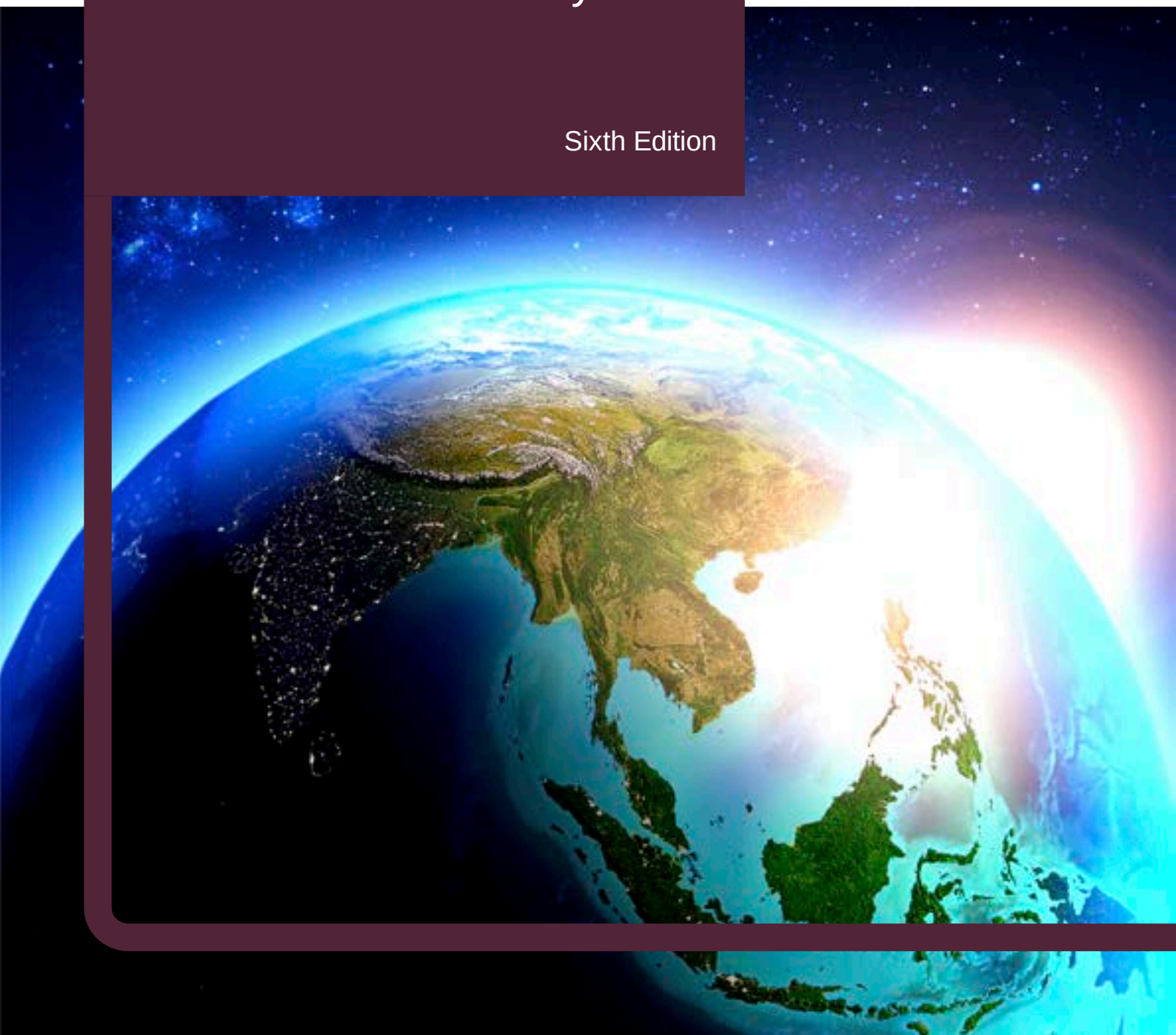
Ministry of Defence

Global Strategic Trends
The Future Starts Today

Sixth Edition



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How to navigate

The Executive Summary summarises all the findings into six drivers of change, 16 focus areas and 40 strategic implications.

Discernible patterns of change are described in Part 1 under thematic headings, and then described in a regional context in Part 2.

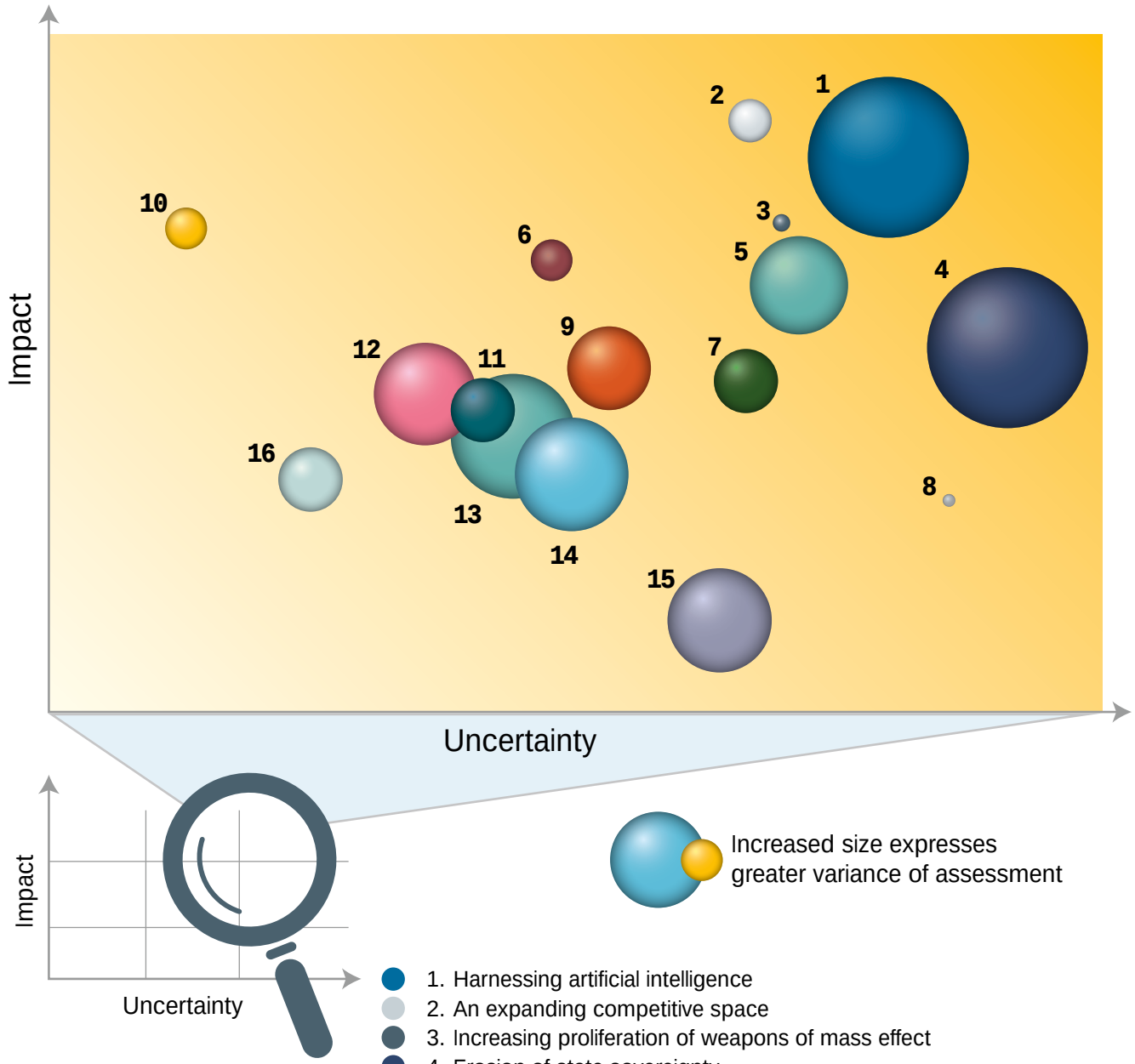
Key deductions for defence and security are highlighted in bold throughout Part 1.

At the end of each thematic chapter in Part 1, alternative future worlds are described along with potential watch points, discontinuities and implications.

Defence and security deductions are highlighted in the lower half of each box.

An illustrative map of key global stresses bridges the thematic and regional sections. A more detailed map is at the back of the publication.

Exploring uncertainty



Increased size expresses greater variance of assessment

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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).

This publication is the sixth edition of Global Strategic Trends. The findings and deductions contained in this publication do not represent the official policy of the UK government or that of the United Kingdom's Ministry of Defence (MOD). It does, however, represent the view of DCDC, a department within the MOD.

Foreword

"Resolving the tension between foresight and inherent uncertainty is the holy grail of sound strategy"

Dr Frank Hoffman – US National Defense University

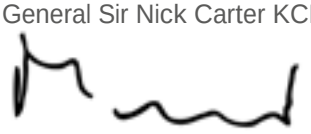
We are at an inflection point. Many future trends are familiar; environmental stress and changing demography, accelerating technological change, the increasing importance of information, greater human empowerment and national and international transitions in both economic, political and military power. Much less familiar is the unprecedented acceleration in the speed of change, driving ever more complex interactions between these trends. The cumulative effect represents a strategic challenge that requires a strategic response.

We must learn to think differently and develop the agility to enable continuous adaptation. Creating, inventing, designing, introducing new processes, new ways of thinking, new forms of leadership and management which enable new ideas to be embraced, new technologies to be exploited and integrated, transforming our current system into one which is permanently innovative, adaptable, responsive and proactive. We need to explore new ways of finding answers for future, unforeseeable threats, to be ready to harness fleeting opportunities, and seek new ways to keep on finding answers and opportunities. It means changing the way we think, act, and acquire equipment, exercise command, lead. We are at a paradigm shift in the character of conflict: we need to change the way we do things fundamentally. The future starts today.

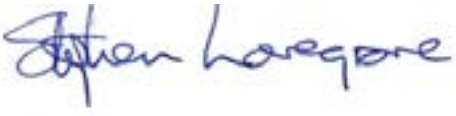
Since its inception in 2001, the Global Strategic Trends publication, part of a wider strategic analysis programme led by our Development, Concepts and Doctrine Centre, has undertaken continuous research to identify the key drivers of change that will shape and reshape our world. This analysis helps Defence, and our cross-government partners, to identify future developments, spot potential disruptions and detect weak signals that need to be evaluated. This helps improve our strategic foresight, offering us the potential to evolve upstream of threats and opportunities. As Dr Hoffman notes, however, there is no predictive holy grail. Like the actual holy grail, though, the synthesis referred to above has never been, and will never be found. Nevertheless, the development of a working long-term view is indispensable to any organisation that seeks to think, invest and act strategically, notwithstanding that the only certainty about the future is its inherent uncertainty. Foresight can prepare us better for an unexpected challenge; agile adaptation will close the gap.

Drawing on analysis from across other government departments, other nations' governments, business and academia, this sixth edition of Global Strategic Trends focuses on supporting those who are formulating Defence policy, strategy and capability development, making it more relevant and useable. To better explore the range of uncertainty that exists, the illustrative 'future worlds' give an insight into alternate, plausible futures and discontinuities. The 'impact and uncertainty' analysis helps to quantify how confident we can be in our understanding of the key drivers. Without offering solutions, this work identifies the issues that need to be addressed and so helps us judge where – and perhaps when – we must invest our efforts. We commend it to you.

Chief of the Defence Staff
General Sir Nick Carter KCB, CBE, DSO, ADC Gen



Permanent Secretary
Stephen Lovegrove CB



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Introduction and method

Purpose. Global Strategic Trends (GST) provides a strategic context for those in the Ministry of Defence (MOD), and wider government, who are involved in developing long-term plans, policies and capabilities. Without an impartial strategic context there is a risk that planners, policymakers and capability developers would assume a future that supports their assumptions and bias. This publication seeks to improve foresight and encourage better strategic choices to shape the future we want, build preparedness for alternative futures, and create an organisation that can adapt to the evolving future. Additionally, it aims to alert readers to changes that are likely to become threats but may, if addressed promptly, provide opportunities. To ensure it is objective, GST is based upon evidenced trends (discernible patterns of change). GST does not attempt to predict the future (it cannot), but instead it is an aid to thinking about the future.

Genesis. The need for the MOD to set out a future strategic context was articulated in the 1998 Strategic Defence Review. To meet that requirement, and as part of a broader strategic analysis programme, the first edition of GST was published in 2003. GST has been a key element of the MOD's contribution to both the National Security Strategy and the Strategic Defence and Security Review and '…was one of the main contributions to the policy-making process that culminated in the 2015 UK strategy'.[1] Elements of this edition of GST have also been used to develop the National Risk Assessment.

Scoping. Work on this sixth edition of GST (GST 6) started in early 2016 with a review of previous editions to identify gaps, inconsistencies, enduring trends and, most importantly, topics for further study. This work was augmented by an online literature review and an online survey. The literature review identified future-focused topics that had attracted greatest interest (as measured by number of publications) since GST 5 was published in 2014. The online survey was designed to collect, from a diverse and international audience,[2] thoughts and ideas about the future, and hence potential topics for research. This work culminated in a workshop that brought together partners from academia, government, industry and the non-profit sector, both domestic and international, to test and validate our ideas. The workshop identified 39 topics for research and during the research phase a further three topics were identified and researched.

Research. Each topic was researched by a member of the Development, Concepts and Doctrine Centre's (DCDC's) Futures Team. A literature review was the starting point, followed by workshops, interviews and, in most cases, the commissioning of at least one research paper. In total, over 70 pieces of academic research were commissioned from 42 different institutions. A key output of the research was identifying the trends, and the

1 Lunn, J. and Scarnell, E., (14 December 2015), House of Commons Briefing Paper 7431, *The 2015 UK National Security Strategy*, page 5.

2 Responses were received from participants in five continents.

projection of those trends forwards. Data has been used to generate projections, where appropriate, whilst recognising the limitations of this technique (the future rarely follows the smooth projections of statistical models). These projections do, however, give a direction, and often a sense of the speed of change. Finally, the findings from the various activities were brought together into a single paper for each topic.

Validation. From the outset, we have attempted to manage bias, where practical, by adopting a structured approach that considered a wide variety of viewpoints and perspectives. As well as sharing and testing the findings from each topic individually, the collective findings from the entire programme of work have been shared, tested and validated at workshops and seminars with academia, partners across government and with international partners in over 40 countries on five different continents. In addition, DCDC's Development Analysis and Research Team have 'red teamed' the work, testing the logic and looking for inconsistencies, contradictions and quality of evidence.

Collaboration. When compared with previous editions, GST 6 has benefited from an unprecedented level of collaboration. As well as support, comment and advice from partners across government, the Department for International Development provided the foundation research for two topics and the Force Development Directorate of the New Zealand Defence Force also provided two foundation papers. Officers from Australia, Germany, Finland and Sweden have been embedded in the Futures Team throughout the production of GST 6, ensuring that the work has continuously benefited from an international perspective.

Fusion. The sheer volume of information in the 27 thematic topics (plus oceans and space) meant that it was necessary to further consolidate them. This also allowed a cross-impact analysis of the significant ideas to be conducted, which highlighted the interactions between the major drivers and trends. The result is five 'fused' thematic chapters that comprise Part 1 of GST 6, which are:

- environment and resources;
- human development;
- economy, industry and information;
- governance and law; and
- conflict and security.

The geographic topics have translated into 13 individual chapters in Part 2, and all but one of these chapters covers a geographic region of the world consisting of a number of countries. The exception is Russia, which is so vast, stretching from Europe to almost North America, it is a region in its own right.

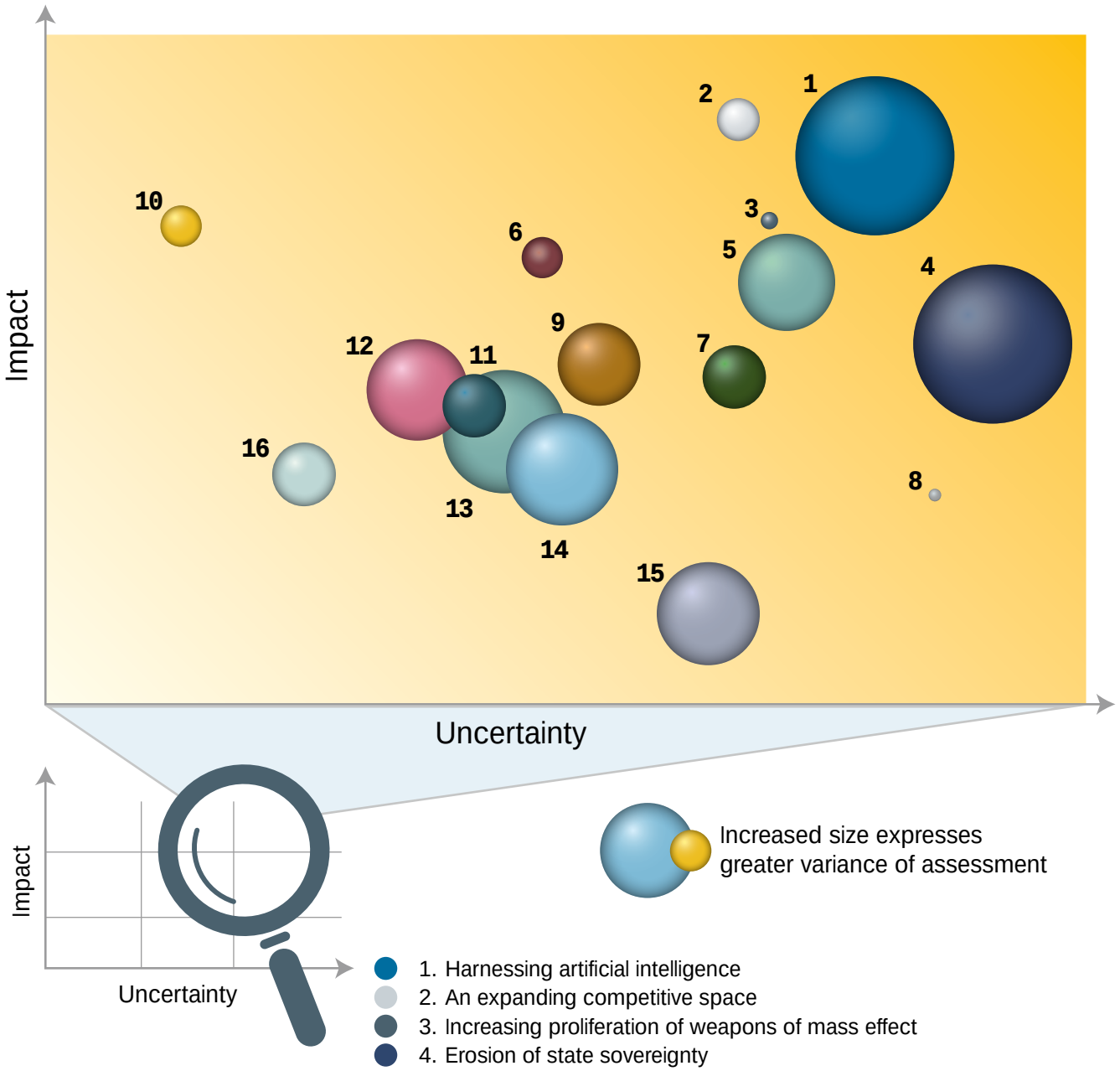
As with GST 5, a journalistic approach (focusing on conveying the findings through the written word) has been taken and this has been supplemented by a first order analysis to identify key deductions, which have been highlighted in bold within the text. Attempting to describe how the world might look over the next 30 years inevitably involves extrapolation and imagination, and so, as in GST 5, probabilities have not been assigned to our findings. Given the inherent uncertainty, such figures would be simplistic, and probably misleading. Instead, GST 6 should allow the reader to draw their own informed and nuanced conclusions about the future.

New features. Feedback has, however, highlighted that a trends-based approach can give too linear a view of the future as it flags continuity rather than discontinuity. To address this, with the support of the Defence Science and Technology Laboratories (Dstl), four 'future worlds' have been produced (further detail can be found on pages 21-29). At the end of each thematic chapter, the most important trends have been analysed through a 'future worlds' lens offering plausible alternatives to the outcomes described in the chapter. Watch points (indicators that an aspect of a future world is likely to emerge) and possible discontinuities (factors that will change the path of a trend) have also been produced. Each set of future worlds is also accompanied by a number of deductions for defence and security and implications. In addition, an impact and uncertainty analysis has been conducted. The analysis has drawn on multiple inputs, including a crowd-sourced survey, to produce an assessment of the scale of impact and the uncertainty (if the impact will be realised or not) and the variance of that assessment. A visual representation of this work is on page 10. A global stress map has also been produced that illustrates where in the world we judge the key stresses (described in the thematic chapters) are likely to have the greatest impact.

