68 Gabelaia, I. and Bagociunaite, R., International Conference on Reliability and Statistics in Transportation and Communication (1 February 2024), 'The Impact of "Quiet Quitting" on Overall Organizational Behaviour and Culture', pages 366–378.

While it remains uncertain what levels of automation and artificial intelligence will be achieved in practice, it is likely that increasing amounts of routine work will be done by machines

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Rising life expectancy and declining birth rates mean that countries will increasingly rely on older workers to boost the workforce, particularly across Northern America, Europe, East Asia and Latin America. In addition, countries may also seek to attract more women into the workplace. This may provide a key opportunity to boost GDP in the future, with research suggesting that closing the gender employment gap could add up to US $2 trillion to global GDP.[69]

With 97% of global population growth taking place in emerging or developing economies,[70] these regions could potentially become the new centres of global economic growth. On the other hand, if states within these regions are not able to provide sufficient employment opportunities themselves, they may increasingly be regarded as a source of workers for the developed world – particularly among a younger generation keen to work overseas – thereby limiting their own economic development.[71]

Automation and artificial intelligence. While it is hard to estimate the true economic impact of automation and artificial intelligence on the global economy, most studies suggest that it will lead to an increase in global GDP through productivity gains and the expansion of services.[72] By 2030, it is estimated that artificial intelligence and automation could add a total of US $15.7 trillion to the global economy;[73] in reality, given the potentially rapid growth in capacity and capability, as well as the increasing interconnectedness of machines, this figure could be significantly higher. While having the potential to create new jobs in some areas, these technologies could also prove highly disruptive to existing workforce requirements, with an increasing number of roles across sectors at risk of being carried out by artificial intelligence and automation. Although the

69 Citi GPS: Global Perspectives & Solutions (March 2022), *Women Entrepreneurs: Catalyzing Growth, Innovation, and Equality*.
70 PwC (2019), 'Megatrends: The five global shifts reshaping the world we live in'.
71 Boutenko, V., et al., BCG Henderson Institute, World Economic Forum (16 November 2022), '5 key predictions for the future of talent migration'.
72 European Commission (14 February 2022), 'Data Act – Factsheet'.
73 PwC (2017), 'Sizing the prize: What's the real value of AI for your business and how can you capitalise?'.

precise rate and extent of job replacement remains uncertain, some estimates suggest that there is a 50% chance that machines will outperform human beings at every task within 45 years.[74] As labour costs rise and these new technologies become more sophisticated, this could have an impact on both developing and developed countries, potentially leading to early reversals in industrialisation in developing countries as well as significant unemployment in developed economies. While it remains uncertain what levels of automation and artificial intelligence will be achieved in practice, it is likely that societies of the future will see increasing amounts of routine work, whether mechanical or computational, done by machines, leaving the creative or strategic decisions to humans.[75] In extreme cases, the only human involvement may be on the part of investors, that required by law or a regulatory body, or by employees whose cost is too low to justify the cost of automation.

Resources. Rising populations, increasing wealth and continued economic development in many parts of the world will drive a growth in demand for energy commodities and other raw materials. Energy will remain of critical importance, with gas and oil security – a long-standing geostrategic issue – likely to be a continuing concern. In parallel, an increasing requirement for critical minerals and other materials required to drive the digital and green energy transitions will bring other regions more firmly into focus.

Out to 2055, the growing diffusion of economic power will influence where resources are needed, while access to raw materials will drive further increases in global power competition. In particular, the desire to secure access to critical minerals may increasingly drive relations between states. At present, as a result of Chinese dominance of critical minerals markets, many countries have become dependent on China; for example, it supplies at least 90% of the European Union's rare earth mineral requirements.[76] While efforts to diversify supply chains are already under way, this could become an increasingly important driver in geostrategic relationships in the future. Where vital resources are located, and where processing takes place, could be key to determining the world's economic and political winners and losers over coming decades.

As demand for resources increases, this could lead to competition extending into the shared spaces. Out to 2055, this may contribute to an increase in tension and potentially conflict, particularly where states seek to use access to resources as a lever for other purposes.

Capital. Physical capital, including infrastructure, production facilities and the means of transport, will remain important for the global economy and many individual businesses out to 2055. However, the increasing digitalisation of the economy means that information and non-physical capital, including data and intellectual property, will grow in importance. As non-physical capital is much easier to move across national borders than physical capital, it will be increasingly difficult for states to exert control and levy taxes over businesses. This may present a growing challenge for governments over the next 30 years.

74 Grace, K., et al., *Journal of Artificial Intelligence Research*, Volume 62 (July 2018), 'Viewpoint: When Will AI Exceed Human Performance? Evidence from AI Experts', pages 729–754.
75 Manyika, J. and Sneader, K., McKinsey Global Institute (1 July 2018), 'AI, automation, and the future of work: Ten things to solve for'.
76 Tirone, J. and Nardelli, A., Bloomberg UK (22 January 2023), 'How Europe Needs Freight Trains to Cross Russia From China'.

Large-scale infrastructure projects are reducing the transit times for moving goods around the world

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Trade

Changing patterns of global trade. The global trade to GDP ratio increased from 25–30% in the early 1970s to around 40% in the early 1990s, reaching 55–60% in the period from 2005 to 2024.[77] The ratio reached its height in 2008 and has fluctuated slightly below peak value since. Many factors have contributed to this increase in trade, including: the opening up of previously closed economies; the offshoring of production by firms in industrialised countries; new innovations in the IT and business sectors; cheaper, faster and more reliable transportation and logistics; and the growth of international standardisation. The balance of the trade in goods compared with the trade in services is likely to change over time as the service sector comes to play an ever greater role in the global economy.

At the same time, trading patterns will continue to evolve as Asian states and other rising economic powers assume a more dominant position in the global economy. China, for example, is now the major trading partner for over 120 states,[78] and volumes of South–South trade now increasingly match or exceed those between the Global South and the developed world.[79] Out to 2055, this diffusion of trade links is likely to continue as new economic powers emerge.

Transportation. Although a growth in servitisation is likely to lead to an increasing volume of trade in services, the movement of physical resources and goods will continue to be a significant factor in the global economy. Logistical practicalities and the market drivers

77 Macrotrends (2024), 'World Trade to GDP Ratio 1970-2024'.
78 Green, M.A., Wilson Center (17 January 2023), 'China Is the Top Trading Partner to More Than 120 Countries'.
79 United Nations, Conference on Trade and Development (9 May 2023), 'South-South trade agreement holds key to more sustainable and inclusive growth'.

of speed, cost and reliability will continue to dominate most commercial decisions. As a result, maritime transport is likely to continue to dominate in terms of volume, although technological developments, including automation in terminal handling, tracking and information systems, may lead to more streamlined processes and greater efficiency. Road transport will remain important for moving goods overland, although a shift towards green policies in some regions may see greater use of rail and inland waterways (where feasible). In 2022, for example, the first cargo train with a full-time schedule started to operate from X'ian in China to Duisburg in Germany, the world's largest inland port, reducing transit times for freight transport between China and Europe.[80] While it was previously almost impossible to determine a fixed journey time for the entire route, this will help to manage operating times more efficiently with a total running time of around ten days. However, land routes will still be unable to compete against maritime options on cost or the volume of goods that can be moved, as well as lacking the speed advantage of air transport.

Air transport will continue to play an important role in transporting perishable and high-value goods, although its attractiveness will remain limited by cost considerations and increasingly by environmental concerns. New technology solutions for 'last mile' distribution, including delivery by robots and drones, should see more widespread adoption, although human labour is still likely to feature in the business models of most delivery services.

Changing global economic power

International and regional organisations. Since the middle of the 20th Century, international organisations have played an important role in economic globalisation and the growth of the world economy, facilitating trade and international investments. However, increasing global power competition now appears to be challenging the effectiveness of these institutions, and rather than being viewed as vehicles for cooperation they are instead becoming a focal point for rivalry between states. Designed in the aftermath of the Second World War, many now no longer reflect the realities of global economic power,[81] and are seen as failing to represent the interests of emerging states.

In the absence of any meaningful reform, and if geostrategic tensions continue to increase, the next 30 years could see regional and interest-led blocs assuming an increasingly prominent role, with regionalism becoming the dominant trend, driving changes in patterns of economic cooperation, trade and investment. There are already a growing number of regional trade and financial partnerships and institutions seeking to fill the gaps, including the Asian Infrastructure Investment Bank, which now has a global membership, and the BRICS group, which has recently undergone enlargement. Out to 2055, a trend towards further regionalisation could see a reduction in global cooperation on issues such as regulation and technical standard setting, which could make future economic shocks more difficult to manage.

80 Bachmann, J., New Silkroad Discovery (27 October 2022), 'The first full-time schedule China-Europe freight train left Xi'an, heading to Duisburg'.
81 Jones, E. and Knaack, P. (7 April 2017), *FCA think piece: The future of global finance regulation*, paper prepared for the FCA Future Horizon Conference.

The changing financial landscape

There are currently around 30 banks across the world that are important on a global level. China has four of the ten largest banks in the world, which operate in over 40 countries. However, regional variations exist and in some cases appear to be strengthening; for example, pan-African banks now play a more important role in Africa than long-established European and US banks.[82] The Organisation for Economic Co-operation and Development countries are no longer the only hub for financial innovation; China's AliPay digital payment service has 450 million users, several times the global number of PayPal users. In 2015, AliPay reached a peak processing volume of 85.900 transactions per second, compared with 14.000 for Visa.[83]

Standardisation. The ability to control or influence international standard setting will continue to provide states with significant shaping power over the global economy, with wider geopolitical and security implications. While the West has traditionally pioneered standard-setting initiatives, China has increased its participation in global standardisation bodies in recent years, and has stated its intention to dominate the next generation of technology development by taking a central role in the setting of technical standards.[84] One specific concern has been efforts to change the Internet Protocol under China's 'New Internet Protocol' initiative in 2020,[85] which could have significant implications for the future digital economy as well as global security and personal data protection. Looking forward, there is the potential for others to play a role in this field, including India, although this would require a significant shift to a more internationalist focus.[86] However, regardless of which countries take the lead, out to 2055 it is likely that views on the use and regulation of new technologies in economic and financial systems will increasingly diverge, further limiting cooperation in this area.

Diverging economic models and ideologies. While global economic cooperation in recent decades has been constructed largely around Western ideas of market liberalism, free trade and a limited role for the state, the economic shocks of recent decades and rising levels of government debt in many countries have led to calls for more state intervention in some quarters. Given the current financial volatility and uncertainty, governments in a number of emerging economies are looking to alternative socio-economic models, including more dominant state ownership and control, as a basis for their future economic and social development. Although China appears to be taking the most proactive approach here, promoting the Chinese model to states in the developing world, India may begin to take a more active role in coming decades, and may increasingly be regarded as a model for economic development by countries in the Global South. While the practical implications of this remain uncertain, it may drive further fragmentation in economic governance, resulting in a growing trend towards regionalism over the next 30 years.

82 Enoch, C., et al., International Monetary Fund (30 April 2015), *Pan-African Banks: Opportunities and Challenges for Cross-Border Oversight*.
83 Chen, L., Fintech News (28 December 2016), 'From Fintech to Finlife: the case of Fintech Development in China'.
84 Clarke, L., TechMonitor (15 June 2021), 'Technical standards-setting is shaping up to be the next China-US showdown'.
85 Cerulus, L., Politico (2 February 2022), 'EU drafts counteroffensive to China, US on technology rules'.
86 Chaudhuri, R., Carnegie Endowment for International Peace (9 September 2020), 'On India's Role in Technology Standards'.

Collaboration versus protection of innovation. While global collaboration on science and technology has grown in recent decades, states are also increasingly competing to develop technologies that might trigger the next phase of global economic growth. Rising middle class populations and education standards in the Indo-Pacific region and elsewhere may boost technology development, contributing to the creation of new high-value businesses in the technology, finance and other sectors. Patents will remain a key metric of innovation levels, with China overtaking Japan, Germany and South Korea on numbers of patent applications in the mid to late 2000s and the US in 2010.[87] Although still low by international standards, India saw a 19.4% rise in patents in force in 2021, compared with China (17.6%) and the US (-0.6%).[88] However, the number of patent applications alone is an imperfect measure of innovative capability and, looking forward, the duration, quality and international relevance of patents will be more accurate indicators of performance.

China's increasing patent applications

While data from 2020 shows that China is the clear global leader in patent applications worldwide, significantly higher than the number of applications made by the US or Japan, their success rate is well below that of other countries.[89] This low ratio could either be explained by Chinese patents not fulfilling the requirements for usefulness or creativity, or by the fact that there is limited experience in applying, as China started making patent applications later than other countries.[90] Another indicator with regard to the value of patents is their classification and lifespan. According to China's National Intellectual Property Administration, most patents granted between 2000 and 2017 are 'utility model' and 'design' patents, which are a much lower standard of innovation than 'invention patents'.[91] It should also be noted that Chinese patents have a significantly shorter lifespan than patents in other economies. However, even if China has not yet reached the level of innovation of other leading economies, trends suggest that they could see their success rate improve in the future.[92]

De-risking of critical technologies and supply chains. Geopolitical tensions in recent years have seen critical dependencies – including Russian dominance of European gas supplies and China's increasing control over critical minerals, supply chains and infrastructure – prompting growing concern at the international level. As a result, the world may see an increasingly securitised approach to foreign investment in areas such as critical infrastructure and security-related technology, as well as growing attempts to de-risk critical supply chains and other vulnerabilities. As recent events have demonstrated, however, supply chains are both vulnerable and highly flexible; while markets, value chains and routes can be blocked with little warning, they can just as quickly adapt and find new accommodations under changed geostrategic conditions.

87 World Bank (2020), 'Patent applications, residents – China, World, United States, Germany, Japan, Korea, Rep'.
88 World Intellectual Property Organization (WIPO) (2022), *World Intellectual Property Indicators 2022*.
89 WIPO IP Statistics Data Center (2021), 'Total patent applications' and 'Total patent grants'.
90 Santacreu, A.M. and Zhu, H., Federal Reserve Bank of St. Louis, Economic Synopses Number 14 (4 May 2018), 'What Does China's Rise in Patents Mean? A Look at Quality vs. Quantity'.
91 Center for Strategic and International Studies, China Power Project (2020), 'Are Patents Indicative of Chinese Innovation?'.
92 Ibid.

While attempts to secure vital supply chains and take a more geostrategic approach to economic interdependencies are likely to increase, market forces will continue to play a dominant role, except in more extreme scenarios (for example, in the case of conflict between major powers).

Economics as an influence tool. Over the next three decades, international financial systems may increasingly be used as tools for global influence and control. For example, Russia's 2022 expulsion from the SWIFT banking system has left it without the ability to process overseas receipts and payments; in reaction to this, China is working to promote its Cross-Border Interbank Payment System as an alternative international payment mechanism to reduce future vulnerability for itself and partner states. In addition, domestic legislation may also be used by powerful states to exert influence and control. The US, for example, has previously used Treasury controls and the dollar-clearing system to try to prevent US entities and overseas financial institutions which trade with them from providing services to Iran and North Korea.[93] In 2019, the US designated China as a currency manipulator and banned its firms from bidding for Federal Government contracts.[94] Threats to de-list them from the New York and other US stock exchanges have also been used against Chinese companies.[95] If this trend becomes more widespread out to 2055, it will result in an increasingly complex and uncertain landscape for global businesses.

United States–China economic tensions. Economic relations may become an increasing area of competition between the US and China out to 2055, with far-reaching implications. The US has employed tools of economic coercion against China at various times since 1949; however, trade tariffs imposed by the US in recent years, and subsequently by China in response,[96] as well as bans on the import of goods made through forced labour,[97] measures against officials associated with human rights violations, and blocking Chinese access to US markets, have taken these tensions to a new height. Bans on the export of US semiconductor products and foreign chips that use American inputs or skills (as most do) have also been put in place, which going forward may disrupt Chinese military capabilities and its high-tech economy. In retaliation, China has responded with measures against foreign firms located on the mainland and restrictions on exports of critical minerals. While there have been some attempts at rapprochement, increasing geostrategic tensions could further exacerbate this situation in future years, placing states and business entities attempting to engage with the US and China in an increasingly difficult position.[98] Given the size and importance of their respective economies, and the strength of China–US interdependence, any move towards a more substantive decoupling could result in a major shock to the global economy, with the long-term ramifications felt throughout the world. It is possible that reciprocated threats could evolve into a form of 'mutually assured economic destruction'[99] between these two giants in the future, although the potential emergence of other economies over the next 30 years adds uncertainty here.

93 Farrell, H. and Newman, A.L., *Harvard Business Review* (January–February 2020), 'Choke Points'.
94 U.S. Department of the Treasury (5 August 2019), 'Treasury Designates China as a Currency Manipulator'.
95 Calhoun, G., *Forbes* (11 August 2020), 'What Happens If Chinese Firms Are Kicked Out Of The U.S. Stock Market'.
96 Bown, C.P., Peterson Institute for International Economics (6 April 2023), 'US-China Trade War Tariffs: An Up-to-Date Chart'.
97 Pao, J., *Asia Times* (22 June 2022), 'Xinjiang import ban worsens China-US relations'.
98 Langer, M-A., Neue Zürcher Zeitung (5 January 2023), 'Chip war between Washington and Beijing: The US is freezing the state of AI in the year 2022 for China'.
99 Thompson, M., *Time* (10 October 2011), 'Mutually-Assured Economic Destruction'.

Economic statecraft. Rising global power competition and concerns over national vulnerabilities have increasingly seen economic levers of power being employed for geostrategic purposes. As prosperity and security programmes overlap and economic levers are used more for security advantages, the global economy is likely to be more influenced by economic statecraft, economic coercion and even economic warfare. This includes measures such as using debt entrapment to gain preferential access to markets and dual-use infrastructure and to garner diplomatic support. Although sanctioning individuals or entities on security, humanitarian or other grounds is an established feature of global relations under international law, sanctions could become an increasing feature of how states interact in times of crisis and war. For example, the unprecedented severity and scale of the measures imposed against Russia in 2022 following its invasion of Ukraine has been described as a watershed moment in global economic history.[100] A key factor has been the ability to build a broad coalition of sanctioning countries from across the globe, making measures harder to circumvent. They have also been unexpectedly broad in their reach, covering a range of sectors across the Russian economy and impacting on the activities of key individuals. Although their impact appears to have been more coercive than deterrent so far, this may set a precedent for the increasing use of sanctions as a tool in future conflicts, particularly where global powers seek to avoid direct confrontation at the military level. However, being subject to sanctions has proved a motivation for conflict in the past, and it is not inconceivable that this unintended consequence could be repeated in the future.[101]

In parallel, physical coercion and attacks on economic targets have increased dramatically in the past few years. The increasing interconnectedness of all instruments of statecraft could further this trend, with attacks on pipelines, undersea cables and other critical national infrastructure potentially increasing over the next three decades. The use of blockades and wider forms of interference with trade and supplies of food and other resources has also increased recently, and such approaches could become more widespread out to 2055. Many states have only just started to rethink their approach to national resilience,[102] which could place them at a disadvantage. As the lines between public and private activity become increasingly blurred, the commercial sector could also be at increasing risk. In addition, economic measures may increasingly be used as a mobilising tool to gain support from citizens and business entities in the event of future tensions between states, as illustrated by replacing foreign customer brands and using public opinion to target certain products following Russia's invasion of Ukraine in 2022. Advances in artificial intelligence, FinTech and quantum technologies, as well as growing reliance on digital infrastructure and data, could further expand the range of economic levers employed in the future.

100 *The Economist* (4 March 2022), 'Nicholas Mulder, who studies sanctions, declares a watershed moment in global economic history'.
101 Calhoun, G., *Forbes* (12 September 2021), 'War With China? The Economic Factor That Could trigger It'.
102 Cornish, P., et al., Cityforum (2022), *Future of Finance for the GST7* (a research paper commissioned by DCDC).

Environment

Overview

Greenhouse gas emissions continue to rise. Although there are significant variations in projections out to 2055, all scenarios forecast a continued increase in atmospheric concentrations of carbon dioxide (CO_2). Average global surface temperature is already up by approximately 1.25° Celsius from pre-industrial levels.[1] Depending on the rate and extent of decarbonisation and other actions, average global temperature could range from 1° Celsius to 5.7° Celsius higher than pre-industrial levels by the end of the century.[2] However, these averages disguise the fact that in some regions, such as the Arctic, temperature increases will be significantly higher. Mean sea levels are rising and the oceans are warming at an unprecedented rate. Some 'tipping points' may also be close, potentially leading to permanent reorganisation of the Earth's climate, with wide-ranging implications for global ecosystems and human lives and livelihoods.

Climate projections indicate that a warming planet will suffer shifts in rainfall patterns and a rise in the number and severity of extreme weather events such as droughts, floods and heatwaves. Far-ranging and permanent changes to regional environments and the shared spaces could also occur, with some areas potentially becoming uninhabitable. Climate change is likely to drive migration at unprecedented levels and amplify the effect of humanitarian disasters, as well as having an impact on the environment, agriculture, infrastructure, economies and the everyday lives of citizens. These pressures could overwhelm some governments, while physical impacts could also challenge the territorial integrity of some states. Climate change could therefore create new risks to stability and security out to 2055, as well as exacerbating existing ones. In some cases, the increasing impact of climate change could trigger violent responses from those affected, as well as contributing to social and political polarisation.

Out to 2055, growing and increasingly urbanised populations will see diets change and demand for food and water grow. Billions of people could continue to face high levels of food insecurity. While food production may benefit from changing weather patterns in some regions, overall global yields could decline by up to 30% by the middle of the century.[3] Climate change could also see an increasing proportion of the world's population suffer some degree of water stress by the middle of the century, with implications for health, energy, infrastructure and wider land use and ecosystems. This increasing competition for vital resources has the potential to fuel grievances and tensions, exacerbating state, regional and global instabilities.

1 Met Office (12 January 2024), '2023: The warmest year on record globally'.
2 Lee, H., et al., Intergovernmental Panel on Climate Change (IPCC) (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*, Table 1, page 10.
3 Hobert, R. and Negra, C., United Nations (UN) Foundation (1 September 2020), 'Climate change and the future of food'.

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Unsustainable resource demands are driving ecosystems to the point of collapse

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Biodiversity loss is taking place on an unprecedented level and is impacting terrestrial, freshwater and ocean species, with wide-ranging implications for the environment, water security and food chains. The expanding and intensified use of land for pastoral and arable farming, as well as increasing overfishing and unregulated fishing, will continue to be major contributors to this. Growing waste and rising levels of pollution are also having an increasing impact on the environment. In addition, expanding urbanisation and human infrastructure will also have an increasing impact on biodiversity out to 2055. The mining of minerals and metals could double by 2060, negatively impacting the environment as well as indigenous populations.[4] An end to the moratorium on deep-sea mining could see these adverse impacts spread to the oceans. Nevertheless, climate change could outstrip all these activities to become the biggest cause of biodiversity loss by 2055. Many ecosystems risk major disruption or collapse, with widespread negative implications for the environment and societies. Government policies and new technological developments will help to address these issues in some regions, while advances in biotechnology and other modern farming techniques could help to meet growing food demands in a more sustainable manner. In addition, efforts to restore damaged land and reintroduce lost biomes (a distinct geographical region with specific climate, vegetation and animal life) are increasing.

Global energy demand seems set to increase significantly by 2055. This, together with concerns over climate change, is likely to drive the increasing diversification of energy sources. Despite some continuing uncertainty over current projections, fossil fuel consumption is generally expected to peak before 2055, although changes to the rate of consumption will be influenced by a number of factors. Nuclear fission will remain a key component of the global energy mix, with the high costs of traditional power station designs spurring increased interest in smaller and more modular options to meet the energy needs of a wider range of users. In addition, nuclear fusion could become a viable and attractive option later in the century.

4 UN Environment Programme, and International Resource Panel (2019), *Global Resources Outlook 2019: Natural Resources for the Future We Want*.

Hydroelectric power is likely to continue to expand in regions where geography supports its use, although climate change could challenge the viability of some projects in the future as freshwater supplies come under increasing pressure. Elsewhere, the solar power sector has experienced exponential growth and will potentially surpass coal to become the largest source of energy in the world by 2027.[5] Wind power has also enjoyed major growth since 2021, with increasing offshore expansion set to boost the sector further. While tidal and wave power is not yet at the same scale as wind, this sector is developing and could form an increasing part of the global energy mix by 2055.

Research continues into a range of energy storage technologies intended to complement renewable energy sources. To date, lithium batteries, which are used in electric vehicles, have been the breakout technology, although alternative battery and storage technologies could increasingly compete with these in the future. This would see dramatic fluctuations in the importance of lithium and other critical minerals. Energy storage development could also spur a further expansion in the electric vehicle market, while future years are likely to see further developments in the field of sustainable and synthetic fuels to meet the needs of the heavy haulage, aviation, maritime, emergency and military sectors.

The requirement to reduce global carbon emissions could see increased investment in methods of carbon capture. In addition, other geoengineering technologies, which aim to offset the effects of greenhouse gases by causing the Earth to absorb less solar radiation, are also being explored; however, considerable uncertainty exists regarding their effectiveness and the wider geostrategic implications of their use. In the near term, carbon-offsetting schemes may continue to go some way to mitigating this challenge.

Rapid advances in satellite coverage coupled with a growth in ownership of mobile devices will see an increase in the volume of data that may be harnessed for environmental monitoring and analysis out to 2055. In future decades, this sort of data will be increasingly used in planning for eco-friendly urban developments and ‘smart cities’, although adapting existing housing and infrastructure will remain important.

Increasing awareness of the negative impacts of climate change is prompting more environmentally conscious purchase decisions and corporate behaviours. However, whether this trend becomes widespread or continues to be limited to certain sectors and regions remains uncertain.

Global power competition will continue to be a significant factor in determining how the world addresses climate and wider environmental challenges out to 2055. Forums such as the Conference of the Parties could increasingly be undermined by competitive or unilateral actions in the future. While China currently dominates many green technology sectors, competition from other states is likely to increase in the coming decades, which could offer governments more options to support their green transition ambitions. A significant increase in demand for critical minerals could lead to new geostrategic rivalries and tensions in regions that have these resources, at the same time as fossil fuel exporters face their own challenges due to dwindling revenue streams.

5 International Energy Agency (December 2022), *Renewables 2022: Analysis and forecast to 2027*, ‘Executive Summary’.

Climate change drivers, trends and uncertainties

Increasing emissions. Between 2010 and 2019 greenhouse gas emissions were higher than in any previous decade on record. By 2019, annual emissions were around 12% higher than in 2010 and 54% higher than in 1990.[6] Global population growth, together with associated socio-economic activity, has driven this rise, which currently outstrips the offset generated by renewable energy transitions. Energy efficiencies and decarbonisation are gaining pace, however, meaning that the annual growth in emissions reduced from 2.1% in 2000–09 to 1.3% in 2010–19; it is still increasing, but not as quickly.[7]

Looking forward, it is likely that emissions will remain highly regionalised and determined by levels of economic growth. While declining populations, efficiencies and decarbonisation investments are seeing emissions reduce in developed countries, it should be remembered that the starting point was much higher in those states than in other parts of the world. In contrast, China, India and many developing states are likely to see emissions rise significantly in coming decades, driven by growing populations and economies. However, the strong link between emissions and economic growth creates significant uncertainty in the forecasts out to 2055. Should China's gross domestic product (GDP) fall 1% short of its 2030 target, for example, its projected coal use would decline by an amount roughly equivalent to the annual demand of Europe.[8] In addition, while the digital transition could reduce emissions associated with travel, it may also become a growing source of emissions in the future as energy requirements for data storage and computing power grow. As a result, forecasts for global carbon emissions vary significantly, although even the most optimistic models presume an increase.

Ozone depletion Successful efforts to eliminate the use of ozone depleting substances, including chlorofluorocarbons (CFCs), have broadly been effective at limiting the expansion of the ozone depletion zone (or hole) over the Antarctic. However, hydrofluorocarbons (HFCs), which replaced CFCs, do still cause some harm, and the zone has not recovered as swiftly as was once hoped.[9] Further, the zone, which experiences seasonal fluctuations in size, recorded one of its largest sizes on record in 2023.[10] There is not yet scientific consensus on the causes of this or the long-term implications. Though ozone depletion does not cause global warming, increased ultraviolet (UV) radiation can cause changes to weather patterns, which can have an impact on agriculture;[11] it may also have a substantial effect on plant and animal health, impacting biodiversity.[12] Therefore, an emerging trend towards increasing ozone depletion would have environmental consequences that could interact with and worsen those caused by greenhouse gas emissions.

Rising temperatures. Global surface temperature has increased more rapidly since 1970 than over any other 50-year period in at least the last two millennia. Between 2011 and

6 Lee, H., et al., IPCC (2023), *Synthesis Report of the IPCC Sixth Assessment Report (AR6): Longer Report*.
7 Dhakal, S., et al., IPCC (2022), *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 'Chapter 2: Emissions trends and drivers'.
8 International Energy Agency (October 2023), *World Energy Outlook 2023*, 'Executive Summary'.
9 National Aeronautics and Space Administration (NASA), 'Is the ozone hole causing climate change?'.
10 European Space Agency (2 October 2023), 'Ozone hole goes large again'.
11 Lindsey, R., National Oceanic and Atmospheric Administration (NOAA), Climate.gov (12 October 2016), '4 ways the ozone hole is linked to climate, and 1 way it isn't'.
12 United States Environmental Protection Agency (11 September 2023), 'Health and Environmental Effects of Ozone Layer Depletion'.

2020, average global surface temperature reached 1.1° Celsius above pre-industrial levels (1850–1900), with 2023 being the single hottest year in history, reaching 1.43° Celsius warmer than the pre-industrial period.[13] Due to lags in the system, even the most optimistic scenarios suggest that mean surface temperature increase above pre-industrial levels could still reach between 1.2° Celsius and 2.0° Celsius by the middle of the century,[14] and between 1.0° Celsius and 1.8° Celsius by the end of the century. Should emissions not be meaningfully reduced until the latter half of the century, an increase of 1.6° Celsius to an upper 'very likely' range of 2.5° Celsius could occur by the middle of the century, continuing to rise to between 2.1° Celsius and 3.5° Celsius by the end of the century. In worst case scenarios, based on a tripling of emissions from today's levels by 2075, the mid-century mean temperature would be 1.9° Celsius above pre-industrial levels with an upper 'very likely' range of 3.0° Celsius, rising to between 3.3° Celsius and 5.7° Celsius by the end of the century.[15] These averages, however, hide significant variations between global regions.