Exploitation. The output from all the activities described have been used to identify 16 focus areas where the potential for profound change to humanity is high, and from these, 40 strategic implications, the issues that will need to be addressed. The findings from previous editions of GST have been taken forward in a subsequent document (the *Future Character of Conflict* in the case of GST 4 and the *Future Operating Environment – Out to 2035* in the case of GST 5). This time, however, to further enhance GST 6's relevance and utility for the defence and security community, selected strategic implications will be taken forward through a series of strategic implications projects. Some papers will be produced in collaboration with international partners and published, while others are likely to be classified and not publicly released.

GST 6 has bene□ted from support, comment and advice from partners across government

Exploring uncertainty



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Executive summary

> ‘The future is already here, it’s just not evenly distributed.’
>
> William Gibson

The world is becoming ever more complex and volatile. The only certainty about the future is its inherent uncertainty, yet we must prepare. We need to encourage curiosity, be comfortable with ambiguity and open to the world of possibility not probability. The purpose of this sixth edition of Global Strategic Trends (GST 6) is to help those tasked with developing long-term policies, strategies and capabilities to think about the future, allowing them to make the necessary choices today to better prepare for tomorrow, seize opportunities and mitigate risks. As with previous editions, our start point has been identifying and projecting trends (discernible patterns of change) to build a series of evidence-based perspectives on the future. The findings from this work is described in the five thematic chapters, and have been distilled below into the six key drivers that our research indicates are particularly important. Dealing with the resulting threats and opportunities will require adaptation, exploitation and action. This work has been further developed in the geographical chapters, illustrating how a global trend can often have an unequal or disproportionate impact in different parts of the world. From this analysis a central idea has emerged: the rate of change and level of uncertainty may outpace good governance and unity. The complex interaction of these trends is potentially game changing and demands a new approach that places strategic adaptability at its core.

Focusing solely on continuity (trends), however, gives an unrealistically linear and predictable view of the future, and risks missing weak signals of potentially major change. Therefore, GST 6 has used two techniques to derive non-linear insights. The first is the production of ‘future worlds’ to explore alternate and plausible futures, including shocks, shifts and surprises. The second has been an impact and uncertainty analysis, which has drawn on multiple inputs to produce an assessment of the scale of impact and the uncertainty (if the impact will be realised or not) and our confidence in that assessment. The output from these, and other, activities (including red teaming and workshops) have identified 16 focus areas that we judge offer great potential for profound change to humanity, and from these we have identified 40 strategic implications, which are important issues that will need to be addressed. It is worth noting that this list is unlikely to be complete and, given the significant complexity and interplay between the drivers and trends and the obvious focus on defence and security issues, further work will be required to develop the ideas more fully, and this will be taken forward in the broader Strategic Analysis Programme.

Trends that require adaptation

Increasing human empowerment. Human security will be enhanced as more people escape absolute poverty and have access to education and health care. Technology is likely to lead to spectacular medical advances and the number of people dying from infectious diseases is likely to reduce, although the number of people suffering from non-communicable diseases, such as obesity and dementia, are increasing. Human empowerment will increase with unprecedented numbers of people having access to almost limitless information, and more people having the means to travel abroad and to maintain relationships with people from outside their immediate community. Equality is improving and increasing numbers of people in developed (and some developing) countries will have the freedom to determine their gender and sexuality. Individualism and personal empowerment is likely to enhance personal fulfilment and the way individuals and communities interact with, and influence, the world around them is evolving, but this may come at the price of more fragmented societies and increasing populism. In addition, inequality is growing, with the rich getting substantially richer but, particularly in developed countries, the middle class and the poor seeing slower economic growth. There also appears to be a growing division within many countries between those with liberal and those with traditional views, and nationalism, religious intolerance and antipathy towards immigrants are on the rise. There are also signs that many governments are becoming more authoritarian.

Power transition and diffusion. As the economic power of Asia increases, the political and military power of China, and to a lesser extent India, will grow, potentially rivalling that of the United States (US). While Russia and Europe will remain important political actors, their influence is likely to diminish and the economic and soft power of the West will reduce. A crucial question is whether the current institutions, mechanisms and norms of the international system can adapt to accommodate this shifting balance of power. If it cannot, the system will fail, disputes will be more difficult to resolve, and these could escalate and lead to conflict. As political power becomes more dispersed and contested it will become harder to forge internationally-binding treaties, and non-compliance and subversion of international laws are likely to increase. The transition of power between states is occurring alongside the diffusion of power within states, which in turn is making the stage on which power plays more crowded. States will face increased competition in the provision of public services that have traditionally been the responsibility of governments and they will be confronted by emerging non-state actors both domestically and internationally. The economic, demographic and political power of many cities (and some regions) is likely to grow relative to the state and this may lead to demands for devolution or at least accommodation. Some countries may not exist in their current form by 2050. A few multinational corporations will become bigger and more powerful, providing vital services that states will depend on, and some will use their power to demand concessions from the state. The sovereignty of the state is, therefore, likely to continue to be eroded and a more complex, potentially decentralised, hybrid system of governance may evolve.

Trends that require exploitation or mitigation

Centrality of information. Processing power, the volume and variety of data and connectivity will continue to grow exponentially, driving the development of artificial intelligence, quantum computing and the ability to solve problems of increasing complexity and difficulty, leading to improvements across all aspects of human endeavour. Digitisation is fundamentally changing how people interact, and leading to a shift in value away from physical goods to the underlying blueprints and designs. As an increasing number of people spend more time conducting an ever-widening range of activities in cyberspace, information will become ever more central to humanity, and conflict. Information will be used to deliver cyberattacks and spread misinformation.

Social media may cause an ‘echo chamber’ effect polarising populations, eroding trust in institutions, creating uncertainty, and fuelling grievances. Without effective regulation and protection, cyberspace and social media will continue to be exploited by criminals and other malicious actors.

Accelerating technological advancement. As well as improving computing power, technology will drive improvements in virtually every area, including medicine, transport and industry. Technologies such as ‘gene editing’ will allow previously untreatable genetic conditions to be cured. Transport will become cheaper, faster and possibly cleaner as electric vehicles become more commonplace and fuel efficiency improves. The automation of industry, including 3D printing, will reduce the time needed to develop new products and allow an increasing number of products to be tailored to the individual customer. Technology will ensure that products are produced precisely in optimum conditions, thereby reducing cost and pollution, and improving performance. The speed of transition from the current model of work to one where machines do much more could, however, be critical. The industrial revolution resulted in considerable upheaval and the loss of many livelihoods, yet the transition took several decades. The change to a significantly more automated world (variously referred to as the 4th Industrial Revolution) involving a range of new technologies that are fusing the physical, digital and biological worlds and impacting all disciplines, economies and industries, is likely to happen faster than previous transitions. This is likely to increase the risk of societal upheaval, grievance and possibly violent protest by the disadvantaged. If well-managed, however, automation could lead to more leisure time, less drudgery and reductions in poverty.

Trends that require action

Increasing environmental stress. Human influence on the climate system will have far-reaching consequences as floods, drought, storms, heatwaves and heavy rainfall become more intense and possibly more frequent. Transport and trade routes, including key chokepoints, are likely to be disrupted affecting global markets and supply chains. Rising sea levels will increase the risk of flooding with low-lying tropical island communities and coastal cities (especially in developing countries) at particular risk. Pollution, habitat destruction and over exploitation will lead to significant reductions in biodiversity and increase the risk that some ecosystems will rapidly collapse. The demand for food and water will increase but some crops will fail and water shortages will become more frequent. The destruction of homes and livelihoods due to natural disasters could also lead to increasing migration and increased tensions. Better management of water and improvements in agriculture (including through technology) could meet rising demand, but this will require investment and action. If not handled effectively, it could lead to disputes, and possibly conflict.

Changing populations and evolving habitats. The population is expected to grow by around 2.1 billion and reach around 9.8 billion people by 2050, but growth will be unbalanced. In many developing countries growth will be rapid and populations will be youthful, whilst most European and East Asian countries’ populations will shrink and age, with more than a quarter aged over 65. As societies age their character is likely to change. Elderly populations tend to be more peaceful, but they are also often more conservative, potentially stifling innovation and change. Ageing populations will also demand increased spending on health care and welfare, straining governments’ budgets. Migration will increase and, if managed effectively, could boost the economies of both countries of destination and origin, however, if badly managed, a lack of integration could lead to fragmented societies. Increasing numbers of people will live in towns and cities, boosting economies, although rapid urban expansion in developing countries will lead to the growth of slums and criminal violence.

Discontinuities

Discontinuities are those factors that cause disruption and change the paths of trends, or even cause them to disappear. Discontinuities will occur in unexpected ways due to the accelerating pace of change and complex interaction of the key drivers described above. Examples include: significant geopolitical shifts in allegiance; societal, ideological or economic paradigm shifts; major conflict; natural disaster; financial crisis; destruction of transoceanic fibre-optic cables and/or space systems; collapse of key multilateral organisations; and the proliferation of a disruptive technology, such as artificial intelligence or genomic editing. Whilst 'Black Swans' (a commonly used metaphor describing the disproportionate effect of previously unobserved, high impact, hard to predict and rare events) often grab the headlines, 'Black Jellyfish' and 'Black Elephants' may have greatest impact. 'Black Jellyfish' are issues we think we know about and understand, but which turn out to be more complex and uncertain, sometimes with a long tail and nasty sting in the end. 'Black Elephants' are a cross between a 'Black Swan' and 'the elephant in the room', these are challenges visible to everyone, but which no one wants to deal with. They are, in effect, blind spots, where due to cognitive bias, powerful institutional forces, short sightedness, or failure (or unwillingness) to read the signals we avoid the unpalatable, potentially at significant cost. A state's inability to identify, understand and implement policy to deal with these issues will increase the risk that they will manifest into large-scale or acute issues with much larger latent cost. This risk often appears more applicable to Western societies where democratically elected governments are less likely to be decisive on highly political issues and where public opinion is divided or social expectations are changing.

What needs to be addressed? Focus areas and strategic implications

Increasing disruption and cost of climate change. The cost of climate change to governments and societies will increase and, as time passes, mitigation measures will become increasingly complex and expensive to implement.

- The demand for a coordinated global campaign to address climate change will grow as acute effects are felt from an increasingly volatile climate and concerns develop about an approaching ecological 'tipping point'.
- Geoengineering (deliberate, large-scale manipulation of an environmental process) could become a strategic geopolitical (and irreversible) choice for governments.
- Defence and security planning assumptions, not least access, basing, routes, logistics and the environmental envelope in which military capabilities will have to operate, will need to be reviewed.

Increasing demand and competition for resources. Increasing world population and rising living standards are increasing demand on all resources, including food and water, energy and rare earth materials. The effects of food and water shortages are likely to be most keenly felt by the poor, but advances in technology will improve existing, and offer new, food production techniques. Despite advances across all resource categories, distribution will remain unequal, which may lead to social disorder and violence, economic disadvantage and increased interstate and intra-state competition and conflict.

- Effective international governance, including trade agreements, will be vital to ensure distribution and management of global resources.
- Increasing national and global resilience to resource disruptions is essential to national defence and will reduce the need for humanitarian interventions.

Managing demographic change. Rates of migration are likely to increase as transport becomes easier and cheaper to use and populations in many parts of the developing world grow. The rate of urban growth is likely to outstrip the capacity of governments in many developing countries. An ageing population is likely to be a key issue in Europe and East Asia as current models of employment, health/social care and retirement may become unsustainable.

- Strong national and regional leadership will be required to ensure effective management and integration of a growing migrant population.
- Ageing and more diverse workforces will require current models of employment and welfare to be changed.
- The increasing complexity of cities will require militaries to adopt specialist equipment and operating concepts, and improve cooperation with other government partners.

Greater automation and an increasingly diverse workforce. By 2050, machines will play an increasing role in the workplace. The workforce, particularly in developed countries, is likely to include more women, older people and people with physical impairments or cognitive differences, such as autism. In militaries, there may be a shift in the balance between the components of fighting power with an increased use of machines in many combat functions previously performed by humans.

- Automation presents an opportunity to mitigate current challenges of recruiting in some areas. However, developing a workforce that has the intellectual and psychological aptitude to work within an increasingly automated operational environment will present alternative challenges.
- Future employers, including militaries, will need to adopt more inclusive styles of leadership and management and adapt recruiting models, organisational structures and working practices.
- Policy, not technology, will decide if a human is needed inside the decision loop for the use of lethal force.

Rising inequality, reducing social cohesion, and fragmented societies. Whilst inequality between countries has reduced, inequality within countries has increased, with the gap between the haves and have-nots increasing in terms of income, wealth, education, social mobility, prosperity and political advantage. If left unchecked, inequality could lead to instability.

- Governments will need to get ‘upstream’ of the problem to address the causes not symptoms of inequality, rather than just poverty, to avoid the risk of fragmented societies.
- Nested within a whole-of-government approach, the defence and security community should consider placing human security (‘the people’) at the centre of their world view.

Increasing threat from crime and extremism. There is a strong correlation between violence and extremism, and corruption, organised crime and state fragility. The network of organised criminal groups is global, fuelling conflict and connecting conflict areas to our home countries.

- Governments will need to reduce the physical and virtual ungoverned space that provides freedom of manoeuvre to transnational criminal and violent extremist organisations.

- Tackling transnational criminal and violent extremist organisations will require global cooperation and a whole-of-government approach.

Erosion of state sovereignty. The nation state is expected to remain the primary actor in shaping societies and in global politics for at least the next 30 years. However, state authorities may struggle to cope with the rate of change, level of uncertainty and the growing demands of their increasingly diverse populations. States will face increased competition in the provision of public services that have traditionally been the responsibility of governments and will be confronted by emerging non-state actors both domestically and internationally.

- If states are to remain the pre-eminent domestic and global actors, they need to become more agile to effectively shape the rapidly changing environment.

- Governments will need to manage the increasing mismatch between the rising expectations of their citizens and the states' capacity to deliver.

- States will increasingly need to work in partnership with a range of actors, and those that do so effectively will gain a substantial competitive advantage.

An expanded and unregulated information space. An increasingly expanding, unregulated information space (blurring between fact and opinion, and between real and virtual), where there is little or no quality control, combined with the echo chamber effect, will make individuals more susceptible to misinformation and/or radicalisation. Ultra-high speed, ultra-agile networks of interacting smart devices will present societal, organisational and personal challenges, which could potentially be exploited by malign actors.

- A whole-of-society approach to defensive and offensive measures in the information space is necessary to ensure protection against physical and cognitive attack and subversion of society, for example, through legislation and education.

- Consideration may need to be given to establishing national or regional cyber borders to provide defence against increasingly persistent and capable cyber threats.

- Seizing the initiative in the dynamic information environment requires a shift away from a defensive/reactive posture to a concerted whole-of-government approach that includes mobilising networks and continuously updating a truthful and compelling narrative to proactively shape the debate.

Managing technological change. The rate and impact of technological change will be in part cultural (societies' capacity to absorb, and demand for, technological change) and in part technological. The interplay and layering of rapid technological advancements makes prediction extremely challenging and the spread of technology will make it harder to preserve a competitive advantage.

- Collaboration with a range of partners (including industry and allies) and the coherent integration of the national industrial base with the defence science and technology community will be essential to achieve technological transformation and maintain interoperability. This should be underpinned by strong leadership, vigorous experimentation and shrewd investment in military research and development.

- Governments will need to carefully balance investment between augmenting legacy capabilities and developing genuinely new capabilities that could deliver a transformational advantage.

Understanding human enhancement. Human enhancement technologies, including gene editing, physical and cognitive prosthesis, and pharmaceutical enhancement, are nascent now and their development over the next 30 years is likely to offer profound expansion of the boundaries of human performance. The application of these technologies and the integration of human and machine on the battlefield present opportunities to enhance military capability and improve performance of force elements. An actor's willingness and appetite to exploit these technologies may confer a competitive advantage over an adversary.

- Moral, ethical and legal thresholds need to be defined to inform the development of human enhancement technologies within societies and armed forces.

- Timely investment to understand the potential applications and risks of enhancement technologies will generate competitive advantage and could enable global leadership in developing governance frameworks.

Harnessing artificial intelligence. As more devices and people are connected through the Internet, the volume and variety of data created and the speed at which it is gathered and analysed will increase. This will be important for developing and using artificial intelligence and machine-learning algorithms. Applications of artificial intelligence will enable machines to develop perception, reasoning, solve problems, learn and plan. Artificial intelligence will also improve the management and verification of data, data analysis and data integration. It could challenge traditional notions of work, and maybe even human purpose. The rate of artificial intelligence adoption will be affected by culture, governed by policy and affected by commercial developments. Data management will be vital to exploiting artificial intelligence.

- Governments will need to proactively contribute to the debate to build societies' trust and confidence in this emerging technological field.

- A technical, legal and ethical framework needs to be developed with partners and allies to employ artificial intelligence-enabled technologies.

- A failure to understand artificial intelligence capabilities may create vulnerabilities and cede advantage to competitors.

The challenge of affordability. Competing priorities will make the affordability challenge ever starker and necessitate harsh choices. Economic growth could become ever more elusive and countries are likely to spend less on defence unless there is a clear and present threat to the state. Sectors of fast technological change (such as defence) will require an increased share of funding due to rapid obsolescence and high replacement costs. Countries like the United Kingdom (UK), whose financial sector dwarfs the national economy will be more vulnerable to financial crisis and economic warfare.

- In fiscally constrained environments, investing in science and technology is necessary to identify and realise opportunities to gain asymmetrical, or offset, advantage over adversaries.

- Governments will need to adjust to likely growth figures when planning budgets and better articulate the cost/benefit of the 'insurance' value offered by defence.

- Careful consideration will need to be given as to how to create mass effect and whether advantage is best achieved through a few very expensive advanced capabilities or acquiring large numbers of cheaper capabilities.

Adaptation of the rules-based international system. The world order is changing and current rules, norms and institutions are being increasingly challenged, as many believe the current system is biased in favour of the West. Interstate competition (and potentially conflict) may be more about defending old or new 'rules' as if they were a strategic interest in themselves.

- Governments will need to understand their role in a changing world order and how to accommodate emerging powers. Failure to adapt risks a polarised, less-stable world with a higher likelihood of conflict.

- A careful balance between national interests and regional interests will be required when developing alliances and establishing allegiances.

Increasing competition in the global commons. Nations are becoming increasingly reliant upon capabilities and infrastructure that are dependent upon access to the global commons (cyberspace, the oceans, polar regions and space). Maintaining freedom of action in the global commons will thus be a vital objective for governments. Governance will continue to be a contentious issue as increasing levels of activity in the global commons could lead to a rise in competition, and possibly conflict.

- The reinforcement of existing, and where necessary establishment of new, multilateral global governance frameworks is essential to ensure continued access to the global commons. An international framework for the governance of space and cyberspace provides an opportunity for international collaboration.

- Governments will need to invest in homeland resilience (and by implication redundancy and spare capacity) to protect national vulnerabilities.

- As activity in the Arctic increases, competition is likely to intensify and governments will need to establish methods of cooperation, otherwise militarisation and conflict may follow.

An expanding competitive space. As the balance of power shifts, competition between states and other actors is likely to intensify and become ever more persistent. Conflict will be most likely where relative power differentials are greatest or when power is contested or redistributed. The number of intra-state and non-state conflicts is increasing and the boundary between war and peace is becoming increasingly blurred. However, the level of interconnectedness and dependencies could increase the cost of armed conflict. Actors will, increasingly, use a hybrid approach to warfare and confrontation below the threshold of armed aggression, going beyond military and economic activities and opening-up new arenas of conflict, including in space, cyberspace, sub-oceanic and, potentially, augmented and virtual reality.

- Actors who develop the capabilities, potentially including disruptive technologies, and a robust framework that most effectively exploits this expanding conflict space will derive a significant advantage.

- States will need to be prepared for state-on-state warfare, including through collective defence alliances, whole-of-government approaches and strengthening homeland resilience.

Increasing proliferation of weapons of mass effect. The number of nuclear-armed states could rise and increasing investment in tactical nuclear weapons and electromagnetic pulse weapons will increase the risk that nuclear weapons are used. The cost of developing chemical, biological and radiological weapons is likely to reduce and advances in genetics and biological sciences have increased the risk of their use through new delivery mechanisms that will make detection hard. Further, the

'weaponisation of information for influence' may provide opportunities for state and non-state actors to deter or coerce adversaries asymmetrically.

- Deterrence strategies need to adapt to new and emerging weapons of mass effect and an expanding competitive space.

- Arms control regimes, already under stress due to differing interpretation and application, will need to be robustly enforced to restrict proliferation of weapons of mass effect, and modified to cope with a new range of weapons, such as cyber weapons and using artificial intelligence in conflict.

A □nal thought

Few would dispute that the character of conflict is changing, for example, distance is becoming increasingly irrelevant as a security buffer and the West's technological advantage is reducing. The physical dimension could become less important than the cognitive and moral dimensions. Warfare could become ever more personalised with individuals and their families being targeted in novel ways. However, war is inherently a human activity whose character is determined by politics, strategy, society and technology. Whilst it is envisaged that humans will continue to be central to the decision-making process, conflicts fought increasingly by robots or autonomous systems could change the very nature of warfare, as there will be less emphasis on emotions, passion and chance.

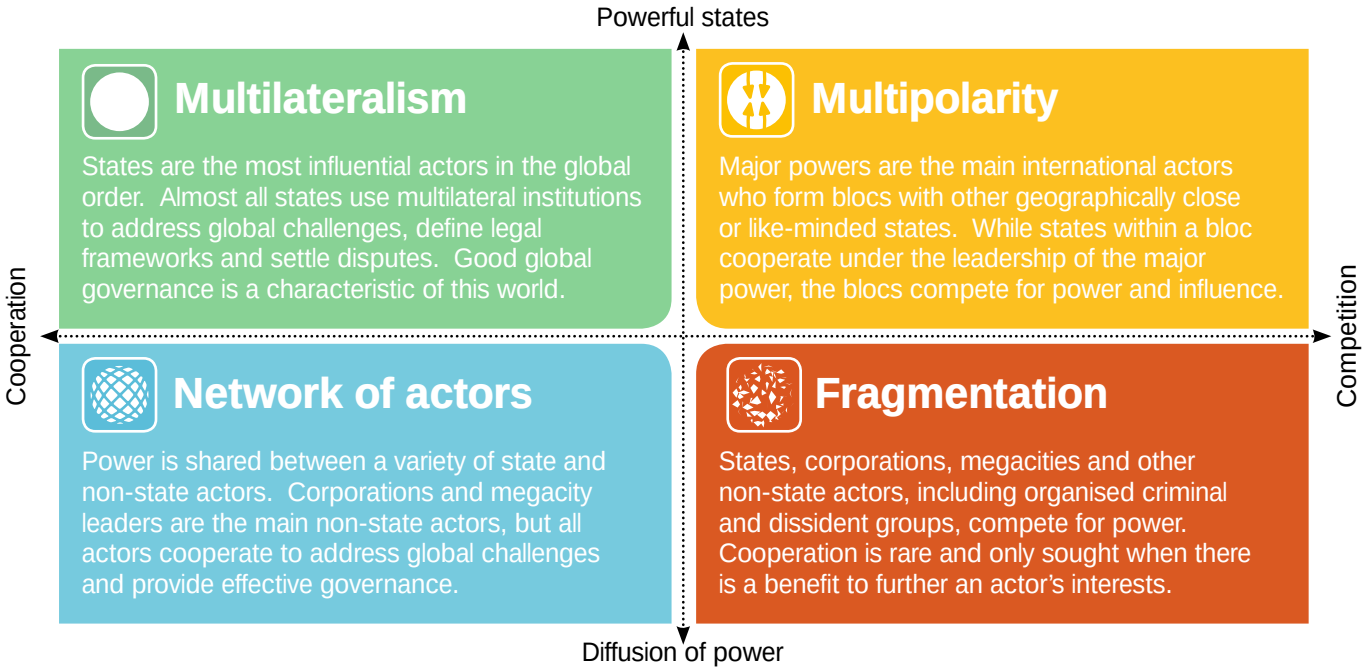
Machines may be used for many combat functions previously performed by humans

Future worlds

Four future worlds are provided for each of the five thematic chapters. Two variables are used to define the four future worlds, namely, distribution of power and cooperation. Distribution of power varies between centralised power (where states are the main actors) at one end of the spectrum, and diffused power (where state power is eroded and the power of non-state actors increases). The level of cooperation varies between full and open cooperation of actors at one end of the spectrum to intense competition between actors at the other. The alternative future worlds are not a summary of the five thematic chapters.

This 'two by two' combination of variables creates four different future worlds: multilateralism, multipolarity, network of actors and fragmentation. This allows readers to contrast the outcomes described in the thematic chapters with alternatives, which should allow for a more thorough consideration of the future. This approach draws on the work of our international partners, and in particular the Australian Department of Defence's *Future Operating Environment: 2035*.[3]

Whilst the worlds are written as though they are mutually exclusive, some aspects of one world will crossover into other worlds. By providing descriptions of alternative futures, we hope to illustrate the significant impacts of not only drivers and trends but also of decisions and choices. The characteristics of each of the worlds are described below. An important question to consider is – which of the four worlds might today's choices drive us towards?



3 Commonwealth of Australia, Vice Chief of Defence Force, (15 November 2016), *Future Operating Environment: 2035*.

Multilateralism

In the multilateral world, states remain the most influential actors in the global order. Almost all states support the use of multilateral institutions to address global challenges, define legal frameworks and settle disputes. Good global governance, driven by individual states and their populations, is a characteristic of this world.

Environment and resources. States recognise the challenges and threats of climate change, and cooperate to adapt and mitigate against them. Cooperation also includes protection of the natural environment, including biodiversity. With a growing global population, the demand for resources, including food, water and energy, grows. Resources are traded in interconnected-interdependent markets. States collaborate using multilateral institutions to mitigate the inequalities that exist from unequal distribution, access and consumption. Access to mineral resources is regulated to ensure fair competition and access rights, which benefits local populations. In a world where constant and unhindered exchange of resources is an important feature, it is a shared interest of states to preserve and protect the global commons.

Human development. Continued globalisation is an important feature of the multilateral world and human empowerment continues in most places. With only a few exceptions, access to information is ubiquitous. States recognise the need to regulate the information environment and collaborate to protect citizens. One way to balance the remaining global inequalities, caused by different speeds of development, is by migration from poor regions into wealthy ones. Consequently, most successful societies are multicultural, but, the state remains an important component of people's identity. Uncontrolled illegal economic migration remains a challenge for international institutions and states.

Economy, industry and information. Economies are largely driven by a free market model. States are constantly seeking to find the right balance between open and unregulated financial trade to maximise economic growth, and a certain amount of regulation to keep the financial markets stable. Despite high levels of cooperation at the global scale, different speeds of economic development continue to exist. Countries like China and India manage to sustain their economic rise and the shift of economic power from the Global West to the Global East has continued. A relatively benign international security environment means that technological change is almost exclusively driven by economic interests instead of defence and security interests. Global interchange of technological advances results in a high rate of innovation. There is a growing divide between the wealthier, better educated urban population and the rural population. Additionally, the societal consequences of a rapid and unbalanced global transition towards a digital economy is difficult to handle for many states, and this causes domestic inequality and dissatisfaction.

Governance and law. States recognise that global challenges are best addressed in multilateral institutions. Organisations such as the United Nations and the World Trade Organization are strengthened. The demand of new powers for more influence in multinational institutions is increasingly accommodated and, thus, the process of institutional reform is largely successful. In general, international law has primacy over national law. By using the multilateral framework, states manage to limit organised crime and its impacts. However, a divide exists in this world between elites who orchestrate the multilateral institutions and those who perceive themselves as powerless. At the national level, strong and effective state institutions have the capacity to address the political, societal and environmental challenges. States provide a sufficient level of public services to the population, although unequally. Though challenged by the transition towards a digital economy, agile governments retain some form of welfare system.

Con□ict and security. The security environment reflects the cooperative nature of this world. States do not have an incentive to disturb the current order through conflict if they can pursue their interests within the existing order by leveraging their soft power. Competition and confrontation is managed cooperatively in a multinational framework. Consequently, states seek to spend less on defence and invest more in economic prosperity. Violent conflict mainly occurs where unaddressed regional pressures (for example, sharp population growth, resource scarcity and weak states) overlap with global challenges (such as, climate change, pollution and inequality). Where conflicts do arise, the framework of multinational institutions is able to successfully resolve them and mitigate many of the underlying factors. The number of deaths due to conflict continues to decrease.

Multipolarity

In the multipolar world, major powers are the main international actors that form blocs with other geographically close or like-minded states. While states within a bloc cooperate under the leadership of the major power, the blocs themselves compete for power and influence.

Environment and resources. The formation of blocs, and the competition between them, prevents international efforts to focus on global challenges, such as climate change. Measures to adapt to climate change, and attempts to preserve the natural environment and biodiversity are unsuccessful. Opportunities to harness natural resources for human benefits, such as medical advances, are limited to a handful of nations. The redistribution of resources (including water, food and energy) outside of blocs is limited. Similarly, access to mineral resources required for industrial processes is fiercely contested. For states without secure access to resources, shifting towards a more circular economy is incentivised to build resilience against resource politics and resource scarcity. The consequence is an increasing global resource inequality and competition. Rather than connecting people and economies, the global commons are highly contested.

Human development. The information environment is critical for both communications and economic prosperity. As a consequence, states place a particular emphasis on the security and control of the information environment, partly to prevent external interference. Societies are less diverse and cohesion is achieved by the common perception of a threat. On a global scale, the interruption of migration puts greater pressure on areas with large population growth, while also creating economic and societal pressures for ageing societies. Human enhancement is used to mitigate economic and health impacts of ageing populations. Urban areas, as economic hubs, are home to large proportions of populations. Domestically, megacities are accommodated by making them the capitals in their states. While most urban areas are well-connected to other urban areas within the blocs, links beyond the borders of blocs are rare.

Economy, industry and information. Global trade is perceived as zero-sum and most blocs pursue protectionist trade policies, raising trade barriers. Security has a high priority and consequently the free flows of goods, information and people is limited beyond the bloc borders. Similarly, financial flows between the blocs are strictly controlled. International trade institutions are sidelined and ineffective. Domestically, prosperity agendas aim to lower domestic inequality and increase national resilience. Expenditure on defence and security-related innovation is proportionally high and, as a result, technological development is focused mainly on security-related applications. However, reduced global cooperation and the spread of technology reduces its rate of development. Due to the competitive security environment, innovation is less constrained by ethical concerns.

Governance and law. Multilateral institutions, such as the United Nations, are constantly blocked and fail to deliver solutions. This leads to the evolution of regional institutions and legal frameworks within the blocs under the leadership of the major powers, creating further barriers between blocs. Organised crime is used by blocs as an instrument of hybrid and covert interference, with the aim of exploiting vulnerabilities and undermining opposing actors. The competitive environment increases the demand for strong leadership personalities who, once in power, pursue less liberal and more nationalistic politics. Unpopular domestic decisions are justified through the lens of global competition and national interests. Internally, states seek to control the distribution of critical services, particularly welfare, to strengthen national resilience. This, in combination with a slower rate of economic and technological change, allows nationalistic political leaders to manage the transition to the digital economy comparably well.

Con□ict and security. The security environment is highly competitive between the blocs. Conflicts are managed by deterrence and coercion outside of multilateral institutions. Persistent competition results in volatility, constant vigilance, mistrust and a high potential for misunderstanding. Reduced global interconnectivity changes the cost-benefit calculus for the use of hard power, increasing the risk of conflict. The potential for big shifts in the global power balance exists and defence spending is generally high, although wide variations exist between states and between blocs. The number of deaths due to conflict is low as blocs mostly contain violence, however, there is a high risk of major conflict. The disempowerment of multilateral institutions prevents the development of international legal frameworks for new weapons, such as electromagnetic pulse weapons or personalised biological weapons.

Network of actors

In the networked world, power is shared between a variety of state and non-state actors. Corporations and megacity leaders are the main non-state actors, but all actors cooperate to address global challenges and provide effective governance.

Environment and resources. The network of state and non-state actors understands the urgency of global challenges and how they affect their individual interests. As a result, there is a shared willingness to adapt measures that deal with the impacts of climate change and invest further in measures that mitigate significant future harm, preserve the natural environment and biodiversity, and reduce waste and pollution. The economic network spans around the globe, and so states, as well as non-state actors, have a vested interest in reducing resource inequalities. So, while states allow access to their resources, corporations prove to be efficient in managing the distribution process. Access to mineral resources for industrial processes is also managed fairly. Recycling and substitution are necessary to mitigate resource scarcity, but are also implemented to make industry more efficient. States and non-state actors are partnering to preserve and efficiently exploit the global commons.

Human development. The new skillsets required in the digital industries drive migration of those who possess the right, but rare skills. Whilst almost everyone has access to information, the development is mainly driven by corporations and entrepreneurs based on economic interests. In general, people are treated as consumers rather than citizens. Most successful societies comprise people from many different origins. Despite this, there is a seller's market for loyalty and identity, which is led by non-state actors, including megacities and corporations. Most people have multilayered identities that not only reflect allegiances to non-state actors, but also a particular nation or region.

Economy, information and industry. Global trade is characterised by the free market model. The high number of actors manage the fair and benign economic competition in layered and connected networks. However, with a larger and more diverse set of actors, authority is dispersed and decision-making takes longer. Managing these complex networks is challenging for rising powers with authoritarian political systems. The reformed global trade organisations are part of many of these networks. Technological change is driven mainly by non-state actors and their economic interests. This cooperation allows a greater ability to leverage technology. However, cooperation becomes difficult when interests clash, for example, over the regulation of financial markets. Actors seek to balance autonomous and human production, but investment in digital and financial markets at the expense of capital and labour has led to increased inequality between socio-economic groups.

Governance and law. Organisations like the United Nations and the World Trade Organization are intact and manage to accommodate the variety of actors, including megacities. However, there is constant pressure for continual reform to make international institutions adapt to the new world order. The spread and impact of organised crime is limited by hybrid global governance. Geography and state territory are of lesser importance in this world and instead it is the function of actors that matters most. Due to slower decision-making, the political process for managing the transition to digital economies is hardly keeping pace. Domestically, states seek to mitigate the impacts of this transition by working together with corporations to provide services in the most effective and efficient way. However, the supplementary services are not affordable for everyone.

Con□ict and security. The security environment is mostly peaceful. Although states differ in their defence and security organisations, common trends include reduced defence spending and the private contracting of large parts of the armed forces. Corporations and urban areas seek to prevent conflicts from escalating to protect their investments and avoid discontent and disruption among their populations. Nevertheless, confrontations, mostly around economic issues, still exist but they are usually settled by mediation using the multilateral framework, hence the number of deaths due to conflict remains relatively low. Coalitions and alliances are formed by shared interests and are constantly shifting. Leveraging smart power through a variety of overlapping networks is demanding and creates a highly-dynamic security environment. The high speed of technological advances, driven by corporations and their economic interests, and their potential for weaponisation, creates a challenging environment for international law. States seek to reduce the risk of proliferation whilst corporations seek to protect their share of sales in the small defence market.

Fragmentation

In the fragmented world, states, corporations, megacities and other non-state actors, including organised criminal and dissident groups, compete for power. Cooperation is rare and only sought when there is a benefit to further an actor's interests.

Environment and resources. In a world characterised by persistent competition, it is impossible to address global challenges like climate change and biodiversity loss. Some actors attempt to do the minimum necessary to adapt to the severe consequences they are facing. The stress caused by the impacts of these challenges adds to the tension caused by resource inequality, which cannot be addressed effectively due to the chaotic state of the global order. Weak states who fail to protect citizens from resource price shocks come under increasing pressure. Response to natural disasters is uncoordinated at the state level with private companies stepping-in to provide humanitarian assistance in exchange for access rights to resources. The global commons, particularly space, are heavily contested.

Human development. Many people seek refuge from the impacts of climate change and migrate to more habitable regions and cities. Together with a greater number of mostly economic migrants, they change the composition of many societies where levels of integration are low, which compounds cultural divergence. Additionally, a significant number of people are stateless. Societal cohesion deteriorates in this world, at least in part because of the states' weakness but also because of the multitude of other identification points. States are already too weak to provide governance in the information environment, which is nevertheless widely accessible and an essential resource, but also exploited by all actors to further individual interests.

Economy, industry and information. Global trade is unregulated and the system is based on unconstrained markets, which increases the problems of inequality. Global trade organisations are dysfunctional. Actors negotiate bilateral agreements if they provide the opportunity to further their interests. However, most agreements are short lived. Technological change is mainly driven by private corporations and shared with the cities that host them. Due to the high likelihood of conflict, the focus is mainly on technology relevant to security. The development rate is high but uneven and less constrained by ethical concerns. Hence, the implementation of new technologies, such as autonomy, is governed weakly, leading to increased inequality. The unregulated information environment is highly contested and exploited by a variety of actors. Notwithstanding, it is used for a high volume of digital transactions which are, under these circumstances, susceptible to theft of intellectual property.

Governance and law. Global governance is almost impossible. The United Nations still exists but is unable to provide solutions and international law is sidelined. Institutions, such as the World Trade Organization, are weak and easily undermined. States lose their role in service provision as well as their legitimacy to raise taxes. Non-state actors seek to exploit this to further weaken states and gain more power. While states struggle to manage the transition towards a digital economy and reform the welfare states, corporations, as well as cities, design new service provision models without the burdens of bureaucracy and accountability. Organised crime cannot be addressed without global cooperation. It is spreading and increasing its role in all illicit activities where money can be earned. Conversely, the monopoly on law enforcement of many states is eroded.

Con□ict and security. The security environment is chaotic and multilateral organisations are unable to settle conflict. Conflict is omnipresent and defence and security spending is high for all actors. Coalitions are fluid and based on national interests rather than norms and values. In this environment, hard power is required to survive and project influence. With a dysfunctional international legal framework, technology is weaponised where feasible and seen as beneficial, without ethical constraints. Most conflicts are regionally contained and of smaller size. Nevertheless, continuous fighting in some places results in increasing numbers of deaths.


JAN SERVA
pepsi

Environment and resources

Synopsis

Human influence on the climate system will have far-reaching consequences over the next 30 years with floods, droughts, storms, heatwaves and heavy rainfall all expected to become more intense and possibly more frequent. Transport and trade routes, including chokepoints such as the Panama Canal, are likely to be disrupted, affecting global markets and supply chains. The demand for food and water will increase, but some crops will fail and water shortages are likely to become more prevalent. Such shortages, along with the destruction of homes and livelihoods as a result of natural disasters, could also lead to increasing migration and conflict. Better management of water supplies and improvements in agriculture (not least by harnessing technology) could meet rising demands for food and water, but this will require investment and action. Rising sea levels will increase the risk of flooding, with low-lying communities (for example, tropical islands and coastal cities) in developing countries at particular risk. The demand for energy and mineral resources will also increase and shortages can be expected, with some nations potentially hoarding supplies deliberately. Competition and disputes could lead to conflict, although advances in technology are likely to open up new sources, improve recycling and facilitate further exploitation of renewable energy.

Pollution, habitat destruction and over-exploitation will lead to significant reductions in biodiversity and increase the risk that some ecosystems will rapidly collapse, with substantial loss of animal and plant species. Catches of tropical fish are likely to reduce, harming coastal communities and possibly leading to an increase in piracy. The governance of the global commons (cyberspace, the oceans, polar regions and space) will continue to be a contentious issue, especially in space where the increasing number of actors will lead to a progressively congested and contested environment. Dependency on space-based capabilities for a range of services, including navigation, precision timing and communication, is growing, yet so are the risks, such as a collision from space debris or deliberate actions by malicious actors.

Climate change

Temperature. The Earth's climate is warming and by 2050 the average global temperature is likely to rise by between 1° Celsius and 2° Celsius and there is widespread scientific agreement that this is because of human activity.[1] The impact of climate change is already noticeable with 17 of the 18 warmest years on record (since 1880) occurring since 2000.[2] Inertia in the climate system means that temperatures will almost certainly continue to rise, regardless of any mitigation. Recent estimates suggest that even if the commitments made under the Paris Agreement of 2015 are met, temperature rises are likely to reach between 2.3° Celsius and 3.5° Celsius by 2100.[3] In addition to increases in average temperature, climate change will probably result in future weather events that are more extreme than today's. Floods, droughts, storms, heatwaves and heavy rainfall are all expected to become more intense and possibly more frequent. Military equipment will need to be able to operate in these increasingly extreme conditions.

The Paris Agreement. In 2015, world political leaders agreed to take action to keep global temperature rise below 2° Celsius (compared to pre-industrial levels), with the aim of holding rises to a safer limit of 1.5° Celsius. To achieve these goals, greenhouse gas emissions need to peak as soon as possible, before rapidly declining and becoming net-zero in the second half of the 21st Century. This could occur if manmade emissions are substantially reduced and greenhouse gases are removed (through afforestation or by using carbon capture and storage technologies).