Rising and warming seas. Thermal expansion and ice sheet melt mean that out to 2055 sea level rise will be unavoidable, with recent trends suggesting that the rate of rise may be faster than previously predicted. The global average rate of sea level rise has increased steadily in recent decades, with the annual rate in 2006–18 almost double that of 1971–2006.[16] Current predictions suggest that it could double again by the middle of the century under 'middle of the road' scenarios, and that the rise could be significantly higher if climate system tipping points are reached.[17] At the same time, warming oceans could be less capable of mitigating the effects of global climate change. The oceans currently act as the Earth's primary heat sink, accounting for over 90% of climate heat absorption and serving to modulate temperatures and weather patterns.[18] They are also the largest absorber of CO_2, removing 30% of human-generated CO_2 from the atmosphere and producing 50% of all oxygen.[19] Over time, rising temperatures will result in increasing de-oxygenation and acidification of the world's oceans. As well as having potentially significant implications for marine biomes and wider ecosystems, this will also impact on the oceans' ability to sequester CO_2 and hence mitigate climate change.

Tipping points. Some studies indicate that global mean temperatures are close to, if not already past, the threshold beyond which certain planetary boundaries will be crossed. In some cases, such tipping points may result in abrupt and irreversible shifts in global environmental systems, potentially leading to rates of change unprecedented during the industrial era thus far; however, other tipping points such as ice sheet collapse are likely to result in transition over much longer periods (centuries to millennia). The reorganisation of these systems could result in substantial changes in global temperatures, rainfall patterns and sea level rise, with wide-ranging implications for ecosystems, agriculture, infrastructure, energy, water resources, economies and security.[20]

13 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*.
14 According to the IPCC's 'very likely' range modelling.
15 Masson-Delmotte, V., et al., IPCC (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.
16 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*.
17 Masson-Delmotte, V., et al., IPCC (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.
18 NOAA (22 January 2020), 'Ocean Heat Content Rises'.
19 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, Outlook, Uncertainties, Shocks and Strategic Implications* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
20 Cottrell A., et al., Met Office (2022), *Tipping points in the climate system from a defence and security perspective: Science Report* (a research paper commissioned by DCDC).

Tipping points that could be reached by 2055

Ice sheet melt. The Greenland and West Antarctic ice sheets may already have reached a point at which irreversible melting is inevitable. While the full implications will play out over millennia, ice sheet melt could contribute an additional 20 centimetres to sea level rise by 2055. This loss of ice will have a range of effects – some unpredictable – on global weather systems over the next three decades and beyond.[21]

The Atlantic Meridional Overturning Circulation. The ocean currents that carry warm water from the tropics to the North Atlantic – the Atlantic Meridional Overturning Circulation (AMOC) – are slowing. Substantial slowdown of the AMOC could lead to the cooling of the Northern Hemisphere, impacting on global rainfall patterns and contributing an additional 50 centimetres to sea level rise in the North Atlantic basin. The implications for agriculture, wildlife, transport, energy production and coastal infrastructure would be significant. Europe, for example, could experience a 26% reduction in agricultural productivity in some scenarios. While there is an extremely low likelihood of total collapse by 2055, during the next three decades it is possible that a line could be crossed which would see effects lasting far into the future. Northwestern Europe could cool by 5–8° Celsius, reducing temperatures to below pre-industrial levels irrespective of rises elsewhere in the world.[22]

Labrador Sea convection. There is a moderate likelihood that a sub-component of the AMOC, Labrador Sea convection, could have started to slow independently by 2055, potentially reducing long-term warming across northern Europe by up to 1–2° Celsius. This could significantly impact rainfall patterns and weather extremes in much of Europe and lead to shifts in equatorial rainfall.

The Amazon rainforest. Climate change, in combination with deforestation, could plausibly cause the Amazon rainforest to begin an irreversible transition to a savannah-like biome by 2055, with the effects enduring into the following century. If it occurs, the loss of the Amazon rainforest would release large volumes of CO_2 into the atmosphere and amplify global warming rates. Rainfall generated by the rainforest is also a critical source of fresh water across Latin America, meaning that this would have implications for agricultural, industrial and hydropower production.[23]

Combined impacts. In some scenarios, climate system tipping points could interact, creating a cascade effect. A reduction in Amazon rainfall, for example, could affect weather in the South Atlantic and Antarctica, as well as in the Northern Hemisphere. Melting ice shelves in the Arctic and Greenland could accelerate the slowdown of Atlantic circulations.[24]

21 Scott, M., NOAA, Climate.gov (12 March 2019), 'Antarctica is colder than the Arctic, but it's still losing ice'.
22 Cottrell A., et al., Met Office (2022), *Tipping points in the climate system from a defence and security perspective: Science Report* (a research paper commissioned by DCDC).
23 Ibid.
24 Ibid.

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Extreme weather conditions such as flash flooding are likely to become more frequent

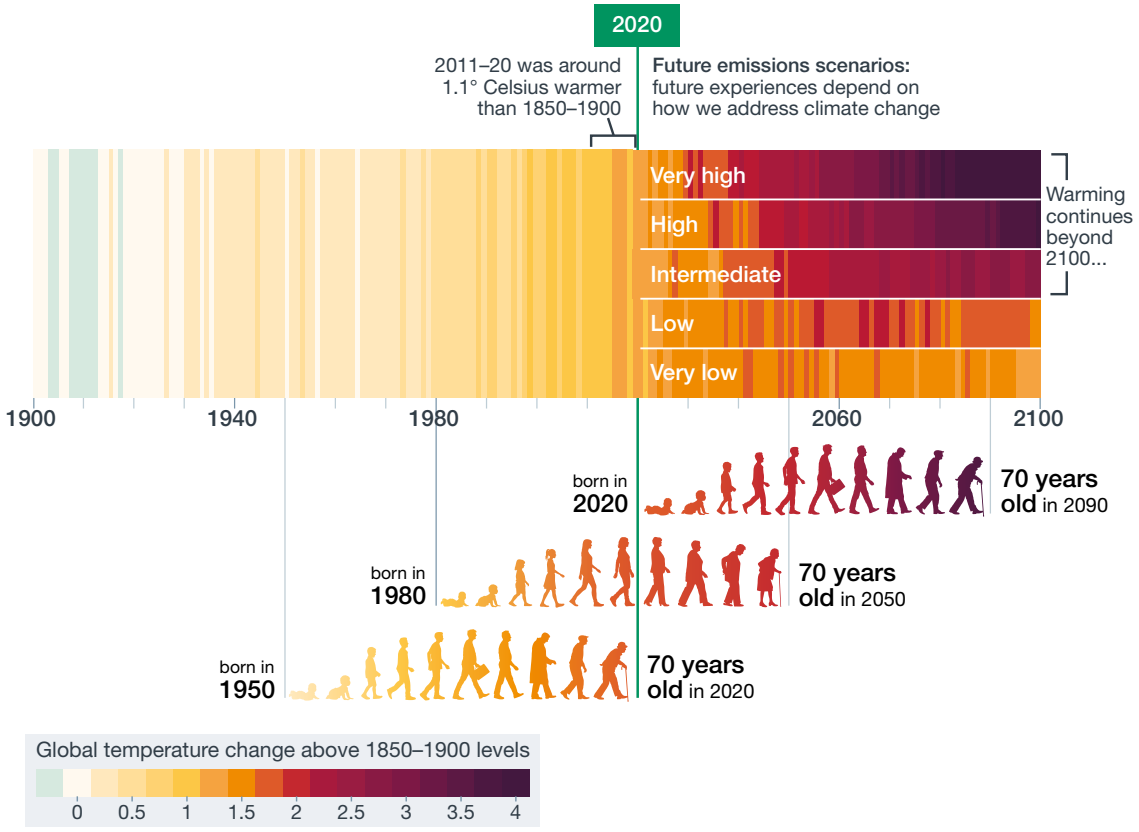
Climate change impacts

More frequent and severe weather events. Out to 2055, a warming planet will see an increase in the frequency and severity of extreme weather events; many dry regions are likely to become drier, while incidences of flash flooding, the intensity of storms, and the frequency and intensity of heatwaves and droughts are all projected to increase. Without significant adaptation and mitigation, such events could cause or contribute to significant numbers of deaths and injuries, as well as loss and damage to property, infrastructure, agriculture, economies and the environment. A 1.5° Celsius warming scenario, for example, could drive a projected 200% increase in the number of people affected by floods in Colombia, Brazil and Argentina, 300% in Ecuador and 400% in Peru.[25] In Europe, the number of deaths each year due to extreme heat could double from 60,000 in 2022 to 120,000 by the middle of the century.[26] The Intergovernmental Panel on Climate Change predicts that extreme coastal flooding, which occurred once a century in the past, could become an annual event by 2100.[27] Growing climatic impacts will also exacerbate other societal, economic and security risks, including food and water insecurity and disease.[28]

Disruptive and permanent impacts to regions and the shared spaces. Climate change could result in more disruptive and permanent impacts to some regions and the shared spaces. In the absence of appropriate adaptation, for example, more locations could become too hot for human habitation. Under a high population and medium-high emissions scenario, 3.5 billion people could experience average annual temperatures of 29° Celsius or higher by 2055. While these conditions are currently only found in the Sahara Desert, they could affect 19% of the global land surface by 2070.[29] Meanwhile,

25 Pörtner, H.-O., et al., (Eds.), IPCC (2022), *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, page 62.
26 World Health Organization (2023), 'Climate crisis: extreme weather'.
27 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*.
28 Ibid.
29 Xu, C., et al., *Proceedings of the National Academy of Sciences* (PNAS), Volume 117, Number 21 (26 May 2020), 'Future of the human climate niche'.

increases in logging and burning activity are affecting the Amazon rainforest's ability to act as a carbon sink, with evidence suggesting that parts may now be net carbon emitters.[30] In addition, changes to mountain and tundra ecosystems as a result of glacial ice retreat or permafrost thaw could become irreversible.[31] Climate change is also rapidly changing the geographical characteristics of the Arctic and Antarctic, and by extension influencing the composition of their natural ecosystems; for example, migratory patterns of fish and their predators have changed significantly in both northern and southern oceans. Melting ice will have a range of effects on ocean currents and global weather systems, many of which are still unknown. Ice melt could also result in a rise in raw material extraction and military and other activity in these regions, potentially leading to an increase in environmental degradation due to pollution and growing infrastructure development.



Source: Intergovernmental Panel on Climate Change (2023)

The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near term

Human costs. Climate change is likely to have an increasing impact on where people live and work over the next three decades, as well as on health and well-being. Between 3.3 and 3.6 billion people already live in locations that are classified as highly vulnerable to climate change,[32] and this number is expected to rise further by 2055. According to the United Nations High Commissioner for Refugees, around 31.8 million people were internally displaced due to extreme weather events in 2022, an increase of

30 Gatti, L., et al., *Nature* (14 July 2021), 'Amazonia as a carbon source linked to deforestation and climate change'; Flores, B., et al., *Nature* (14 February 2024), 'Critical transitions in the Amazon forest system'.
31 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*, page 5.
32 Pörtner, H.-O., et al., (Eds.), IPCC (2022), *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, page 51.

41% compared with 2008;[33] this could reach 216 million people displaced globally by the second half of the century, with the poorest and most vulnerable being most impacted. In addition, the World Health Organization estimates that climate change could cause or contribute to approximately 250,000 additional deaths per year between 2030 and 2050.[34] Urban areas are likely to be particularly impacted by longer and more intense heatwaves, the effects of which may be compounded by the loss of essential services such as energy and health care. In April 2023, an extreme heatwave with record-breaking temperatures caused deaths, closure of public services and damage to infrastructure in Southeast Asia; six cities in north and east India recorded temperatures of around 44° Celsius.[35] Events of this sort could be an increasing feature of future years. Water- and vector-borne diseases, famine, respiratory illness and malnourishment, as well as mental health challenges due to the trauma of extreme events and the loss of livelihoods and culture, could all increase as a result of these intensifying climate impacts.[36] Pressures of this sort could see the world's poorer regions becoming more at risk of humanitarian disaster, and increasingly dependent on external support.

Economic and infrastructure costs. In addition to human costs, climate change will have an increasing impact on economies and infrastructure. The impact on human health, for example, could increase global workforce costs by United States (US) $2–4 billion per year by 2030,[37] while more than 800 million jobs could become vulnerable as a result of climate impacts, affecting Africa and the Indo-Pacific region in particular.[38] According to the World Economic Forum, the costs of climate-related damage to infrastructure could reach between US $1.7 and US $3.1 trillion per year by the second half of the century,[39] equivalent to around a third of global infrastructure spending today. In Europe alone, a failure to adapt to extreme weather events could increase damage to infrastructure ten-fold by the end of the century.[40]

In parallel, climate adaptation and mitigation measures will place increasing economic pressure on states. Current estimates for the annual costs facing developing states alone by the middle of the century are US $340–600 billion, although these are continually being revised upwards as climate impacts are increasingly understood.[41] As global populations continue to urbanise, expanding coastal and other megacities will become increasingly vulnerable to sea level rise, high temperatures and increases in incidences of tropical cyclones, intense rainfall and coastal flooding, particularly where infrastructure is already inadequate for growing populations. Ports, roads, rail and other infrastructure (including offshore facilities) could also be increasingly affected. In some places the cost of addressing climate impacts could be prohibitive, leading to vulnerable regions being abandoned and resulting in a corresponding increase in migration. However, delays to adaptation could greatly increase the damage and cost resulting from climate impacts in the long term.

33 Internal Displacement Monitoring Centre (2023), *Global Report on Internal Displacement 2023*.
34 World Health Organization (12 October 2023), 'Climate change'.
35 Ratcliffe, R. and Ellis-Petersen, H., *The Guardian* (19 April 2023), 'Severe heatwave engulfs Asia causing deaths and forcing schools to close'.
36 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*.
37 World Health Organization (12 October 2023), 'Climate change'.
38 Consultancy.uk (17 November 2022), '800 million jobs could be impacted by climate change disruption'.
39 Bennett, P., World Economic Forum (12 October 2023), 'Climate change is costing the world $16 million per hour: study'.
40 Forzieri, G., et al., *Global Environmental Change*, Volume 48 (January 2018), 'Escalating impacts of climate extremes on critical infrastructures in Europe', pages 97–107.
41 Watkiss, P., et al., UN Environment Programme (2023), *Underfinanced. Underprepared. Inadequate investment and planning on climate adaptation leaves world exposed: The Adaptation Finance Gap Update 2023*, 'Chapter 5', pages 217–258.

The impact of climate change on staple crops poses risks for global food security

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Challenges to sovereignty. The combined economic, human and other costs of climate change could increasingly challenge the authority of some states over the next 30 years. An inability to mitigate or adapt to climate impacts, for example, could become an increasing source of dissatisfaction towards governments or systems of governance. This may see external powers and non-state actors gaining increasing leverage, in some cases using this to secure access to resources or for military purposes. In more extreme scenarios, climate change could begin to significantly reshape the territorial integrity of the world's most vulnerable states. Small island states, such as those in the Pacific Ocean, are already facing existential threats from the combined effects of extreme weather and rising seas, in combination with ongoing economic challenges and uncontrolled resource extraction. Given the fact that the definition of a sovereign state includes the requirement that it possesses a defined territory and a permanent population, the consequences for island states that lose either of these may be significant and international support may be required.[42] Changes to the geophysical environment driven by climate change could create competing claims for associated maritime zones,[43] intensifying existing boundary disputes but also creating new ones where territories offer access to valuable resources such as critical minerals.

Stability and security. The combined impacts of a changing climate on societies, economies and governments could, when taken together with other factors, create new stability and security risks over the next three decades. Most obvious of these will be the need to prepare for more frequent and large-scale humanitarian and disaster relief responses; however, the geopolitical implications of climate change could prove far more widespread. Offers of support to affected state governments on renewable

42 Sancken, K.E., *UCLA Journal of Environmental Law & Policy*, Volume 38, Issue 2 (2020), 'The Price of Sovereignty in the Era of Climate Change: The Role of Climate Finance in Guiding Adaptation Choices for Small Island Developing States'.

43 The University of Sydney (12 September 2022), 'Is climate change disrupting maritime boundaries'.

technology development and climate adaptation are already being used to obtain influence and, in some cases, increased military access; the next three decades could see this trend deepen further. The actions of states and other actors seeking to exploit the opportunities created by a changing physical environment could lead to new areas of tension and crisis. For those affected by climate change, particularly in vulnerable regions, a sense of injustice could spark new forms of radicalism or compound existing religious, economic and cultural divides. Across the globe, increasing demands for climate action may lead to further political and social polarisation and more radical forms of climate activism, potentially resulting in the emergence of fully fledged eco-terrorism. As impacts build, states might find themselves imposing climate responses that impinge on human, property and other rights, thereby testing the resilience of both authoritarian and liberal governance structures.

Food and water

Growing food demand and insecurity. By 2055, the global demand for food is projected to be at least 50% higher than it is today.[44] Demand will grow in all regions, but the largest increases are expected to be in sub-Saharan Africa and East and South Asia due to rapid demographic growth and the expected increase in their middle class populations. As some countries become wealthier and increasingly urbanised, food consumption patterns are also expected to shift towards more calorie and protein rich diets. Nevertheless, almost 10% of the world's population was undernourished in 2021, with almost 193 million people in 53 countries experiencing acute food insecurity at crisis levels or worse.[45] Looking forward, the number of people affected by food insecurity is projected to rise to 3.4 billion by the middle of the century, a 43% increase (equating to approximately 1 billion people) on 2021 levels.[46]

The impact of climate change and changing land use on food supplies. Food insecurity is likely to be increasingly exacerbated by changes to land use and the impacts of a shifting climate over the next three decades. Urbanisation and rising sea levels will impact land availability, and soil erosion and fertility losses will increasingly affect crop production. Production of the world's staple crops – maize, wheat and rice – will all be increasingly affected by changes in the Earth's temperatures. Climate change is projected to have negative impacts on maize production in Africa, Asia and Northern and Latin America, soybean production in Asia and Oceania, and wheat crops in Africa, Asia, Europe, Russia and Latin America. In contrast, some regions could benefit from changing climates; rice production in Northern and Latin America, for example, and wheat production in Northern America could all increase under warmer and wetter conditions, although such studies may not fully account for climate-driven changes in pests and diseases. Taken overall, however, the impact on global food production is likely to be negative, with declining crop yields, loss of arable land and an increase in severe weather events and droughts. Without effective adaptation, global yields could decline by up to 30% by the middle of the century.[47]

44 Searchinger, T., et al., World Resources Institute (19 July 2019), *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050*.
45 World Wildlife Fund (WWF) (2022), *Living Planet report 2022 – Building a nature-positive society*.
46 Institute for Economics & Peace (October 2021), *Ecological Threat Report 2021: Understanding Ecological Threats, Resilience and Peace*, page 34.
47 Hobert, R. and Negra, C., UN Foundation (1 September 2020), 'Climate change and the future of food'.

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Water scarcity could affect health, biodiversity, agriculture and industry, and drive conflict where scarce resources are shared

Water demand and stress. As the most fundamental requirement for agricultural, industrial and energy production, as well as for all life, water will remain a key resource, driving regional and global politics. A number of the world's regions are already subject to water shortages, with an estimated 50% of the global population exposed to extremely high levels of water stress for at least one month a year. This number could rise by a further billion people by the middle of the century, particularly in regions with limited access to fresh water supplies.[48] In Central Asia, for example, around 90% of all fresh water is collected in the Syr Darya and Amu Darya rivers;[49] since the 1990s the average temperature in Central Asia has risen by 1.5° Celsius, twice the global average,[50] significantly impacting the glaciers that feed these rivers and leading to interruptions in supply. As demand rises and supplies come under increasing threat, access to water could have growing geopolitical and security implications. There are 150 countries sharing river basins that supply 52% of the global population,[51] and projections suggest that by the middle of the century almost 1 billion people may live in highly disputed basins.[52] Although in theory this has the potential to generate opportunities for collaboration, in practice, a favourable up-river location is often exploited by states for strategic advantage. In Southeast Asia, for example, the Indus, Brahmaputra, Ganges, Mekong and Yangtze rivers supply water to 25% of the global population;[53] however, all have their source on the Tibetan plateau in an area under Chinese control. Pollution and climate impacts in many of these transboundary regions are already high, compounding pressures further.[54]

48 Kuzma, S., et al., World Resources Institute (16 August 2023), '25 Countries, Housing One-Quarter of the Population, Face Extremely High Water Stress'.
49 Foreign, Commonwealth and Development Office, Gov.uk (17 July 2023), Policy paper: *UK–Central Asia region development partnership summary, July 2023*.
50 Duenwald, C., et al., International Monetary Fund (30 March 2022), *Feeling the Heat: Adapting to Climate Change in the Middle East and Central Asia*.
51 McCracken, M. and Wolf, T., *International Journal of Water Resources Development*, Volume 35, Number 5 (March 2019), 'Updating the Register of International River Basins of the World', pages 732–782.
52 de Bruin, S.P., et al., *International Journal of Water Resources Development*, Volume 40, Number 1 (13 March 2024), 'Projecting Conflict Risk in Transboundary River Basins by 2050 Following Different Ambition Scenarios', pages 7–32.
53 Webster, P.J., et al., *Bulletin of the American Meteorological Society*, Volume 91, Issue 11 (1 November 2010), 'Extended-range probabilistic forecasts of Ganges and Brahmaputra floods in Bangladesh', pages 1493–1514.
54 World Bank (2022), 'Water'.

Biodiversity loss and pollution

Accelerating biodiversity loss. Biodiversity is declining at a faster rate than ever before in human history. Global wildlife populations have declined by more than two thirds since 1970, with freshwater species witnessing the greatest overall loss.[55] A million plant and animal species are currently threatened with extinction, while the world is losing the equivalent of 27 football pitches of forested area every minute.[56] The implications of forestry loss are particularly significant, as these areas provide a home to half of the world's species as well as being a critical source of fresh water, food, flood protection and livelihood. Forests also act as a major carbon sink. Mangrove forests and other estuarine ecosystems, as well as the world's oceans, are facing significant challenges to biodiversity. Plankton, fish stocks, coral reefs and algae are all at risk, with wider implications for food chains and global ecosystems. The scale of this impact could be far greater than currently understood given the ongoing discovery of new species, and hence the likely full impact is unknown.[57]

Food production. Food production remains a significant cause of biodiversity loss, estimated to pose a threat to 64% of land species, 69% of freshwater species and 77% of ocean-based species.[58] Of the world's total habitable land, 46% of it is now used for agriculture, with livestock production accounting for 77% of global farmland use but producing only 18% of the world's calories and 37% of total protein.[59] Between 1962 and 2017, an area around half the size of China (roughly 470 million hectares) was converted into pasture.[60] In Latin America, deforestation for farming purposes saw half of the highly biodiverse Cerrado region converted to agricultural land by 2018.[61] Agricultural production is also intensifying, placing increasing pressure on soil fertility and biodiversity. Out to 2055, growing pressure on food supplies could lead to the increased use of pesticides, fungicides and other intensive approaches, which could have further negative consequences for local ecosystems.[62] These developments could also fuel further negative environmental impacts, including the loss of pollinators, the spread of invasive plant, insect and animal species, and heightened vulnerability to pests and pathogens. Expanding fleets, overfishing and illegal, unreported and unregulated fishing could also have an increasingly detrimental impact on freshwater and ocean biodiversity.

Urbanisation and infrastructure. Out to 2055, rising urbanisation and infrastructure development will have an increasing impact on biodiversity and pollution levels. Many of the world's cities are located in areas rich in biodiversity such as floodplains, estuaries and coastlines. Current trends suggest that global urban land cover will expand by between 800,000 and 3.3 million square kilometres by the end of this decade, a two- to five-fold increase on 2000 levels, potentially resulting in the considerable loss of plant and animal habitats in key biodiversity hotspots, including the Atlantic Forest Region

55 WWF (2022), *Living Planet report 2022 – Building a nature-positive society*.
56 WWF, 'Forests'.
57 MarineBio (2023), 'Did You Know…? Marine Life/Ocean Facts…'.
58 Tilman, D. and Williams, D., The Royal Society, 'Preserving global biodiversity requires rapid agricultural improvements'.
59 Ritchie, H. and Roser, M., Our World in Data (September 2019), 'Land Use'.
60 The Royal Society, 'How does the growing global population and increasing consumption affect biodiversity?'.
61 Lee, C., Earth.org (29 September 2021), 'Soybean Products and Its Environmental Impact'.
62 Bellasio, J., et al., RAND Europe (2022), *The future of ecosystem services out to 2055 : Exploring drivers of change, future trajectories, and their implications for geostrategic affairs* (a research paper commissioned by DCDC).

of Brazil, the Cape of South Africa and coastal Central America.[63] Urban expansion will continue to affect freshwater biodiversity; the Western Ghats mountain range in India, for example, is expected to support 81 million people by the middle of the century, placing increasing pressure on its hundreds of fish species. Urbanisation also increases the risk of introducing non-native and invasive species into an environment. In addition to the impact caused by urban development and growing waste, the expansion of offshore infrastructure will also have an impact on many marine species, either from pollution, as a result of oil spills, for example, or through disturbance to natural habitats and migratory routes. Out to 2055, a significant upscaling of offshore wind, digital, military and other critical marine infrastructure could create new challenges for marine biomes.

Trade and resource extraction. According to some studies, international trade is already responsible for 30% of threats to global species, with 17% of biodiversity loss being due to the production and export of commodities.[64] In 1970, 27 billion tonnes of minerals and metals were extracted but by 2017, this had risen to 92 billion tonnes and could reach 190 billion tonnes a year by 2060, including for use in renewable and digital technologies.[65] Despite efforts to reduce the environmental impacts, extracting and transporting raw materials has the potential to disturb natural habitats and lead to soil and water pollution. In the future, therefore, land mining could contribute to increasing biodiversity loss, as well as impacting those who depend on the surrounding environment. Regions where limited state capacity results in insufficient regulation and oversight, or where unsafe extraction and refining methods are commonplace, will be at particular risk.

Although currently subject to an international moratorium on extraction, interest in the oceans' abundant reserves of critical minerals is likely to increase by 2055. While this could support the renewable energy transition and potentially offset the requirement for destructive land mining, there is significant uncertainty regarding the potential damage that this might cause to marine biomes. Many potential seabed mining sites are located within vulnerable marine ecosystems, including some where the depth means that there is little understanding of the natural environment. The plumes arising from such activity can travel thousands of kilometres and spread across reefs, fish habitats and transit routes, thereby contributing to pollution in the wider region.

Pollution and waste. Pollution and waste disposal already present a pressing global challenge, and one that is likely to increase further over coming decades. By the middle of the century, for example, global annual waste generation could increase by 73% to 3.88 billion metric tonnes;[66] emerging economies will account for much of this growth, with waste in East Asia and the Pacific region expected to increase from 468 to 714 million tonnes over that period.[67] The world's developed countries are likely to remain the largest producers of waste over the next few decades; by the middle of the century, the population of North America is projected to generate 2.5 kilograms of waste per person per day, compared with 0.63 kilograms generated by those living in sub-Saharan Africa.[68]

63 Secretariat of the Convention on Biological Diversity (2012), *Cities and Biodiversity Outlook*.
64 The Royal Society, 'How does the growing global population and increasing consumption affect biodiversity?'.
65 UN Environment Programme, and International Resource Panel (2019), *Global Resources Outlook 2019: Natural Resources for the Future We Want*.
66 World Bank (11 February 2022), 'Solid Waste Management'.
67 World Bank, Statista (20 September 2018), 'Projection of waste generation worldwide in 2016, 2030, and 2050, by region (in million metric tons)'.
68 World Bank, Statista (20 September 2018), 'Projection of waste generation per capita worldwide in 2050, by region (in kilograms per day)'.

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The increasing use of the oceans and waste generated from the shore could also see marine pollution levels rise significantly

While global recycling of plastic waste is expected to increase from 9% in 2019 to 17% in 2060, this will still be lower than the proportion going to landfill (50%) and for incineration (20%), alongside significant unregulated dumping.[69] At the same time, electrical and electronic waste (e-waste) has become the fastest growing source of waste worldwide and could triple to 120 million tonnes per year by the middle of the century.[70] This will be exacerbated as clean energy systems reach their end of life, producing yet more e-waste, although recycling industries are emerging to capitalise on this trove of critical materials. By the middle of the century, the value of the materials extracted from solar panel recycling could amount to US $15 billion.[71]

Out to 2055, the increasing use of the oceans and waste generated from the shore could see marine pollution levels rise significantly. Discarded fishing gear will continue to present a major threat to marine ecosystems. The ingestion of microplastics threatens biomes and food chains[72] and alters the distribution of pests and invasive species carried on ocean litter debris.

Climate impacts on biodiversity. While urbanisation, infrastructure development and resource extraction are currently the main causes of biodiversity loss, if temperature increases exceed 1.5° Celsius by 2055 (which is considered extremely likely), climate change could overtake them to become the biggest threat to biodiversity. Under a 1.5–2° Celsius warming scenario, 10–20% of species could be at high risk of complete

69 Organisation for Economic Co-operation and Development (OECD) (3 June 2022), 'Global plastic waste set to almost triple by 2060, says OECD'.
70 Kantaria, P., Verdict (24 January 2019), '50 million tonnes of e-waste could triple by 2050'.
71 International Renewable Energy Agency (IRENA) and International Energy Agency Photovoltaic Power Systems (2016), *End-of-Life Management: Solar Photovoltaic Panels*.
72 WWF (20 October 2020), 'New Report from WWF Says Addressing Abandoned Fishing Gear Must be Central in the Fight Against Plastic Pollution'; UN Environment Programme (19 May 2016), 'Plastic and Microplastics in our Oceans – A Serious Environmental Threat'.