Rainfall. Global average rainfall is expected to rise and periods of heavy rain are likely to become more intense and frequent. Floods have accounted for 47% of all weather-related disasters since the mid-1990s[4] and about half the world could experience increased flooding in the next 30 years. Outbreaks of waterborne diseases often accompany flooding, along with damage to agriculture and soil fertility caused by increased run-off and soil erosion. Climate change-related disruption to rainfall patterns and higher temperatures, alongside increased demand, may also lead to many regions suffering water shortages.

> "By 2050 the average global temperature is likely to rise by between 1° Celsius and 2° Celsius."

Impact on agriculture. Weather and climate affect all aspects of agriculture. The effects of climate change (such as heat-stress and drought) are likely to result in poorer yields and greater variability from one year to the next. The Russian heatwave of 2010 contributed to a doubling of global wheat prices, illustrating some of the practical consequences of climate change, and similar events can be expected in the coming decades. While more effective irrigation could mitigate some of the agricultural impacts of climate change, it may not be a viable solution everywhere. Changes to the climate could have a positive impact in some parts of the world. For example, more frost-free days in parts of Europe and North America will probably lengthen the growing season.[5]

1 Anticipated 1-2° Celsius rise is relative to the 1986-2005 period. Intergovernmental Panel on Climate Change (IPCC), (2014), *Climate Change 2014; Synthesis Report*.

2 United Nations (UN), (2017), *UN Climate Change Annual Report 2017*.

3 International Energy Agency, (2017), *World Energy Outlook 2017*.

4 Centre for Research on the Epidemiology of Disaster (CRED) and The United Nations Office for Disaster Risk Reduction (UNISDR), *The Human Cost of Weather Related Disasters, 1995-2015*.

5 Davie, J., *et al.*, Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

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Floods, droughts, storms, heat waves and heavy rainfall are expected to become more intense and possibly more frequent

Impact on cities. Urban areas are often warmer than the surrounding countryside because of their high-density energy generation and the prevalence of building materials that retain heat. This 'urban heat island effect' means that some cities could experience temperatures 2° Celsius to 3° Celsius warmer than the global average.[6] Warmer temperatures are likely to exacerbate urban pollution, which could lead to increased problems for people with asthma, allergies and other respiratory diseases. As cities expand, there will be greater pressure to develop land in areas prone to environmental hazards, such as flooding and landslides. In 2000, around 30 million people lived in urban floodplains in Asia. This is projected to increase to between 83-91 million by 2030 and 119-188 million by 2060.[7] Combined with the effects of climate change, this suggests that the impact of natural disasters will be more severe in urban areas.

Impact on transport and trade. Increasingly intense storms, sea level rises and longer periods of heavy rain will disrupt shipping. Air transport is also likely to be affected, for example, the polar front jet stream (a current of fast-moving air in the upper atmosphere) will probably strengthen and, during the winter, incidents of high turbulence might be 40-170% more frequent. Without mitigation, this could lead to longer flight times, higher fuel consumption and an increased need for aircraft maintenance. Inland waterways are also likely to be affected by climate change, for example, the cost of shipping on the North American Great Lakes is forecast to increase by 9% by 2050 as water levels drop. Other parts of the world may experience much higher rainfall and might have to close inland waterways as they become unsafe for use.[8] In some parts of the world, rising temperatures are likely to buckle railway tracks, overheat underground rail networks and melt tarmac surfaces. Increasingly heavy rainfall will affect road networks. Roads in many parts of the world are often impassable because of rain and subsidence, and this will be amplified by climate change.

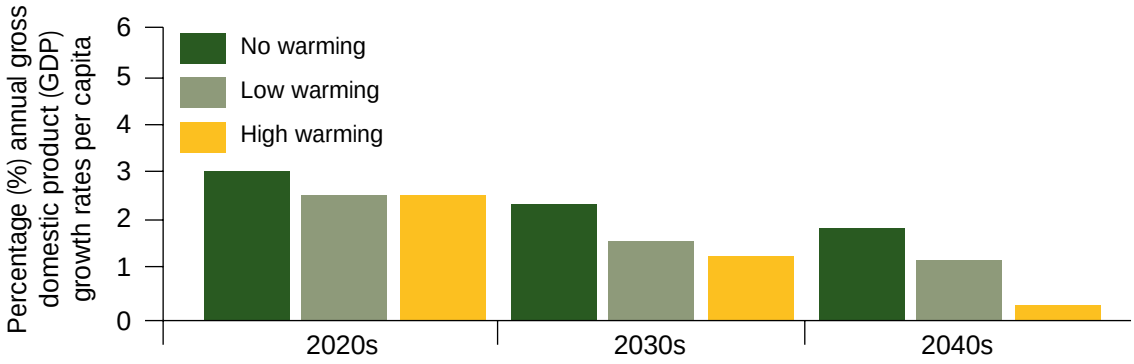
6 Estrada, F., *et al.*, Nature Climate Change, Volume 7, (June 2017), *A global economic assessment of city policies to reduce climate change impacts*.

7 Government Office for Science, (October 2011), *Migration and Global Environmental Change*, page 110.

8 Davie, J., *et al.*, Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for DCDC.

Impact on the economy. Without mitigation, the damage from climate change is likely to reduce global economic growth and could cause an economic decline. Mitigation is, however, likely to be costly. It is estimated that the energy sector alone will need to invest United States (US) $3.5 trillion annually,[9] but delaying action would be more costly. For example, delaying climate mitigation investment beyond 2030 is expected to increase the 2030-2050 costs by between 14-44%, relative to taking immediate action.[10] The economic impact of climate change will be felt before 2050, for example, those countries most vulnerable to the effects of climate change are expected to experience increased debt repayments of around US $168 billion due to climate risk from floods, droughts and severe weather events over the next ten years.[11]

Global growth rates per capita, under different climate change scenarios



Note: Data based on International Panel for Climate Change scenarios.

Source: International Climate Initiative

Impact on defence and security. Climate change will require ships, aircraft and vehicles to operate in more extreme environmental conditions and planning assumptions (such as where ships and aircraft can be based and when routes will be passable) will need to be revised. Climate change may also drive responses that exacerbate migration and security challenges. For example, prolonged periods of extremely low rainfall have been cited as a probable reason for increases in violent conflict, as a result of scarce vital resources.[12] Criminal, or even terrorist, groups could take advantage of the stresses that climate change may bring. For instance, climate-induced disruption of water supplies and impacts on agriculture could be used as a tool to push individuals to join dissident groups. Such shortages of vital resources, along with the destruction of homes and livelihoods as a result of natural disasters, could also lead to increasing migration and con□ict, particularly in developing countries that do not have the capacity to mitigate these effects.

> “Global consumption of energy is likely to have risen by between 40-60%.”

Energy

Demand. By 2050, global consumption of energy is likely to have risen by between 40-60% and the way the world meets its growing energy needs will probably look quite different from today. The historic link between rising gross domestic product (GDP) and energy consumption appears to be weakening as the global population growth slows and economies become service sector based, rather than manufacturing based.

9 The World Bank, (2018), ‘Climate Change’.

10 IPCC, (2014), *Climate Change 2014: Synthesis Report*.

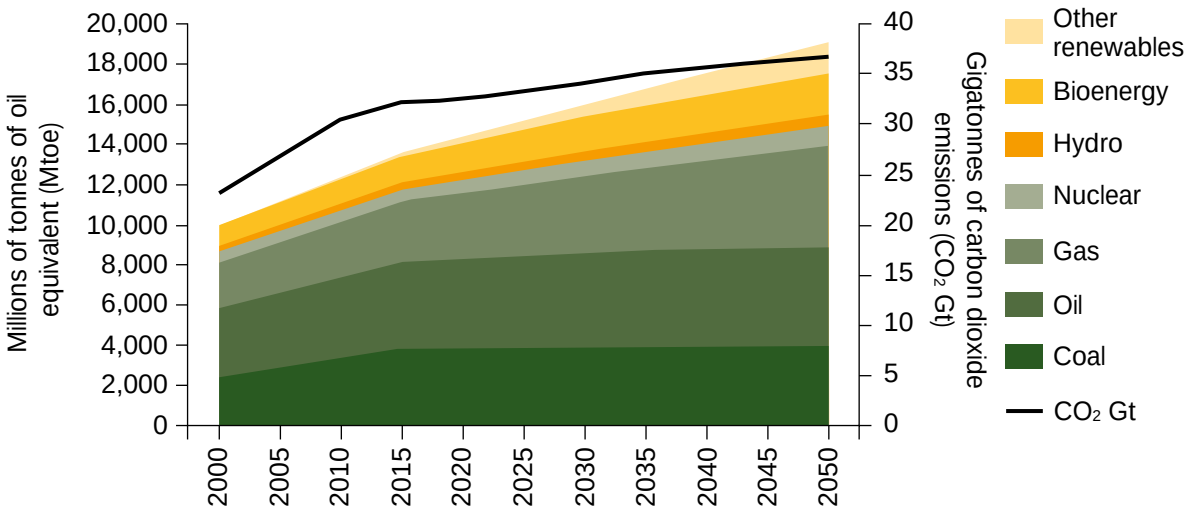
11 UN Climate Change, (3 July 2018), *Climate Change is Driving Debt for Developing Countries*.

12 Davie, J., *et al.*, Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for DCDC.

Global growth in energy consumption looks likely to slow to 1% per annum, about half the annual speed of increase seen between 2000 and the present day.[13] The yearly rate of growth in energy consumption will be unequal around the world. In future, developed economies could see average increases of around 0.5%, compared with 1.4% in developing countries.[14] Industry will probably continue to consume the largest proportion of energy, followed by energy used in buildings (domestic use and use by service sectors), and then transport. Energy consumption is likely to increase most rapidly in buildings however, not least because of increasing urban populations. Consumption increases will probably grow most slowly in industry, as it becomes more energy efficient. Over the last 25 years, efficiency measures have saved an amount of energy equivalent to the total current demand of China, India and Europe combined, and further improvements are likely in the future.[15]

Greenhouse gases. Annual carbon dioxide (CO_2) emissions from energy generation have started to flatten out in the past few years, and might peak in the 2030s. Projections suggest that hydrocarbons are likely to remain the main source to meet overall energy demand, at around 70%, by 2050. To keep temperature rises below 2° Celsius, hydrocarbon use would need to be half of this.[16] While carbon capture will probably be an essential part of mitigating the effects of climate change in future, it is not happening at the rate needed to meet long-term climate goals.

Total global primary energy demand



Source: International Energy Agency, *World Energy Outlook 2017*

Fuel. Oil will probably remain the world's largest source of energy (meeting just under a third of needs) by 2050, while consumption of coal is likely to stabilise, in line with political commitments to tackle climate change and improve air quality. Gas will probably replace coal as the second largest energy source sometime in the mid-2030s, generating around 26% of the world's power by 2050. China is likely to become the second largest net importer of gas, behind Europe, and a key player in future energy markets.

13 Rennie, C., Pointer Energy, (2017), *Global Strategic Trends: The Future of Energy; a primer on trends and drivers of energy technologies through to 2050*, a research paper commissioned by DCDC.

14 The International Energy Agency, (2017), *World Energy Outlook 2017*.

15 Renewable Energy Policy Network for the 21st Century (REN21), (2017), *Advancing the Global Renewable Energy Transition: Highlights of the REN21 Renewables 2017 Global Status Report in Perspective*, page 10.

16 Rennie, C., Pointer Energy, (2017), *Global Strategic Trends: The Future of Energy; a primer on trends and drivers of energy technologies through to 2050*, a research paper commissioned by DCDC.

Warmer temperatures are likely to exacerbate urban pollution

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By 2050, approximately 75% of the world's oil could be used in Asia, making it the most important global market for oil exports. China is likely to consume more oil than the US by 2030. India, although likely to consume less oil than China, is expected to see the most rapid increase in consumption.[17] Oil and gas production in the US could reach record-breaking levels by the mid-2020s, fundamentally altering the oil and gas market, although oil from Middle East is likely to remain important. Liquefied natural gas (LNG) could also account for the vast majority of growth in long-distance gas trade, something that is likely to make many new cross-border pipeline projects uncompetitive.[18] By 2050, the US could emerge as the world's largest producer of LNG.

Renewables. Renewable means of energy production (such as wind, solar, bioenergy, hydro and geothermal) are the fastest growing sources of energy. Together with nuclear energy, renewables could rise to meet around a quarter of all energy needs and over half of total electricity generation capacity by 2050. In some countries, renewables could become the cheapest source of new electrical power generation.[19] China will probably remain the world's largest investor in renewable energy, as well as one of the leading manufacturers and exporters of energy technologies, from solar equipment to high-voltage mega-grids that could enable long distance and even international transmission. More energy is also likely to be generated from nuclear power over the next 30 years, with probable global increases of around 1.6% per year.[20]

Networks. The rapid rise of renewables is likely to be accompanied by increases in energy storage and digitisation, as well as energy market changes and investment in electricity networks. The power sector is likely to become more complex as a result of rapidly evolving interdependent technologies, new business models and a shifting

17 The International Energy Agency, (2017), *World Energy Outlook 2017.*

18 *Ibid*., pages 69, 26-28, and 90.

19 The US Energy Information Association, (23 July 2018), 'Today in Energy'.

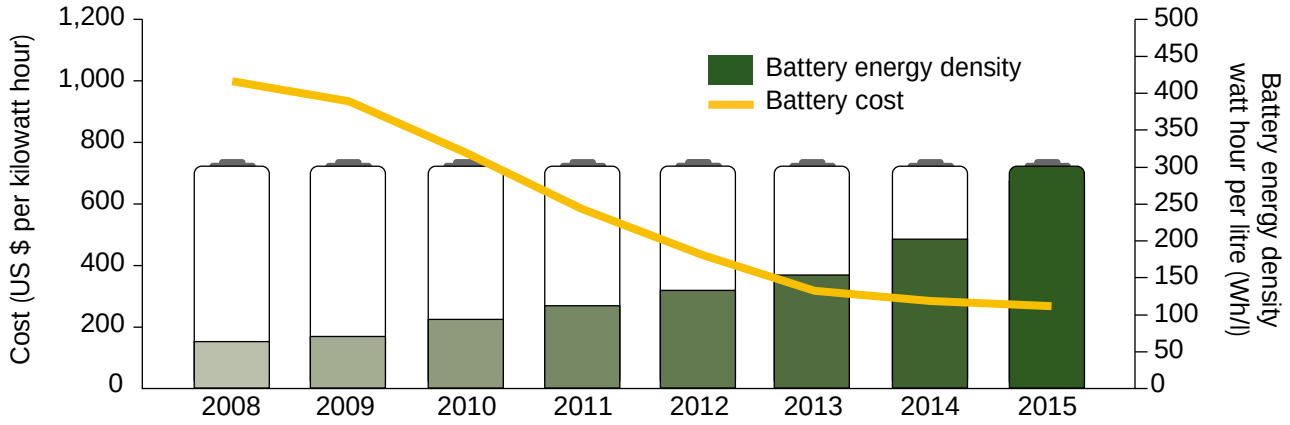
20 The International Energy Agency, (2017), *World Energy Outlook 2017*, page 74.

regulatory landscape.[21] Information technology and automation could radically transform energy supply and demand, including locating and extracting oil and gas more efficiently and effectively, and improving storage and distribution. It will also allow devices to almost instantaneously adjust their energy use in response to the prevailing conditions. For example, a domestic washing machine might only become active when there is plentiful energy (such as when a strong wind drives a turbine), and pause when supply reduces or is diverted elsewhere (perhaps if the wind drops or the householder switches on a kettle).

> “Information technology and automation could radically transform energy supply and demand.”

Storage. As costs reduce and storage volumes grow, batteries (and potentially capacitors) will play an increasingly important role in storing electricity on a large scale.[22] Thermal storage might become more significant in regions where there is high demand for heating and cooling, by storing energy when demand is low and releasing it later. Pumped hydro-energy reserves have dominated large-scale power storage for over a century, accounting for 95% of today's installed capacity. This proportion, however, is likely to fall in coming years as other forms of storage become more common. For example, surplus energy might be used to compress gas, which could subsequently be released to generate electricity.

Evolution of battery energy density and cost



Source: United States Department of Energy

Complexity. Over the next 30 years, power will be generated in an increasing number of ways from multiple sources. Both large- and small-scale wind, solar and battery technologies are likely to become cheaper and more effective. Coupled with digitisation, these advancements could make it easier for central and decentralised energy generation to work together, providing power for domestic use as well as industrial use. Small-scale electricity generation and storage in residential and commercial properties are likely to be linked to mega-grids that cross administrative or even national boundaries. Cities and towns could run their own energy systems, or connect to other areas to obtain security of supply and generate income. Other new business models could also emerge, such as 'pay-as-you-go' systems where solar panels and batteries are rented as needed, bringing electricity to remote areas without the need for expensive infrastructure.[23] Increasingly digitised and electri□ed energy systems will probably be more ef□cient and □exible, but they are also open to new vulnerabilities. As the number of actors in the energy system increases, it will almost certainly become more complex, making inherent risks harder to understand and manage. This could increase the risk of a systemic failure.

21 World Economic Forum, (10 March 2017), *The Future of Electricity: New Technologies Transforming the Grid Edge*.

22 World Energy Council, (2016), *World Energy Resources: E-Storage*.

23 International Energy Agency, 'Technology Roadmap Series'.

Some mineral resources are likely to be increasingly scarce

Mineral resources

Demand. Worldwide demand for resources has been rising sharply over the last century. Between 1900 and 2010, global resource consumption grew from nine to 71 gigatons. Over the same period, the amount of material used to sustain one individual showed a corresponding increase, from 4.6 to 10.3 tons per person, per year.[24] As the world's population grows and becomes more prosperous, the demand for products made from mineral resources is also likely to rise. However, this is unlikely to lead to an exponential rise in the use of all resources, for example, demand for iron ore tends to level out as GDP per capita increases.[25] Nevertheless, on current trends, some mineral resources are likely to be increasingly scarce. Governments, industries and academics have already raised concerns about future demand outstripping supply for rare earth elements (which are crucial components for a range of advanced technologies) and basic industrial metals. In the coming decades, some countries may be tempted to deliberately limit supplies of scarce resources for geopolitical gain (resource nationalism) and tension over resources, possibly including military action to secure supplies, cannot be ruled out.

Demand for mineral resources will vary geographically. Currently it is driven mainly by China, which consumes 40% of metals worldwide.[26] While in the near-to-medium term the Chinese requirement for steel is likely to decrease (due to a surplus), it will probably grow in the long term due to continued urbanisation and infrastructure modernisation. Similarly, the country's need for base metals (such as copper, aluminium and nickel) is likely to grow due to modernisation of China's power supply.[27] However, over the next 30 years, India could overtake China to become the world's largest consumer of resources.

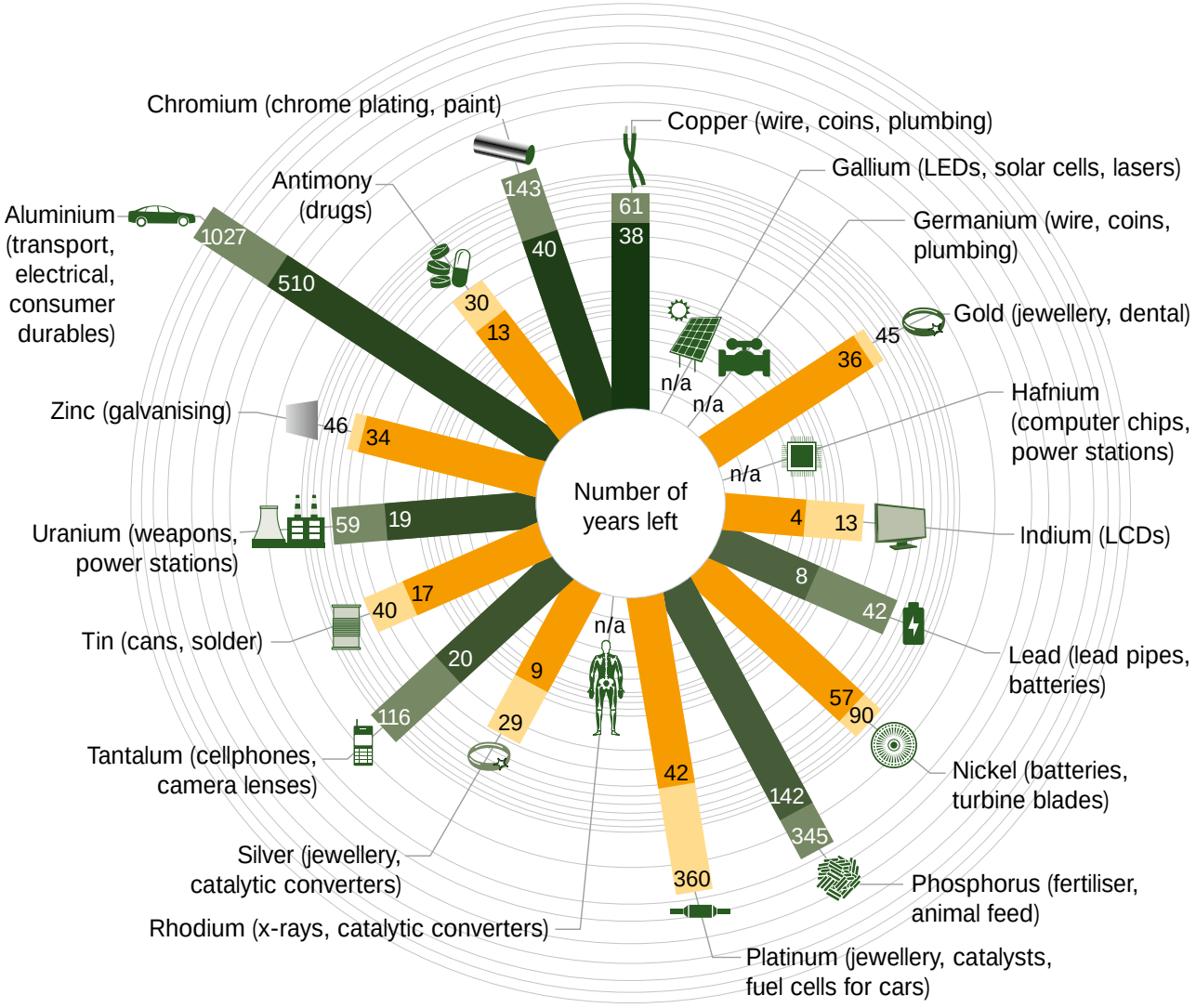
24 Mayer, A., *et al.*, (2017), *How Countries' Resource Use History Matters for Human Well-being – An Investigation of Global Patterns in Cumulative Material Flows from 1950 to 2010.*

25 Graedel, T., *et al.*, Proceedings of the National Academy of Sciences of the United States of America (PNAS), (2015), *On the materials basis of modern society.*

26 Lee, B., *et al.*, Chatham House, (2012), *Resource Futures – A Chatham House Report.*

27 Roberts, I., *et al.*, (2016), *China's Evolving Demand for Commodities.*

Forecast depletion of mineral resources



Note: Years left based on 2015 global consumption rates (lower gure) and half the United States 2015 consumption rate (higher gure). For example, gold has 35 years left on the 2015 global consumption rates or 45 years left at half the 2015 US consumption rate.

Source: New Scientist

By 2017, scientists had identified approximately 300,000 materials, compared with just 12 widely used a century ago.[28] Carrying on this trend, new, more complex materials (for example, materials with novel structures, such as carbon nanotubes or composite materials made from many elements) are likely to be developed. If materials become more complex in future, they could also be harder to reuse and recycle, although recycling processes for most materials are likely to become much more efficient and effective. Recycling and substitution are likely to become increasingly important, both to obtain resources and for environmental and economic considerations. For example, aluminium recycling can reduce energy and associated greenhouse gas emissions by up to 90-95%, compared to initial production.[29]

28 Powell-Turner, J., Frith Resource Management, (2017), *Future of resource and materials*, a research paper commissioned by DCDC.

29 Moya, J. A., *et al.*, European Commission, (2015), *Energy Efficiency and GHG Emissions: Prospective Scenarios for the Aluminium Industry.*

New materials. The future of energy storage is likely to take advantage of new and emerging materials, as well as those we are familiar with today. Next generation batteries and other forms of renewables could enable renewable energy to match supply with demand. Advances in energy storage using sodium, aluminium and zinc-based batteries could, for example, make mini-grids increasingly feasible.

Graphene nanocoating could help improve battery efficiency. Graphene flakes could be used to produce incredibly lightweight construction material, possibly reducing the energy needed for building materials. Hexagonal boron nitride has already been combined with graphene to improve lithium-ion batteries and supercapacitors, suggesting further improvements as the technology matures. It is feasible that gas-based lithium-ion batteries could become available for use in high-altitude drones. Flexible batteries spun from fibres could make energy storage part of everyday items, like smart clothing or e-textiles. This could transform electricity needed to power personal electronic devices like smartphones, making it an attractive option for defence or aid organisations that currently experience logistics restrictions in hard-to-reach areas, or locations impacted by natural disasters.

Using uranium as a base material could transform how industry makes bulk chemicals, polymers, new drugs and plastics. Self-fixing concrete could reduce the cost and energy required to maintain and repair roads. Self-powering solar harvesting roads where power generating technologies are integrated in transportation infrastructure might allow roadways or paths to light themselves, or melt snow and frost.

A new form of aluminium bubble wrap has recently been developed that could revolutionise packaging. It weighs 30% less than regular sheet metal but is nearly 50 times stronger.

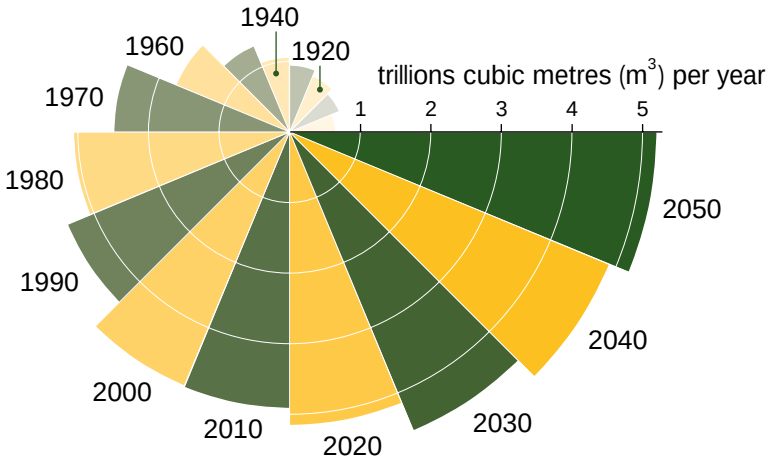
Water

Demand. By 2050, demand for water is expected to increase by between 20-30%, meaning that over five million cubic kilometres is likely to be consumed annually. Greater urbanisation, population growth and an expanding economy could mean that industrial and domestic demand for water will increase faster than in the farming sector, but agriculture is likely to remain the largest overall user. By 2050, the amount of water needed to irrigate crops is likely to increase by approximately 40%, compared with 2010,[30] although this figure could fall if improved techniques are implemented and increased investment occurs. With the exception of North America and parts of Europe, industry's consumption of water is likely to grow worldwide in the coming decades, and the manufacturing sector's demand for water could be 400% higher by 2050 than in 2000. The greatest increases in domestic water demand are expected to occur in Africa, Asia and Central and South America, although there will probably be a significant rise in every region, apart from western Europe where usage is likely to remain fairly constant. While in principle there is sufficient water in most countries to meet projected demands, systemic problems will probably lead to shortages in some areas. Without effective governance, pollution and extraction will not be controlled and significant quantities of water will be lost through leaks. In many countries there are insufficient funds to operate and maintain current systems, let alone invest in new ones.[31]

30 UN Water, (2018), *World Water Development Report 2018: Nature-based solutions for water*.

31 Benton, T., *et al*., (2017), *Food and water systems and security: looking to the future*, a research paper commissioned by DCDC.

Global freshwater use withdrawals (agriculture, industry and domestic use)



Source: Our World in Data, University of Oxford

Availability of water. The rate at which water is being extracted from the ground is believed to be close to the maximum sustainable level. Groundwater provides drinking water to at least 50% of the world's population, and around 2.5 billion people depend solely upon groundwater to satisfy their daily water needs. However, a third of the Earth's largest aquifers are already being drained at an unsustainable rate and by 2050, groundwater extraction could be 39% higher than current levels.[32] Climate change is likely to mean that average global rainfall will rise and episodes of heavy rain will become more frequent and intense. This will increase the risk of flooding in many parts of the world, although other regions are likely to experience a drier climate. Changes in precipitation and greater evaporation (due to higher temperatures) are likely to mean that large parts of the globe experience droughts of increased frequency, intensity and duration. Renewable surface and groundwater resources will probably reduce significantly in most dry subtropical regions. Rivers fed from glaciers are likely to become less reliable, leading to water security concerns in the Alps, Andes and central Asia.[33]

> "Almost half of the world's population is unlikely to have reliable access to clean water by 2050."

Water quality. While some regions might experience an absolute shortage of water over the next 30 years, declining quality is likely to be a bigger issue. For example, an estimated 85% of Bangladesh's groundwater is contaminated, and water pollution has worsened in almost all rivers in Africa, Asia and Latin America since the 1990s.[34] Water quality in coastal areas is also likely to be affected by saltwater intrusion. Today, 2.1 billion people lack access to safe drinking water and 4.5 billion do not have adequate sanitation. These figures are projected to worsen, with almost half of the world's population unlikely to have reliable access to clean water by 2050, and around 90% of people facing such shortages are expected to be living in southern and eastern Asia.[35]

Pollution will continue to be a major factor behind declining water quality and it is also often associated with waterborne diseases. Agriculture is a key contributor to pollution, as excess nutrients (for example, nitrates and phosphates in fertilisers) run off fields and into water supplies. Currently, around 80% of industrial and urban wastewaters are released into the environment without treatment, causing contamination with substances

32 UN Water, (2018), *World Water Development Report 2018: Nature-based solutions for water.*

33 Davie, J., *et al.*, Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for DCDC.

34 UN Water, (2018), *The United Nations World Water Development Report 2018: Nature-based solutions for water.*

35 UN, (2017), *The United Nations World Water Development Report, Wastewater The Untapped Resource 2017.*

that are toxic, hard to treat and persistent over decades. Antibiotics and other microbial agents are also discharged in wastewater from people and livestock, leading to an increase in the prevalence of antibiotic-resistant waterborne pathogens.[36]

Water management. In many parts of the world, water management is an international issue with around 40% of the global population living in 263 river basins that cross national boundaries. However, 158 of these basins lack any form of collaborative agreement on the control of their rivers.[37] Shared waters can provide a motivation for dialogue and cooperation between neighbouring countries, even where disputes over other issues exist. For example, Pakistan is seeking an arrangement with India and Afghanistan for river basin and transboundary aquifer management. In other parts of the world, friction over river management could worsen in the coming decades, for example, there are plans to build dams on the Amu Darya, Mekong and Nile rivers and the Tigris-Euphrates river system, but none of these waterways have comprehensive treaty arrangements in place. Lack of effective governance and management will result in unsustainable use of water in many parts of the world and, combined with the disruptive effects of climate change (particularly where water resources are shared), tensions are likely to increase, possibly leading to con□ict.

Wasted water. Water loss through inadequate or poorly maintained infrastructure will continue to affect water management. In Organisation for Economic Co-operation and Development (OECD) nations, leakage currently ranges from 44% in Mexico City (where there is an acute water scarcity problem), to 4% in Amsterdam. In the United Kingdom (UK), total leakage in England and Wales is over 20%.[38] Deteriorating infrastructure in many of the world's most vulnerable countries is wasting large quantities of water, reducing availability and resilience. For example, in the late 2000s, an estimated 60% of Syria's water was being lost through leaks, which greatly compounded drought-driven crop failures. With sufficient investment, the amount of water lost through leaks could be reduced considerably, but without adequate funding, the situation will worsen.

Advances in technology could make unusable water □t for drinking using minimal amounts of energy

36 Benton, T., *et al.*, (2017), *Food and water systems and security: looking to the future*, a research paper commissioned by DCDC.

37 *Ibid.*

38 *Ibid.*

Replacing livestock with insect proteins could liberate one third of agricultural land for other uses

Technology. Advances in technology have the potential to reduce consumption and make useable water from sources such as seawater and wastewater. Many developments that may have a dramatic impact on water sustainability are already being implemented today. For example, pricing mechanisms and smart metering are starting to encourage people to reduce the amount of water they use. Systems that allow buildings to capture rain and make use of greywater (mildly contaminated water, such as water used for washing) are becoming more economically viable. Techniques that use the heat or organic matter from waste treatment (for heating or generating biogas) are beginning to make wastewater processing cheaper and far more energy efficient. Wastewater treatment technologies, such as filtration and reverse osmosis, are also reducing in cost whilst becoming more reliable and effective. At the cutting edge is biomimicry, which copies the processes that allow some fish and plants to live in both salty and fresh water, using minimal energy.[39]

Food

Agriculture. Agriculture currently occupies around 38% of the world's total land (4.9 billion hectares) and this is likely to grow to around 40% by 2050. Improvements in productivity, rather than substantial increases in the amount of land used, are expected to meet most of the increase in demand for food.[40] The potential for developing new agricultural areas is limited, and some existing farmland is likely to be lost in the coming decades due to urban expansion and sea level rise. This loss means that yields will probably need to increase by about 35% by 2050, at an annual growth rate of 0.9%. However, a range of factors are likely to make this rate of increase challenging, including climate change, competition for natural resources, underinvestment and technology gaps.[41]

39 Benton, T., *et al*., (2017), *Food and water systems and security: looking to the future*, a research paper commissioned by DCDC.

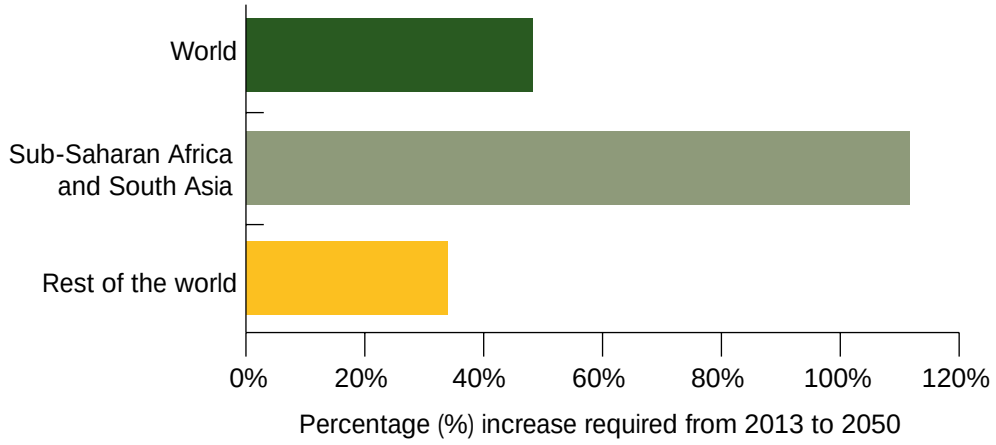
40 UN Food and Agriculture Organization (FAO), (2017), *The future of food and agriculture: Trends and challenges*.

41 *Ibid.*

> By 2050, global annual demand for meat products could be 76% higher than 2005 levels.

Diets. By 2050, average levels of food production will probably have to increase by around 50% (from a 2012 baseline) if the demands of the world's population are to be met. In sub-Saharan Africa and South Asia, however, production is likely to need to more than double. The challenge of feeding the world in a sustainable way over the next 30 years will be further compounded by changing diets. As people become richer, they tend to eat more vegetable oils, meat, dairy and sugars. Calorific consumption is likely to increase to as much as 2,800 Calories per day in developing countries, and over 3,000 Calories per day in developed economies by 2050.[42] Since the 1960s, global meat production has more than tripled (from 72 billion kilograms in 1961 to 258 billion in 2005), and per capita consumption of fish has more than doubled. The average amounts of milk, dairy products and vegetable oils eaten by each person have also almost doubled since the 1970s.[43] Greater consumption, and changes in diet, need increasing levels of resource to sustain it, which will probably have implications for land use, water consumption and greenhouse gas emissions. For example, production of animal protein typically requires 2.5-10 times more energy than it takes to generate the same amount of protein from plants, and about a third of cereal production is currently diverted to animal feed. On average, producing a kilogram of beef requires around 30 times more water than a kilogram of wheat. By 2050, global annual demand for meat products could be 76% higher than 2005 levels.

Projected increase in agricultural production required to meet expected world demand (2013-2050)



Source: Statista

Food security. Just eight crops provide 74.2% of the calories eaten by people: maize (20.4%); wheat (18.4%); rice (15.5%); palm oil (6.2%); soya (5.7%); barley (4.4%); sugar cane (3.6%); and potatoes (2.0%).[44] Dependence on such a small number of crops could be a critical vulnerability should one of them fail, particularly since most are produced in just five main areas or 'breadbaskets': Latin America (soya and sugar cane); Midwestern United States (soya and maize); Europe (wheat); Asia (rice); and Southeast Asia (palm oil). The impact of climate change may increase the probability of simultaneous 'breadbasket' failures, with the potential for devastating impacts on the global food market. There could also be knock-on effects for worldwide stability, as higher food prices, in combination with poor governance, have been shown to heighten the risk of protests, riots and con□ict.

42 Laverick, M., (2017), *Food Security 2050 – 'Dietary Middle-Classing' and the Importance of South East Asia in Predicted Global Protein Deficiencies*, a research paper prepared for DCDC.

43 UN FAO, (2017), *The future of food and agriculture: Trends and challenges*.

44 Benton, T., *et al*., (2017), *Food and water systems and security: looking to the future*, research paper commissioned by DCDC.

kynny / iStock.com

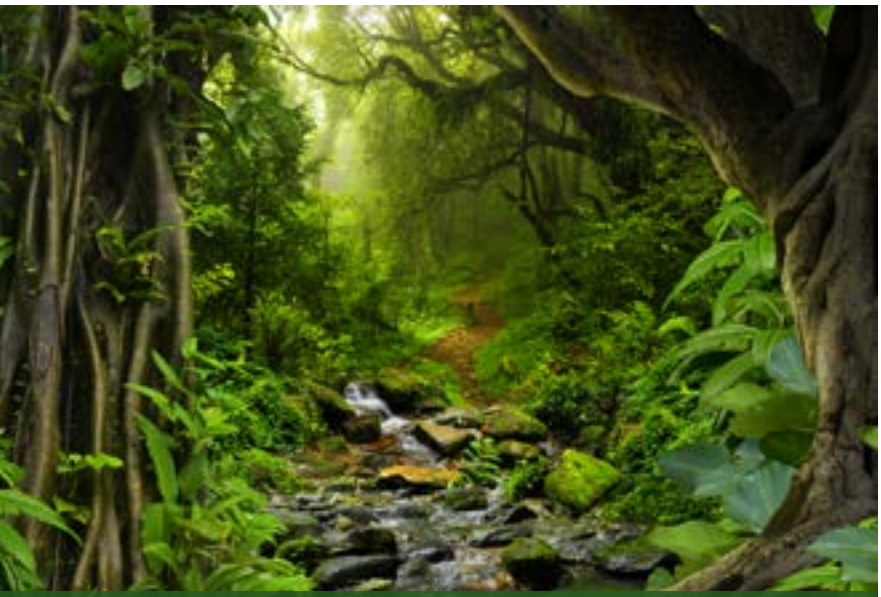
Hydroponics could reduce the land and resources needed to grow food

Trade will almost certainly continue to be essential to global food security, with nearly every country likely to remain dependent upon imports for a significant proportion of their food. Widespread international trade in essential crops, coupled with global competition and technological developments, have driven up yields and, for the most part, lowered prices. Although this trend is likely to continue, even small changes in supply can have large effects on costs. The effects of climate change are likely to disrupt agriculture and future global price spikes cannot be ruled out, nor can the risk of increasing malnutrition. Wealthier countries are likely to be able to cope much better with price spikes, whilst developing countries will probably remain the most adversely affected.

Technology and innovation. Technology is likely to play a major role in improving agricultural productivity over the coming decades. For example, genetic engineering has the potential to boost yields and increase the resistance of crops to pests and environmental stresses, including heat and exposure to saltwater.[45] Widespread adoption of techniques such as hydroponics (where plants are grown in mineral solutions instead of soil) could mean that it is possible to significantly reduce the amount of land and resources needed to produce some types of food. This could make farming in urban areas more practical. 'Lettuce factories' have already been developed in Japan, where plants are grown in laboratory-like conditions. In these 'factories' every aspect of agriculture is precisely controlled, including the temperature, frequency and intensity of light, and the level of CO_2 and other gases. They consume 95% less water than conventional methods, do not need to use pesticides and are unaffected by the weather. The use of big data and information technology could allow farming to occur at the individual level (specific plants or animals) rather than the field or herd, allowing pesticides, nutrients and water to be applied precisely, significantly reducing waste and cost, as well as boosting productivity.