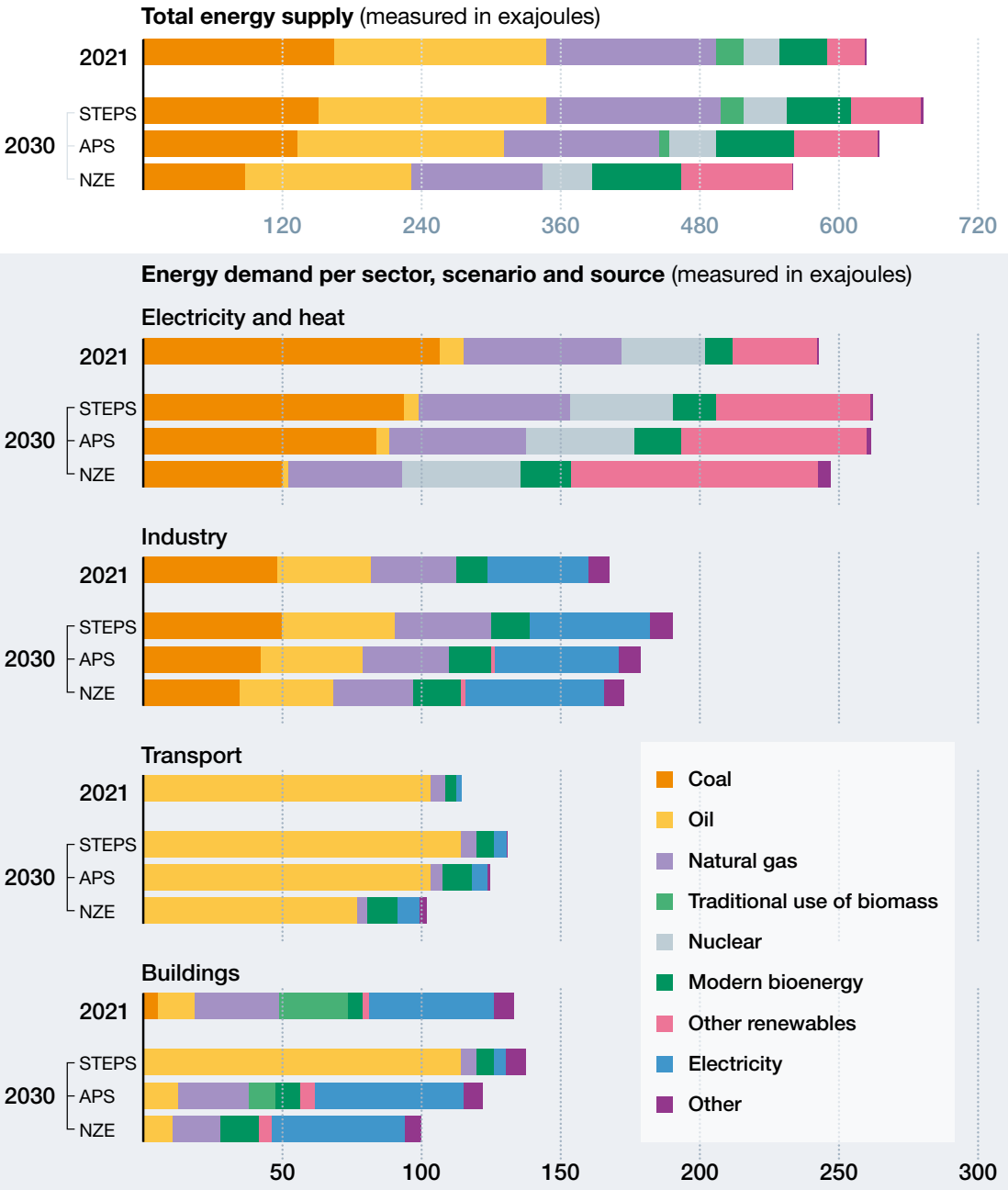
global extinction; at 2° Celsius, this could rise to 20% of amphibians and over 30% of pollinators.[73] A warming of 1.5° Celsius will also result in a loss of 70–90% of warm-water corals, rising to more than 99% in a 2° Celsius scenario.[74]

Ecosystem collapse. The combined impacts of expanding human habitation, land and sea use, resource extraction, pollution and climate change mean that many of the world's ecosystems are already under increasing stress. Looking forward, the projected loss of 20% of species at 2° Celsius warming will be sufficient to significantly destabilise global ecosystems and change the way in which they function.[75] Ocean warming and acidification, for example, have already caused widespread coral loss, affecting marine food webs, the ocean's nutrient cycle and food chains. Should such collapses become more widespread, this could have catastrophic consequences for societies and economies, as well as wider life on Earth. Habitat and ecosystem destruction could lead to the disappearance of many cultural heritage sites, with significant economic, societal and other implications. For example, increased flooding in the Ecuadorian Amazon due to economic activity and climate change has destroyed the homes, communities and food production practices of the indigenous people.[76] Ecosystem disruption could also contribute to rising levels of migration, due to increasing food insecurity and societal destabilisation.

Energy transition, decarbonisation and climate adaptation

Global energy demand. Over the next three decades, growing populations and economies, as well as changing lifestyles, including the digital transition, mean that global energy demand seems set to rise. While the exact rate of growth will depend on a number of variables, projections based on current trends and policies range from a 25%[77] to a 34%[78] increase by 2055, although other studies suggest that it could be higher or may even potentially decline in the most optimistic scenarios.[79] The desire to reduce dependency on traditional energy supplies, combined with concerns about climate change, could drive increasing diversification of fuel sources out to 2055, with renewable energy forming a significant part of this.[80] The pace of developments in the renewable energy market suggests that many countries and energy companies are already moving in this direction,[81] although this picture will vary from region to region.

73 Pörtner, H.-O., et al., (Eds.), IPCC (2022), Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, pages 259–260.
74 WWF (2022), *Living Planet report 2022 – Building a nature-positive society*.
75 Pörtner, H.-O., et al., (Eds.), IPCC (2022), *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, page 259.
76 Masaquiza Jerez, M. and UN Department of Economic and Social Affairs (23 June 2021), *Challenges and Opportunities for Indigenous Peoples' Sustainability*.
77 Ibid.
78 U.S. Energy Information Administration (11 October 2023), *International Energy Outlook 2023*.
79 International Energy Agency (October 2023), *World Energy Outlook 2023*.
80 Ibid, page 99.
81 International Energy Agency (1 December 2021), 'Renewable electricity growth is accelerating faster than ever worldwide, supporting the emergence of the new global energy economy'.



Stated Policies Scenario (STEPS)
Reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, as well as those that have been announced by governments around the world.

Announced Pledges Scenario (APS)
Assumes that all climate commitments made by governments around the world, including nationally determined contributions and longer-term net-zero targets will be met in full and on time.

Net-Zero Emissions by 2050 Scenario (NZE)
Sets out a narrow but achievable pathway for the global energy sector to achieve net-zero carbon dioxide emissions by 2050.

Source: International Energy Agency (2022)

Global energy demand by sector and scenario

Fossil fuels. While modelling varies between scenarios, fossil fuels are likely to remain a significant part of the global energy mix out to 2055. Forecasts based on low adaptation, high emission scenarios predict an increase in the use of natural gas between now and the middle of the century, and only modest falls in the use of oil and coal.[82] Conversely, intervention scenario forecasts suggest that marked reduction in fossil fuel use is possible by the middle of the century, with fossil fuel contribution to net energy use falling to as little as 25% of 2020 levels.[83] In practice, however, regional variations in fossil fuel consumption will reflect different stages of economic development and national policies. East and South Asia, for example, may remain significant users of fossil fuels out to 2055, whilst also seeing significant growth in renewables.[84] Some regions and countries may struggle to make the necessary investment in alternative energy sources; to date, developing and emerging economies have only attracted about 15% of global investment in renewables.[85] Real or perceived levels of risk, due to insecurity and political instability, volatile exchange rates, liquidity and insurance concerns and low levels of grid and infrastructure development, have been a frequent stumbling block and may continue to be in the future.[86]

Renewables. Over the next three decades, renewable energy sources of a range of types will provide an increasingly important contribution to the energy mix. For example, hydropower and geothermal energy are already well-established clean energy sources that will continue to make a contribution where they are geographically viable. Currently, more power is produced by hydroelectricity than by wind or solar power. Looking forward, however, increasing levels of drought, as well as competition from other sectors such as agriculture and industry for water use, cast doubt over the long-term viability of some projects. In addition, geographical restrictions limit the scope for significant sectoral growth. Solar photovoltaic energy has seen exponential growth in recent decades, and is poised to surpass coal by 2027 to become the largest energy source in the world.[87] In the future, sun-rich regions such as Australia and North Africa could benefit significantly from further cost efficiencies, potentially becoming net exporters of solar photovoltaic energy.

Wind energy has witnessed a steady expansion in recent years, and will need to expand further if net-zero targets are to remain viable.[88] In addition to existing on- and offshore locations, advances in siting technologies will also allow the exploitation of deep ocean locations, with several sites already using floating turbines. Taken together, these trends suggest that wind power may be the world's dominant source of energy by 2055.[89] To date, despite predictable tidal patterns and relatively high-power output, marine energy has proved more technically challenging and expensive than wind options. A combination of state incentives and market efficiencies may bring costs down in the future and increase the share of marine energy, although uncertainty surrounding the impact on local biomes remains a cause for concern.

82 McKinsey & Company (18 October 2023), *Global Energy Perspective 2023*.
83 International Energy Agency (May 2021), *Net Zero by 2050: A Roadmap for the Global Energy Sector*.
84 International Energy Agency (October 2023), *World Energy Outlook 2023*, page 251.
85 IRENA and Climate Policy Initiative (2020), *Global Landscape of Renewable Energy Finance 2020*.
86 IRENA (2021), *World Energy Transitions Outlook: 1.5°C Pathway*.
87 International Energy Agency, 'Solar PV'.
88 International Energy Agency, 'Wind'.
89 IRENA (2019), *Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation paper)*.

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Significant growth in wind energy generation will be required to meet emissions reduction targets

Nuclear. Nuclear fission will remain a key component in the energy mix of many states over the next 30 years; 438 plants currently operate in 38 countries, with a further 60 under construction as of 2024.[90] Research on fusion, which offers greater output with less radioactive waste, continues. While there are still significant engineering challenges to overcome to make fusion viable, if these challenges can be overcome, it could form a significant part of the global energy mix by the second half of the century, with several countries having already announced ambitious projects to drive this technology forward.

Electric vehicles and transportation. The electrification of domestic land transport is one of the more promising avenues for reducing emissions. International Energy Agency modelling suggests that the electrification of China's vehicle fleet alone accounted for 30% of global emissions reduction in 2022. The current global stated electric vehicles policies will displace 5 million barrels of oil per day (five times Australia's rate of consumption) by 2030 alone (although there are early indications that markets may exceed this target).[91] The efficient production of sustainable fuels will be another key factor in the effort to decarbonise transport out to 2055. The significant energy density advantage of liquid fuels over batteries means that they are likely to remain critical to the heavy vehicle, emergency service, maritime, aviation and military sectors, where endurance and mass are the overriding factors.

Carbon capture. Various approaches to remove CO_2 from the atmosphere will complement efforts to reduce emissions out to 2055. Estimates suggest that 5 gigatonnes of carbon per year would need to be removed to meet net-zero targets,[92] but the feasibility of achieving such scale is uncertain. Reforestation, where trees absorb the CO_2 into wood, for example, is limited by available land, and is subject to increasing wildfire and drought risk, and these projects can be prone to fraud. It would take a forest nearly the size of India to absorb 5 gigatonnes of CO_2 per year. If half of the UK's land area were planted, it would absorb about 240,000 tonnes per year.

90 World Nuclear Association (April 2024), 'World Nuclear Power Reactors & Uranium Requirements'.
91 International Energy Agency (April 2023), *Global EV Outlook 2023: Catching up with climate ambitions*.
92 Global CCS Institute (2023), *Global Status of CCS 2023: Scaling up through 2030*.

Carbon capture, utilisation and sequestration technologies (CCUS), which remove emissions from industrial processes or fossil-fuelled power plants, have had some commercial use so far. However, while a rush of project announcements indicates a continued desire to apply these approaches in hard-to-decarbonise sectors,[93] CCUS technologies are energy intensive and often need to be tailored to individual industrial facilities. This lack of scalability has seen little reduction in cost for 40 years, leading to estimates that a CCUS reliant pathway to net zero may cost at least US $30 trillion more than a low-CCUS pathway.[94] Direct air capture and storage (DAC+S) technology, which extracts CO_2 from the atmosphere, is even more energy intensive, but the same system can be deployed anywhere, which may allow economies of scale. While the DAC+S industry is still nascent, future technology developments or market factors such as plunging renewable power costs or changes in the industrial value of captured CO_2 could see very large plants becoming feasible in the future.

Geoengineering. Geoengineering covers a range of technologies, including those that have the potential to reflect the sun's energy or allow more infrared radiation to escape into space, creating a net-cooling effect on the climate. Options include stratospheric aerosol interventions, marine cloud brightening, ground-based Albedo modifications, ocean Albedo change and cirrus cloud thinning.[95] However, all of these technologies carry different risks and are unlikely to be as effective in reducing global warming as lowering greenhouse gas emissions.[96] Furthermore, limiting the impact of these types of technologies to a particular country or region is practically impossible, suggesting that their use by any state or bloc could have wider geostrategic implications.[97] Future years may see increasing global effort to regulate and limit their use.

Energy options and choices. In addition to the economic, political and other risks associated with a transition away from fossil fuels, many governments will face difficult choices when selecting technologies to meet their future energy needs and allow them to compete on global markets. Given that many technologies could require significant upscaling to be competitive, choosing which areas to invest in could prove a significant dilemma for many states. Many renewable technologies are already commercially viable, but out to 2055, new technologies currently in demonstration or prototype phase could prove a better investment.[98] This could encourage states to pursue a wide portfolio of different options; however, this will be expensive, and not affordable for all. For example, energy storage, distribution, CCUS and transition to electric vehicles all require significant investment if they are to be viable to meet demand as the world changes, and not every government will have the financial headroom to invest in all technologies. At the same time, not all old technology is equally carbon intensive, and not all low-carbon technologies are equally low carbon, making prioritisation a difficult task.

93 International Energy Agency (September 2023), *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach – 2023 Update*.
94 Way, R., Smith School of Enterprise and the Environment, University of Oxford (4 December 2023), 'Heavy dependence on Carbon Capture and Storage 'highly economically damaging', says Oxford report'.
95 European Commission, European Commission's Group of Chief Scientific Advisors (3 August 2023), *Scoping paper: Solar Radiation Modification*.
96 Corry, O. and Kornbech, N., *International Relations in the Anthropocene* (21 April 2021), 'Geoengineering: A New Arena of International Politics', pages 95–112.
97 *The Economist* (6 July 2019), 'What if geoengineering goes rogue?'.
98 International Energy Agency (May 2021), *Net Zero by 2050: A Roadmap for the Global Energy Sector*.

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Satellites can help with the monitoring of activities and trends, including deforestation

Wider sustainability opportunities and choices

Monitoring and understanding. So far, a key challenge to achieving environmental sustainability has been the limited ability to monitor the activities and trends that are changing the planet, particularly in the shared spaces and in regions where governance capacity is low. Out to 2055, new technologies and programmes will increasingly help to address these shortfalls. State and commercial satellite coverage of the Earth's surface, atmosphere and oceans is set to grow significantly in the coming decades. Satellite and cable Internet coverage, combined with increasing ownership of portable devices, will also boost the availability of environmental data. Parallel advances in artificial intelligence will allow this information to be applied more effectively, providing alerts, modelling and solutions to a variety of environmental challenges.[99] A number of related research programmes are already in progress, and if successful will enable more targeted actions and greater oversight of environmental impacts. While this could prove a powerful aid to the governance of the natural environment, these developments could also exacerbate the 'blame game', which has become an increasing feature of global power competition and could increase concerns over rising levels of surveillance.

Sustainable living. Out to 2055, adapting homes, towns and cities to consume less energy and fewer resources will be a major factor in efforts to address climate change and environmental degradation, although the extent to which these efforts are successful will vary according to region and level of development. While purpose-built smart city projects may offer an alternative to existing models of urban development, technological uncertainties, macro-economic constraints and other factors could also make them high risk bets. Given the fact that the majority of states are already highly urbanised, interventions to encourage retrofitting of smart meters and insulation may be as important as large-scale capital investments. For some cities, however, particularly in developing states with significant levels of informal housing, adaptation may prove almost impossible.

99 Maher, H., et al., AI for the Planet Alliance (July 2022), *How AI Can Be a Powerful Tool in the Fight Against Climate Change*.

Technologies such as robotics, artificial intelligence and vertical farming may support new food production methods

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Water management. Policies and technologies to improve water and wastewater management will be critical to climate change adaptation and biodiversity protection. Many parts of the world are already experiencing levels of water stress, but as the Earth's temperature increases, this could also extend to regions more used to water abundance. In other cases, countries will increasingly have to adapt to high levels of rainfall and storms that overwhelm existing water management systems. Sharing technologies and policy ideas between regions will be critical.[100] New technologies could play a growing role in reducing water waste, with an automated leak prevention system saving 71 million litres of drinking water each month in one Indian city alone.[101] Governments are also increasingly acting to protect waterways; in the last few years, for example, legal rights have been granted for the Whanganui River in New Zealand and all rivers in Bangladesh.[102]

Alternative food production methods. A range of technologies could help to address the growing demand for food, while at the same time minimising increases in CO_2 emissions and protecting biodiversity. Remote crop monitoring, real-time management of livestock, weed control and the automation of farm machinery are examples of techniques already being increasingly employed.[103] The integration of technologies such as robotics, artificial intelligence and vertical farming have made the Netherlands one of the world's largest exporters of food produced with below-average emissions.[104] Artificial intelligence-enabled satellite and drone monitoring, bioengineering and automation are being used on farms in Latin America, and could over time be upscaled to the global level. Biotechnology advances, including crops with greater resilience to pests, diseases and weather extremes, could provide new ways to tackle increasing food insecurity in the future. Developments in aquaculture in Southeast Asia offer new methods for producing maritime protein that are less destructive than traditional fishing.

100 Jacobsen, R. and ENSIA, *Scientific American* (29 July 2016), 'Israel Proves the Desalination Era Is Here'.
101 Viola, C.O., World Bank (15 June 2020), 'The future of water: How innovations will advance water sustainability and resilience worldwide'.
102 O'Donnell, E., *Griffith Law Review*, Volume 29, Issue 4 (2020), 'Rivers as Living Beings: Rights in Law, but No Rights to Water?', pages 643–668.
103 Smarter Technologies, 'The Complete Guide to Smart Agriculture and Farming'.
104 Reiley, L., *The Washington Post* (21 November 2022), 'Cutting-edge tech made this tiny country a major exporter of food'.

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Significant effort is being spent on research and recovering ecosystems through rewilding projects

Out to 2055, trends towards richer and less sustainable diets could also come under increasing scrutiny.[105] While insect-derived protein, using macroalgae for animal feed, 3D-printed and synthetically cultured meats as well as meat alternatives may offer potential offsets to growing demand, technical challenges, environmental considerations and consumer preference could limit scalability.[106]

Ecosystem restoration. The United Nations claims that 'restoring forests, peatlands and mangroves, along with other natural solutions, can provide over one-third of the greenhouse gas mitigation needed by 2030', and that more broadly ecosystem restoration can reduce economic loss, improve food security, cut pollution of water supplies, improve human health and avoid species extinction.[107] Ecosystem restoration can help halt and reverse degradation, resulting in improved ecosystem services and recovered biodiversity.[108] Projects under this banner range from those aiming to conserve intact ecosystems, returning some or all of degraded ecosystems to an earlier point, or otherwise trying to bring humanity and nature into a more balanced relationship.[109] However, many projects have suffered failures, setbacks or challenges, including the failure to take into account livelihood needs, limited or ineffective engagement with key stakeholders, and a lack of scientific understanding.[110] The World Resources Institute assesses that successful ecosystem restoration projects require empowered local leadership who learn from other projects and have access to relevant data, strong public policies and incentives, and effective training and mentorship.[111]

105 Shukla, P., et al., (Eds.), IPCC (2022), *Climate Change 2022: Mitigation of Climate Change*. Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.
106 Treich, N., *Environmental and Resource Economics*, Volume 79, Issue 1 (19 March 2021), 'Cultured Meat: Promises and Challenges', pages 33–61.
107 UN Environment Programme (3 June 2021), *Becoming #GenerationRestoration: Ecosystem Restoration for People, Nature and Climate*.
108 Ibid, page 7.
109 UN Environment Programme, and Food and Agriculture Organization of the UN (April 2023), *Action Plan for the UN Decade on Ecosystem Restoration, 2021–2030*.
110 Science Task Force for the UN Decade on Ecosystem Restoration (2021), *Science-based ecosystem restoration for the 2020s and beyond*.
111 Anderson, W., World Resources Institute (17 May 2021), 'Pressing Questions About Ecosystem Restoration, Answered'.

Ecosystem restoration projects

The grasslands of the Loess Plateau in China were degraded and eroded by thousands of years of farming, affecting food production, water and air quality. A restoration project funded by the World Bank and the Chinese government was partially successful, reducing flood risk and erosion and increasing grain yields and local incomes. However, the failure to understand local ecosystems led to incorrect species selection and an over-focus on trees, leading to significant failures in some areas.[112]

The 'Great Green Wall' is an initiative to restore degraded land across 8,000 kilometres and 11 countries of the Sahel, and slow the encroachment of the Sahara Desert. It has evolved from a tree-planting project in its early stages to a more complex set of ecological initiatives. In 2020, one-fifth of the target 100 million hectares of land had been restored, but the project has suffered from slow and uneven funding pipelines related to instability in parts of the region.[113]

Corals, including those that make up the Great Barrier Reef, are vulnerable to rising ocean temperatures, poor water quality and harmful fishing activity. There is currently a range of political, scientific and community projects that between them work to restore the Great Barrier Reef. Despite setbacks, such as a large-scale bleaching event in 2022, overall progress is positive.[114]

In cities, trees can improve air and water quality, prevent erosion, clean contaminated land and provide thermal control. Many urban forest projects are under way or planned around the world. In New York City, a million trees were planted through community projects between 2013 and 2016, and the Forest for All New York City coalition aims to achieve 30% canopy cover by 2035, ensuring equitable distribution of urban green environments.[115]

Beavers can be effective in generating large areas of wetland, slowing the flow of streams and rivers and protecting downstream land from flooding. These wetlands can in turn support extensive ecosystems. In 2011, one beaver family was introduced in Devon, UK. The resulting wetlands store 56 litres of water per square metre of land, reducing the potential for downstream flooding. At peak flow, 30% less water left the site than entered it, and it contained 30% less sediment. The number of beetle species at the site has tripled, which has in turn increased the number of bat species present, leading to a significant improvement in overall biodiversity.[116]

A project based in Texas aims to use genetic techniques to reintroduce the woolly mammoth to Arctic ecosystems. De-extinction is a controversial discipline, with many arguing that funding would be better spent on conserving existing species. However, the project claims that de-extinction may be necessary in the future if currently endangered species cannot be saved, and that mammoths could have a disproportionate impact on carbon capture and methane sequestration by compacting permafrost in the Arctic tundra.[117]

112 Buckingham, K., et al., World Resources Institute (15 December 2014), 'Taking Culture into Account in Restoring China's Loess Plateau'.
113 *Nature* (18 April 2023), 'Is Africa's Great Green Wall project withering?'.
114 Commonwealth of Australia (February 2024), *Great Barrier Reef Progress Report to UNESCO World Heritage Centre*.
115 NYC Urban Forest Task Force, *NYC Urban Forest Agenda: Toward A Healthy, Resilient, Equitable, and Just New York City*.
116 The Wildlife Trust (October 2023), *The Wildlife Trusts' Beaver Reintroductions*.
117 Colossal Laboratories and Biosciences, 'A Better World'.

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With growing public awareness increasingly influencing purchase choices, many companies are now placing environmental issues at the centre of their corporate responsibility programmes

Industrial decarbonisation. While green energy production and transport solutions have seen significant advances in recent years, the decarbonisation of industry has been slower; the International Energy Agency estimates that global industry is currently responsible for 25% of greenhouse emissions.[118] Out to 2055, however, a combination of technological and policy developments could lead to further decarbonisation of this sector, although there remains significant uncertainty as to what can be achieved in practice. Decarbonising industry is a more complex challenge than with other sectors, as there are no commercially established alternatives to the central chemical reactions that form part of industrial processes and which often demand high temperatures.[119] Progress to date has been slow, partly because of the risk associated with investing in these new technologies, but also because the long lifetime of equipment makes replacement costly.[120] As a result, many businesses will continue to look to the carbon offset market to meet emissions targets, financing CO_2 sequestration activities such as reforestation. This offset market could therefore grow from US $2 billion per year to as much as US $250 billion per year by the middle of the century.[121] However, concerns regarding the effectiveness and transparency of some schemes could prove a limitation.[122]

Corporate responsibility and circular economies. With growing public awareness increasingly influencing purchase choices, many companies are now placing environmental issues at the centre of their corporate responsibility programmes. Alongside public statements and targets, as well as greater scrutiny of supply chains, this has resulted in developments such as including 'nature' as a board issue.[123] At the same time, consumer habits are gradually changing; the backlash against the environmental impact of fast fashion, for example, has prompted a shift towards sharing, leasing,

118 International Energy Agency (March 2023), *CO2 Emissions in 2022*.
119 International Energy Agency (11 July 2023), 'Industry'.
120 Ibid.
121 Morgan Stanley (11 April 2023), 'Where the Carbon Offset Market Is Poised to Surge'.
122 UN Climate Change (18 November 2023), 'UN Body agrees vital carbon crediting guidance ahead of COP28'.
123 Surmanski, S., National Association of Corporate Directors (25 August 2022), 'How Resilient Is Your Business to Nature Loss?'.

reusing, repairing, refurbishing and recycling rather than purchasing new goods.[124] Out to 2055, the rising adoption of servitisation models (where consumers pay for a service or hire an item rather than buying the product) could also increase the availability of sustainable choices for consumers.[125] However, with today's global economy still fundamentally driven by consumption, growth and profit, it remains unclear whether such circular economy approaches will become more widespread, or remain limited to certain sectors and regions.

Geostrategic context and implications

Global power competition. While climate change and environmental degradation constitute shared global challenges, the associated policy responses and technical and resource solutions being pursued by states and other actors may be increasingly impacted by rising global power competition. Tensions around resources, uneven climate change impacts and the question of reparations has already emerged as states work to agree mitigation and adaptation strategies.[126] Out to 2055, global governance structures may struggle to keep pace as rapid technological change interacts with the threat of climate change. Developments such as solar geoengineering may pose substantial regulation and oversight challenges, particularly in the shared spaces.

Pledges and funding. Based on current national pledges, the world seems unlikely to achieve the Paris Agreement target of limiting the global average temperature increase to 1.5° Celsius.[127] Many policy and financial responses fall short of even that ambition.[128] While a number of developed economies have moved rapidly on renewable energy and other responses, legacy emissions, plus the fact that many developing countries will be more severely impacted by climate change[129] but receive only limited support for adaptation and mitigation programmes, are increasingly proving a source of tension. While global powers compete to occupy the moral high ground in this debate, in reality, most have a mixed record. Additionally, a number of fossil fuel exporters have sought to influence pledges, while others have been accused of 'green-washing' – making false or misleading statements to appear environmentally friendly while undermining progress towards climate objectives. Out to 2055, growing acrimony may increasingly undermine progress and could, given pressures in other areas of global governance, impact the future effectiveness of the Conference of the Parties and other initiatives dedicated to combatting the threat of climate change.

Technological leadership and leverage. Aside from the role that renewable technologies could have in meeting national transition policies, an ability to upscale and export them to others offers producers the potential for significant leverage over global markets and geopolitics. In that regard, China's dominance in key renewable energy sectors, its growing electric vehicles industry and control of critical mineral supplies could prove a major boost to its aspirations for global leadership. While China currently seems to have a strong lead in renewable technologies, out to 2055, a more competitive playing field could emerge.

124 European Parliament (24 May 2023), 'Circular economy: definition, importance and benefits'.
125 Karamitsos, D., World Economic Forum (20 November 2020), 'What is servitization, and how can it help save the planet?'.
126 Guivarch, C., et al., International Monetary Fund (September 2021), 'Linking Climate and Inequality'.
127 Lee, H., et al., IPCC (2023), *Climate Change 2023: Synthesis Report: Summary for Policymakers*.
128 International Energy Agency (May 2021), *Net Zero by 2050: A Roadmap for the Global Energy Sector*.
129 Bennett, P., World Economic Forum (12 October 2023), 'Climate change is costing the world $16 million per hour: study'.

The last few years have seen increasing global concern over supply chain and other vulnerabilities, spurring the US, UK, European Union and East Asian states such as Japan and South Korea to implement policies and fund investments that over time may make them increasingly competitive. India is also likely to expand its renewable technology offer in the coming decades. At the same time, competition to provide support for infrastructure development and other forms of climate adaptation and disaster relief assistance is likely to increase, as states seek to use their expertise to gain influence. For many of the states that are being courted in this manner, the ability to leverage competing powers may prove another way to maximise support for their own climate and wider strategies.