Technological innovations could also reduce pressure on resources by making novel alternatives to meat widely available, such as substitute meat derived from plant protein, growing laboratory-cultured meat or using insects as a protein source. The replacement of 50% of the world's livestock consumption with insect proteins could mean that more than a third of existing agricultural land could become available for other uses.

45 Benton, T., *et al*., (2017), *Food and water systems and security: looking to the future*, research paper commissioned by DCDC.



Global forest coverage could stabilise or even increase

If traditional livestock continues to be consumed at high rates, there are still ways to make efficiency savings, for example, algae could be cultured to provide animal feed. An area three times the size of Texas, if used to grow algae, could produce ten times more protein than is currently generated by global soybean harvests. Advances in automation could enable faster harvesting, storage and distribution, substantially reducing the amount of food loss. Currently, approximately a third of all food produced is wasted.[46]

Agriculture and the environment. Unless more environmentally-sensitive techniques are employed, agriculture is likely to continue to cause widespread environmental damage. The sector is the second largest emitter of greenhouse gases, and intensive farming techniques are also linked to soil degradation, pest resistance and water pollution. Agriculture is a major driver of habitat destruction, contributing to the removal of mangrove forests, salt marshes and seagrass beds.[47] By 2050, intensive farming could account for 70% of the predicted loss of terrestrial biodiversity.[48] This could, in turn, result in unchecked expansion of pest species, as well as reducing resilience. Loss of biodiversity will mean that there is less genetic material available for breeding new crops and plant varieties that could allow food systems to adapt to climate change.

Natural habitats

Ecosystems. Functioning ecosystems oxygenate and purify the air, absorb CO_2 and toxins, clean water and provide raw materials and food. However, pollution, climate change and widespread habitat destruction has led to significant damage. Climate change also appears to be altering the life cycles of animals and plants. In Europe, for example, plants now leaf, flower and fruit earlier than they did in the 1970s, and migratory birds have been arriving sooner in the year.

The harm to ecosystems between 1997 and 2011 due to land-use change alone has been estimated to have cost between US $4.3-20.2 trillion,[49] and this figure can be expected to increase significantly in the coming decades. Global terrestrial biodiversity (measured as mean species abundance where 100% means maximum natural species diversity and 0% means no original species are found) was estimated to have fallen to 68% in 2010 and is forecast to drop to 60% by 2050. This may be a conservative estimate, as it does not take into account the risk of a 'tipping point' (where relatively small changes cascade through a highly-interdependent structure) being reached where ecosystems rapidly collapse, leading to substantial loss of animal and plant species. The Amazon basin ecosystem may be at particular risk from this effect, as complex interactions between deforestation, forest fires and climate change could turn the area

46 UN FAO, (2017), *The future of food and agriculture: Trends and challenges.*

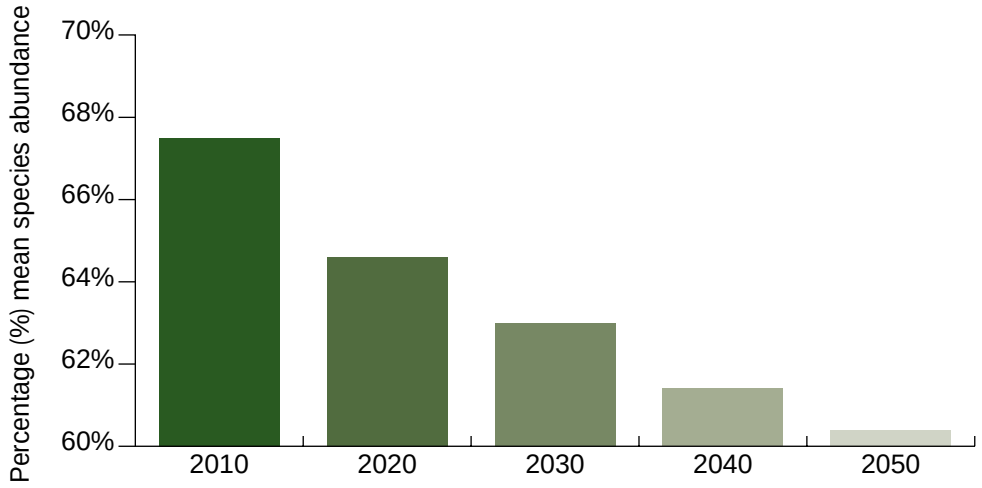
47 UN FAO, (2016), *The State of the World Fisheries and Aquaculture.*

48 UN Water, (2017), *The United Nations World Water Development Report, Wastewater The Untapped Resource 2017.*

49 Davie, J., *et al.*, Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for DCDC.

from a rainforest to a savannah. Such a shift would almost certainly have global impacts, including the loss of a major carbon sink. Some studies even suggest that a planetary-scale tipping point (resulting in widespread damage to the global ecosystem) could be reached.[50]

Projected change in global terrestrial mean species abundance



Source: Organisation for Economic Co-operation and Development

Forests. Demand for land and timber has resulted in significant tropical deforestation in recent decades, although the rate of deforestation has slowed in some of the most badly-affected countries, including Brazil and Indonesia. By 2020, the amount of the world covered by forest could stabilise or even start to increase, driven mainly by greater afforestation in temperate areas. Rising temperatures in high northern latitudes are likely to expand the range of boreal forests, while higher concentrations of CO_2 could stimulate plant growth globally. However, if the effects of climate change worsen in the next 30 years (as seems likely), reduced soil moisture and greater vulnerability to fire, drought, pests and diseases could prevent forests expanding, and may even cause dieback.[51]

Waste

Waste management. Globally, around two billion tonnes of solid household waste are produced each year, probably rising to three billion tonnes by 2050.[52] Lower-income cities in Africa and Asia are likely to double their household waste generation in the next 15-20 years. In most developed countries, comprehensive waste management systems have been developed. However, in many developing parts of the world, open dumping, uncontrolled burning and unmanaged composting are widespread,[53] with simple dumpsites (where waste is deposited with little or no operational controls or environmental protection) receiving approximately 40% of the world's waste.[54] If it is not properly managed, waste can cause pollution and disease, especially in densely-populated areas. Open dumpsites can be particularly harmful to health, as well as to the environment, for example, run-off from dumps can contain persistent and

“Globally, around two billion tonnes of solid household waste are produced each year, probably rising to three billion tonnes by 2050.”

50 European Environment Agency, (2015), 'SOER 2015 – The European environment – state and outlook 2015'.

51 Met Office, (2017), 'Dangerous climate thresholds'.

52 The World Counts, 'World waste facts'.

53 Stringfellow, A., *et al.*, University of Southampton, (2017), *The future of solid waste management to 2050*, a research paper commissioned by DCDC.

54 International Solid Waste Association (ISWA), (2016), *A Roadmap for closing Waste Dumpsites: The World's most Polluted Places*.

By 2050, plastic production could quadruple and there could be more plastic than □sh (by mass) in the oceans

harmful pollutants that contaminate local waterways. Similarly, dust and debris blown from these sites may agitate respiratory illness, open burning sometimes releases toxic gases, and animals feeding at dumpsites can introduce toxins and pathogens into the food chain. As populations grow and urbanisation increases, many more people are likely to dispose of their waste in simple dumpsites, with harmful consequences for human health and the environment.

Land□ll sites. In developed economies, engineered landfill sites are often designed to reduce health risks, protect underlying soil and groundwater, and collect harmful emissions (such as methane, which can be burned to produce electricity). These sites often need investment and management for over 100 years after they stop receiving waste. Developed countries are also increasingly recovering resources from waste by various means, decreasing the amount of landfill. For example, landfill in the European Union fell by 50% between 1995 and 2005 (from 144.2 million tonnes to 60.7 million). Over the same period, recycling more than doubled from 25 million tonnes to 69 million. While developed (and in time, developing) economies are likely to reduce their use of landfill, some capacity will continue to be required, not least to deal with waste resulting from unplanned events such as floods and earthquakes. The hurricanes in Houston and the Caribbean Islands in 2017 highlighted the immense amounts of waste that can be produced by a natural disaster and damage from such incidents can be expected to worsen. Flooding (which climate change is expected to increase) will pose a particular hazard to landfill sites as pollution could leak out when landfills are flooded, and non-engineered dumpsites could collapse catastrophically.[55] There are estimated to be over 1,700 licensed and historic landfills in coastal flood and erosion buffer zones in England and Wales[56] and in certain low-lying parts of the world future pollution from coastal landfills is anticipated to be a major issue.

55 Stringfellow, A., *et al.*, University of Southampton, (2017), *The future of solid waste management to 2050*, a research paper commissioned by DCDC.

56 Beaven, R. P., *et al.*, (2017), *The impact of coastal landfills on shoreline management plans*.

Plastic. The low price, versatility, strength and durability of plastic have led to its widespread use in multiple industries around the world. Global production of plastic products has risen from around two million tonnes a year in the 1950s to 322 million tonnes in 2015, and production could quadruple by 2050. Plastic waste has also increased, with around 274 million tonnes generated annually at the start of this decade,[57] and plastic waste is found almost everywhere, particularly in the oceans and along shorelines.

Nanomaterials. Nanomaterials are already being used in a wide variety of industries, with global production estimated to produce 320,000 tonnes a year.[58] Although the use of these substances can deliver significant benefits, their effects on health and habitats are not well understood. Nanomaterials are probably accumulating in the environment, perhaps entering the wastewater system by passing through treatment works and accumulating in sewage sludge. Waste of this kind is typically spread on soil (potentially entering the food chain), or incinerated, with the resulting ash often used in the construction industry or put into landfill. In open dumps, without mitigation measures, run-off is likely to cause contamination. The amount of waste nanomaterials accumulating in the environment is, therefore, almost certainly increasing, yet the impact is unknown.

Alternatives to waste. The 'circular economy' is a relatively new concept that may alter the way waste is managed in the future. Unlike in the traditional economy (where items are made, used and disposed of), in a circular economy, resources are kept in use for as long as possible to extract their maximum value. Consequently, products are designed and optimised for disassembly and reuse. Instead of owning a product, it is often leased or shared, reducing the amount of resources needed to meet a community's needs. As automation and technology improve, it is likely that it will become much cheaper to sort and separate waste, increasing the amount of material that can be recycled, reused, composted and (as a last resort) incinerated or treated. By 2050, today's waste products could be valuable resources.

deepblue4you / iStock.com

As technologies improve, the amount of material that can be recycled, reused or composted will increase

57 Geyer, R., *et al.*, Science Advances, (2017), 'Production and fate of all plastics ever made'.

58 Keller, A. A. and Lazareva, A., *Environmental Science and Technology Letters*, (2014), 'Predicted Releases of Engineered Nanomaterials: From Global to Regional to Local', pages 65-70.

Most coral on tropical reefs could die by 2050

Global commons – oceans

Sea level rise. Climate change will lead to a rise in the sea level. From 1901 to 2010, the average sea level rose by around 0.19 metres and, by 2050, it is projected to rise by a further 0.17-0.38 metres,[59] although it has been suggested this figure could be much higher. Fluctuations in ocean circulation mean that rates of sea level rise in some areas will be significantly different from the worldwide average. For example, since 1993 the rate of sea level rise in the Western Pacific has been up to three times greater than the global average. A higher sea level will increase the frequency of coastal flooding and storm surges, with the numerous low-lying island nations in the tropics particularly vulnerable to flooding. Areas located near current and former glaciers or ice sheets could, however, experience a fall.[60] Approximately 50% of people live in coastal regions and most of the world's largest cities are on or near the coast, rendering them particularly vulnerable to flooding. If a major city is flooded, military assistance is likely to be needed, both at home and overseas.

> "Fishery yields in tropical areas could decline by 40%."

The marine environment. Climate change is likely to have an increasing effect on marine ecosystems. Variations in the timing of plankton blooms, migration patterns and spawning of fish have already been observed in recent decades, while tropical corals are under threat from higher temperatures and ocean acidification. On current trends, the coral on most tropical reefs could die over the next 30 years and this will greatly decrease marine biodiversity and dramatically reduce fish stocks, which are already at risk. In 2011, around 29% of global fish stocks were considered to be overfished, and about 61% were fully exploited.[61] Fishery yields in tropical areas could decline by 40% by 2050, but in high-latitude waters, the catch could increase by as much as 70%.

Pollution. Pollution is leading to the creation of 'dead-zones' in parts of the ocean and it is estimated that at least 26% of all the carbon released as CO_2 from fossil fuels, cement manufacture and land use changes between 2002 and 2011 was absorbed by the oceans. In total, the oceans probably contain around 93% of the world's CO_2.[62]

59 IPCC, (2014), *Climate Change 2014: Synthesis Report*.

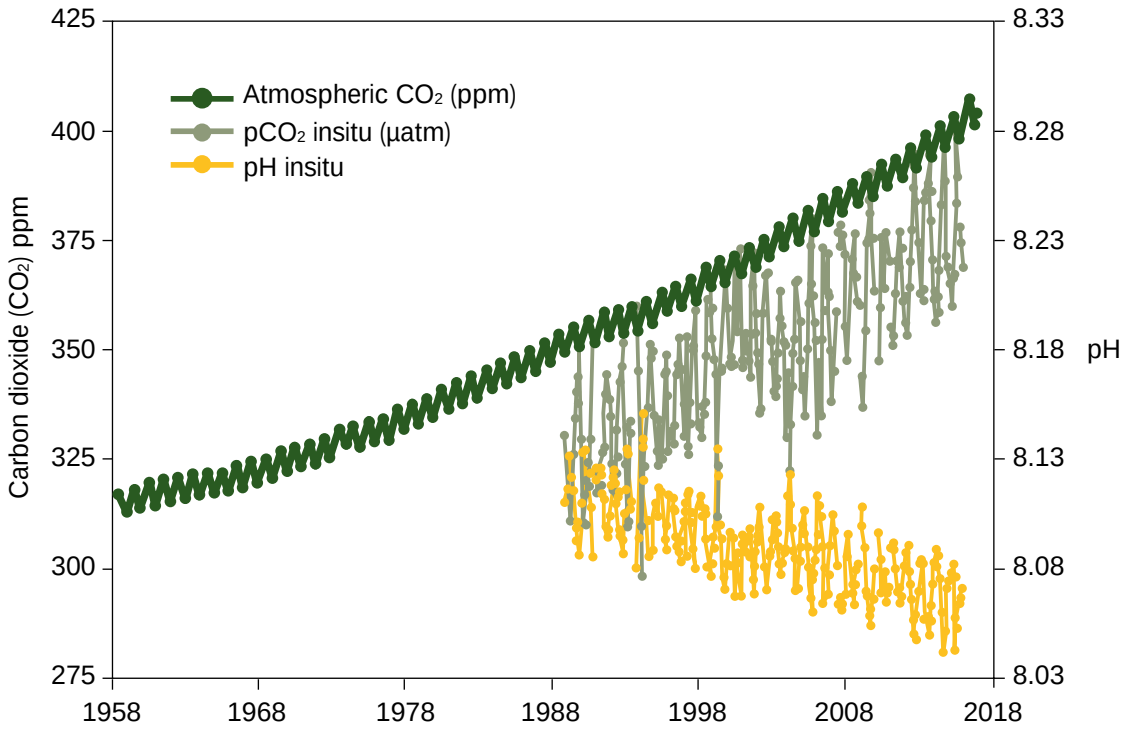
60 IPCC, (2014), *Observations: Oceans*.

61 European Environment Agency, (2015), 'SOER 2015 – The European environment – state and outlook 2015'.

62 Science and Issues Water Encyclopedia, *Carbon Dioxide in the Ocean and Atmosphere*.

As more CO_2 is absorbed, the oceans will become more acidic, harming wildlife, particularly calciferous organisms such as corals and shellfish. Increasing levels of plastic waste are found almost everywhere in the oceans and along shorelines, including on the beaches of remote uninhabited islands and in deep ocean sediments. This vast amount of non-biodegradable debris is likely to have wide-reaching health implications for people and marine life. An abundance of plastics in the oceans is also likely to facilitate the spread of invasive species that are transported on floating debris, further disrupting ecosystems. Without significant improvements in waste management, the amount of plastic waste in the oceans could increase by an order of magnitude within just a decade. On current trends, by 2050 there will be more plastic than fish (by mass) in the oceans.[63]

Atmospheric dissolved carbon dioxide and sea water acidity (pH) in the North Paci□c



Note: Data taken around the islands of Hawaii. Partial pressure of CO_2 (pCO_2) is measured in atmospheric units.

Source: Adapted from: Dore, J. E., Lukas, R., Sadler, D. W., Church, M. J. and Karl, D. M.

Shipping. By 2050, shipments of raw materials are likely to double to Western economies and quadruple to other regions, and global freight trade could grow between 330-380%. Technology is likely to reduce the cost of shipping, for example, a completely crewless container ship (the *Yara Birkeland*) may be operational by 2020. The melting of polar ice is likely to provide new, shorter sea routes through the Arctic. However, climate change is likely to result in increasingly intense storms, sea level rise and periods of more intense rainfall, which are expected to disrupt shipping, increase the frequency of port closures, reduce the speed of passage, require routes to be altered, damage infrastructure and disrupt major trade routes.[64] Maritime choke points (for example, the Panama Canal) could be affected by climate change, disrupting international trade and security of supplies and potentially exacerbating geopolitical tensions.

63 Ellen MacArthur Foundation, (2016), *The New Plastics Economy — Rethinking the future of plastics.*

64 Bailey, R. and Wellesley, L., Chatham House, (27 June 2017), *Chokepoints and Vulnerabilities in Global Food Trade.*

The number of illegal maritime incidents is expected to continue to increase

VanderWolf Images / Shutterstock.com

Seabed. Whilst vast quantities of oil and gas have been extracted from the seabed for decades, there has been little large-scale extraction of minerals, but in the coming decades, deep sea mining is likely to be commercially viable. The environmental damage from this type of mining could, however, be substantial, for example, releasing contaminated water and sediment-laden plumes.[65] The numbers of pipelines and cables running across the ocean floor are also likely to increase. For example, the European Union is currently scoping the possibility of laying the longest undersea pipeline ever built between Israel and southern Europe.

Governance of the seas. The International Maritime Organization and the United Nations Convention on the Law of the Sea (UNCLOS) are likely to provide the governance framework for the seas. However, there remain certain areas where tensions will persist, in particular over disputed claims and access to resources, not least in the South and East China Seas.[66] These will require careful monitoring and management to avoid escalation and conflict, which would disrupt free and open access to sea lanes and marine resources, thereby hindering more general international economic and political cooperation. UNCLOS is also likely to be tested by disagreements on deep sea mining and contested claims of ownership. The International Maritime Organization will need to modify regulations in response to advances in technology, for example, automated shipping and new energy-efficient means of propulsion (such as solar power or modern sails).

Criminality at sea. Piracy, smuggling and human trafficking are likely to continue to afflict maritime activity. The number of illegal maritime incidents has grown since the mid-1990s, a trend that is likely to continue. The effects of climate change (including flooding and storm damage) and disruption to fisheries are likely to be destabilising to coastal communities in developing countries, which may lead to an increase in piracy and associated disruption to trade routes. As maritime traffic becomes increasingly reliant on automated technology and interconnectivity, cyberattacks on shipping (and maritime infrastructure) can also be expected.[67]

65 Global Ocean Commission, (November 2013), 'A sustainable development goal for the global ocean'.

66 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, a research paper commissioned by DCDC, page 56.

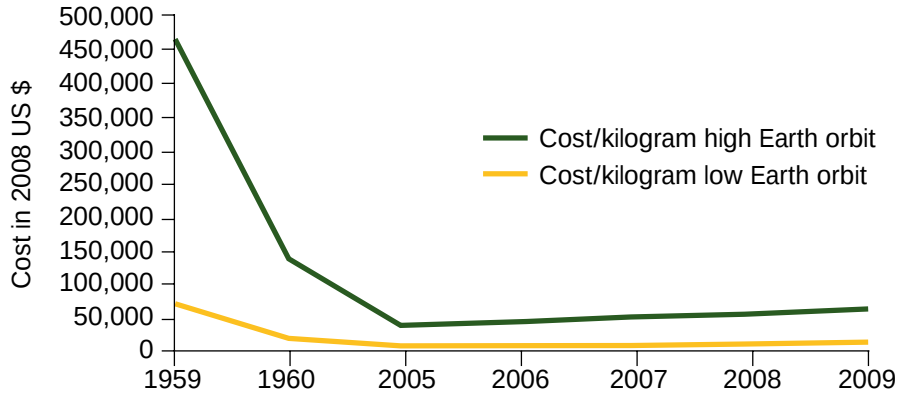
67 Deloitte, (2017), 'Cyber Security in the shipping industry'.

Extreme space weather is rare but could knock out satellites, interfere with navigation systems and disrupt power grids

Global commons – space

Spacecraft. Between 1960 and 2005, the cost of launching a rocket (vertical launch system) reduced tenfold whilst lift capacity has increased tenfold. In the coming decades, costs could continue to fall and capacity increase. The development of new materials, along with advances in production, design and construction techniques have reduced the weight and improved the capacity of components, whilst increasing their resilience. Driven by lower costs, new designs of rockets that are reusable have started to be tested, such as Blue Origin's New Shepard rocket or the SpaceX Falcon series. There have also been promising developments in horizontal launch systems (where vehicles are lifted into the sky by an aircraft, before launching into space), which could be used for space tourism and putting objects into low-level orbit. Concepts include the European Space Agency's IXV space plane,[68] Virgin Galactic's SpaceShipTwo, and China's ambition to launch a rocket from a Y-20 strategic transport craft. Future developments in new types of jet engine and rocket technology may allow access to space in the same way as a commercial aircraft takes off and lands.[69]

Satellite launch costs



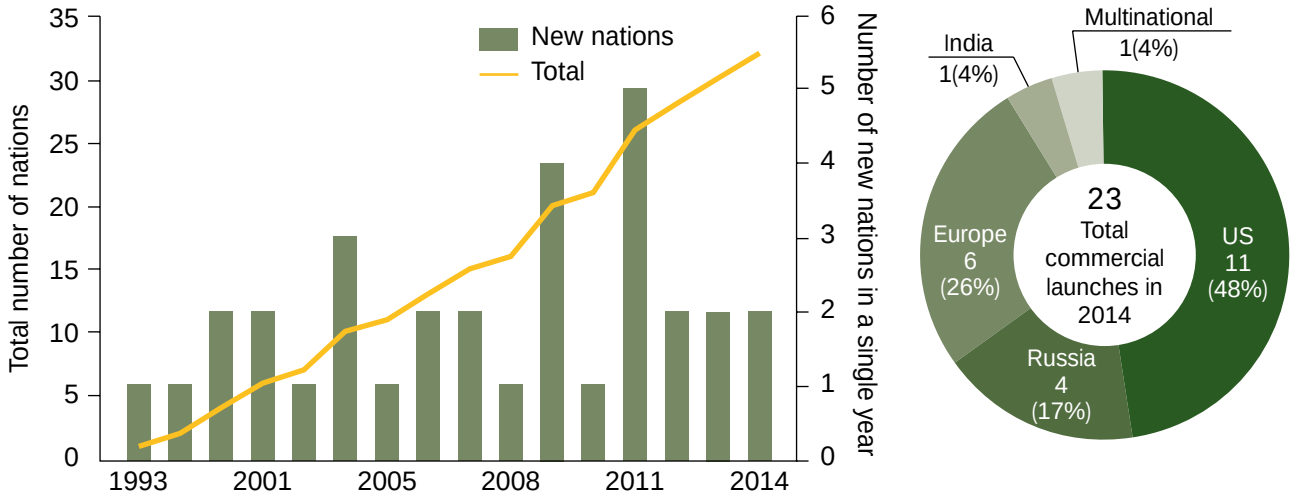
Source: Aerospace.org

68 European Space Agency, (February 2015), 'ESA Experimental Spaceplane Completes Research Flight'.

69 Ceurstemont, S., *New Scientist*, (17 May 2017), 'Plasma jet engines that could take you from the ground to space'.

Launch capability. The number of countries able to put satellites into space using their own launch facilities have increased from two in the 1950s (US and Russia) to over 11 in 2017, with New Zealand being the latest, and by 2050 this figure looks certain to grow. Spaceports are being developed in Canada, China, Italy, New Zealand, Norway, Portugal, Spain, Sweden, the UK and the US. China has opened a commercial facility in Hainan province where it is planning on launching its space station into orbit,[70] and Russia's new Siberian Cosmodrome launched its first rocket in 2016.[71] In 2000, only five countries had launched satellites which could observe the Earth. By 2014, there were over 30, with launches no longer solely government-funded and in 2014, 23 of the world's 92 launches were commercial. The market for launching satellites has seen a significant worldwide increase in value, with revenue almost doubling since 2001. The global space industry is expected to grow from around US $350 billion in 2017 to over US $640 billion in 2030, principally driven by the commercial sector (which had a 76% share in 2017). By 2050, the figure is likely to exceed US $1 trillion.

Total worldwide orbital launches



Sources: Union of Concerned Scientists; Federal Aviation Authority

Capabilities. Innovation will continue to drive space capabilities. Entrepreneurs have proposed ambitious new projects such as: new launch platforms; on-orbit-servicing; space mining; in-space manufacturing; and the colonisation of Mars.[72] Advances in the miniaturisation of electronics, energy storage and remote power generation have already driven significant improvements in space-related technology, and will continue to do so. For example, the average lifetime for communication satellites lengthened from 11 years in 1996 to 15 years in 2015, and the resolution of images from observation satellites sharpened by more than 50% between 1999 and 2014. **By 2050, non-state actors could acquire high-resolution satellite images of anywhere on Earth, although only the wealthy will be able to achieve continuous coverage.** Small satellites called 'nanosats' (most commonly used for Earth observation and remote sensing) are becoming increasingly numerous. Launches of nanosats increased from two in 1998 to almost 300 in 2017.[73] By 2050, there could be many thousands of nanosats, increasing the risk of an accidental collision. Automated and remotely-controlled technology is already in use in space (for example, operating the International Space Station), and as advances in automation and artificial intelligence continue, systems are likely to be developed for more complex tasks, for example, to mine asteroids or build structures on the Moon or further afield.

70 David, L., Space.com, (2 April 2017), 'China's New Spaceport to Launch Country's Largest Rocket Yet'.

71 Solovyov, D., Reuters, (27 April 2016), 'Russia launches first rocket from new spaceport at second attempt'.

72 Quintana, E., RUSI, (9 August 2017), 'The New Space Age: Questions for Defence and Security'.

73 Bhavya, L., *et al.*, Science and Technology Policy Institute, (June 2015), 'Global Trends in Space Volume 2: Trends by Subsector and Factors that Could Disrupt Them'.

Dependency. A broad range of systems are dependent on space including the Global Navigation Satellite System (GNSS), which is used for a range of services, including navigation, accurate timings for financial transactions, electrical power distribution and communication. Economies are becoming increasingly dependent upon space-based systems, for example, in 2015 it was estimated that 11.3% of the UK's GDP was directly supported by GNSS.[74] As the number of systems dependent on space-based capabilities increases, both developed and developing countries will become increasingly reliant upon them and so too will their vulnerability to disruption. For example, when a single US satellite malfunctioned in 1998, it not only disrupted television and communication systems, it also stopped credit card systems from processing payments, weather radars went blind and some automated petrol station pumps stopped working.

Risks. Threats to space capabilities include: accidental collisions form space debris; space weather; malicious jamming and spoofing; and, possibly, anti-satellite weapons. Denying access to certain types of space capability is not hard or expensive. Many satellite ground stations are vulnerable to attack and a standard GPS jammer can be bought for as little as GBP £20 over the Internet (found through a simple Internet search). Between 2013 and 2017, over 90 GPS jamming incidents were reported by pilots through the National Aeronautics and Space Administration's (NASAs) safety reporting system.[75] In addition, extreme space weather events (for example, Coronal mass ejections, which are bursts of high energy particles from the Sun) are rare but could occur by 2050, and these have the potential to knock out satellites, interfere with navigation systems and disrupt power grids. The impact of these events may, however, be at least partially mitigated by improved space situational awareness, allowing the prediction and detection of space weather and mitigating action to be taken.

> "Economies are becoming increasingly dependent upon space-based systems."

Governance. Since the signing of the Outer Space Treaty in 1967, there have been significant changes in the way space is used and who has access, and there are other emerging issues that the Treaty does not cover, such as space debris. At least 17,000 trackable pieces of debris have entered orbit since Sputnik 1 was launched in 1957.[76] Space debris is of growing concern, especially for high-risk orbiting platforms such as the International Space Station. The current Treaty also does not consider ownership of space assets by anyone other than national governments, which does not reflect the increasing trend towards space commercialisation. International dialogue on the use of space has developed in the decades following the 1967 Treaty, with proposals including cooperating to enhance space situational awareness, improving data-sharing and implementing mechanisms to safely remove debris. But, the fact that not a single new treaty has been concluded to tackle these problems since 1979 indicates not only how far space law currently lags behind the requirement in practice, but also how difficult it will be to obtain international agreement on an appropriate way forward.[77] As in other areas, soft law instruments, such as a non-binding code of conduct, may be more feasible as a first step towards cooperation than the ratification of a formal and universally applicable treaty.

Military operations. The military uses space-based assets for a range of purposes. These include navigation, early warning systems, surveillance, intelligence gathering and military communication. Dependency on space-based capability, however, brings vulnerability. Militaries are, therefore, developing alternative capabilities, including unmanned aerial sensors, long-range high endurance communication drones and the use of traditional microwave and terrestrial towers. By 2050, space-based weapon systems may also be deployed,[78] which could include nuclear weapons.

74 Sadlier, G., *et al.*, London Economics, (June 2017), 'The economic impact on the UK of a disruption to GNSS', page iii.

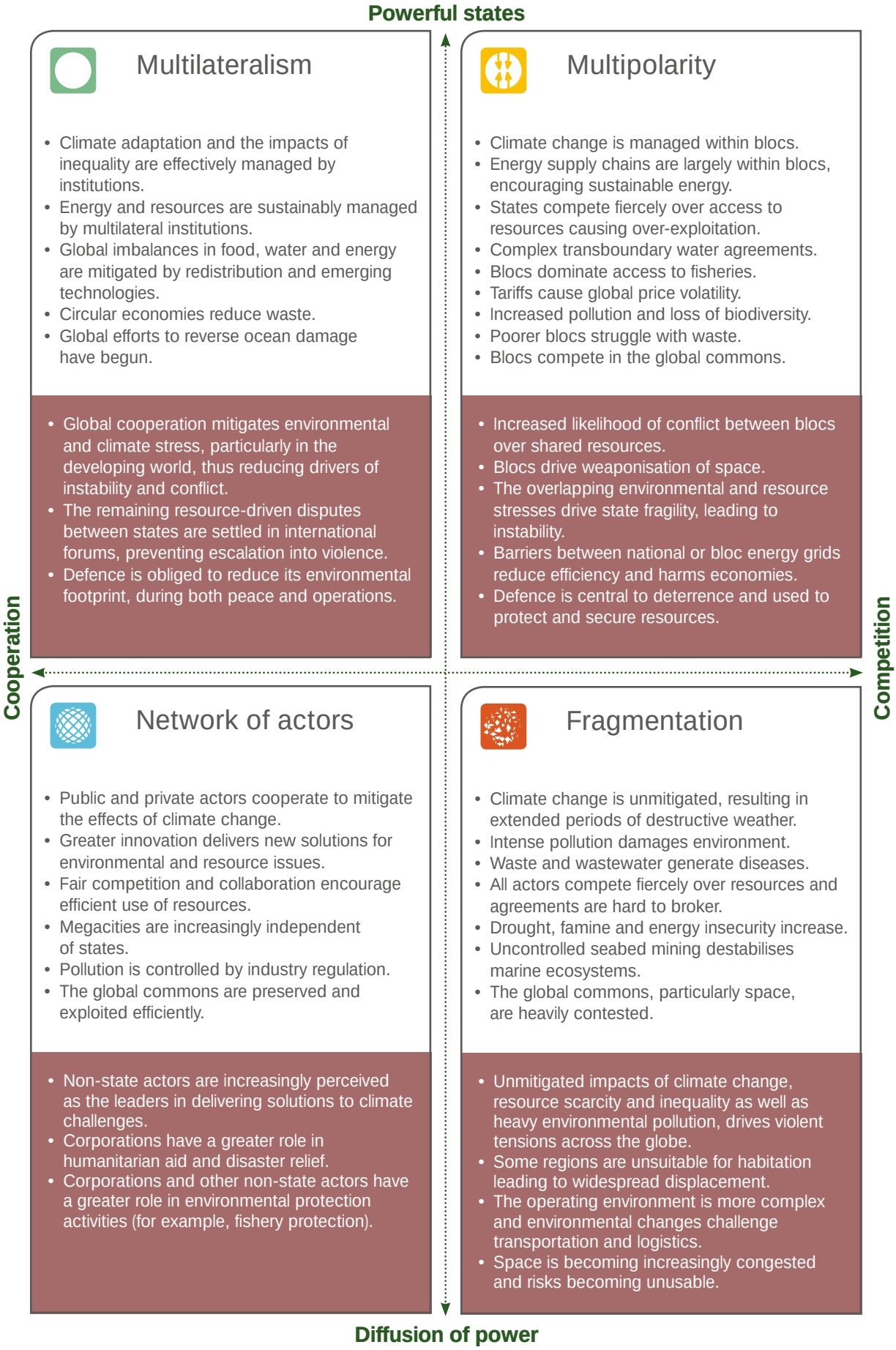
75 Buesnel, G. and Holbrow, M., (June 2017), 'GNSS Threats, Attacks and Simulations'.

76 European Space Agency, (21 February 2018), 'About Space Debris'.

77 Ling, Y., (2011), 'The Future of Space Law', page 546, in Muller, S., *et al.*, *The Law of the Future and the Future of Law.*

78 Heath, V., (10 April 2016), 'The Weaponization of Space and the Future of Star Wars'.

Future worlds: Environment and resources



Watch points

- Shifts in the rate of climate change.
- Changes to the frequency, duration and intensity of extreme weather and the damage caused.
- Speed of change in natural habitat, for example, biodiversity, soil quality and desertification.
- Effects of, and policy on, climate change.
- Progress towards climate targets.
- Adoption of carbon capture technology.
- Societal attitudes on environmental issues.
- Complexity of materials, their impacts on the environment and effectiveness of waste treatment.
- Increased seabed mining and drilling.
- Progress towards sustainable non-carbon based economy.
- Conflicts over resources.

Discontinuities

- Abrupt changes in the natural environment.
- Ecosystem tipping point reached.
- Unilateral adoption of geoengineering.
- Public acceptance of sustainability and its costs.
- Breakthrough in energy technology (cold fusion).
- Rapid technological development enabling local production of food, water and energy.
- Pandemics infect both crops and livestock.
- Uncontrolled spread of invasive species.
- New resource with one monopoly supplier.
- Major competition in the global commons.
- Attack on transoceanic fibre-optic cables and/or space systems.

Implications

- The climate is changing and will have major consequences for humanity. The impacts of climate change need to be mitigated effectively, otherwise it could act as a driver of instability and conflict with far-reaching humanitarian, economic and geopolitical consequences.
- Defence needs to take the implications of the changing environment into consideration. The requirement to support humanitarian aid and disaster relief operations might be more frequent, while the local operating environment will be more complex and contested.
- As reliance on space-based capabilities increases, investment in resilience needs to keep pace.
- Systems to mitigate food and water scarcity and disruptions to supplies need to be developed to avoid shortages and prevent instability.
- Waste that pollutes food and water needs to be better understood, prevented and properly managed.
- Access to resources is important for economies. Recycling and substitution in agricultural and industrial processes may help to reduce resource demands and susceptibility to supply shortages.
- The uptake of renewable energy and other low carbon technologies could increase the resilience of national energy supply.
- The impacts of climate change will increasingly challenge extant defence and security planning assumptions such as basing, logistics or the environmental envelope for capability development.
- As competition in, and reliance on, the global commons increases, governments will need to invest in ensuring freedom of action.
- Good governance that invests in climate change adaptation and enables fair access to resources is important for stability and security, as well as efficient and unhindered access to supply and transport routes.

Human development

Synopsis

By 2050, the global population is expected to reach 9.8 billion people, but growth will be unbalanced. Many developing countries will experience rapid population growth, with the population of Africa almost doubling, whilst the size of populations in many European and East Asian countries will shrink. More people will live in towns and cities, boosting economies, although rapid urban expansion in developing countries will lead to the growth of slums and criminal violence. Nevertheless, human security will be enhanced as more people escape absolute poverty and have access to education and health care. The number of people dying from infectious diseases is likely to reduce and advances in medicine, particularly gene editing and gene therapy, could potentially lead to spectacular medical advances. The risk of a global pandemic will, however, endure, and the number of people suffering from conditions such as obesity and dementia is increasing, as is the prevalence of antimicrobial-resistant bacteria.

Human empowerment will also increase. Unprecedented numbers of people will have access to almost limitless information and more people will have the means to travel abroad and the ability to maintain relationships with people from outside their immediate community. Equality between the sexes is improving and increasing numbers of people in developed (and some developing) countries will have the freedom to determine their gender and sexuality. Divorce is also becoming more common, as are single-parent families. Individualism and personal empowerment is likely to enhance personal fulfilment, but this may come at the price of more fragmented societies and increased populism. Inequality is rising and there appears to be a growing division within many countries between those with liberal views and those with traditional views. The 'echo chamber' effect of social media may drive further division within societies, which may be exploited by external actors. Because of demography, the followers of the main religions will increase in number, although they may be less devout. Increasing numbers of people are, however, searching for spiritual guidance online, meaning the number of people who could be targeted for religious radicalisation could also rise.

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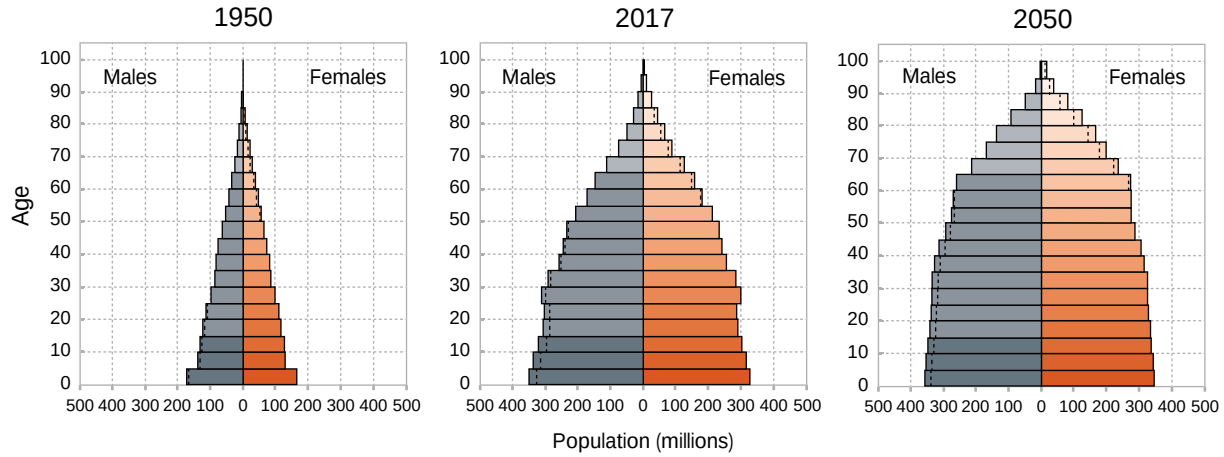
Demography

Population. In 2017, the global population reached 7.6 billion and by 2050 it is expected to reach 9.8 billion. Half of this growth is likely to be concentrated in just nine countries: the Democratic Republic of the Congo, Ethiopia, India, Indonesia, Nigeria, Pakistan, Tanzania, Uganda and the United States (US). By 2050, China, India, Indonesia, Nigeria, Pakistan and the US are likely to have populations in excess of 300 million and Africa's population will probably double to around 2.5 billion. In the same time frame, populations of some East Asian countries are likely to reduce, as are several European countries, for example, the populations of Bulgaria, Croatia, Latvia, Lithuania, Poland, the Republic of Moldova, Romania, Serbia and the Ukraine are expected to shrink by more than 15% out to 2050.[1]

Global population



Source: United Nations, Department of Economic and Social Affairs. Population Division

Marriage and family. Marriage rates are declining and divorce rates are increasing across the world. In the US the proportion of adults who had never been married increased from 8% of women and 9% of men in 1970 to 17% of women and 23% of men in 2012.[2] In the Middle East the divorce rate is also increasing, for example, in Kuwait there are six divorces for every ten marriages, up from just over five in 2015; and in Egypt, President Abdel-Fattah el-Sisi's has stated that four in ten marriages end in divorce. In China, although divorce is relatively rare (about three per thousand marriages), the rate doubled between 2006 and 2016.[3] Same-sex marriage and cohabitation are also becoming more acceptable in many (though not all) parts of the world, as are mixed-race relationships. The number of families with just one child is rising, a trend that is likely to continue. More children are being raised in one-parent households, the use of medical interventions to enable single people to have children is becoming more widespread, and adoption agencies are also increasingly accepting applications from one person. If, as expected, these trends continue, traditional family bonds can be expected to loosen. This may mean that traditional values are less likely to be passed on, with societies possibly becoming more progressive and/or fragmented, potentially weakening social cohesion.