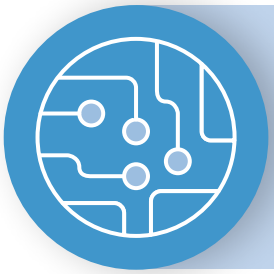
Access to resources. The potential pace and scale of the energy transition could have significant implications for global resource demand and access to resources, with wider geostrategic and security implications. Between 2017 and 2022, for example, demand for lithium tripled, while the demand for cobalt increased by 70%, copper by 50% and nickel by 40%. International Energy Agency projections for global critical mineral demand range from a 200% to a 350% increase by the middle of the century. Accompanying market volatility has seen the reversal of a decade-long reduction in renewable energy prices from 2012 to 2022. As the world's largest metal refining hub, China relies heavily on these imports, often from a small number of sources, and is therefore seeking ways to diversify its supplies, actively investing in mining assets in Africa and Latin America, the latter being home to 60% of the world's currently accessible lithium. Between 2018 and the first half of 2021, Chinese companies invested US $4.3 billion in lithium assets, twice the amount invested by the US, Australia and Canada combined.[130]

As a result of this increasing demand for critical minerals, the shared spaces could become an increasing focus for resource extraction activity. There may be more critical minerals on the ocean floors than on all the world's continents combined, and while deep-sea mining is currently subject to a moratorium, a number of states are actively positioning themselves to take an early lead. Similar developments could follow in the Antarctic region when the 1991 Protocol on Environmental Protection becomes open for review and potential modification in 2048. The demand for critical minerals could see new forms of rivalry emerge which may match or even exceed the current focus on fossil fuels. The fact that many of these reserves are located in fragile states may give rise to new instabilities and security challenges.[131] Existing fossil fuel exporters could see their own prospects reduced by these developments. While some countries in Southwest Asia are seeking to diversify their economies in anticipation of this, it is unclear whether this will prove successful, and could lead to new tensions and a rise in instability if not sensitively managed. Similarly, while Russia's fossil fuel exports will continue to find markets in East and South Asia in the medium term, out to 2055 it could also come under increasing strain due to lost revenues.

However, there is the potential for significant advances in material science and manufacturing processes over the next 30 years, which could lead to groundbreaking new technologies. These could fundamentally alter energy systems and associated geopolitics. Although technological and commercial barriers will remain by 2055, hydrogen, space-based energy, clean coal with carbon capture and storage along with nuclear and microbial fuel could play a greater role in the global energy mix, opening new opportunities for skills development, investment, trade and global leadership.

130 International Energy Agency (July 2023), *Critical Minerals Market Review 2023*.
131 Auty, R. (1993), *Sustaining Development in Mineral Economies: The Resource Curse Thesis*.

Information and technology



Overview

Out to 2055, advances in information storage will see a rapid growth in the volume of global data generation. While for the foreseeable future this will be greater than the capacity to process and analyse it, new data storage technologies could lead to significant reductions in processing time in the longer term. Future developments in processing power could transform the way society deals with information, while quantum computing will allow some problems to be solved much more quickly than conventional computing. Taken together, these advances may lead to far-reaching changes in a wide range of sectors, including financial services, manufacturing and engineering.

In the future, governments and businesses will be increasingly dependent on having access to data on citizens and consumers to improve their decision-making. Future advances in sensor technology, including quantum sensor technology, will see sensors becoming increasingly prevalent in society. While this may in many respects lead to improvements in people's everyday lives, it may give rise to new vulnerabilities, as well as increasing the ability of governments to monitor the activities of their citizens.

Further advances in communications technology will result in ever greater improvements in connection speeds and reliability. Over the next three decades, the increased commercial viability of satellite-based Internet communications could potentially result in complete and uninterruptible global coverage, bringing significant benefit to societies and economies. The tools that people use to access the Internet will change, and smart devices will become increasingly prevalent. However, not all will have access to these new technologies, which will reinforce existing inequalities.

Artificial intelligence advances will bring benefits in a number of fields, although the ability of society and governments to keep pace with developments and put in place the appropriate regulatory safeguards will remain a concern. The manipulation of artificial intelligence for malicious or unethical purposes will become increasingly widespread, resulting in an urgent need to address and counter artificial intelligence biases.

The global energy mix will see a gradual shift from fossil fuels to the increasing use of renewables and other forms of clean energy over the next 30 years, leading to new resource dependencies. While solar power is expected to become the world's leading renewable energy source by 2024, advances in the technologies underpinning wind power could see this increasing its market share. Elsewhere, nuclear power and hydrogen may play an increasing role, and alternative methods of biofuel production, including the use of algae, may open up fresh opportunities in this field.

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Advances in autonomous technology mean that human intervention may no longer be needed for some modes of transport

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Out to 2055, as the number of mobile devices and electric vehicles grows and the demand for electricity increases, the ability to store energy will become increasingly critical. While lithium-ion batteries dominate at present, solid-state batteries are expected to replace this technology over time, leading to smaller, lighter and safer batteries. In the longer term, further technological advances could see solid-state batteries themselves superseded.

The growth in electricity-based transport solutions is likely to result in a gradual move away from fossil fuel dependency, with urban transport in particular undergoing major changes. Advances in automated transport will see solutions such as last mile delivery by drones and fully autonomous urban transport becoming increasingly widespread. The technology underpinning self-driving vehicles is expected to become increasingly sophisticated, potentially removing the need for human intervention altogether in some modes of transport; however, there will be a pressing requirement for regulation to be put in place to govern their use, not least to cover the question of liability and responsibility for accidents.

Advances in the fields of additive manufacturing (3D printing), automation, artificial intelligence and new materials will revolutionise manufacturing processes and the production of goods. While this will provide opportunities for some, the ability of governments and societies to exploit these advances remains a key uncertainty. In particular, the rapid implementation of automated processes may lead to widespread unemployment in some countries, potentially leading to instability.

In the field of health care, the next three decades are likely to see the increasing use of well-being techniques, preventative medicine and personalised health care strategies, aimed at preventing rather than treating illness and disease. However, while health care techniques will become increasingly sophisticated, not all will be able to afford access to these new forms of treatment, exacerbating already existing health inequalities.

Increasing demand for transplants may see further research into the possibilities offered by techniques such as xenotransplantation (the transfer of organs, cells and tissues from animals to humans) and creating laboratory-grown tissue from a person's own cells. In

other areas, advances in gene editing could offer new breakthroughs and opportunities, although the use of such techniques will continue to give rise to ethical concerns.

The spread of infectious diseases will continue to pose a challenge for societies across the globe out to 2055. The threat of antimicrobial resistance (AMR) will be a particularly pressing concern, potentially limiting the ability to treat some diseases, thereby resulting in significant numbers of deaths.

Biotechnology advances may lead to major improvements in food production, helping to address rising global demand. However, developments in the field of bioweapons may see these becoming increasingly prevalent, raising the possibility of their use against humans, animals and food supplies.

The blurring of the boundaries between the physical, digital and biological worlds will transform human lives and society. Future years are likely to see important advances in human-machine teaming, enabling more effective collaboration between people and uncrewed systems, as well as the increasing use and availability of human augmentation techniques, including for military purposes. While such developments are likely to result in significant improvements and opportunities for many, the questions of safety and ethics will remain a concern.

Connectivity, data and processing power

Global data. Advances in information storage technology are enabling a rapid increase in global data generation. The total volume of data produced in 2010 was two zettabytes (one zettabyte being the equivalent of 250 billion DVDs or 10^{21} bytes); estimates suggest that this will increase to 181 zettabytes a year by 2025.[1] Going by this trend, total global data generation could surpass 32,500 zettabytes annually by 2055.

The value of data. In the future, government and business decision-making will be increasingly dependent on having access to relevant data about citizens and consumers, and the quality of decisions will be determined by the ability to make sense of that data. The physical and digital protection of data will consequently become more critical, with near-term cloud-based solutions tying states to external service providers.[2] By extension, these novel computing solutions are likely to become increasingly important in global power competition and add greater complexity to issues surrounding data sovereignty.

Advances in data storage and processing. For the foreseeable future, the volume of data will exceed the capacity to access, process and analyse it. However, there are promising new concepts of data storage that may be developed further over coming decades. These include DNA storage and 5D optical storage, which have the potential to store large amounts of information over a significant amount of time, and in-memory computing (in-memory analytical processing), which could reduce processing time for data retrieval. Quantum storage, which promises to revolutionise computing and communications, is also on the horizon.

1 IDC, Statista (7 June 2021), 'Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2020, with forecasts from 2021 to 2025 (in zettabytes)'.
2 Chen, A. and Lin, N., *Journal of Knowledge Management*, Volume 20, Number 5 (12 September 2016), 'Global dispersion of offshore service providers: an information processing perspective', pages 1065–1082.

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Developments in quantum computing may accelerate advances in a diverse range of fields

Since their invention in 1948, transistors have been pivotal in shaping developments in computing and were a significant factor behind the transition from the Industrial Age to the Information Age. However, developments in parallel processing and advances in the miniaturisation of integrated circuits (microchips), which so far have driven improvements in processing power, will soon reach the limits of physics, prohibiting further performance increases.[3] Future developments will focus on task-specific processors and software, with advances in graphene, metamaterials, biological, neuromorphic, optical, analogue and quantum-based chip designs offering unique problem-solving approaches. Out to 2055, neuromorphic chips could drive revolutionary advances in artificial intelligence, potentially transforming the way in which society interacts with information and leading to the development of new systems able to produce personalised medical diagnoses at speed.[4] Quantum computing will allow certain problems to be solved far more quickly than conventional computers.

These developments may contribute to revolutionary changes in a number of fields, including financial services, manufacturing, artificial intelligence, cybersecurity and chemical and biological engineering. Embracing these innovations will be crucial to harness their full potential amid a rapidly evolving technological landscape. However, regulation, not least the ability to anticipate future developments and legislate accordingly, will remain a challenge.

Developments in sensor technology. Future developments in sensor technology will result in further miniaturisation, increased energy efficiency and integration with external services such as the cloud. Early research using the unique properties of quantum entanglement (relationships between particles and/or photons over time and space) suggest that future sensors may have the ability to 'see around walls', through adverse weather conditions and may even enable the interpretation of brain waves from a distance.[5] By 2055, quantum sensor technology could be at the stage where it can be

3 IBM, 'Think: Tech news, education and events'.
4 Aboumerhi, K., et al., *Journal of Neural Engineering*, Volume 20 (22 August 2023), 'Neuromorphic applications in medicine'.
5 The UK Quantum Technology Hub in Quantum Enhanced Imaging (11 February 2022), 'How can quantum imaging shape the future of transport'; Fields, R.D., *Scientific American* (10 March 2020), 'Mind Reading and Mind Control Technologies Are Coming'.

used to identify the precise location of minerals under the Earth's surface and in space, and could even (when combined with another technology such as artificial intelligence) increase capabilities in underwater observation and sensing.[6] Over the next 30 years, sensors will become more numerous within both public and private settings, including in urban, rural and subterranean environments. Data from sensors could be used to make cities safer, detect pathogens,[7] improve health care, change the way in which people communicate (including through smart devices), help tackle pollution and improve waste management. At the same time, data from increasingly sophisticated sensors may make humans more vulnerable to malicious actors, as well as increasing the ability of state governments to understand, manipulate and control their citizens, potentially undermining individual privacy and freedoms and creating new policy, legal and ethical challenges.

Communication developments. Advances in Internet speed and accessibility have drastically transformed the way in which society communicates and accesses information. In the last 30 years the world has progressed from dial-up connections with a bandwidth of a mere 14.4 kilobits per second in the 1990s,[8] to today's fibre-optic technology, which connects continents at speeds of up to 10 gigabits per second.[9] Future developments in fibre-optic technologies and infrastructure are expected to result in further increases in data flow capacity,[10] as well as enabling enhanced security measures to protect against tampering.[11]

Over the next three decades, the reduced cost of space access and improvements in inter-satellite communication[12] will see satellite-based Internet becoming more commercially viable, potentially offering complete global coverage in future years. This uninterruptible global connectivity will bring significant benefit to societies and economies, as well as allowing remote locations to be explored (for example, by enabling automated and remotely managed deep-sea mining) without the requirement for large-scale infrastructure investment.[13]

Combined with advances in mobile communication devices, there are likely to be parallel developments in the tools that individuals use to access the Internet, with augmented reality glasses, smart contact lenses and devices that merge the physical and biological worlds potentially becoming more commonplace in the future. As smart devices become increasingly prevalent, economies and societies will rely on them more for everyday tasks, including personalised health surveillance, virtual and augmented reality interactions and accessing public services. Embracing these technological advances will undoubtedly lead to a more connected and innovative world, where information and communication become seamless and pervasive. However, inequality of access to the technology is likely to be an enduring concern and could lead to tensions.

6 Lanzagorta, M., IEEE Xplore, Conference: OCEANS 2015 – MTS/IEEE Washington (11 February 2016), 'Quantum sensing in the maritime environment'.
7 Nnachi, R., et al., *Environment International*, Volume 166 (August 2022), 'Biosensors for rapid detection of bacterial pathogens in water, food and environment'.
8 Plusnet, 'Who invented the Internet?'.
9 Prysmian (5 April 2022), 'What is the maximum speed of fibre optic cable?'.
10 STL (8 June 2022), 'Advances in Fibre-Optic Cable and Connectivity'.
11 STL (31 March 2023), 'The Security and Reliability of Fiber Optic Networks for Critical Infrastructure'.
12 Nijhawan, A., All About Circuits (24 March 2022), 'Inter-satellite Optical Links: A New Frontier for Communications Technology'.
13 Sun, K., et al., *Sensors*, Volume 21 (25 November 2021), 'Review of Underwater Sensing Technologies and Applications'.

Artificial intelligence

Out to 2055, advances in artificial intelligence are expected to bring significant benefits in a wide range of socio-economic areas. From on-edge systems (such as those that enable automated driving, health and social care diagnostics)[14] to more complex advances (such as self-developing artificial intelligence with reasoning and interpretative skills),[15] artificial intelligence is developing faster than the associated governance structures or ethical and regulatory controls, challenging the ability of society to keep pace with developments.

Edge artificial intelligence. This refers to on-device artificial intelligence data processing and decision-making, which reduces or eliminates the need for a cloud connection. The number of edge artificial intelligence devices could triple by 2030[16] due to advances in processing power, storage, communications and sensors, increasing the influence of artificial intelligence in a number of fields. Combined with advances in material science, applications may include smart clothing, visual-processing smart contact lenses and health-interpreting smartphone applications. In the future, edge artificial intelligence will have the ability to exploit large amounts of data and enable storage and processing at the network edges, thereby increasing resilience.

Manipulation of artificial intelligence. There are a number of case studies that demonstrate failings in the way in which algorithms are taught and show how easily artificial intelligence can be manipulated, from incidences of misidentification in legal cases[17] to the manipulation of consumer choices and political opinions.[18] Such incidents may become increasingly prevalent out to 2055, with some individuals and groups potentially encouraging the development of artificial intelligence biases for malicious purposes. The ability to understand, mitigate and regulate to address biases in artificial intelligence systems will be crucial.

Management of bias

Artificial intelligence bias is often generated from the data on which the algorithm is trained. During the COVID-19 pandemic, triage algorithms scored the chest x-rays of COVID patients scanned in the lying position as more acute than those standing – because the severe cases in the training data were from critical patients scanned in a lying position.[19] Other examples are more revealing, such as Amazon's axed artificial intelligence-based recruitment programme, which revealed a bias against women in the ten years of hiring data on which it was trained.[20] Techniques such as explainable artificial intelligence promise to reduce such failures, and perhaps more powerfully, reveal many uncomfortable truths about the human systems they replace, thereby providing a platform for accountability.[21]

14 STL Advisory Limited (2017), 'Digital health at the edge: Three use cases for the healthcare industry'.
15 Heaven, W. D., *MIT Technology Review* (27 May 2021), 'AI is learning how to create itself'.
16 Ding, A., *Computer Communication Review* (27 November 2021), 'Roadmap for Edge AI: A Dagstuhl Perspective'.
17 Najibi, A., Science in the News (24 October 2020), 'Racial Discrimination in Face Recognition Technology'.
18 Brundage, M., et al. (February 2018), 'The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation'.
19 Heaven, W. D., *MIT Technology Review* (30 July 2021), 'Hundreds of AI tools have been build to catch COVID. None of them helped'.
20 Parikh, N., *Forbes* (14 October 2021), 'Understanding Bias in AI-enabled hiring'.
21 Silberg, J. and Manyika, J., McKinsey Global Institute (June 2019), 'Notes from the AI frontier: Tackling bias in AI (and in humans)'.

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The application of artificial intelligence systems has enhanced a number of areas, including museum experiences

Advances in artificial intelligence reasoning and application. Despite these challenges, it is likely that the capacity of artificial intelligence, with its increasing ability to contextualise from multiple information strands, will surpass that of a human on image-based tasks by 2030.[22] Artificial intelligence systems already have the ability to recognise and perceive objects in images and videos, while generative artificial intelligence can compose and recreate media; this technology has gained significant attention and has been applied in diverse areas, such as creating digital clones of deceased actors to use in current projects, improving film dubbing, enhancing museum experiences and assisting individuals with speech impairment.

Looking ahead, generative artificial intelligence could continue to revolutionise media and marketing, allowing businesses to target individual preferences more accurately.[23] It could also lead to interactive operating systems as well as personalised media, virtual health care[24] and educational services.[25] Through natural language processing applications (such as OpenAI's ChatGPT or Google's Bard), generative artificial intelligence will be used not only to facilitate data retrieval, report writing and business transactions, but also for multilingual information access. By 2055, the use of natural language processing applications may be helping to break down language barriers between different societies, fostering greater global connectivity.

22 Ober, H., Neuroscience News (31 July 2023), 'AI vs Human Reasoning: GPT-3 Matches College Undergraduates'.
23 Koidan, K., Topbots (8 June 2020), '8 AI Companies Generating Creative Advertising Content'.
24 Bajwa, J., et al., *Future Healthcare Journal*, Volume 8, Number 2 (July 2021), 'Artificial intelligence in healthcare: transforming the practice of medicine', pages e188–e194.
25 United Nations (UN) Educational, Scientific and Cultural Organization (2023), 'Artificial intelligence in education'.

Artificial intelligence and actors

Advances in artificial intelligence technology have enabled the recreation of actors, both living and deceased, in films and media, profoundly impacting the film industry's future. The digital resurrection of James Dean in 'Back to Eden' exemplifies this potential. However, this development raises ethical and legal concerns, including consent, authenticity, property rights and the impact on original performers' legacies. While recent actors' strikes have achieved some success in ensuring protection from artificial intelligence use and image rights, the long-term evolution of the film industry and future regulatory developments concerning the data on which artificial intelligence models train remain uncertain.[26]

Impact of artificial intelligence. As generative artificial intelligence develops, it may cause disruption to job markets, enhancing productivity while reducing the need for human employees. In addition, the potential for the misuse of generative artificial intelligence to create deepfakes[27] is also a growing concern. Artificial intelligence is already being exploited for unethical and/or illegal purposes, from creating explicit content to spreading disinformation to influence elections.[28] In response to this, efforts to develop deepfake detection techniques are expected to intensify,[29] and these will become an increasingly vital tool for governments, businesses and security and intelligence agencies.

In the longer term, advances in generative artificial intelligence that is able to self-code or self-develop are not an implausible development. Self-coding artificial intelligence could revolutionise the computer gaming industry through crowd-sourced development and personalised gaming experiences.[30] It could also reshape human–computer interactions and modify human behaviour,[31] leading to novel experiences such as virtual space holidays[32] or jobs in virtual worlds.[33] Emerging neural interfaces could improve the ability of artificial intelligence to interpret human expressions, emotions and physical characteristics,[34] to the point where artificial intelligence algorithms know more about an individual than they know about themselves, possibly interpreting human thoughts before they become conscious reality.[35] The moral, ethical and legal implications of these developments will most likely be

26 Velasquez, S.J., BBC (19 July 2023), 'How AI is bringing film stars back from the dead'.
27 Mazzucchi, N., Hybrid CoE, Hybrid CoE Paper 14 (June 2022), *AI-based technologies in hybrid conflict: The future of influence operations*.
28 Padmanabhan, D., Queen's University Belfast (12 October 2023), 'Use of AI in elections could damage fabric of democracy according to Queen's researchers'.
29 Almars, A., *Journal of Computer and Communications*, Volume 9, Number 5 (May 2021), 'Deepfakes Detection Techniques Using Deep Learning: A Survey', pages 20–35.
30 Zhu, J. and Ontañón, S., Foundations of Digital Games '20: Proceedings of the 15th International Conference on the Foundations of Digital Games (17 September 2020), 'Player-Centered AI for Automatic Game Personalization: Open Problems'.
31 Dezfouli, A., et al., *PNAS*, Volume 117, Number 46 (4 November 2020), 'Adversarial vulnerabilities of human decision-making'.
32 Roman, M., et al., *Sustainability*, Volume 14, Issue 2 (6 January 2022), 'Virtual and Space Tourism as New Trends in Travelling at the Time of the COVID-19 Pandemic'.
33 Rathnaweera, D. and Jayathilak, R., PLoS One, Volume 16 (19 November 2021), 'In employees' favour or not?—The impact of virtual office platform on the work-life'.
34 Murugesu, J., *New Scientist* (30 March 2020), 'Mind-reading AI turns thoughts into words using a brain implant'; Rainey, S., et al., *Science and Engineering Ethics*, Volume 26 (30 April 2020), 'Brain Recording, Mind-Reading, and Neurotechnology: Ethical Issues from Consumer Devices to Brain-Based Speech Decoding', pages 2295–2311.
35 Cuzzolin, F., et al., *Psychological Medicine*, Volume 50, Issue 7 (May 2020), 'Knowing me, knowing you: theory of mind in AI', pages 1057–1061.

widely debated in coming years and may lead to increasing pressure to regulate or restrict the use of artificial intelligence in future, particularly in liberal democracies where there is a strong expectation of personal freedoms and responsibility.

Digital twins. Digital twins are virtual representations of physical objects, systems or processes, designed to simulate, analyse and optimise real-world scenarios. Created exclusively or with a combination of sensor data, machine learning algorithms, advanced modelling techniques and synthetic environments, they accurately mirror their real-world counterparts. Digital twins have potential application across various sectors, such as manufacturing, health care, smart city development, aerospace and the automotive industry, with future developments leading to increasingly sophisticated and accurate representations and modelling.[36] As the technology progresses, digital twins may integrate with other enabling technologies such as artificial intelligence, augmented reality and social media, potentially allowing an individual's online representation to endure beyond their physical lifetime.[37] This integration could result in more advanced simulations and predictions, empowering governments, businesses and organisations to improve decision-making and enhance overall efficiency.

Energy generation, storage and renewables

The green energy transition. In the future, the global energy mix is expected to see a gradual shift away from fossil fuels in favour of renewables, electrification and low-carbon hydrogen.[38] Securing raw materials for low-carbon energy production, along with improving production capacity, will be crucial. China's significant control over the minerals required for green energy production will drive competing actors to increase their efforts to identify new sources, and in the long term potentially develop new technologies with different dependencies.[39] At the same time, fossil fuel-exporting states will face the challenge of achieving economic diversification to maintain current levels of growth, and may face instability as a result of this transition process if popular expectations are not met.

Renewable energy advances. Renewable energy has experienced remarkable growth in the last decade, driven primarily by scalable solar and wind power. Despite high investment costs due to elevated commodity prices, utility-scale solar photovoltaic power is the least expensive option for new electricity generation in most countries. China, leading in capacity, added 100 gigawatts in 2022, a 60% increase from 2021; other countries are also significantly increasing their capacity, for example, India and Brazil.[40] As a result of these developments, it is predicted that solar energy, particularly photovoltaic collection using semiconductor materials, will become the primary global renewable energy source by 2024.[41] Sun-rich regions have vast potential to capitalise on large-scale photovoltaic farms, making it the most cost-effective method of electricity generation, with further cost reductions anticipated by 2055.

36 Sharma, A., et al., *Journal of Industrial Information Integration*, Volume 30 (November 2022), 'Digital Twins: State of the art theory and practice, challenges, and open research questions'.
37 Bruneault, F., et al., *Applied Human Rights* (27 June 2023), 'The privacy of the dead: Human dignity in digital afterlife: an information ethics perspective', pages 185–204.
38 International Energy Agency (October 2023), *World Energy Outlook 2023*, 'Table E1. Electricity generation: World, Reference case'.
39 Institute for Energy Research (5 June 2019), 'China Controls Global Rare Earth Mineral Trade'.
40 International Energy Agency, 'Solar PV'.
41 International Energy Agency (December 2022), *Renewables 2022: Analysis and forecast to 2027*, 'Renewable electricity'.

The demand for energy storage is likely to drive interest in hydropower

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Wind power, currently the second cheapest form of renewable energy production, has also seen increased investment in recent years. China installed 37 gigawatts in 2022, including 7 gigawatts offshore. That same year, Europe added 13 gigawatts to its capacity, while the UK, second only to China, installed almost 3 gigawatts of offshore wind capacity.[42] At present, wind power is predominantly onshore and in coastal areas, which require simpler foundations and allow easier maintenance access than offshore sites.[43] However, a new trend towards offshore developments will enable the use of larger turbines, and benefit from stronger winds and less restrictive planning requirements. Projects include a 25 megawatt floating offshore wind farm situated off the coast of Viana do Castelo, Portugal and a 30 megawatt floating wind farm off the coast of Peterhead, Scotland.[44] Advances in siting technology will enable the exploitation of deep ocean locations, with several sites already using floating turbines.[45]

Out to 2055, other forms of renewable energy production such as biofuels, geothermal energy, hydropower (which includes energy storage within water reservoirs) and marine energy will become increasingly prevalent.[46] However, their cost relative to solar and wind power are likely to see them confined to specialist applications.

Managing supply and demand. As renewable energy sources begin to meet a rising proportion of energy demand, the ability to balance supply and demand on traditional energy grids will become increasingly challenging. Decentralised energy systems, drawing power from local networks, are likely to become increasingly dominant. These systems will

42 International Energy Agency, 'Wind'.
43 Ren, Z., et al., *Renewable and Sustainable Energy Reviews*, Volume 144 (July 2021), 'Offshore wind turbine operations and maintenance: A state-of-the-art review'.
44 UN Regional Information Centre for Western Europe (21 April 2022), 'Floating wind turbines: a new player in cleantech'.
45 Johnson, A., et al., *Science* (21 April 2022), 'Offshore renewables need an experimental mindset'.
46 Wilberforce, T., et al., *Energy*, Volume 175 (15 May 2019), 'Overview of ocean power technology', pages 165–181.

foster increasing competition between energy providers and empower local communities to control their own energy production, requiring grid modernisation in developed regions and grid expansion in developing ones.[47]

Electrical energy storage. Electrical energy storage technology will play a crucial role in the ability to maintain a reliable energy supply, not least as an increasing number of mobile devices and electric vehicles begin to increase the demand for power. Lithium-ion batteries currently dominate the market, serving electric vehicles and short-duration electricity storage applications; development is currently ongoing to achieve improvements in their power density, safety and charge/discharge rate, as well as to address concerns over rising dependency on lithium as a critical mineral. Over time, solid-state batteries are expected to supersede lithium-ion technology, offering smaller, lighter and safer batteries containing organic and inorganic electrolytes, such as metallic sodium and metallic lithium.[48] Over the next 30 years, there is the potential for advances in material science and manufacturing processes to lead to the development of ground-breaking new technologies that could surpass solid-state batteries. Supercapacitors are also a promising area of storage technology, boasting superior power density and charging capabilities. Currently, capacitors are used in public transport systems such as buses and trams in major cities and are recharged at specialist stations; charging facilities may evolve further in the future, potentially into underground wireless systems using magnetic coils.[49] Electric vehicles and drones will become more robust and capable of travelling longer distances into remote areas, which will enable improvements in surveillance capabilities, search and rescue operations, delivery services and innovative methods of transportation.

Alternative energy sources. Although technological and commercial barriers remain, by 2055, hydrogen, space-based energy[50] and clean coal with carbon capture and storage[51] could play a greater role in the global energy mix, opening up new opportunities for trade, investment and skills development. Nuclear fission is already used for commercial electricity generation in over 438 plants across 38 countries, with a further 60 under construction as of 2024.[52] Fission reactors may become smaller and modular, with more than 80 small- and medium-sized modular reactors under development around the world,[53] making new nuclear power plants quicker and cheaper to build.[54] Fusion, a greener and safer alternative to fission, is currently under development, but for now is less mature, and achieving commercial viability remains challenging. Even with early commercialisation by 2035–40, fusion power may only contribute a small percentage to global energy production by 2055 due to industrial requirements and technical complexity.[55]

47 Wieczorek, A., et al., SSRN (16 February 2022), 'Decentralised Energy Futures. Emerging New Logics of Energy System Organisation'.
48 He, X., IDTechEx (18 October 2023), 'Empowering the Future: The Progress of Solid-State Battery Technology'.
49 Yuvaraja, S., et al., *Frontiers in Energy Research*, Volume 10 (7 July 2022), 'A Comprehensive Review of the On-Road Wireless Charging System for E-Mobility Applications'.
50 Lea, R., Space.com (12 June 2023), 'Scientists beam solar power to Earth from space for 1st time ever'.
51 Bhavsar, A., et al., *Case Studies in Chemical and Environmental Engineering*, Volume 8 (December 2023), 'The current scope and stand of carbon capture storage and utilization – A comprehensive review'.
52 World Nuclear Association (April 2024), 'World Nuclear Power Reactors & Uranium Requirements'.
53 International Atomic Energy Agency, 'Small modular reactors'.
54 Crownhart, C., *MIT Technology Review* (8 February 2023), 'We were promised smaller nuclear reactors. Where are they?'.
55 Ball, P., *Scientific American* (1 June 2023), 'What Is the Future of Fusion Energy?'.

The ‘food versus fuel’ debate could lead to growing interest in new methods of biofuel production

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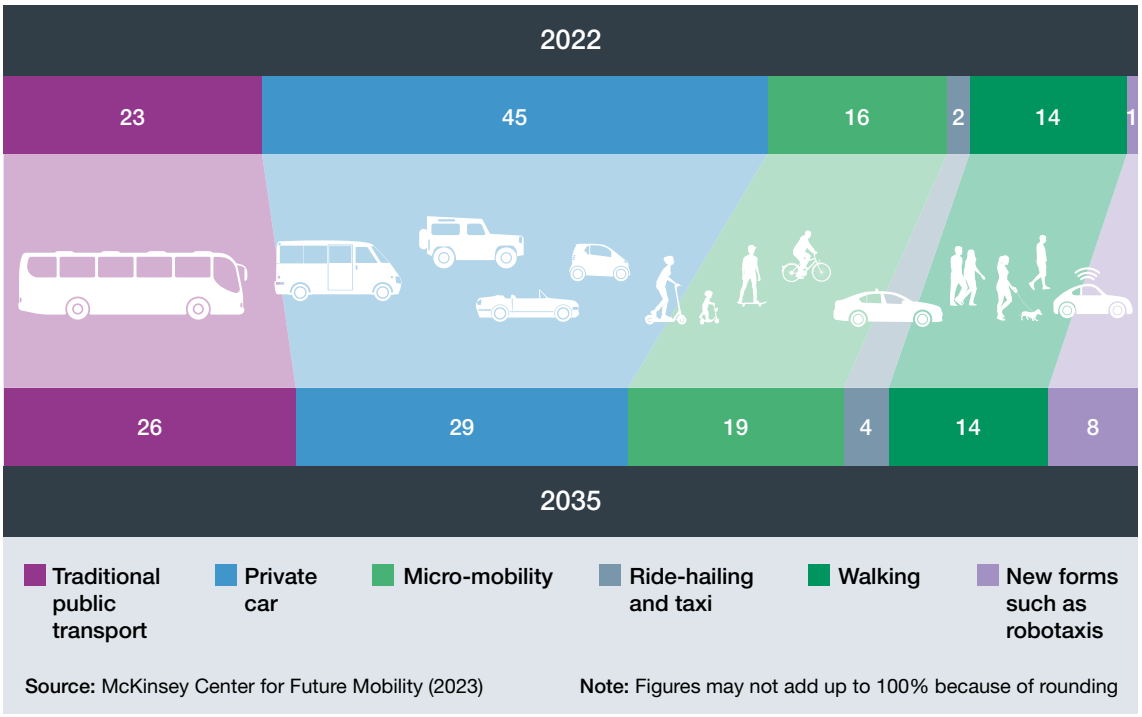
Investment in hydrogen energy production via electrolysis is growing, but high production costs currently hinder large-scale exploitation. Early concept space-based power projects are also under development, offering the potential for abundant energy without terrestrial constraints such as night or cloud cover, providing eight to nine times more power than photovoltaics on Earth.[56] While significant investments have been made in carbon capture and storage, cost and efficiency issues persist, particularly in relation to retrofitting older power plants.[57]

Biofuels and energy generation. The majority of biofuels are currently used in transportation as an eco-friendly alternative to fossil fuels. However, the ‘food versus fuel’ debate raises concerns as traditional agricultural methods for producing biofuels compete with food production. To address this, alternative methods, such as using algae for biofuel production, are being explored to assess their economic viability.[58] New types of microbial fuel cells, similar to metal-based batteries, show promise as portable energy sources. While current microbial fuel cells are only able to generate sufficient electricity to power small devices such as calculators, small fans and light-emitting diodes (LEDs), they are able to provide power over a significant period of time. This has generated interest in their potential application to power technologies requiring low input, such as waste treatment processes, implanted medical devices or equipment in remote areas where electricity infrastructure is limited. Future developments may see an increase in the power outputs and operational lifetimes of microbial fuel cells, potentially opening new avenues for their use as a replacement for traditional and often more environmentally damaging fuel sources.[59]

56 Perkins, R., California Institute of Technology (Caltech) (1 June 2023), ‘In a First, Caltech’s Space Solar Power Demonstrator Wirelessly Transmits Power in Space’.
57 S&P Global, Statista (8 June 2023), ‘Estimated cost ranges for carbon capture and storage (CSS) and carbon dioxide removal (CDR) solutions as of 2023, by approach or technology (in U.S. dollars per ton of CO_2)’.
58 Jabłońska-Trypuć, A., et al., *Energies 2023*, Volume 16, Number 4 (10 February 2023), ‘Using Algae for Biofuel Production: A Review’.
59 Vinoth Kannan, S.R., et al., *Valorization of Wastes for Sustainable Development: Waste to Wealth* (2023), ‘Chapter 2 – Mitigation of environment crisis: conversion of organic plant waste to valuable products’.

Transportation

The move to net zero. While fossil fuels may remain the dominant energy source for transport until 2030, countries with net-zero policies are likely to increasingly move towards electricity-based solutions over the next 30 years. Urban transport in particular will see significant changes, with the rise of micro-mobility devices such as electric bikes and scooters offering commuters a cheaper and greener alternative to traditional modes of transportation. By 2055, micro-mobility may be the primary means of transportation in some smart cities. However, not all modes of transport will necessarily have electric alternatives. Shipping, long-distance air travel, military transport, emergency services and heavy road freight may require energy-dense fuel supplies, such as synthetic biofuels, liquid hydrogen or green fossil fuel combustion, which currently face economic and technological barriers to their widespread adoption.



Modes of transport worldwide out to 2035, as a percentage

Advances in automated transport. Out to 2055, the integration of sensor and semiconductor technologies, artificial intelligence, positioning, navigation and timing systems and laser scanning as part of the Internet of things will revolutionise both public and private transportation. This convergence will pave the way for fully autonomous driving, which will eventually become an integral part of future intelligent transportation systems. Developments in autonomy will lead to new business opportunities, with services such as last-mile delivery by autonomous drones and fully autonomous urban transport becoming more prevalent. In maritime transport, not only has this shift led to a reduction in crew sizes, but future advances may potentially eliminate the need for a crew altogether.[60] These changes may also usher in the automation of functions such as self-inspection, self-maintenance and self-assembly, performed by drones and underwater robots.

60 Kooij, C. and Hekkenberg, R., *Maritime Policy & Management*, Volume 49, Issue 6 (2021), 'The effect of autonomous systems on the crew size of ships – a case study', pages 860–876.

New aircraft designs, such as Archer Aviation's electric aircraft, have the potential to see the introduction of the long awaited flying car of the future

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Regional tensions and low levels of cooperation between key global actors could hinder the seamless integration and automation of transportation systems across borders. However, if states are able to recognise the opportunities as well as the challenges that these developments offer, there is the chance for them to work together to adopt global standards and protocols, enabling greater integration of passenger and goods movement within multimodal transport networks.

Impact of automation. The current landscape of personalised vehicles that can self-drive under limited constraints is set to expand further in the future, potentially reaching a point where decision systems operate without any human intervention. As this technology evolves over the next 30 years, the issue of legal liability for incidents involving highly automated vehicles is likely to be tested in various ways through litigation.[61] A key uncertainty will be the policy, legal, ethical and other frameworks governing the delineation of responsibility between users, owners, engineers and designers of automated systems.

The changing dynamics of how humans interact with automated transport will also impact the process of obtaining a driving licence. In the future, normal and specialist licences, such as those for heavy goods vehicles, may require individuals to pass a test to account for any potential 'skills fade' and ensure that they can take control of a vehicle if the autonomous system fails. Driving licences may also become digitised and be able to communicate with vehicles to ensure their legal operation.[62]

In logistics, automation is already being used to track and monitor the movement of goods. In the future, automated maritime transport and heavy goods road trains may be operated with only one human operator or potentially none at all. Automation will also transform public transportation and some countries may adopt fully automated rail or bus systems, offering efficient and reliable services. Furthermore, in urban settings, consumers may increasingly

61 Pattinson, JA., et al., *Humanities & Social Sciences Communications*, Volume 7 (18 November 2020), 'Legal issues in automated vehicles: critically considering the potential role of consent and interactive digital interfaces'.
62 European Commission, 'Electronic driving licences'.

opt to hire personalised automated transport instead of owning vehicles. Overall, developments in the automation of transportation offer the potential for increased safety, efficiency and convenience. However, addressing current legal, ethical and safety concerns will be crucial to ensure the smooth integration of these technologies in the future.

Advanced air mobility. New aircraft designs, such as Archer Aviation's electric vertical take-off and landing aircraft and BETA Technologies' electric vertical aircraft, have the potential to make air transport accessible to a larger number of private individuals and commercial actors, with projections that the sector could be worth over United States (US) $510 billion by 2040.[63] Drone transport will occupy an important stake in the market, with over 75,000 vehicles expected to be operational by 2030,[64] and projections that this will grow further by 2055. Advanced air mobility will also find applications in logistics, with companies such as Amazon, DHL, UPS and Zipline pioneering short-distance drop-on delivery services. In the medical field, advanced air mobility is already being used to deliver blood supplies in Rwanda, and may eventually be used for disaster management and casualty transportation during emergencies. By 2055, advanced air mobility could be helping to bridge the gap between urban and rural populations, with drones regularly delivering life-saving medical supplies and products to remote locations.

Blood transport in Rwanda and Ghana

An example of advanced air mobility is the partnerships that both Ghana and Rwanda have with the US company Zipline, a drone delivery service, which successfully transports blood, vaccines and other medical supplies to rural hospitals and clinics. This service can reduce delivery times to under an hour. Outside of Kigali in Rwanda, approximately 75% of blood is delivered by drones. Between 2019 and 2021, this service is estimated to have saved an additional 727 lives in Ghana. As technology advances, further improvements in aerial blood and medical supply transportation can be expected, enabling quicker and more widespread access to health care.[65]

Manufacturing and production

Out to 2055, evolving technologies such as additive manufacturing, automation, artificial intelligence and the development of new materials (such as the ultimate goal of ambient superconductors[66]) will have an impact on the manufacturing industry, and by extension on economies, societies and the environment.

Additive manufacturing. While additive manufacturing presently holds significant value for prototyping, rapid tooling and custom components, its ultimate long-term potential is believed to lie in large-scale multi-material printing,[67] although there remains uncertainty as

63 Innovate UK (August 2021), *UK Transport Vision 2050: investing in the future of mobility*.
64 Ibid.
65 Kremer, P., et al., *Science Robotics*, Volume 8, Issue 85 (20 December 2023), 'Bringing underserved communities life-saving aid through aerial logistics'.
66 Castelvecchi, D., *Nature* (1 September 2023), 'How would room-temperature superconductors change science?'.
67 Nazir, A., et al., *Materials & Design*, Volume 226 (February 2023), 'Multi-material additive manufacturing: A systematic review of design, properties, applications, challenges, and 3D printing of materials and cellular metamaterials'.

to whether it will be capable of supplanting more cost-effective mass production methods and any improvements are likely to be sector specific. For certain goods, however, the widespread uptake of additive manufacturing has already changed logistics, product design, intellectual property, local production and mass customisation. In addition, 4D printing (where additive manufacturing structures change in response to external stimuli) shows promise in various fields.[68] Additive manufacturing has already had an impact on the world's societies and economies, and studies suggest that by the middle of the century this technology could lead to a 5–27% reduction in global energy usage by streamlining supply chains and reducing production waste.[69] A number of countries, including the US, Canada and China, are currently investing in additive manufacturing to bolster their security, defence and energy capabilities.[70] In the medical industry, 3D bioprinting has already resulted in the successful creation and transplant of tissue, which could potentially reduce reliance on donor organs.[71] Similarly, 4D printing could have applications in paediatric care, using responsive materials or cells that adapt with a child's growth, thereby reducing the need for further invasive surgery.[72]

Automation and robotics. Automation has already significantly transformed manufacturing, with software and data-driven processes evolving to enable greater collaboration between human and machines, boosting efficiency and product quality whilst reducing labour and production costs.[73] The integration of artificial intelligence and the Internet of things into automated processes over the past decade has propelled further advances in this field. Internet of things products connecting machines, computers and sensors enable remote monitoring of manufacturing processes and facilities to enhance production and quality. Similarly, algorithms fuelled by artificial intelligence and ever-increasing amounts of data have enabled automation to extend into non-routine tasks and areas once deemed beyond technology's reach, for example, financial analytics, payment processing, call centres, fraud detection and real-time inventory analysis for supply chains.[74]

Many manufacturers already use some form of robotics and artificial intelligence, and looking forward there is a clear trend towards the increased adoption of artificial intelligence-powered robots in coming decades.[75] In the future, machines will handle much of the mechanical and mathematical workload, while humans focus on creative and strategic decisions.[76] However, the rapid roll-out of automation may lead to large-scale unemployment in some sectors, and if not sensitively managed this could lead to instability. The extent and pace of automation will be critical to determining its impact, and governments will play a crucial role in managing the transition.

68 Monfared, V., et al., *Metals and Materials International*, Volume 29 (3 June 2023), 'Science and Technology of Additive Manufacturing Progress: Processes, Materials, and Applications', pages 3442–3470.
69 Verhoef, L., et al., *Energy Policy*, Volume 112 (January 2018), 'The effect of additive manufacturing on global energy demand: An assessment using a bottom-up approach', pages 349–360.
70 The Information and Communications Technology Council (29 April 2021), *Just Press "Print": Canada's Additive Manufacturing Ecosystem*, page 53.
71 Jiang, R., et al., *Technological Forecasting and Social Change*, Volume 117 (April 2017), 'Predicting the Future of Additive Manufacturing: A Delphi study on economic and societal implications of 3D printing for 2030', pages 84–97.
72 University of Maryland, IEEE Spectrum (8 October 2019), '4D Bioprinting Smart Constructs for the Heart – Maryland researchers investigate new 4D printing techniques to control stem cell cardiomyogenesis'.
73 Tilley, J., McKinsey & Company (7 September 2017), 'Automation, robotics, and the factory of the future'.
74 Herrell, K., *Forbes* (9 February 2024), 'Understanding AI And ML In The Real-Time Economy'.
75 Kandukuri, G., Saxon (16 December 2022), 'Impact of AI in Manufacturing- Improved Quality and Efficiency'.
76 Manyika, J. and Sneader, K., McKinsey Global Institute (1 June 2018), 'AI, automation, and the future of work: Ten things to solve for'.

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The impact of automation on the workforce will require careful management

New materials. Significant efforts are being devoted to developing new materials and advanced manufacturing techniques, which out to 2055 is expected to expand the range of materials used in manufacturing. This will lead to higher quality, cheaper and more environmentally friendly products, offering innovative solutions to current and future challenges. For instance, the super-conductive properties of graphene may propel emerging technologies that rely on superconductivity from the laboratory to commercial applications.[77] In addition, metamaterials could be developed to provide new sensor and computer devices.[78] Nanomaterials, when finely divided, exhibit unique properties, such as nano-silver's antibacterial capabilities for medical equipment sterilisation[79] or titanium dioxide nanoparticles' combustibility as an additive to biodiesel fuel.[80]

Ability to exploit advances. The combined impact of additive manufacturing, artificial intelligence, automation and the development of new materials will have a profound effect on manufacturing processes, distribution, sales and working patterns. However, technology development is only one factor; the true influence will depend on how societies exploit these advances. International collaboration and knowledge-sharing will be crucial to make the most of the opportunities offered; however, the social, political and geopolitical climate will remain a critical uncertainty affecting the pace of development.

Medical advances, health care and biotechnology

Health care. The global health care burden will increase out to 2055 as healthy life expectancies (the healthy period of an individual's life) fail to keep pace with increasing actual life expectancy. As a result, there will be a greater shift towards the promotion of

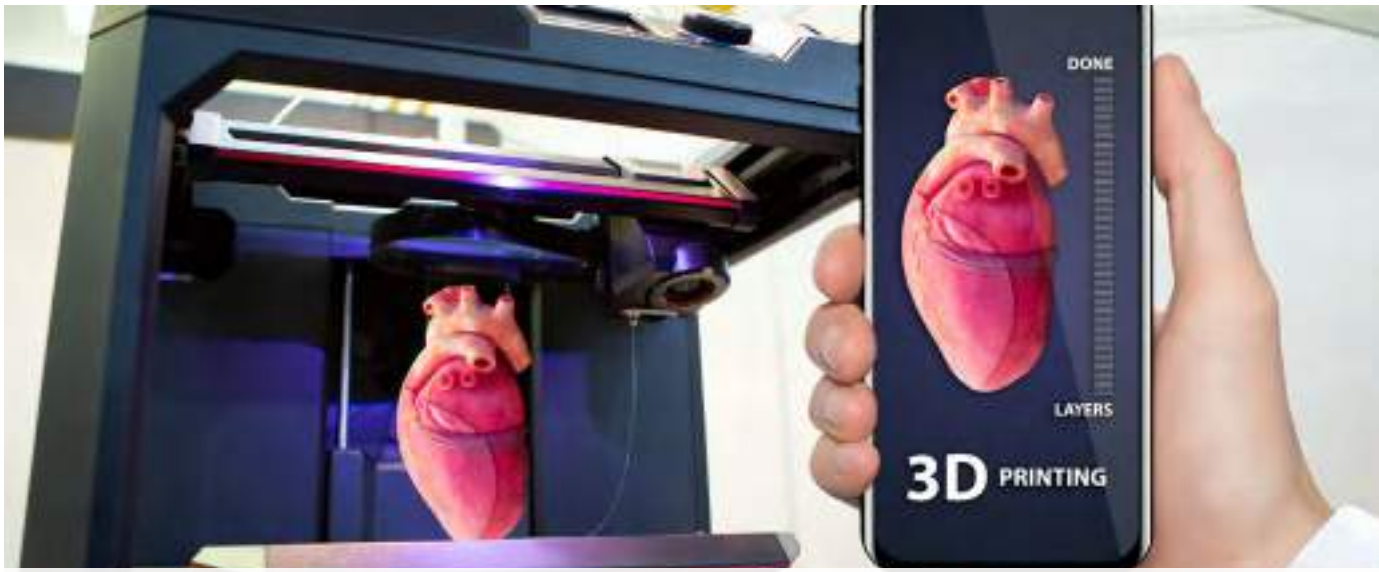
77 Dumé, I., *Physics World* (19 February 2021), 'Twisted trilayer graphene could help make high-temperature superconductors'.
78 Kumar, R., *Materials Today: Proceedings*, Volume 56, Part 5 (2022), 'Overview on metamaterial: History, types and applications', pages 3016–3024.
79 Marassi, V., *Royal Society Open Science*, Volume 5, Issue 1 (31 January 2018), 'Silver nanoparticles as a medical device in healthcare settings: a five-step approach for candidate screening of coating agents'.
80 Sunil, S., et al., *Materials Today: Proceedings*, Volume 44, Part 1 (2021), 'Studies on titanium oxide nanoparticles as fuel additive for improving performance and combustion parameters of CI engine fueled with biodiesel blends', pages 489–499.

well-being techniques, preventive medicine and individualised health care, in an effort to prevent rather than treat illness and disease at its onset.[81] Health care and well-being strategies are likely to become increasingly personalised and based on an individual's unique characteristics and physiology, with the monitoring of therapies, diets and exercise becoming more data-driven and tailored towards a person's specific needs. Techniques might include targeted pharmacology, personalised vitamins and supplements and bespoke diets, as well as more sophisticated methods that harness a patient's own immune system to fight illness.[82] However, it is likely that not everyone will be able to afford access to these treatments, potentially resulting in increasing health inequalities.

Over the next three decades, technology developments will enable the more widespread use of remote interactions between health care providers and patients, through telehealth services, smart devices for monitoring long-term conditions[83] and user-friendly digital diagnostic tools. These developments will offer ways for more regular and personal interaction between patients and clinicians, especially in secondary and tertiary care, offering increased support beyond the hospital setting. Technology advances combined with an improved understanding of human disease will pave the way for more curative therapies, with the potential for many of the illnesses that currently blight society to eventually disappear entirely. In areas where these treatments are more readily available, this may enable greater freedom in lifestyle choices, including those with negative health implications such as smoking, drug use and the excessive consumption of food and alcohol.

Transplant medicine and artificial organs. The demand for transplants as a result of chronic disease and organ failure is expected to grow in the future, leading to a shortfall in the availability of compatible organs and donors.[84] Xenotransplantation (the transplantation of organs, cells or tissues from animals to humans) is one option that may help to address this issue, with advances in genetics and immunology potentially helping to identify new ways to reduce the likelihood of organ rejection.[85] Organoids are another promising area for future development. These clusters of cells originate from stem cells and function as miniature versions of full organs. Significant progress has been made in growing organoids on a small scale for major organs such as the brain, heart, liver, lungs, stomach, gut and skin.[86] Future developments may see the production of laboratory-grown tissue from an individual's own cells, offering the potential to restore partial or full function in diseased or damaged organs. Both 3D and 4D bioprinting are also being explored as a means to produce artificial organs; developments in this field have already seen the successful recreation of body structures, including blood vessels, providing an insight into its potential application for organ reproduction.[87] However, fully functioning 3D- and 4D-printed organs are unlikely to be used in the near term due to the complexities of integrating them into the human body. In the meantime, research will focus on using 3D- and 4D-printed tissues as valuable tools in clinical research.

81 Kennedy, F., *Policy Design and Practice*, Volume 3, Issue 4 (9 March 2020), 'Beyond "prevention is better than cure": understanding prevention and early intervention as an approach to public policy', pages 351–369.
82 Rizzo, A., et al., *Journal of Clinical Medicine*, Volume 11, Issue 21 (November 2022), 'Cancer Immunotherapy: Harnessing the Immune System to Fight Cancer'.
83 Peyroteo, M., et al., *JMIR mHealth and uHealth*, Volume 9, Issue 12 (21 December 2021), 'Remote Monitoring Systems for Patients With Chronic Diseases in Primary Health Care: Systematic Review'.
84 Sterri, A.B., et al., *Cambridge Quarterly of Healthcare Ethics*, Volume 31, Issue 3 (28 July 2022), 'Ethical Solutions to the Problem of Organ Shortage', pages 297–309.
85 Gallagher, J., BBC News (13 March 2022), 'Xenotransplantation: Are pigs the future of organ transplants?'.
86 Zhao, Z., et al., *Nature Reviews Methods Primers*, Volume 2, Number 1 (1 December 2022), 'Organoids'.
87 Kim, J., *International Journal of Stem Cells*, Volume 15 (28 February 2022), 'Lo and Behold, the Lab-Grown Organs Have Arrived!'.



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The application of bioprinting will initially focus on bone and skin, but could potentially be extended to entire organs in the future

Mental health and psychology. In coming years, mental health treatment may involve the use of specifically tailored and individualised artificial intelligence that is able to understand and respond to patients in a human-like manner.[88] Future applications of artificial intelligence therapy may even delve into the realm of 'grief tech', where artificial intelligence interprets the data footprint left behind by the deceased to bring their memories and presence to life for those in mourning.[89] Additionally, those experiencing loneliness might find solace in personalised artificial intelligence avatars able to engage in conversations and interactions, mimicking human companionship to some extent. This artificial intelligence-based support could prove valuable in combatting feelings of isolation and enhancing emotional well-being.[90]

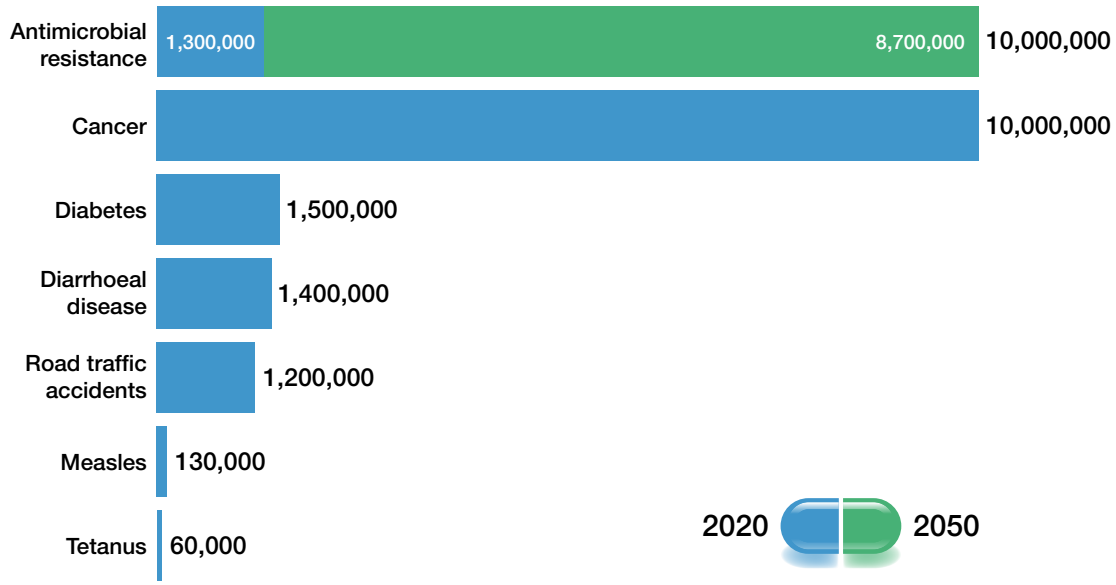
Genetic engineering. The early 2010s saw the development of the revolutionary CRISPR-Cas9 genetic editing technique, transforming the field of genetic engineering with the potential to alter human genes to eliminate disease, create more resilient agriculture and livestock, and eradicate certain pathogens entirely. Since its discovery, CRISPR has shown promise in curing genetic and autoimmune disorders and even neurodegenerative diseases. Potential future applications of gene editing could revolutionise health care and biology, offering solutions such as a cure for cancer,[91] halting the ageing process,[92] and even enabling non-therapeutic modifications, which could lead to the creation of 'designer babies'.[93] It may also pave the way for creating entirely new, genetically engineered species.[94] Moreover, the cost of using CRISPR technologies is steadily decreasing, with

88 Minerva, F. and Giubilini, A., *Topoi*, Volume 42, Issue 3 (31 May 2023), 'Is AI the Future of Mental Healthcare?', pages 809–817.
89 Reese, A., *New Scientist* (14 November 2023), 'How AI avatars of the deceased could transform the way we grieve'.
90 Zheng, Q., et al., *Journal of Safety Science and Resilience*, Volume 4, Issue 4 (December 2023), 'Artificial intelligence empowering research on loneliness, depression and anxiety — Using Covid-19 as an opportunity', pages 396–409.
91 University of Oxford (3 September 2021), 'Vaccine for treating cancer made possible using Oxford COVID vaccine technology'.
92 Le Page, M., *New Scientist* (6 January 2021), 'CRISPR doubles lifespan of mice with rapid ageing disease progeria'.
93 Hercher, L., *MIT Technology Review* (22 October 2018), 'Designer babies aren't futuristic. They're already here'.
94 Ball, P., *Scientific American* (May 2023), 'Synthetic Morphology Lets Scientists Create New Life-Forms'.

a simple genetic alteration now available commercially for less than US $300.[95] However, as the cost continues to decline and the technology becomes increasingly accessible, there is concern that it could fall into the hands of hostile actors and be used for malicious purposes. In addition, the use of gene editing techniques will continue to raise legal, policy and ethical questions, particularly around issues of consent and the potential exacerbation of social inequalities.

Disease control. The threat of infectious disease outbreaks will continue due to microbial adaptation, ecological changes, shifts in human demographics and behaviour, encroachment into animal habitats and alterations in public health practices. However, out to 2055, advances in technology may offer more responsive ways to combat emerging and re-emerging pathogens.

Over coming decades, AMR will pose a particularly significant challenge for humanity, with projections indicating that global deaths resulting from AMR could reach 10 million annually by the middle of the century if the risks are not addressed.[96] As AMR increases, certain infections will become untreatable, making routine medical care more challenging and potentially leading to significant loss of life. From a technological standpoint, addressing AMR will require a continuous supply of new antimicrobials to overcome resistance, but innovations in therapy development will be equally crucial. Artificial intelligence and machine learning will play an increasingly important role in the design of new antimicrobials and synergistic drug combinations,[97] as well as improving the surveillance of AMR pathogens to better support clinicians.[98] Advanced biosensors will also be essential for point-of-care testing, enabling rapid diagnosis of emerging cases, particularly in the most clinically vulnerable patients.



Source: United Nations Environmental Programme, Bracing for Superbugs 2023

Projected mortality from AMR infections compared with today's causes of death

95 Cropper, N., American Security Project (29 April 2020), 'CRISPR is Making Bioweapons More Accessible'.
96 Interagency Coordination Group on Antimicrobial Resistance (April 2019), *No Time to Wait: Securing the future from drug-resistant infections*.
97 Talat, A. and Khan, A., *Drug Discovery Today*, Volume 28, Issue 4 (April 2023), 'Artificial intelligence as a smart approach to develop antimicrobial drug molecules: A paradigm to combat drug-resistant infections'.
98 Goodswen, S., et al., *FEMS Microbiology Reviews*, Volume 45, Issue 5 (September 2021), 'Machine learning and applications in microbiology'.

Furthermore, research into vaccinations targeting AMR pathogens will continue out to 2055, and their success will be vital in reducing reliance on antimicrobials and minimising the threat posed by emerging AMR strains. Due to the risk of exhausting the supply of effective antibiotics, there will be growing demand for the development of alternatives, including a greater focus on bacteriophages, antimicrobial proteins, targeted enzymes, probiotics and other approaches that strengthen the body's innate response mechanisms.

Food production. Genetic engineering has significant promise to contribute to improvements in food production, whether directly by enhancing the nutritional content of food products or indirectly by improving resistance to pathogens and drought in crops and livestock. Out to 2055, as populations grow and agricultural productivity potentially falls, this will be crucial for meeting the growing demand for food supplies.[99] Cell-cultured meat, for instance, has become more affordable and sustainable in recent years, with the production cost for one pound of meat now thought to be as low as US $9.80, a significant reduction on the US $330,000 price tag of the first cultivated meat burger in 2013.[100] 3D printing of plant-based meat substitutes has also been successfully trialled, although whole cuts such as lamb chops or steaks have proved more difficult to imitate. As 3D bioprinting research advances, the move from the laboratory to the marketplace is already in progress, and prices are expected to decrease further by 2055. Switching to plant-based meat alternatives could support feeding 350 million more people than is currently possible.[101]

Bioweapons. The development and use of biological weapons of mass effect has historically been a complex feat and been the subject of specific prohibitions under international law, which has to a great extent constrained their use. However, advances in artificial intelligence, quantum computing and synthetic biology, as well as increased investment in biological agent research, are lowering the barriers to access, which out to 2055 could increase the likelihood of their use by a broad range of actors against humans, animals and food supplies. The maturity of the technology is now at a stage where the fundamental characteristics of organisms could be repurposed to spread more quickly, infect a greater number of people, survive for longer in hostile environments, demonstrate greater resistance to treatment and create deadlier effects. As genetic modification techniques such as CRISPR become easier to use, with 'do-it-yourself' kits and online tutorials widely available, this will lead to growing concerns about access to these technologies. However, although low-sophistication biological weapons may be of interest to non-state actors, access to more sophisticated pathogens and techniques is likely to remain limited to the most technologically capable global actors.

Fusing of the physical, digital and biological worlds

Over the next 30 years, the boundaries between the physical, digital and biological worlds will become increasingly blurred. This will fundamentally transform human experiences, including the way people live, work and connect with one another. The ability to embrace this technological shift could drive global integration, increase income levels and enhance the quality of life for many. However, it could also bring new forms of inequality, as well as exacerbating existing ones.

99 U.S. Food & Drug Administration (5 March 2024), 'GMO Crops, Animal Food, and Beyond'.
100 Bandoim, L., *Forbes* (8 March 2022), 'Making Meat Affordable: Progress Since The $330,000 LabGrown Burger'.
101 Shepon, A., et al., *PNAS*, Volume 115, Number 15 (26 March 2018), 'The opportunity cost of animal based diets exceeds all food losses', pages 3804–3809.

Prosthetics and cybernetics. Prosthetics have evolved from basic devices made from wood and metal to highly specialised tools allowing amputees to live more active and independent lives. Some of the more advanced prosthetics include lightweight running blades, which allow amputees to run and jump with relative ease, and responsive leg and hand prosthetics that adapt to the physical environment; all of these have been made possible by advances in materials science, engineering and computer technology. Future developments are likely to use a combination of advances in cybernetics and artificial intelligence to translate signals generated by the brain into physical movement.[102] Further developments in prosthetics may see them reach a point within the next 30 years where they are able to enhance human capability beyond biological baselines, leading to significant advances in human augmentation.

Human-machine teaming. Future approaches to human-machine teaming will continue to focus on how humans can best collaborate with uncrewed systems, robots, virtual assistants, algorithms and other non-human intelligent agents. As artificial intelligence-enabled machines become more capable of taking on advanced decision-making roles, future developments will focus on enabling humans and machines to develop mutual understanding (such as developments in explainable artificial intelligence[103]) and anticipate each other's decision-making abilities. Human-machine teaming applications will range from providing driving aids in vehicles to more sophisticated developments such as using surgical assistants in operating theatres, so that over time machines will be perceived by humans as more akin to partners than mere tools.

Human augmentation. Human augmentation can be described as the application of science and technologies to temporarily or permanently improve human performance,[104] and it spans a range of areas including brain-computer interfaces, wearable technologies and pharmaceuticals. As humans become more integrated with the digital world, brain-computer interfaces may develop to the point where they can influence rational decision-making processes. In a world where these interfaces are vulnerable to hacking, an individual's capacity for rational thought and decision-making could potentially be altered by malicious actors.[105]

Out to 2055, human augmentation technologies will be increasingly available across society and are projected to reach a market worth of over US $545 billion by 2030,[106] with decreasing cost and growing acceptance of their use accelerating their adoption. However, the full extent of the policy, legal, ethical, social and security implications remains uncertain, and warrants careful consideration. In addition to wider society, the military will also continue to explore the use of human augmentation for strategic, operational and tactical purposes.

102 Haseltine, W., *Forbes* (25 October 2023), 'Bionic Breakthrough: The Future Of Bioelectronic Prosthetics'.
103 Defense Advanced Research Projects Agency, 'Explainable Artificial Intelligence (XAI)'.
104 Development, Concepts and Doctrine Centre (2021), *Human Augmentation – The Dawn of a New Paradigm*.
105 Mezzina, G., *Sensors*, Volume 21, Issue 24 (10 December 2021), 'A Cybersecure P300-Based Brain-to-Computer Interface against Noise-Based and Fake P300 Cyberattacks'.
106 Fortune Business Insights (March 2024), *Human Augmentation Market Size, Share & Industry Analysis, By Technology, By Device, By Application, and Regional Forecast, 2024 – 2032*.

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Human augmentation, for example, in the form of exoskeletons, could potentially improve the strength and stamina of human operators

Digitisation and social interaction. Out to 2055, further advances in digitisation will lead to hyperconnected societies, enabling the widespread use of more interactive forms of engagement across vast distances. Advances in cross-reality, digital twin technology, telepresence and the emerging metaverse will immerse users in increasingly captivating experiences, accessible through lighter, faster and more integrated mobile devices. These technologies will become commonplace in work, education and social settings by 2055, facilitated by improvements in connectivity, bandwidths and network reliability. Both governments and commercial entities will face public pressure to meet the demand for these new technologies, with some using this as a tool for political leverage. However, prohibitive costs may limit access to these technologies, and thus exacerbate existing inequalities.

Blending the physical and virtual realms will introduce new policy, legal and ethical challenges, as the delineation of boundaries and issues of legal jurisdiction and responsibility become increasingly complex. Out to 2055, both state and non-state actors may exploit this ambiguity to advance their own objectives or boost their power and influence. The ability to ensure safety will be paramount; adopting anticipatory security standards that are able to keep pace with new technology developments and evolving threats will be vital to protect states, societies, businesses and individuals from hostile actors operating across the digital landscape. For example, the potential for the hacking of biological devices, such as pacemakers and neural interfaces, highlights the importance of effective cybersecurity measures.

Future industrial developments, driven by the convergence of the physical, digital and biological worlds, will bring profound changes in processing, operations and services. In manufacturing, decentralised and digitalised processes will see automated production elements responding dynamically to their environment, boosting productivity and quality and reducing costs. However, the rise of intelligent machines may also result in significant job losses, impacting the workforce and exacerbating socio-economic inequality.

Conflict and security

Overview

The emergence of a growing number of powerful actors is likely to lead to a more congested and complex security landscape out to 2055. While still lower than Cold War levels, global defence spending has risen for the past two decades and may continue to do so as a range of increasingly powerful states seek to compete or respond to uncertainty. Violent extremists, terrorist organisations, transnational criminals and malevolent cyber actors could also increase their reach by 2055, creating new challenges and uncertainties. Meanwhile, a growing number of non-governmental and charitable actors could also add to the complexity of future defence and security operations.

Multinational corporations may also take on more prominent stability and security roles in the future, while a range of wealthy or otherwise powerful individuals with global reach, including religious and business leaders, could have increasing prominence in global affairs. However, technology advances and greater connectivity will also provide an increasing number of platforms for the ordinary citizen to influence debate. While international and regional organisations are likely to remain important global actors, states will seek to diversify their relations, leading to shifts in allegiance and potentially the emergence of new groupings. Pressure to reform existing global governance structures may also increase, and may result in the weakening of some institutions if new and emerging powers feel that their interests are not being adequately met.

Changing energy and resource demands, as well as shifts in trade flow patterns and supply chains, could see new centres of competition emerge, including in the shared spaces. The rapid expansion of infrastructure in already congested and contested land and maritime territories, increased resource extraction in the shared spaces, and growing competition for access to key space orbits and cyberspace assets could all drive a rise in global tensions. Climate change could lead to increasingly frequent disruption and in some cases permanent changes to agriculture, infrastructure and global trade routes; it could also threaten the viability of some coastal cities and regions and small island states, with wider security implications.

In an increasingly interconnected world, the impact of disruptive economic crises, disease outbreaks, new conflicts and other shocks could again prove major sources of instability. Future economic, social and political pressures could have a significant impact on the authority and legitimacy of state governments, and shortfalls in performance could see other actors playing a more prominent role in delivering state functions. While such pressures could limit the capacity of state governments to take part in overseas military operations, they could in some cases drive an increase in aggressive behaviour to distract from domestic failings.

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The weaponisation of space and development of space-based weapons could greatly increase the risks posed by weapons of mass effect

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While the international system has always been competitive, an increasing blurring of the boundaries between diplomatic, information, military and economic levers of power risks undermining key elements of global institutions and frameworks intended to prevent escalation into conflict. While efforts to promote and preserve multilateralism continue, sub-divisions along regional and interest-based lines could reduce opportunities for future cooperation. While the increasing use of economic levers of power could prove an alternative to military confrontation in the future, the changing global economic balance could equally be a trigger for conflict.

Changes in the nuclear balance of power may result in new accommodations by 2055. However, a more crowded nuclear order will bring its own risks, given rapidly expanding stockpiles, emerging missile technologies and differing approaches, which might complicate escalation management and lead to miscalculations. Advances in space-based, digital and biotechnologies could also expand the range and scope of weapons of mass effect. International legal frameworks intended to place limits on such weapons may come under increasing pressure and may fail to keep pace with new technologies. Diverging norms and values are also fuelling division, while the growing ability to manipulate information as a result of advances in artificial intelligence and other technologies could make managing future crises increasingly challenging.

Variations in demographic structure, economic performance and rates of technology adoption could see states and regions pursuing widely different approaches to combat power out to 2055. While the growing use of autonomous and digital platforms, surveillance and other capabilities seems likely to become an increasingly prominent feature of the future battlefield, states will seek to combine new technologies with existing capabilities in pursuit of operational advantage. Increasingly widespread access to data and intelligence could also have far-reaching implications, while renewable energy transitions could create new dilemmas for the generation and employment of defence and security forces in the future. Notwithstanding these developments, weaker states and non-state actors will continue to seek asymmetric advantage over powerful opponents.

The presence of a wider array of actors, alongside a growing number of shared and existential challenges and the transformational impact of new technologies, could generate new strategic approaches in the future. The ability to build a new deterrence architecture fit for a multipolar world will be an essential prerequisite to avoid the worst of outcomes; at the same time, how best to contain the spread and use of nuclear and other weapons of mass effect will also remain a key question. In the face of a more uncertain future, increasing resilience and agility may be key determinants of success. An increasingly competitive and multipolar world could see shifts in geostrategic alignments and partnerships, which alongside the growing use of proxies and other non-attributable actors could lead to the emergence of new risks.

A congested and complex security landscape

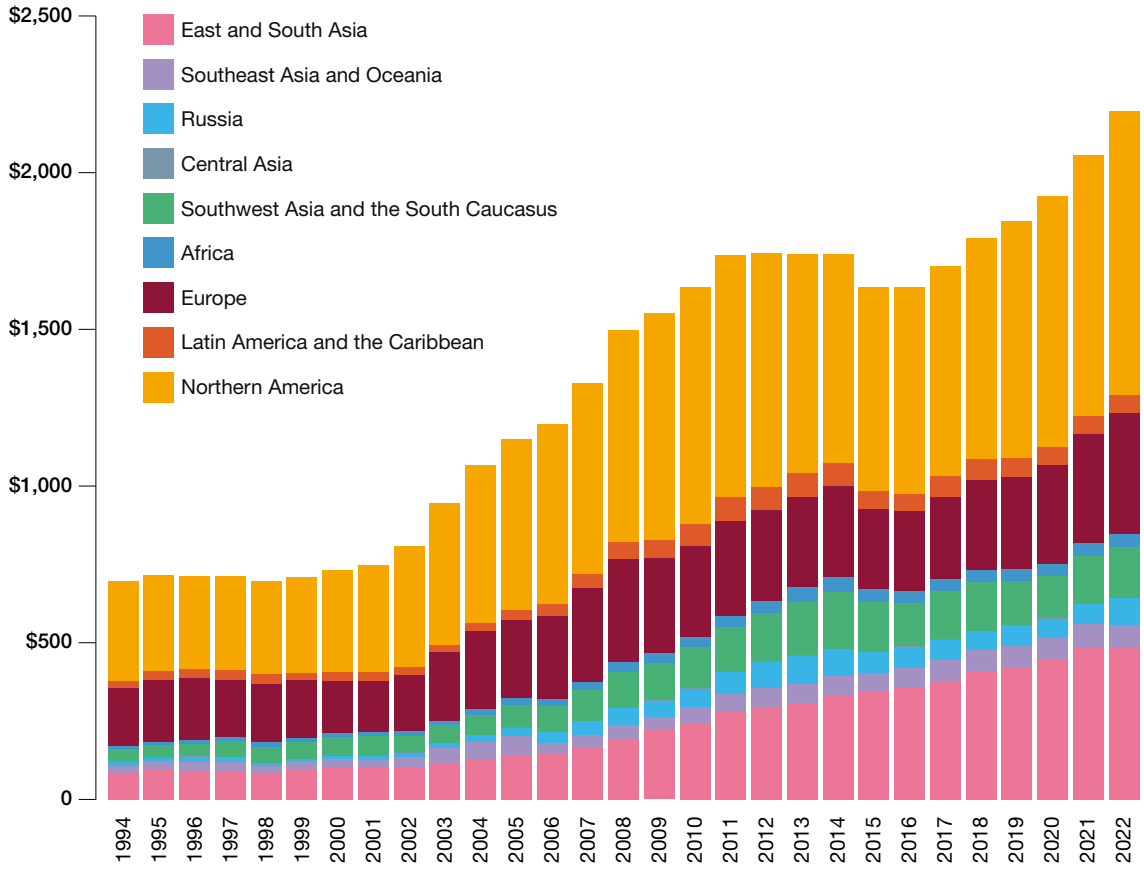
Out to 2055, the global security landscape is likely to become increasingly congested, with the emergence of a growing number of more powerful and empowered actors. While a more crowded arena could lead to new forms of cooperation, it could also lead to increased rivalry, confrontation and conflict.

Changing balance of military power. Changes in levels of defence spending could lead to significant alterations in the balance of military power out to 2055. Although still lower than Cold War levels, global defence spending increased by 19% between 2013 and 2022, reaching a record high of United States (US) $2,240 billion by the end of that period.[1] Overall, the US remains the largest global military spender, with a budget of US $905.5 billion in 2023 – considerably higher than the combined spending of China and Russia.[2] However, its capacity is increasingly being stretched across multiple regions, and the high cost of investment in state of the art capabilities, alongside rising pressure on government spending, could see this coming under increasing strain. Meanwhile, China's defence budget (officially US $219.5 billion but estimated to be considerably larger if all military-related spending is taken into account) increased for the 29th consecutive year in 2023, and while still behind the US it has leveraged considerable mass and technological advantage out of this investment.[3] However, China's defence spending is coming under increasing pressure against other national priorities such as investments in science and technology, improvements in food security, public security and debt servicing, which is also likely to continue over the coming decades.[4] Russia doubled its defence budget to US $100 billion in 2023 and now defence spending accounts for a third of all its public expenditure.[5]

The Indo-Pacific region has overtaken Europe in its share of global defence spending, even while the latter saw the largest increase in the post-Cold War era in 2022.[6] India, for example, increased its defence spending by 47% between 2013 and 2021 while Japan aspires to have the third largest defence budget in the world by 2027.[7] Other significant

1 Tian, N., et al., Stockholm International Peace Research Institute (SIPRI) (April 2023), SIPRI Fact Sheet, *Trends in World Military Expenditure, 2022*.
2 International Institute for Strategic Studies (IISS) (12 February 2024), *The Military Balance 2024*, 'Chapter Two: North America', page 36.
3 IISS (12 February 2024), *The Military Balance 2024*, 'Chapter Five: Asia', page 253.
4 IISS, Military Balance Blog (8 March 2024), 'China's defence budget boost can't mask real pressures'.
5 Reuters (4 August 2023), 'Exclusive: Russia doubles 2023 defense spending plan as war costs soar'.
6 SIPRI (April 2023), 'Military expenditure'.
7 Kavanagh, J., Carnegie Endowment for International Peace (8 February 2023), 'Japan's New Defense Budget Is Still Not Enough'.

investments saw Saudi Arabia move from eighth to fifth largest spender in 2022 with a US $75 billion defence budget.[8]



Source: Stockholm International Peace Research Institute (2023) **Note:** figures show constant 2021 US $ billion

Military expenditure per global region (constant US $ billion)

Reasons for this increase in spending vary from state to state, from deterrence in the face of regional threats to responding to crises and attacks; for example, Ukraine's defence budget increased by 640% in 2022.[9] While the longer-term implications of this trend remain unclear, and increased expenditure will not necessarily lead to military supremacy and success on the battlefield, shifts in the global balance of military power could lead to greater instability and increase the risk of miscalculation in the future.

Political violence, extremism and criminality. Armed political factions within states, as well as violent extremists and criminals, could also increase their capability and reach out to 2055. Deaths resulting from intrastate and criminal violence have remained a significant contributor to global mortality rates in recent years, with at least 237,000 people dying as a result of organised violence in 2022.[10] By comparison, a United Nations study on homicide estimated that overall there were around 458,000 victims in 2021.[11]

Much of this violence takes place in regions where factors such as weak governance, ethnic and religious tensions, the presence of a growing but unfulfilled youth population

8 SIPRI (April 2023), 'Military expenditure'.
9 Tian, N., et al., SIPRI (April 2023), SIPRI Fact Sheet, *Trends in World Military Expenditure, 2022*.
10 Bäckström, E., Uppsala University (13 June 2023), 'Number of deaths in armed conflicts has doubled'.
11 United Nations (UN), Office on Drugs and Crime (2023), 'Global Study on Homicide 2023'.

and the impact of climate change and other forms of environmental degradation are contributing to increasing social and political instability. Africa, for example, had the largest share of the world's internal confrontations in 2020,[12] and faces growing threats from violent extremism.[13] Meanwhile, some states in Southwest Asia risk being overwhelmed by internal instability and violence, while serious and organised crime is becoming increasingly powerful in regions such as Latin America,[14] and it is extending its reach across Asia, Africa and Europe. In many of the affected regions, violent non-state actors often have more significant capabilities than the governments opposing them; this may continue as government finances come under increasing pressure. Cyber criminals, proxies and other actors are becoming an increasingly dominant force, a trend that could accelerate as Internet access becomes more widespread. While international and regional organisations will continue to play an important role in supporting governments to address the threat of political and criminal violence, private military and security companies are also becoming more prominent actors, and may play an increasingly major role in the future.

The third and fourth sectors. Non-governmental organisations (NGOs) and charities have played a critical role in stability and security for decades, a trend which seems likely to continue and potentially increase. Global NGOs and charities were valued at US $329.3 billion in 2020, their value having increased by around 6.9% each year since 2015, and this figure may reach US $528.1 billion by 2030.[15] While individual organisations in Northern America and Europe such as Save the Children, Oxfam, Doctors Without Borders (Médecins Sans Frontières) and the global humanitarian network of the International Committee of the Red Cross (ICRC) currently lead the sector, much of the new growth is taking place in emerging economies. The Indo-Pacific region was the largest NGO and charitable market in 2020, for example, accounting for 38.2% of the total, and it is expected to be the fastest-growing region going forward, followed by Southwest Asia, Africa and Eastern Europe.[16] Over the next 30 years, it is likely that charities and NGOs will continue to operate across a wide range of security issues, including health, human and workers' rights and environmental concerns, and looking forward, they may expand their activities further. Rising global awareness may increase the focus on this sector, with 85% of funding already coming from online donations.[17] In the future, NGOs and charities may increasingly invest in predictive analytics to boost and maintain support, and capitalise on developments such as crowd funding.[18] A rise in the prevalence of commercial–NGO partnerships could also drive the emergence of a 'fourth sector', leveraging the power of business and markets to address social and environmental concerns.[19]

12 Pettersson, T., et al., *Journal of Peace Research*, Volume 58, Issue 4 (1 July 2021), 'Organized Violence, 1989–2020, with a special emphasis on Syria'.
13 Institute for Economics & Peace (February 2024), *Global Terrorism Index 2024: Measuring the Impact of Terrorism*.
14 Despradel, M. and Matera, M.A., Center for Strategic & International Studies (15 January 2020), 'Latin America and the Caribbean in the New Decade: How Did we Get Here?'.
15 Research and Markets, GlobeNewswire (29 March 2022), 'Global $525+ Bn NGOs and Charitable Organizations Markets Analysis, Opportunities and Strategies, 2015 – 2020, 2025F, 2030F'.
16 Ibid.
17 Ibid.
18 The Business Research Company (January 2022), *NGOs And Charitable Organizations Market 2022 – By Type, By Mode Of Donation, By Organization Location, And By Region, Opportunities and Strategies – Global Forecast To 2030*.
19 Fourth Sector Group, 'What Is the Fourth Sector?'.

Commercial interests and actors. Commercial interests have always been a major factor in governments' stability and security considerations; the need to protect access to resources and trade flows is a significant influence on state behaviour. Out to 2055, however, the importance of this driver could increase due to a growth and changes in resource demand. In addition, an increase in resource extraction in the shared spaces, including space, could also lead to new security requirements in the future.

Over the next three decades, multinational corporations are likely to play an increasing role in addressing a wide array of global security challenges, including climate change mitigation and cybercrime.[20] Some commercial entities will become increasingly powerful actors in their own right. Many states already rely on commercial actors to fulfil a range of defence and security functions, including support to shipping and logistics; out to 2055, this trend may increase further as government spending budgets come under increasing pressure. Private military and security companies could also play a growing role in delivering domestic state security functions. Space capabilities, communications and other technical services are likely to become increasingly dominated by the commercial sector, a development that has already seen conflicts of interest emerge between governments and global commercial partners. If this trend continues out to 2055, states could see the provision of critical security services being increasingly driven by the interests of these actors.

Private military and security companies

Soldiers of fortune, or mercenaries, are as old a phenomenon as conflict itself. The 21st Century has seen a resurgence in powerful private military and security contractors or companies providing armed combat or security services in military operations and conflict areas, as overstretched and smaller military forces have been deployed in numerous low-intensity conflicts and counterinsurgencies, Iraq and Afghanistan being the major ones. However, the lines that differentiate illegal mercenaries and legal private military and security companies continue to be blurred. Increasing state fragility has seen private military and security companies operating much more independently to secure areas with precious resources and to reinforce regimes under pressure. Although their status and way of operating differs significantly, some of these companies – such as the rebranded Wagner Group (widely considered a mercenary group) that operates in several African states – are infamous for their brutality and human rights abuses. Nevertheless, the Wagner Group has had significant impact on African geopolitics. The impact of powerful private military and security companies, being tools for influence and power projection, is likely to increase, and they will potentially play independent roles with growing geopolitical shaping power in their own right. States may increasingly struggle to curb the growing influence of these groups.[21]

20 Frist, B., *Forbes* (21 August 2023), 'Businesses Will Help Us Tackle Our Climate Challenge'.
21 Swed, O. and Burland, D. (August 2020), 'The Global Expansion of PMSCs: Trends, Opportunities, and Risks'; Garcia, M., Modern Diplomacy (6 December 2023), 'War for Profit: Implications of the Growing Private Security Industry'.

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The increasing accumulation of private wealth is giving some individuals state-like influence

Powerful and empowered individuals. While the corporate power of tycoons, moguls and oligarchs is well-established, a growing number of exceptionally wealthy or otherwise influential individuals could play a more significant role in global security in the future. Private entrepreneurs leading advances in digital or space technologies, for example, or leaders of major philanthropic foundations whose budgets exceed the social, health and educational provision of some countries such as Bill Gates, Jeff Bezos and Wang Xing,[22] could increasingly rival state governments in their power and reach. With some also exercising significant power through their ownership of digital media, their ability to influence global narratives could also grow out to 2055, challenging the ability of state governments to control the agenda. In addition, a growth in the size of some religions, driven by population increase in some parts of the world, could see some religious leaders becoming increasingly powerful in the next three decades. Together with their control over valuable resources and ability to mobilise compassion and anger across global populations, this could see them play an increasingly important role in global stability and security in future years. At the same time, an increasingly interconnected world will provide a growing number of platforms for citizens to command attention on a wide range of issues, such as climate change, gender inequality and racial injustice, in some cases with stability and security implications.

International and regional organisations and partnerships. International and regional organisations are likely to continue to play a central role in security and conflict management out to 2055. However, states will increasingly look to diversify their security and other relationships, and the next three decades could see shifts and changes in allegiances. While major blocs such as the North Atlantic Treaty Organization (NATO), the European Union and the Association of Southeast Asian

22 Vogel, P. and Kurak, M., International Institute for Management Development (IMD) (December 2019), 'The past, present and future of Chinese philanthropy'.

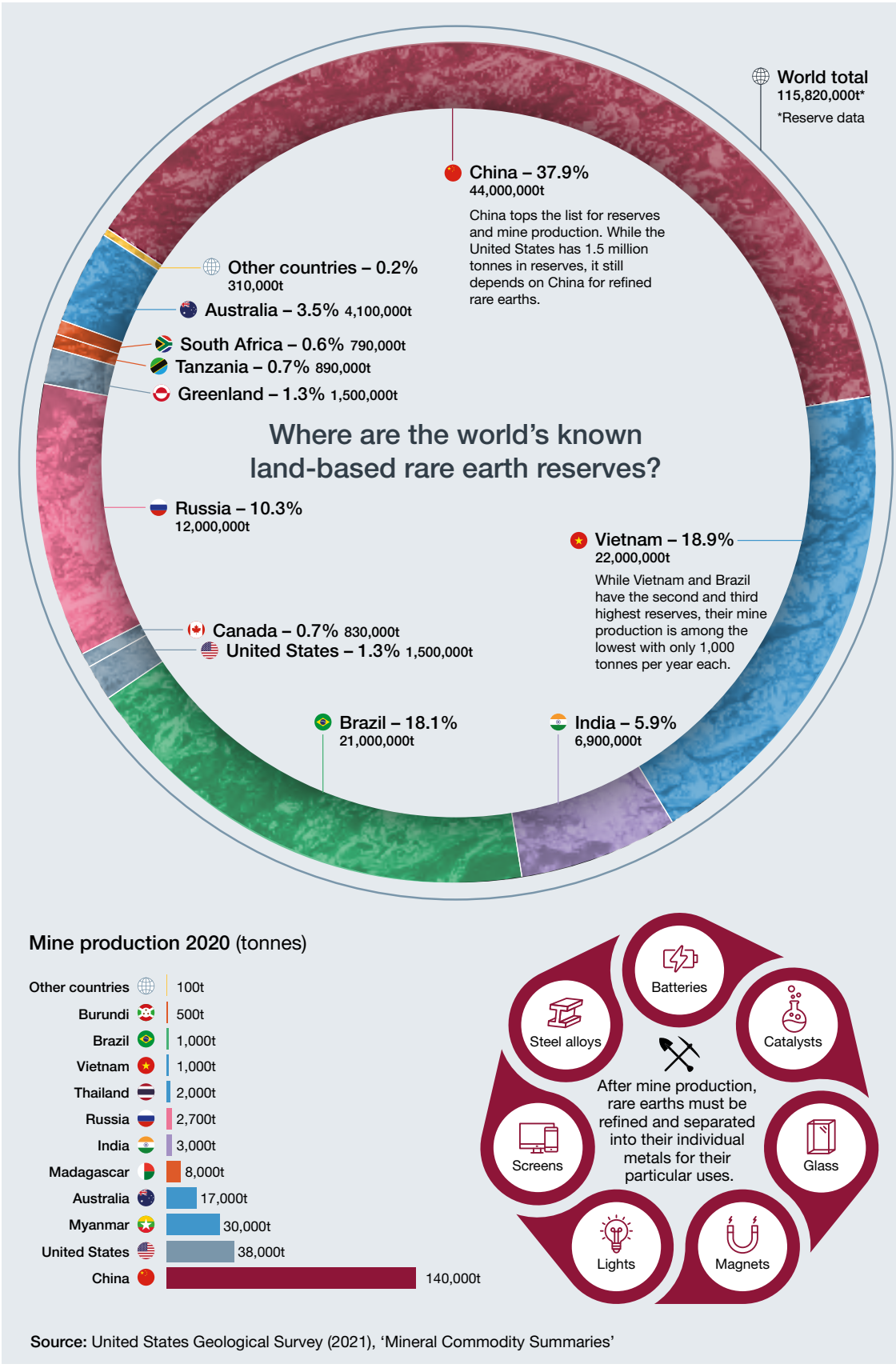
Nations seem likely to endure, other organisations and wider partnerships may become increasingly prominent out to 2055. In the future, non-state actors, such as multinational corporations and NGOs, could become more active players in regional and global security arrangements, or even establish alternative forums that challenge traditional approaches to global governance. At the same time, an expansion in the number of regional and other groupings may result in states being able to selectively disengage where cooperation initiatives do not fit their own agendas. Therefore, while many of these new global and regional bodies could give greater voice to emerging powers, these new groupings could also make managing interstate relations increasingly challenging due to conflicting agendas and interests. Pressure to reform existing international governance mechanisms is increasing; if demands for reform are not met, this could lead to the weakening, breakdown or replacement of some organisations, limiting their ability to prevent and manage conflict, with the result that future conflicts could have even more far-reaching impacts.

Sources of stress, instability and conflict

The world is likely to be subject to an increasing range of social, political, economic, environmental and technological pressures out to 2055. While each of these alone could act as a driver of instability and conflict, the complex interplay of multiple factors in an increasingly interconnected world could lead to new uncertainties and shocks, with significant implications for global security.

Broadening resource and trade security challenges. The desire to protect trade routes and secure access to key resources such as energy and raw materials is likely to remain a key driver of geostrategic behaviour However, the dominant actors, resources and locations could change during this period, potentially triggering new tensions. For example, while fossil fuel demand is likely to continue over the next 30 years, this will increasingly come from East and South Asia; as a result, countries in these regions could assume a more prominent role in supply protection, cooperating or competing with traditional guarantors. At the same time, demand for the critical minerals required to enable the renewable energy and digital transitions could grow several-fold, with sources in Europe, Latin America, Africa, the polar regions and across the ocean floors becoming the subject of increasing competition, potentially spurring tension and conflict. As the global middle class population continues to grow, the need to secure access to food supplies from a range of sources – including those in the Global South and the shared spaces – could become a growing driver for security activity. In an increasingly climate-stressed world, access to water is also likely to become a growing source of tension.

Trade flow patterns are also likely to change by 2055, driven by innovations in additive manufacturing (3D printing) and automation alongside the potential emergence of new centres of production. Efforts to protect and diversify supply chains could lead to new forms of cooperation or tension. As the digital economy becomes increasingly important, the desire to secure access to intellectual property and data, as well as key components such as semiconductors, could drive an increase in global tensions and insecurity.



Source: United States Geological Survey (2021), 'Mineral Commodity Summaries'

Locations of the known land-based rare earth reserves

In 2023, Storm Daniel destroyed a quarter of Derna, Libya after two dams collapsed, killing over 10,000 people and displacing up to 40,000

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Increasingly congested territories and shared spaces. Out to 2055, the significant expansion of global infrastructure could give rise to new tensions. Much of this activity is likely to take place in already congested (and in some cases contested) land and maritime territories, exacerbating existing tensions in regions such as the South China Sea, where fishing, resource extraction and military activity already take place in disputed zones. A predicted 50-fold global increase in offshore wind farms by 2055,[23] alongside other renewable energy projects, and an increase in the number of pipes and cables as states seek to diversify their hydrocarbon and renewable energy supplies, could exacerbate existing tensions and create new hostilities. At the same time, as cable networks and other forms of digital infrastructure expand across the globe, this could give rise to new vulnerabilities and security risks, including the deliberate or accidental disruption of vital data flows.

As new technologies increasingly enable resource extraction in previously inaccessible parts of the polar regions and oceans, this could lead to further changes in security requirements. Competition over access to key space orbits could also intensify by 2055, while cyberspace is likely to be subject to increasing rivalry. While new forms of collaboration could arise to address these increasing security concerns, there remains the risk that such developments will more likely lead to an increase in tension rather than cooperation, with significant implications for global stability and security.

The growing impact of climate change. Climate change is already a source of increasing instability and the World Health Organization estimates that it will cause or contribute to 250,000 additional deaths per year between 2030 and 2050[24] as populations are impacted by more frequent and extreme weather events, as well as permanent changes in the Earth's climate. By 2055, therefore, climate change could be a major driver of global instability and insecurity, impacting both emerging and developed economies and both urban and rural populations. For example, many of the world's rapidly expanding

23 Gourvenec, S., et al., University of Southampton (2022), *Blue Economy in the Future: Context, outlook, uncertainties, shocks and strategic implications* (a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC)).
24 World Health Organization (12 October 2023), 'Climate change'.

megacities are located in coastal regions, which over the next three decades are likely to be significantly affected by climate change. Some small island states could become unviable due to rising sea levels and environmental degradation, potentially leading to an increase in migration as well as uncertainty over the sovereignty of extensive maritime territories. More broadly, extreme weather events could lead to the temporary or permanent displacement of millions, creating new stability and security challenges. Critical infrastructure and arable land could suffer irreparable damage in some countries. While ice melt could see new routes open across the Arctic seas, major choke points such as the Suez and Panama Canals could be increasingly impacted by climate change, potentially changing patterns of global trade and associated security arrangements.

Increasingly disruptive shocks. In an increasingly interconnected world, the occurrence of unforeseen shocks with wide-ranging stability and security implications on a global scale could increase. Such disruptions could come from a range of sources; the 2008 financial crash, for example, began in the US sub-prime market but led to worldwide job losses, austerity and an estimated loss of US $2 trillion in global gross domestic product,[25] as well as changing the global power balance. Looking forward, a collapse in China's massive real estate sector could have global consequences, while the rapid growth in digital currencies and financial technology could also make the global financial system more vulnerable in the future. The COVID-19 pandemic also demonstrated how quickly a health crisis can spread around the world; the World Health Organization estimates that the pandemic killed at least 3.3 million people[26] and cost the global economy in excess of US $12.5 trillion.[27] Human encroachment into natural habitats, as well as growing antimicrobial resistance and other factors, means that the world may see an increase in global health emergencies in the future. While potentially a major driver of global growth, artificial intelligence advances could result in new disruptive shocks in the future. Finally, as Russia's 2022 invasion of Ukraine and Hamas' 2023 attack on Israel and the subsequent aftermath have demonstrated, wars with global implications can materialise suddenly and with terrible consequences.

Challenges to state authority. While future global shocks will have an impact on relations between states, they will also present a significant challenge to governments already under pressure from a range of factors. The 2008 financial crash, for example, helped to fuel popularism and political division, while in addition to its human and economic costs, the COVID-19 pandemic undermined trust in institutions and information. Out to 2055, many emerging and even developed economies could face a growing array of pressures that may increasingly demand their attention, including rising migration (whether inbound or outbound), and economic and wider social challenges. While some states should prove resilient and be able to adapt to meet these pressures, others may struggle due to factors such as poor governance, corruption and high levels of inequality. In some cases, weakened states could see non-state actors step in to assume a more prominent role in the delivery of state functions. Thus, while many states may wield increasing power on the global stage over the next few decades, their ability to act may be constrained by domestic, economic and political factors, as well as the growing influence of non-state actors. Although this could have an impact on the agency of states as global security actors, and therefore limit their capacity for external aggression, it could also create new risks, including the use of military force to distract from domestic pressures.

25 Merle, R., *The Washington Post* (10 September 2018), 'A guide to the financial crisis – 10 years later'.
26 World Health Organization (21 May 2021), 'The true death toll of COVID-19: Estimating global excess mortality'.
27 Reuters (20 January 2022), 'IMF sees cost of COVID pandemic rising beyond $12.5 trillion estimate'.

Increasingly blurred boundaries. The next 30 years could see an increasing blurring of the boundaries between peaceful behaviour, competition, conflict and war. Current trends suggest that in coming decades the world is likely to witness increasing investment in dual-use infrastructure and technologies; (often unattributable) interference with space, maritime and other infrastructure; the increasing use of 'lawfare'[28] and other approaches to constrain geostrategic options; and disinformation, espionage and interference in domestic politics. Out to 2055, the increasing normalisation of these activities could heighten the risk of miscalculations and misjudgements, leading to a growth in tensions and potentially conflict.

Expanding economic statecraft. The global economy is far more intertwined now than at any previous moment in history, a trend which is likely to increase further out to 2055. However, the growing use of tariffs, debt entrapment, sanctions and other forms of economic statecraft could see state approaches to economic relations becoming increasingly securitised over coming decades. The unprecedented level of sanctions imposed against Russia following the 2022 invasion of Ukraine, for example, could lead to a further expansion in the use of economic levers as an instrument of geopolitics, including potentially economic and other forms of blockade. With the world's major economies being increasingly dependent on each other, this could in time develop into a form of 'mutually assured economic destruction'[29] under which states chose to limit their military actions for fear of the economic consequences. However, while potentially helping to avoid direct confrontation, such approaches have also inadvertently contributed to the outbreak of conflict in the past (for example, the Japanese attack on the US in the Second World War) and could do so again.[30] At the same time, many states will remain undeterred by prolonged periods of economic coercion or find ways to circumvent them.

Nuclear proliferation and deterrence. In 2022 there were an estimated 12,000 nuclear warheads around the world. While this is still fewer than the 60–70,000 held at the height of the Cold War,[31] future growth in nuclear arsenals could increasingly impact the balance of power and principles of non-proliferation that have underpinned nuclear deterrence since the 1960s. US assessments suggest that China will have 1,500 nuclear warheads by 2035, thereby joining the US and Russia as a major nuclear power.[32] While there are many technical and other challenges associated with the acquisition of nuclear weapons, the number of states possessing these capabilities might increase in the future.[33] Previously small nuclear powers such as North Korea could also become increasingly capable.[34] At the same time, the US, Russia, China and a number of other states are investing in intermediate-range missiles and advanced missile technologies, including hypersonic glide vehicles and hypersonic cruise missiles, which might cause further strategic ambiguity and could have potential implications for strategic stability.[35]

28 The Lawfare Institute (2022), 'A Brief History of the Term and the Site'.
29 Thompson, M., *Time* (10 October 2011), 'Mutually-Assured Economic Destruction'.
30 Calhoun, G., *Forbes* (12 September 2021), 'War With China? The Economic Factor That Could Trigger It'.
31 UN, International Day against Nuclear Tests: 29 August, 'Ending Nuclear Testing'.
32 Creedon, M., et al. (October 2023), *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States*.
33 Aylward, M., et al., Atlantic Council (2024), 'Welcome to 2034: What the world could look like in ten years, according to nearly 300 experts'.
34 Bennett, B.W., RAND (19 April 2023), 'How Kim Jong-un's Fears Shape North Korea's Nuclear Weapons Agenda'.
35 Harriss, L. and Noone, E., UK Parliament (27 June 2023), 'Research Briefing: Hypersonic missiles'.

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Sanctions such as those imposed on Russia following the invasion of Ukraine are an example of economic statecraft

In an increasingly multipolar world, a more crowded nuclear order will pose considerable uncertainty and risk, undermining global stability and security. In addition, differing approaches to escalation management could further erode the threshold for nuclear exchange over coming decades. This could create a complex set of nuclear deterrence challenges, which in more extreme scenarios could even lead to limited exchange, bringing with it the risk of escalation.

New weapons of mass effect. Alongside the growing complexities of nuclear deterrence, advances in disruptive technologies could also expand the frontiers of weapons of mass effect. Space-based directed energy systems and the weaponisation of cislunar space, for example, could outflank current missiles and defensive systems, changing the paradigm of both nuclear deterrence and conventional air power. While cyberattacks are now increasingly seen as a feature of everyday life, future years could see a cyberattack deliver physical, economic and other damage of existential proportions, particularly if artificial intelligence and other technologies expand the scope of what is possible. Given the growing importance of the digital economy, the requirement to address threats to digital communications infrastructure in space and the oceans could become a new consideration. Alongside existing chemical and biological weapons, advances in biotechnology that enable the more precise targeting of individuals, communities and food production could lead to new threats. However, while advances in technology could create new global security challenges, the asymmetric use of everyday capabilities – such as hijacked aircraft – could still provide cheap and effective ways for otherwise less powerful actors to achieve strategic and global impact.

Undermining international frameworks. A growing array of risks to global security could be further exacerbated by the degrading of international legal frameworks and other systems intended to limit the use of force. Treaties covering the development, testing and use of nuclear weapons, for example, could come under increasing strain. Nuclear states

may vary in their willingness to comply with their legal obligations under existing treaties, as well as in their desire to ensure that international law keeps pace with new weapons and technologies. Some existing treaty provisions may be rendered obsolete by 2055 or be replaced by new agreements. Previous agreements seeking to limit the size of conventional forces in some regions have also recently been suspended or disregarded.[36] Treaties that seek to limit the weaponisation of key shared spaces could also be increasingly strained by 2055. Provisions within some frameworks such as the United Nations Convention on the Law of the Sea and the Antarctic Treaty System that seek to limit military action may also be increasingly tested and eroded. Meanwhile, although negotiations to agree a common approach to cyber warfare, new technologies such as artificial intelligence or protecting critical infrastructure in the shared spaces could make some progress, global and regional tensions may limit this.

Competing norms and values. Cultural and religious divisions, as well as historical grievances, are likely to remain powerful drivers of conflict out to 2055. However, ideological norms and values are also re-emerging as an area of divergence between global powers, and could become an increasing driver of competition, tension and conflict. Increasing global interconnectedness could see these fault lines manifest themselves in more complex ways. For example, while opinion polls,[37] as well as recent protests, suggest that democratic values and individual freedoms remain attractive to many in autocratic and theocratic states, polls also suggest that many young people in democracies have less faith in that system of governance, and the idea of universal values as championed by the West is increasingly being called into question. However, those powers that oppose the current system are neither unified or aligned on their preferred values and norms, suggesting that a more complex and diffuse political landscape could emerge out to 2055. Meanwhile, nationalist sentiment and political polarisation is on the rise around the world; while some leaders have sought to capitalise on this, a more interconnected and uncertain age could challenge their ability to control narratives in the future.

Systemic manipulation of information. A further challenge for future conflict management could come from the declining ability of governments to manage domestic public opinion during periods of heightened tension. Views, anger and even violence in relation to specific issues can already spread quickly between regions, cutting across demographic and other divides; this is likely to accelerate further as the world becomes more digitally connected and as evolving technologies make it increasingly difficult to distinguish between fact and fiction. In the absence of major developments in Internet governance, disinformation and misinformation seem likely to have an increasingly corrosive impact on many societies, a trend that could be exacerbated as artificial intelligence enables a growing array of actors to propagate increasingly compelling fake news stories. Mistrust in institutions, information and the concept of truth itself could grow significantly. This increasingly frenetic information environment could make managing international tensions more challenging in the future, further heightening existing security risks.

36 Gordon, M.R., *The Wall Street Journal* (7 November 2023), 'U.S., NATO to Suspend Participation in Landmark Cold War Arms Treaty'.
37 Open Societies Foundations (11 September 2023), *Open Society Barometer: Can Democracy Deliver*.

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The displacement of Rohingya people in Myanmar has been exacerbated by social media disinformation campaigns

Capability dilemmas

Mass and productive capacity. While countries that possess nuclear weapons will continue to rely on them as the ultimate guarantor of their sovereignty, events since 2022 have demonstrated the importance of mass and production capacity as another component of deterrence. This relates not only to the size, capability and stockpiles of in-place forces, but also states' abilities to regenerate lost capabilities at a faster rate than opponents in the event of a prolonged conflict. In the Second World War, for example, the mobilisation of US and other allies' factories was key to the eventual outcome of that conflict. Today, globalisation means that production capacity is often concentrated elsewhere.[38] Meanwhile Russia's mobilisation of its arms production[39] and conversion of other economic sectors in support of its war effort[40] is a salient reminder that in times of war, logistics can become a national civil as well as military issue. In that regard, economic weight and manufacturing capabilities, alongside scale and technological edge, could increasingly become a feature of deterrence and the balance of military power in the future.

Automation and autonomy. With population growth due to slow or reverse in much of the developed world over the next few decades, investment in automated and autonomous capabilities could become a necessity for some governments and a source of advantage for others. Using the US and Chinese research and development budgets for 2023 as an indicator of current trends, high-end and mass-produced drones, high-energy weapons, wide-ranging surveillance capabilities, human-machine teaming and automated and autonomous capabilities, as well as the use of artificial intelligence, quantum and other technologies that enhance command and control and

38 Mandhana, N., *The Wall Street Journal* (13 February 2024), 'China's Shipyards Are Ready for a Protracted War. America's Aren't'.
39 Roth, A., *The Guardian* (15 February 2024), ''A lot higher than we expected': Russian arms production worries Europe's war planners'.
40 Oliphant, R., et al., *The Telegraph* (26 January 2024), 'From scones to drones: inside Putin's arms race that is leaving the West behind'.

decision-making, are likely to become an increasing feature of security and military operations by 2055. The cost of these new technologies in comparison with that of employing a human workforce, as well as societal acceptance of human attrition and legal, ethical and policy concerns regarding automated capabilities, will all be relevant factors in any choices made by states, and different governments will adopt various positions on this. These diverging approaches could have significant implications for the balance of military power in the future, which may give rise to increasing uncertainty and instability. Success or failure on operations and in combat will also potentially influence how quickly and to what extent states and other actors invest in such capabilities. Some may continue to favour traditional forms of mass alongside automated and autonomous capabilities, a choice which may provide a degree of flexibility in an increasingly uncertain world.

Competing for technological advantage. In addition to automation, states and other actors are likely to invest in a wider array of other technologies as they seek to secure military advantage over opponents. Future years may see increasing investment in new counter-access capabilities against air, land, maritime and space platforms, as well as in the electromagnetic spectrum and cyberspace; in response, actors will seek to develop new technologies to overcome these area-denying capabilities, including long-range precision-strike and advanced missiles. In addition, advances in the fields of biotechnology and human augmentation may also increasingly feature in capability development. However, with long lead-in times on capability development and procurement (except when major combat operations force more rapid change), any transitions, particularly in the face of financial constraints, are likely to be gradual. As a result, choices in the coming decades are more likely to include a balance between high-end platforms and dispersed, agile and more survivable forces. Irrespective of any equipment choices, however, the training, ethos and morale of a state's armed forces will remain critical factors in attaining defence and security advantage out to 2055.

Ubiquitous information. While it is already possible for civilian populations to follow conflict developments in real time, the immediate availability of information is likely to increase dramatically due to the rising ownership of mobile devices, increasing access to the Internet across the globe (including in shared and remote spaces) and an exponential increase in commercial space-based observation. Artificial intelligence advances could also make data gathering and analysis capabilities increasingly available to all. While such developments could prove a new source of advantage for defence and security forces, they could also create new risks and uncertainties. The potential levelling-up of intelligence capabilities between state and non-state actors could have wide-ranging implications, for example, for operations security and deception. At the same time, while such technologies might promise increasing transparency, they could equally introduce new 'fog and friction',[41] as a result of cyberattacks, algorithm biases and other factors which undermine trust in the information and intelligence provided. The ability to analyse online statements of opinion as well as images and videos could all be impacted by these developments. For example, advances in artificial intelligence could mean that 'deep fakes' are indistinguishable from reality. The fact that many of these technologies will be provided by corporate actors and powerful elites will further complicate responses.

41 Hughes, Z., War on the Rocks (11 March 2020), 'Fog, friction and thinking machines'.

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Poseidon reconnaissance drones have been manufactured in Cyprus for Ukraine, where rapid mass production and procurement has become a defining feature of the war

The energy transition and sustainability of operations. With the exception of key nuclear-powered capabilities, most defence and security forces are dependent on a global energy market that will be experiencing a low-carbon transition by 2055. For forces that do not adapt to this changing reality, impacts could range from the decreasing availability of fuel and legacy engineering skills through to declining social acceptance of the use of hydrocarbon-powered capabilities in regions being impacted by climate change. Adopting renewable technologies could increase freedom of action by reducing dependence on logistics supply chains. Similarly, developments in additive manufacturing (3D printing) and other advanced forms of production could increase the ability of defence and security forces to operate untethered from their supply bases, thereby enhancing agility. Such transitions are not without risk, including whether renewable and other technologies can be adapted for use on the battlefields, dispersed airfields and oceans where military forces usually operate. In addition, recapitalising and re-engineering costs could prove significant. However, the emergence of new technologies could prompt a potential paradigm shift in these fields by 2055, giving rise to fresh dilemmas and diverging approaches between actors, with implications for the balance of global power.

Increasing asymmetry. An emerging trend since the Second World War has been that small states and weaker actors are statistically more likely to prevail over major powers when fighting on home soil.[42] Materiel and other support provided by the domestic population (as well as outside powers) mean that such actors appear more able to endure and adapt to drawn-out conflicts, even if they are overwhelmed by superior forces in the initial stages. Out to 2055, this feature of conflict seems likely to endure, notwithstanding potential technological advances. At the same time, further reversals in legitimate and lawful behaviours in combat could take place. This development could see different actors take increasingly diverging ethical approaches to new (and old) technologies in the future, as well the more frequent use of war crimes and crimes against humanity as instruments of war.

42 Arreguin-Toft, I. (August 2009), *How the Weak Win Wars: A Theory of Asymmetric Conflict*.

Strategic challenges and opportunities

In an increasingly multipolar world, with a more congested security landscape and the potential for ongoing global power competition to be impacted by a range of economic, environmental, social, technological and other shocks, the world faces a great deal of geostrategic uncertainty. While emerging technologies, increased interconnectivity and shared global challenges raise the possibility of new approaches to geostrategy, an increasing number of conflicts and rising global animosity mean that the choices made in the next ten years could well determine whether the world navigates to a more prosperous, sustainable and equitable future or continues down a dangerous path.

Deterrence. The ability to re-establish a balance in global deterrence will be key to global security in future decades. The last time that global powers engaged on such a journey it involved not only competitive technology advances but also significant academic and policy investment in nuclear arms control, lines of communication and other safety architecture. Given recent crises – such as that between nuclear-armed India and Pakistan in 2019,[43] rising nuclear rhetoric on the part of Russia, uncertainty regarding China's 'no-first use' policies, and questions over other powers' adherence to nuclear controls – designing an architecture that can safely manage a more multipolar nuclear order is urgently overdue.[44] The world also faces a potential proliferation of new forms of weapons of mass effect, suggesting that a broader approach to deterrence may also be required. This could include the use of conventional forces as part of a deterrence response to nuclear and other weapons of mass effect.

Resilience and agility. One consequence of globalisation and growing interconnectedness is that many states and regions are now increasingly vulnerable to a variety of threats. These range from cyberattacks and the corruptive influence of misinformation and disinformation, to supply chain vulnerabilities, attacks on critical and maritime infrastructure and space assets, terrorism, and increasingly the impact of climate change. In addition, while many states continue to maintain some form of air and ballistic missile defence, heightened tensions have also demonstrated potential gaps in the event of a major conflict. While the consequences of such attacks could prove devastating, an absence of protection also undermines deterrence. Out to 2055, the range of threats faced could see growing pressure to increase investment in defence and resilience; however, this could prove challenging in practice given budgetary constraints and competing spending priorities. In some cases, this may see governments increasingly pursuing partnerships with other states as well as non-state actors around shared defence and resilience interests. The increasing range of potential threats means that states may need to be increasingly agile and forward-looking in their approaches; agility could prove the key to success in this changing and uncertain dynamic.

Shifting geostrategic alignments. Out to 2055, another key challenge for governments will be managing changing geostrategic alignments. While these will be driven primarily by the economic, diplomatic and security interests of the states involved, such shifts will also reflect wider changes in the global balance of power as well as efforts to reconfigure (or preserve) the current world order. The fact that some powers will seek to act through state and non-state proxies, client states and other entities leads to additional complexity

43 Biswas, S., BBC News (25 January 2023), 'India and Pakistan came close to nuclear war: Pompeo'.
44 UN, Peace and Security (5 August 2023), 'UN pushes disarmament talks amid fears that drums of nuclear war are beating again'.

and creates new risks. Out to 2055, powerful corporations and individuals might play a more prominent role; in addition, expanding violent extremist and criminal networks could also assume an increasingly global as well as regional dimension. While this changing dynamic could undermine principles of state sovereignty, it could also prove as challenging to manage as relations during the Cold War, with its many small wars and proxies. In more extreme scenarios, this web of global partnerships could come to resemble that which existed before the First World War, with the concurrent risk that proxies, clients and other actors might drag major powers into conflict. At the same time, many of these new alignments also offer opportunities to cooperate on areas of mutual interest, for example, global criminality and the potential impacts of artificial intelligence as well as environmental and other issues, thereby helping to restore the current deficit of trust in international relations.

Restoring trust. Increasing global power competition, alongside a growth in misinformation and disinformation and the many shocks and emerging threats which the world has seen recently, has driven a decline in trust both within and between states, as well a decrease in trust in institutions.[45] In addition to the need to give fresh impetus to deterrence frameworks, finding ways to restore trust will be critical if the worst outcomes are to be avoided. While major states might lead such developments, others, such as middle and emerging powers, leaders and innovators from across the Global South, and entrepreneurs and private citizens, may all play a role in this task.

Zone of Peace and Cooperation of the South Atlantic

The Zone of Peace and Cooperation of the South Atlantic (ZOPACAS), with 24 member states, was established by the United Nations General Assembly towards the end of the Cold War and has played a crucial role in promoting peace and cooperation in the South Atlantic region, connecting a number of countries in Latin America and Africa. In 2023, at a ministerial meeting, these countries reaffirmed their commitment to the ZOPACAS and its aims. At the meeting they also discussed important topics such as environmental protection, drug control, humanitarian assistance, trade and industry, intelligence-sharing and technological cooperation, and promoting peace and denuclearisation.[46] The ZOPACAS provides a good example of how states may cooperate with regard to the spaces shared between two continents to maintain peace. Through its efforts to preserve fishing zones and maintain marine habitats, the ZOPACAS has contributed to a growth in tourism to these regions, resulting in an increase in state revenues.

45 UN, Department of Economic and Social Affairs, Policy Brief Number 108 (June 2021), 'Trust in public institutions: Trends and implications for economic security'.
46 Edwards, M., King's College London (6 October 2023), 'Brazil and the ZOPACAS: An overview of Brazil's interests in the South Atlantic's zone of peace and cooperation'.

An alternative future – investing in trust, society and the planet

Global power competition. While new areas of tension will inevitably emerge by 2055, many of the world's existing frozen conflicts and territorial disputes could remain unresolved; and as global power competition increases, these old flashpoints could become new sources of tension and conflict. Notwithstanding the complex historical factors that have led to these prolonged and seemingly intractable conflicts, out to 2055, renewed efforts to resolve these tensions could help make the world safer, whilst also building trust between global actors. In an increasingly multipolar world, United Nations Security Council reform and other measures to enhance the effectiveness of global governance and security management mechanisms could become increasingly essential to equip the international community with the resources needed to deal with existing and emerging tensions effectively.

Society. The world has recently suffered from a major pandemic and could endure others in the future. Coordinated planning to prepare for future outbreaks could improve the handling of such events and provide new avenues for dialogue. In addition, societies across the globe will become more vulnerable to the spread of disinformation and misinformation as digital technology becomes increasingly prevalent and sophisticated. While states will respond to this in different ways, and some will seek to gain advantage from such developments, finding global mechanisms to control the worst excesses could become as pressing a requirement as arms control in the future. At the same time, improving understanding between communities, through exchanges and other forms of activity, could provide new ways to generate trust, as well as enabling a broader appreciation of the world's many rich and diverse histories and cultures.

Economy. Out to 2055, the world will face a range of potential new risks due to rapid developments in financial technology, cryptocurrencies and other new economic instruments. Collaborative efforts to enhance the resilience of global financial systems and institutions could help to mitigate the impact of future economic shocks, while also helping to build trust between actors. While innovation by major powers will frequently drive new waves of economic growth, emerging powers in the Global South also have much to offer through innovations in agrotechnology, water conservation and other approaches, which could help realise a more equitable and sustainable approach to meeting the world's growing resource requirements. Finding ways to invest collectively in such ventures, rather than for competitive gain, could help to build trust between developing and developed countries, as well as among the global powers, whilst also addressing some of the major environmental challenges facing the planet.

Environment. The need to reduce carbon emissions will become an increasingly pressing issue for many states over the next 30 years, not least as the potential financial cost of the green energy transition could prove a major barrier to progress for some. Finding more multilateral and altruistic approaches to renewable energy burden-sharing could therefore become a more pressing demand, potentially driving more innovative approaches in the future. Regions across the world will be increasingly impacted by the effects of climate change; although both poor and rich states will feel the consequences, the most vulnerable populations and regions could suffer the greatest burden. While offers of infrastructure development and other forms of mitigation will often be used as a tool in the competition

between global powers, out to 2055, some may seek to collaborate more widely on such offers to maximise their impact. In parallel, the development of global and collective disaster relief responses could enhance levels of trust between states while fulfilling a growing need. Similarly, collective efforts to monitor and protect the shared spaces and endangered biomes may offer additional ways to build trust in the future.

Technology, infrastructure and communications. While artificial intelligence offers huge potential benefits, an unrestricted and competitive approach to its development could generate new risks with far-reaching global consequences. Finding ways to collaborate around the safe development of artificial intelligence could therefore become an increasingly pressing issue, offering new avenues through which to build trust between global powers and other actors. As humankind becomes increasingly reliant on space-based technologies, the consequences of deliberate or accidental events that could make low Earth orbit inaccessible for any actor could grow. Efforts to introduce global space traffic control mechanisms could become an increasingly pressing requirement, while also offering new avenues for dialogue and trust-building.

Conflict and security. Nuclear arms control mechanisms will come under increasing pressure over the next three decades. At the same time, developments in weapons of mass effect might give rise to new dangers. While some states may currently be unwilling to engage in dialogue on the issues raised by nuclear weapons and the proliferation of new weapons technologies, preferring to seek strategic advantage for themselves, a future crisis could change that standpoint and reinvigorate interest in arms control. In the interim, however, developing new and effective means to combine all levers of power to deter aggression could provide safeguards against the worst outcomes. Looking forward, the desire to put in place new treaties and restore deterrence may see innovative new approaches being developed by 2055. In parallel, states could find ways to reinvigorate existing frameworks governing the use of the shared spaces in future. While many developing states already maintain a strong commitment to peacekeeping and other forms of collective security, finding ways for other global powers to play a more collective role could help engender trust and address a range of growing global security challenges in future.

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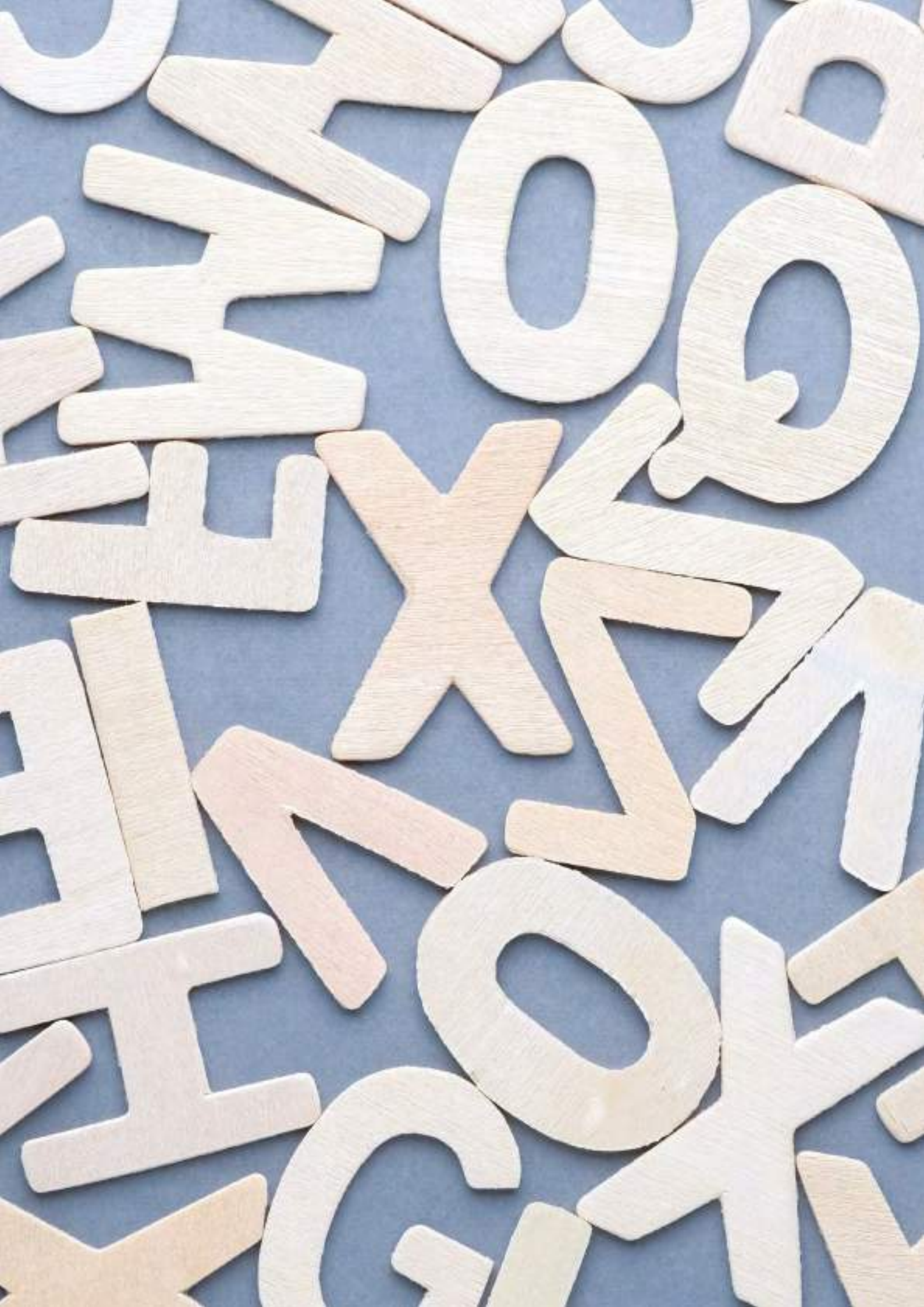

Glossary

Acronyms and abbreviations

AfCFTA	African Continental Free Trade Area
AMOC	Atlantic Meridional Overturning Circulation
AMR	antimicrobial resistance
ASEAN	Association of Southeast Asian Nations
ATS	Antarctic Treaty System
CCUS	carbon capture, utilisation and sequestration technologies
CFCs	chlorofluorocarbons
CO_2	carbon dioxide
DAC+S	direct air capture and storage
DCDC	Development, Concepts and Doctrine Centre
E7	Emerging Seven
EEA	European Economic Area
EU	European Union
FinTech	financial technology
G7	Group of Seven
G20	Group of Twenty
GDP	gross domestic product
GPS	Global Positioning System
GST	Global Strategic Trends
HFCs	hydrofluorocarbons
ICRC	International Committee of the Red Cross
IT	information technology
LAC	Latin America and the Caribbean
MNC	multinational corporation
MOD	Ministry of Defence
MRI	magnetic resonance imaging
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NGO	non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PIF	Pacific Islands Forum
PLA	People's Liberation Army
RECs	regional economic communities
STEM	science, technology, engineering, and mathematics
TEU	twenty-foot equivalent units
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
US	United States
USMCA	United States–Mexico–Canada Agreement
UV	ultraviolet
ZOPACAS	Zone of Peace and Cooperation of the South Atlantic

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Organisations

African Continental Free Trade Area
The African Continental Free Trade Area (AfCFTA) is a free trade area established across the African continent to create a single market for goods and services, facilitate the movement of people, and promote industrial development and sustainable economic growth by reducing trade barriers among member states.

African Union
The African Union (AU) is a body consisting of 55 member states located on the continent of Africa, established to accelerate the process of integration on the continent, promote unity and solidarity among African countries, and foster sustainable development.

Antarctic Treaty System
The Antarctic Treaty System (ATS) comprises the 1961 Antarctic Treaty and related agreements that together regulate international relations with respect to Antarctica. Among its other provisions, the treaty designates Antarctica as a scientific preserve, guarantees continued freedom to conduct scientific research, and bans military activity on the continent.

Arctic Council
The Arctic Council is a high-level intergovernmental forum that promotes cooperation, coordination, and interaction among the eight Arctic States, indigenous communities and other inhabitants on common Arctic issues, particularly on sustainable development and environmental protection.

Asia-Pacific Economic Cooperation
Asia-Pacific Economic Cooperation is an intergovernmental forum established in 1989 to leverage the growing interdependence of the Asia-Pacific region. Its goal is to create greater prosperity for the people of the region by promoting balanced, inclusive, sustainable, innovative and secure growth and by accelerating regional economic integration.

Association of South East Asian Nations
The Association of South East Asian Nations (ASEAN) is a regional intergovernmental organisation comprising ten Southeast Asian countries. It was established to promote political and economic cooperation and regional stability.

Barents Euro-Arctic Council
The Barents Euro-Arctic Council is a multilateral intergovernmental organisation established in 1993 to foster cooperation in the Barents Region (consisting of the northernmost parts of Norway, Sweden, Finland and northwest Russia), focusing on issues such as sustainable development, environmental protection, and cultural exchange among its member states.

Belt and Road Initiative
The Belt and Road Initiative (BRI) is a Chinese-led infrastructure investment strategy aimed at improving connectivity, trade and communication between China and the rest of the world, including Eurasia, Latin America and Africa.

BRICS
BRICS began as an informal grouping of countries that has since developed into an intergovernmental organisation. Its original members were Brazil, Russia, India, China and South Africa, with Egypt, Ethiopia, Iran and the United Arab Emirates joining in 2024. The group collaborates on issues related to economic development, political coordination and cultural exchanges, with a focus on building a more integrated global economy.

Collective Security Treaty Organization
The Collective Security Treaty Organization (CSTO) is an intergovernmental military alliance that was signed on 15 May 1992. It consists of several post-Soviet states, and its primary objectives are to strengthen peace, promote international and regional security and stability, and to protect the independence and territorial integrity of its member states through collective defence and security collaboration.

Combined Joint Expeditionary Force
The Combined Joint Expeditionary Force (CJEF) is a strategic partnership between the UK and France, established to provide a rapid deployment force capable of conducting a wide spectrum of operations, from high-intensity combat to humanitarian assistance.

Combined Maritime Forces
The Combined Maritime Forces (CMF) is a multi-national naval partnership that operates to promote security, stability, and prosperity across international waters in the Southwest Asia region, which encompasses some of the world's most important shipping lanes. Comprising 43 member states, the CMF focuses on countering terrorist acts, preventing piracy, and encouraging a safe maritime environment through collaboration, surveillance and security operations.

Commonwealth of Independent States Free Trade Area
The Commonwealth of Independent States Free Trade Area (CISFTA) is a free trade area encompassing Russia, Ukraine, Belarus, Uzbekistan, Moldova, Armenia, Kyrgyzstan, Kazakhstan and Tajikistan.

Comprehensive and Progressive Agreement for Trans-Pacific Partnership
The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), originally known as the Trans-Pacific Partnership (TPP), is a trade agreement among several Pacific Rim countries that aims to deepen economic ties between these countries, reducing tariffs and fostering trade to boost growth.

Eurasian Economic Union
The Eurasian Economic Union (EAEU or EEU) is an economic union of states located primarily in northern Eurasia. Established by Russia, Kazakhstan and Belarus in 2015, it facilitates the free movement of goods, services, capital and labour, and implements coordinated policies in various sectors of the economy, such as energy, industry, agriculture and transport, to ensure the economic integration of its member states.

European Union
The European Union (EU) is a supranational political and economic union of 27 member states located primarily in Europe.

Five Eyes
The Five Eyes (FVEY) is an intelligence alliance comprising five English-speaking countries: Australia, Canada, New Zealand, the UK and the United States.

Greater Arab Free Trade Area
The Greater Arab Free Trade Area (GAFTA) is a multilateral economic agreement aimed at eliminating all trade barriers and fostering increased trade and investment among Arab countries. Initiated by the Arab League, GAFTA has been instrumental in promoting economic cooperation and facilitating free movement of goods across member states.

Group of Seven
The Group of Seven (G7) is an intergovernmental political and economic forum comprising Canada, France, Germany, Italy, Japan, the UK and the United States, as well as the European Union as a 'non-enumerated member'. Its discussions are focused around issues such as trade, security, economics and climate change.

Group of Twenty
The Group of Twenty (G20) is an international forum comprising 19 countries, the European Union and the African Union, which together represent the world's major economies. The G20 meets annually to discuss and promote high-level policy coordination on global financial stability, climate change mitigation, and sustainable development.

Gulf Cooperation Council
The Cooperation Council for the Arab States of the Gulf, also known as the Gulf Cooperation Council, is a regional, intergovernmental, political and economic union.

International Monetary Fund
The International Monetary Fund (IMF) is an international financial institution that aims to stabilise the global economy by providing monetary cooperation and financial assistance to its member countries. It offers economic analysis, policy advice and technical assistance as well as financial support to countries facing balance of payments difficulties.

Joint Expeditionary Force
The Joint Expeditionary Force (JEF) is a coalition of like-minded states that have come together to contribute high-readiness military capabilities, which can be employed in a range of scenarios, including combat operations, deterrence and humanitarian support. The JEF is led by the UK and includes a group of northern European states willing to work closely in defence and security matters.

North Atlantic Treaty Organization
The North Atlantic Treaty Organization (NATO) is an intergovernmental military alliance of 32 member states in Europe and Northern America. NATO was created in 1949 by the United States, Canada and several western European states to provide collective security against the Soviet Union.

Northern Group
The Northern Group was established to enhance regional security, cooperation and coordination on defence and security issues among its member states, particularly in the northern European region.

Organisation for Economic Co-operation and Development

The Organisation for Economic Co-operation and Development (OECD) is an international organisation that promotes policies to improve the economic and social well-being of people around the world by providing a forum for governments to work together to share experiences and seek solutions to common problems. It comprises 38 member countries and focuses on world trade, economic development and social issues.

Organization of Turkic States

The Organization of Turkic States, formerly known as the Turkic Council, is an international organisation comprising a number of Turkic countries, which aims to promote comprehensive cooperation among Turkic-speaking states. It focuses on fostering cultural, political and economic ties and enhancing mutual relations based on common language and cultural heritage.

Pacific Islands Forum

The Pacific Islands Forum (PIF) is a political and economic policy organisation that consists of 18 member countries and territories in the Pacific region. Its primary purpose is to enhance cooperation between the countries and territories of the Pacific Ocean and represent their interests on the international stage, particularly in relation to economic development, regional security and environmental sustainability.

Quadrilateral Security Dialogue

The Quadrilateral Security Dialogue (QSD), often known as the Quad, is a strategic forum that brings together the United States, India, Japan and Australia. This grouping seeks to promote a free, open and inclusive Indo-Pacific region through collaboration on areas such as defence and security and upholding international order.

Shanghai Cooperation Organisation

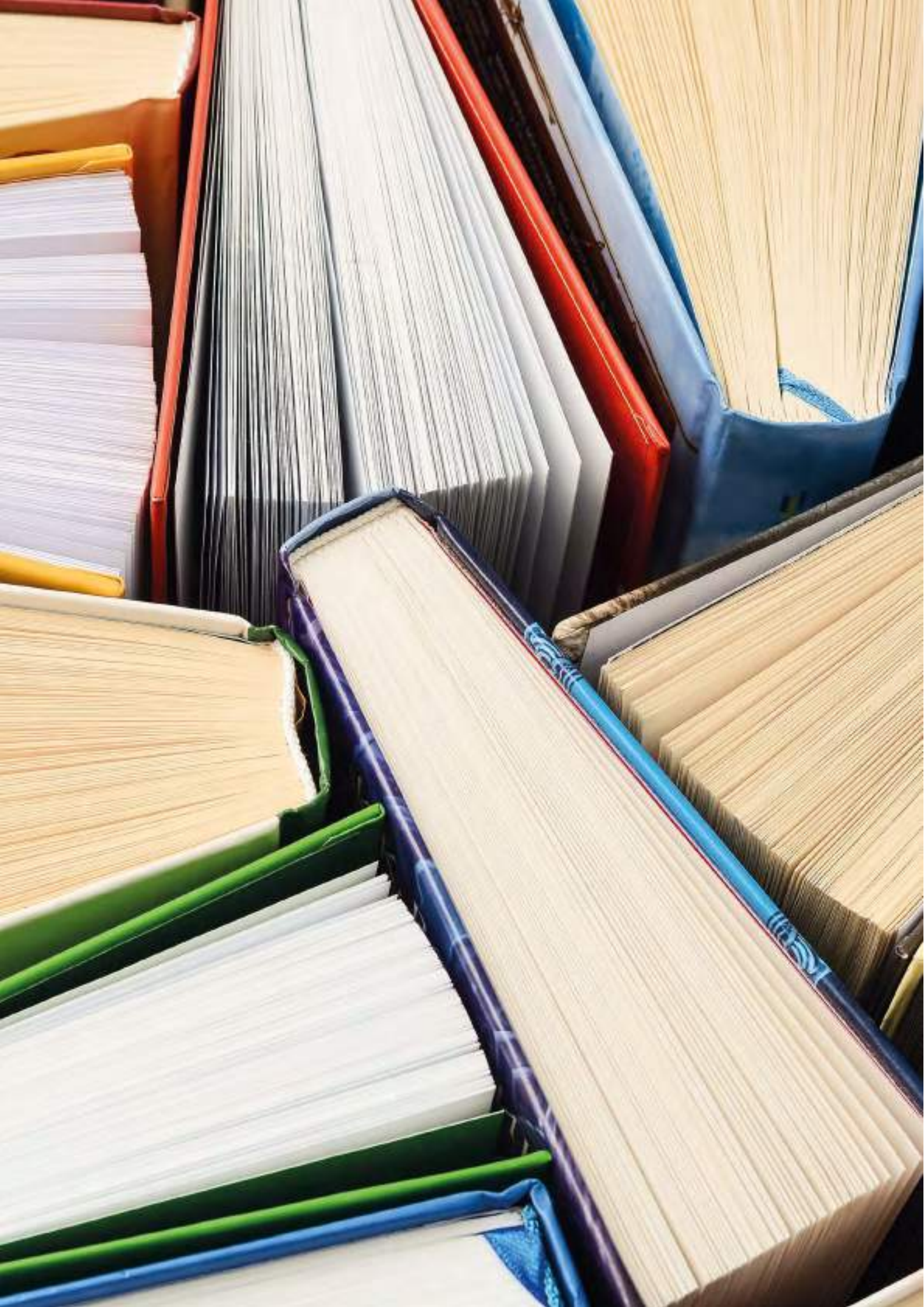
The Shanghai Cooperation Organisation (SCO) is a transcontinental political, economic and security alliance established to enhance cooperation among its member states. Its primary goals are to strengthen stability and security across the region, promote cultural and economic development, and facilitate regional partnerships.

United Nations

The United Nations is an intergovernmental organisation whose stated purposes are to maintain international peace and security, develop friendly relations among states, achieve international cooperation, and serve as a centre for harmonising the actions of countries.

United States–Mexico–Canada Agreement

The United States–Mexico–Canada Agreement (USMCA) is a free trade agreement that replaced the North American Free Trade Agreement (NAFTA) and came into effect on 1 July 2020.



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Future global context: mapping tomorrow's dynamics

This map of interdependencies is an illustrative visualisation of some examples of factors through which the global key drivers are shaping the future strategic environment. It shows the future context in which state and non-state actors will need to shape and adapt to a changing environment.

Primary maritime choke points
Source: Port Economics, Management and Policy (2022)

Launch sites (orbital and sub-orbital)
Source: Bryce Tech (2024)

Proposed launch sites (orbital and sub-orbital)
Source: Bryce Tech (2024)

Polymetallic sulphides

Polymetallic nodules

Cobalt-rich ferromanganese crusts

Exploration areas for deep sea mining
Source: International Union for Conservation of Nature and Natural Resources (2022)

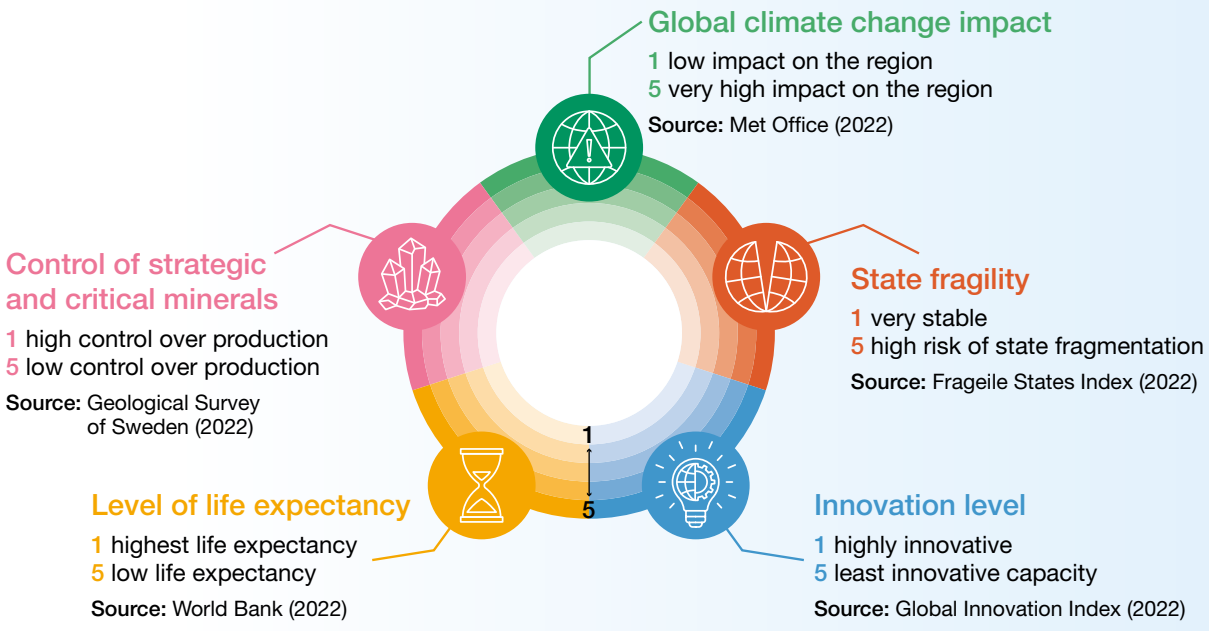
Projected new megacities – percentage increase in population
Source: Institute of Economics and Peace (2022)

Existing megacity status (greater than 10 million in population)
Source: Institute of Economics and Peace (2022)

Underwater cables by density
Source: TeleGeography (2023)

Relevant watchpoints for the future

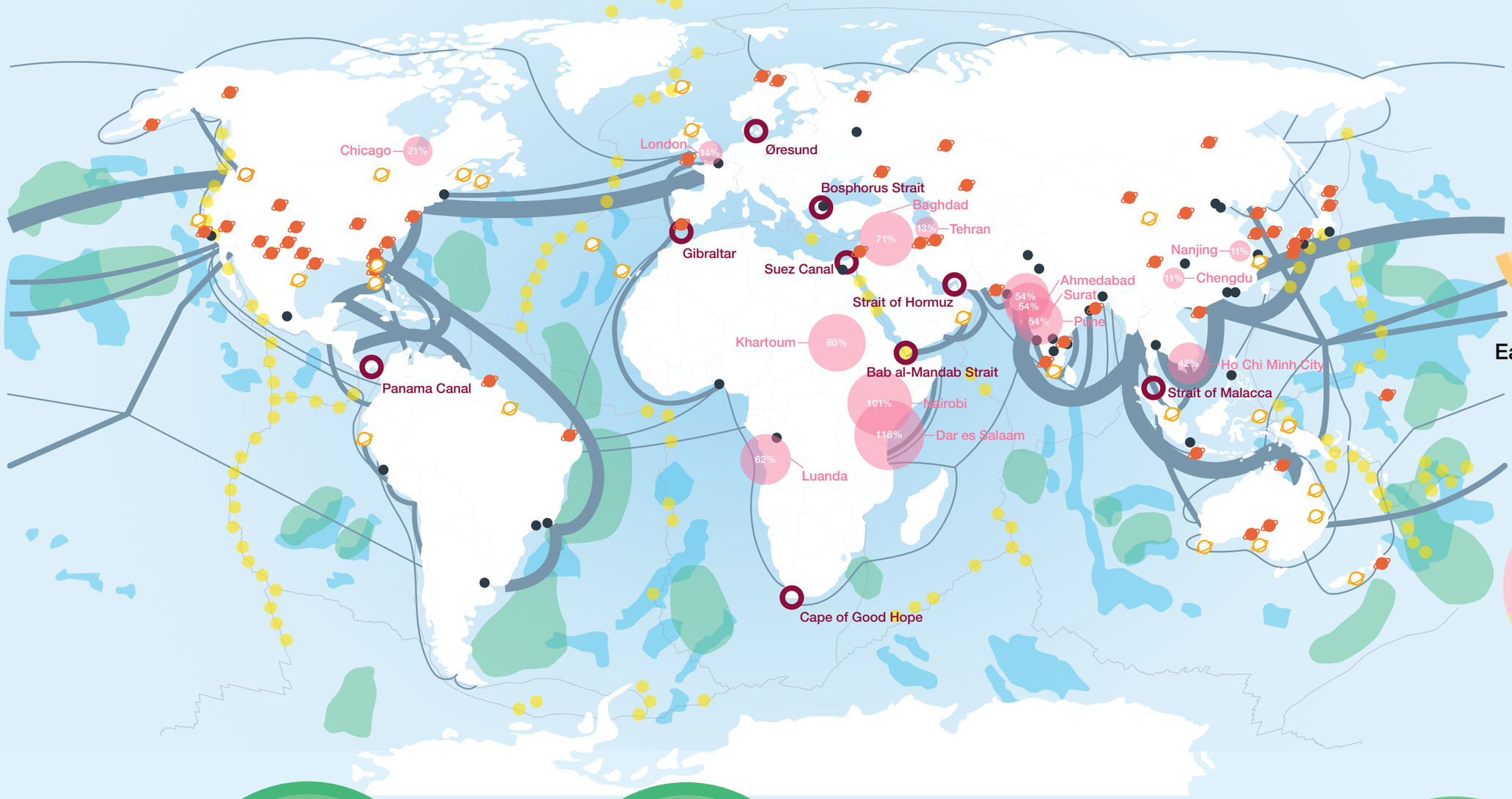
The six global drivers of change shape the strategic environment. The regional graphs illustrate the future relevance of five selected areas: climate change impact, state fragility, level of innovation, life expectancy and control of strategic and critical minerals. The higher the score, the more this may be an area of concern for a region and where it needs to take active measures to be prepared for a changing strategic environment.



Northern America

Europe

Russia



East and South Asia

Southeast Asia
and Oceania

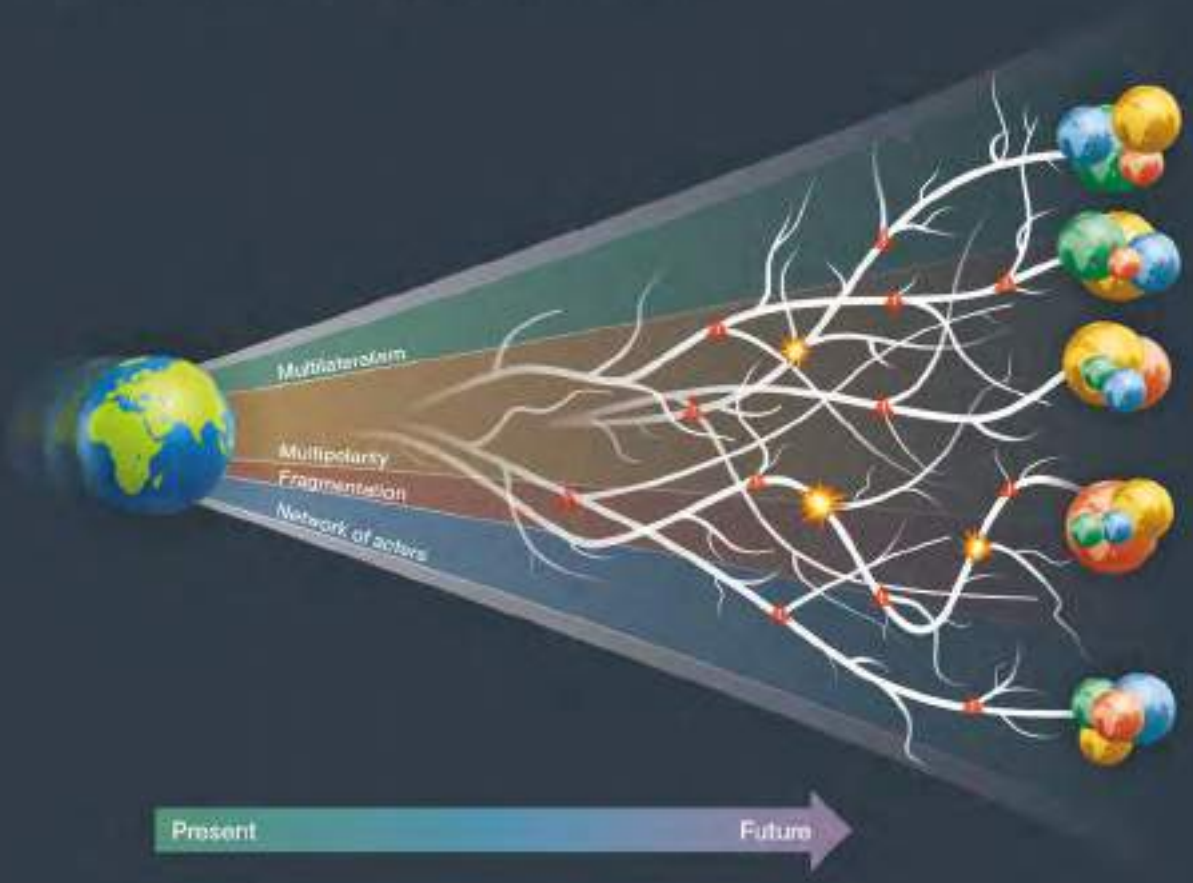
Latin America
and the Caribbean

Africa

Central Asia

Southwest Asia and
the South Caucasus

Global pathways scenarios



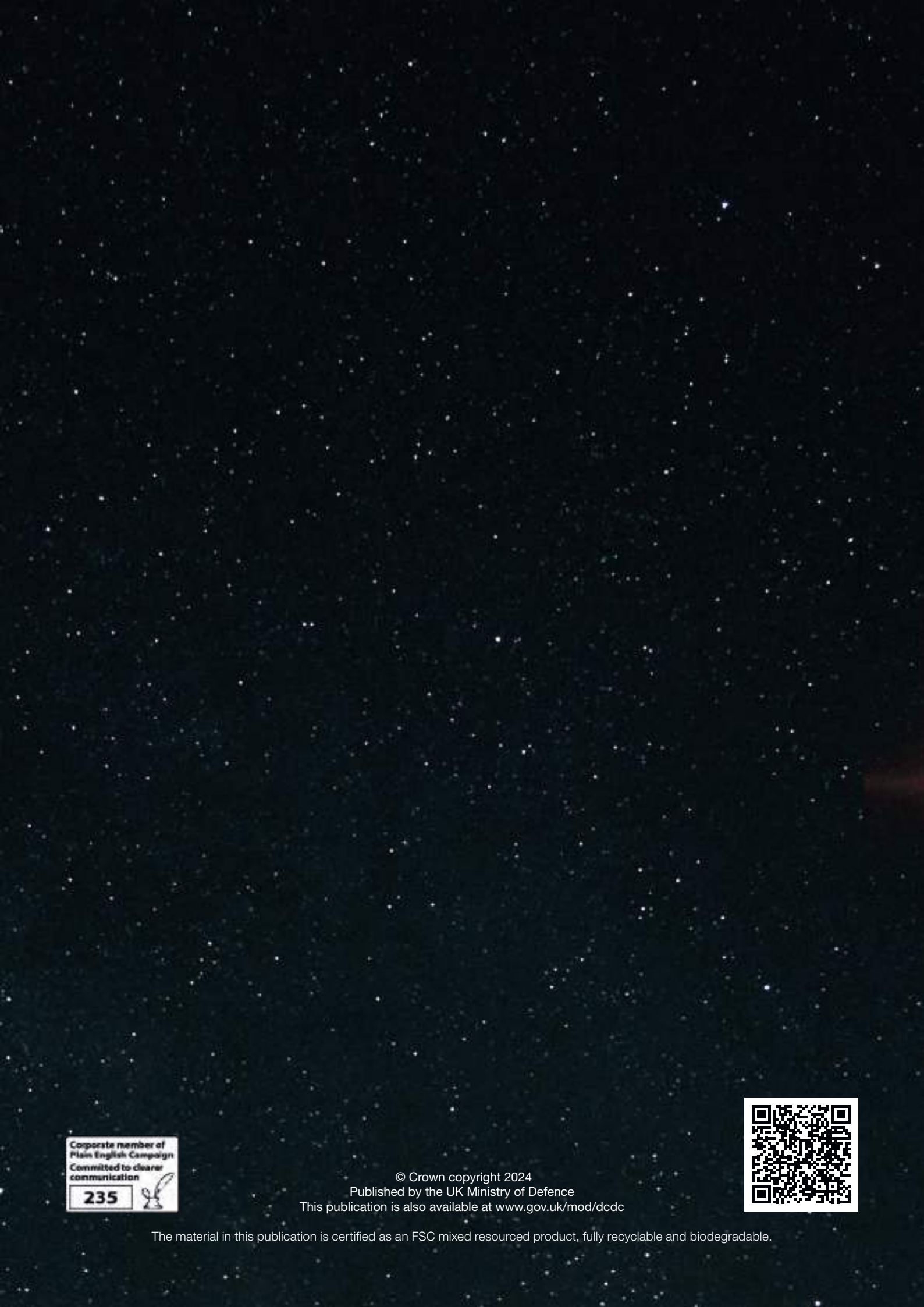
1. Existential threats drive a new multilateral accommodation
Designed to enable an assessment of the factors that could bring the world together, resulting in a new version of multilateralism better suited to meet the needs of the planet and its inhabitants.

2. The current system endures in a multipolar world
Intended to enable an analysis of the factors that may foster continued cooperation between democratic and open societies, enable them to remain attractive partners, and retain their considerable shaping power within the framework of the existing international system.

3. Changing spheres of influence
Depicting circumstances that enable China to expand its global outreach in an increasingly multipolar world, and take a lead in developing and establishing an alternative international order operating under strong Chinese influence.

4. Competition and decoupling leads to conflict and a deglobalised world
Highlighting the risk that increasing competition in a multipolar world could escalate into a major conflict with global ramifications.

5. Incremental instability leads to a new networked order
Portraying a radically different approach to global governance, in which over time a series of factors cause extensive state failure and result in non-state actors playing an increasing role in state, regional and global governance.



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