1 United Nations (UN), (2017), *World Population Prospects: 2017 Revision*, United Nations, page 2.

2 Wang, W. and Parker, K., Pew Research Center, (24 September 2014), *Record Share of Americans Have Never Married As Values, Economics and Gender Patterns Change.*

3 Zhou, V., South China Morning Post, (6 September 2017), 'Marriage rate down, divorce rate up as Chinese couples say I don't or I won't any more'.

Automation of heavy manual tasks should mean that people can work for longer

Ageing. The number of people aged over 60 is increasing by 3.26% per year worldwide, making it the fastest growing age group. In 1950, only 8% of the global population was over 60; in 2015 it was around 12%; and by 2050 it is expected to be over 20%. Probable decreases in fertility combined with increasing life expectancy could mean that, by 2050, more than a quarter of most regions' populations (except Africa's and parts of Asia's) will be aged over 65.[4] If current retirement ages are maintained, the proportion of working-age people to retirees will decrease markedly. Currently, the dependency ratio (the proportion of working-aged people compared to children and the elderly) is 13:1 in Africa but just 2:1 in Japan (the lowest ratio in any country). By 2050, the dependency ratio is likely to have dropped to below 2:1 in seven countries in Asia, 24 in Europe and four in Latin American. Conversely, the working-age populations of Africa and parts of Asia are likely to grow significantly.

Declining dependency ratios are likely to make current models of employment and retirement unsustainable. Some countries are already increasing retirement ages (in 2017, the UK government announced it would raise the state pension age from 67 to 68 after 2037, seven years earlier than originally planned) and further rises are likely.[5] Improvements in health care and technology, such as the automation of heavy manual tasks, should mean that people can work for longer. As societies age, their character is likely to change. Elderly populations tend to be more peaceful, but they are also often more conservative, potentially stifling innovation and change.

> "Declining dependency ratios are likely to make current models of employment and retirement unsustainable."

4 UN, (2017), *World Population Prospects: 2017 Revision*, page 7.

5 Milligan, B., BBC News, (19 July 2017), 'State pension age rise brought forward'.

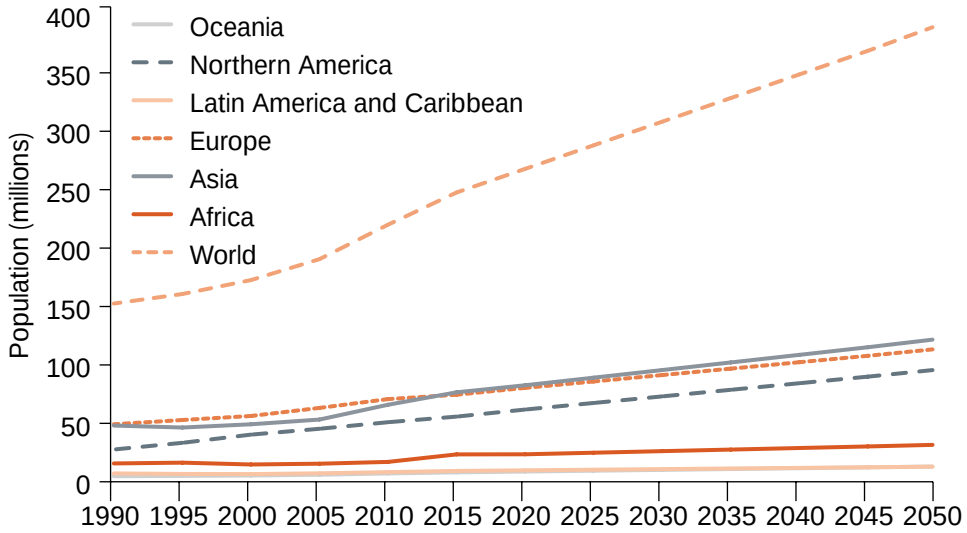
When managed well, migration can have a significant positive effect on both the destination and origin countries

Nicolas Economou / Shutterstock.com

Migration

Growing numbers. Over the past 25 years, the number of international migrants (people who live outside their country of birth) has increased from 152.5 million in 1990 (2.86% of the world's population) to 258 million in 2017 (3.41%). Approximately five million students currently study outside their home countries, and in 2012 international tourist numbers surpassed one billion for the first time.[6] Economic opportunities and the desire to travel, learn and explore will act as a draw for migration. Conflict, environmental degradation and poverty will also lead to migration, and improving communications and transport will make it faster, easier and cheaper to travel. On current trends, there will be around 400 million (4.1%) international migrants in 2050.

Total international migrant population

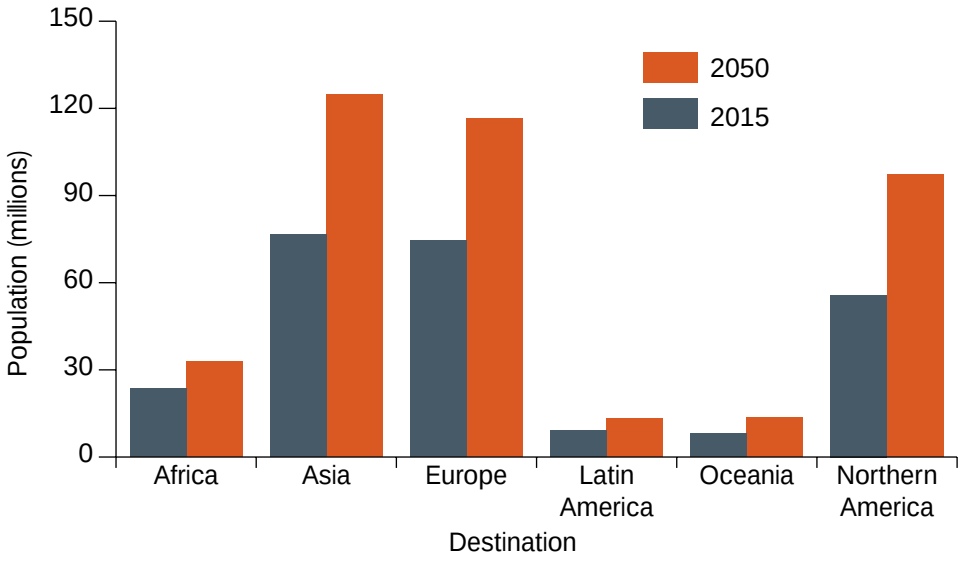


Source: United Nations, Department of Economic and Social Affairs, Population Division

6 Dorman, A. and German, T., (2017), *How will the overarching global political order change over the next 30 years?*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC), page 6.

Origin and destination. In 2017, of the 258 million international migrants, 106 million were born in Asia, 61 million in Europe, 38 million in Latin America and the Caribbean, and 36 million in Africa, with fewer than 20 million originating from North America or Oceania. Asia currently hosts the largest number of migrants (80 million) followed closely by Europe (78 million). As a proportion of the region's population, however, Oceania hosts the most migrants (over 20%) followed by North America (over 15%) and Europe (over 10%), with migrants making up around 2% of the rest of the world's population.[7] Most migrants are concentrated in just a few nations, with more than 50% of the world's migrants in just ten countries. The US has the greatest number of migrants with just fewer than 50 million, followed by Saudi Arabia, Germany and the Russian Federation. The increasing affluence of Asia is likely to make it a more attractive destination for migrants, and the proportion of the region's population (as well as absolute numbers) can be expected to increase.

Migrant distribution by destination



Source: United Nations, Department of Economic and Social Affairs, Population Division

Bene□ts and challenges. Migrants usually create jobs, pay taxes and make social contributions to the host country, and often send remittances home. In 2000, it was estimated that US $126 billion flowed from immigrants back to their countries of origin. This was estimated to have increased to US $575 billion in 2016, which is four times more than the global total spent on overseas development aid.[8] The value of remittances is likely to grow significantly by 2050 and comprise a significant element of the global economy. Despite the benefits they bring to their destination country, migrants often experience discrimination and sometimes persecution. Improving digital connectivity will almost certainly make it easier for migrants to maintain strong links with their country of origin, and this may delay integration with the host community. When managed well, migration can have a signi□cant positive effect on both the destination and origin countries, but if not effectively integrated, ghettos can form and cultural differences between migrant and host population can become a source of tension, an issue that is likely to become more important.

> “The value of remittances is likely to grow significantly by 2050 and comprise a significant element of the global economy.”

7 UN, Department of Economic and Social Affairs, Population Division, (2017), *International Migration Report 2017: Highlights.*

8 International Organization for Migration, *World Migration Report 2018*.

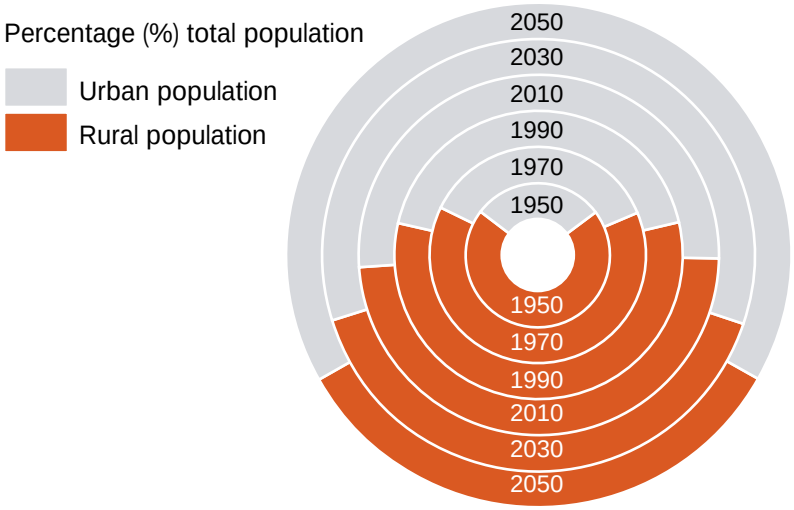
Urban slums lack sanitation and are vulnerable to natural disaster and disease

Herianus / iStock.com

Urbanisation

Population. The number of people living in cities will continue to increase. In 2017, around 55% of the world's population lived in urban areas and this figure is likely to rise to approximately 66% (an extra two billion people) by 2050.[9] With most of the world's population living in urban environments, the future of humanity will be intrinsically linked to the future of cities. Although the proportion of people living in rural areas is reducing, the number of people living there is still growing and is expected to peak at around 3.42 billion in 2025, before reducing slightly to around 3.3 billion by 2050.

Urban : rural population divide over 20 year periods



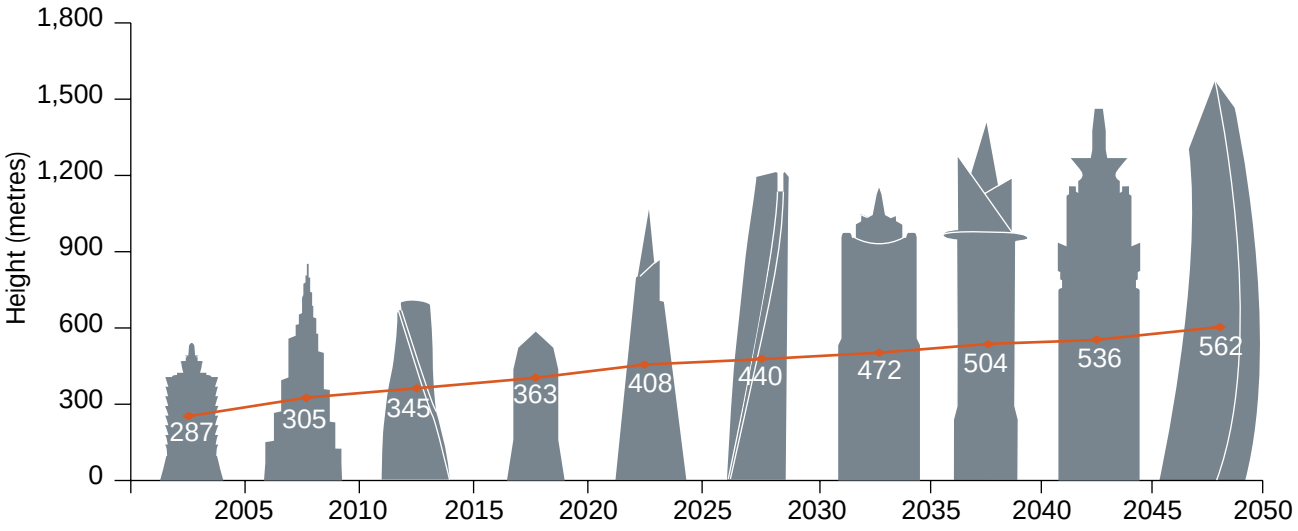
Source: United Nations, Department of Economic and Social Affairs, Population Division

9 UN Department of Economic and Social Affairs (DESA), Population Division, (2016), *The World's Cities in 2016*.

Where we live. In 2015 there were 29 megacities (urban areas with a population greater than ten million), but there are expected to be 41 megacities by 2030 and 50 by 2050. The number of large cities (with a population between five and ten million) is also expected to increase, from 45 today to 71 by 2050.[10] Presently, the largest city in the world is Tokyo with a population of around 38 million, but, by 2050, Mumbai is likely to be the most populous, with a population of over 42 million. In wealthy countries a greater proportion of the population live in cities, but the rate of urbanisation is progressing much faster in poorer countries. Asia and Africa (the world's two least urbanised regions) are experiencing the highest rates of urbanisation. By 2050, Asia's urban population is likely to rise from 48.2% to 64.2%, and Africa's will probably grow from 40.4% to 55.9%.[11] Unlike Africa, Asia is also building skyscrapers at a rapid rate, allowing more intensive urbanisation. In the 1980s, 49% of the world's tall buildings were in North America, but 66% of them are now in Asia.

Urban development. In many developing countries, urbanisation is unplanned, leading to sprawling slum areas that often lack adequate infrastructure (including sanitation) and, hence, are particularly prone to natural disasters and disease. Poor or unmanaged urban growth may also lead to congestion, non-regulated building construction and pollution. These areas are also often poorly governed, lacking basic services and, as such, they are prone to insecurity and risk becoming lawless spaces where police are unwilling or unable to enter. **Without effective governance, criminality and violence in the cities of developing countries could soar and become havens for terrorists.** Despite these hazards, increased urbanisation is likely to boost economic growth (urban areas have approximately 55% of the world's population, but account for over 80% of global gross domestic product (GDP)).[12]

Average height of the world's tallest 100 buildings



Note: Average height of the 100 tallest buildings globally averaged over a five year interval. Forecasts from 2017 are based on a linear extrapolation. Building height beyond 2016 is illustrative.

Source: Council on Tall Buildings and Urban Habitat

10 University of Ontario Institute of Technology, Sustainability Today, (2014) 'City Population 2050'.

11 UN DESA, Population Division, (2014), *World Urbanization Prospects: The 2014 Revision.*

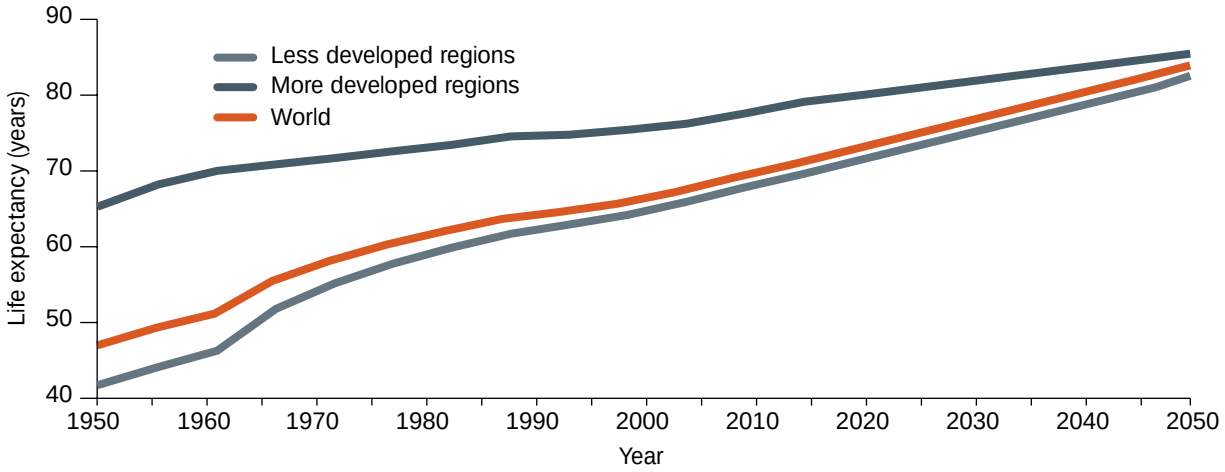
12 McKinsey & Company, McKinsey Global Institute, (March 2011), *Urban world: Mapping the economic power of cities*.

Urban areas will probably also consume the most resources, with over 80% of the world's energy use likely to occur in cities by 2050 (up from 66% today). However, cities present opportunities for efficiencies. Densely-populated areas often lead to shorter commuting distances and delivery times. Congestion, energy consumption and pollution could be reduced by using advanced technology, such as implementing intelligent traffic management (possibly overseeing fleets of driverless cars). Large buildings have smaller surface-to-volume ratios, conserving heat, and future technology could exploit temperature differences to generate electricity. A decade ago the construction of buildings accounted for 30-40% of global energy use, however, new construction materials and methods, improved urban practices and integration of smart technologies could significantly reduce this figure.

Health

Life expectancy. Global life expectancy has increased at a rate of more than three years per decade since the 1950s. Life expectancy was 70 in 2015 and is likely to be around 82 by 2050.[13] Recently, however, research has identified ways to significantly extend the lives of simple animals, such as worms. While formidable obstacles remain, it is plausible that by 2050 these techniques could extend human lives by many years, at least for those who can afford it.

Global life expectancy at birth



Source: United Nations, Department of Economic and Social Affairs, Population Division

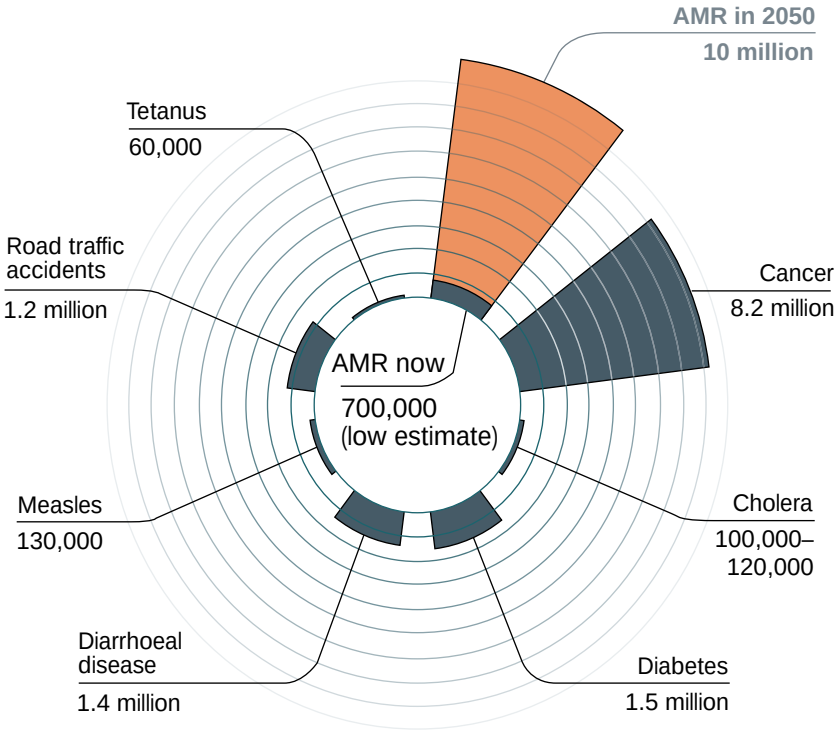
Infectious diseases. Although we are currently better at fighting infectious disease than at any other time in history, the risk of a global pandemic could be increasing. Over the last 100 years there have been at least four global influenza pandemics:[14] Spanish flu in 1918 (50 million deaths); Asian flu in 1957 (two million deaths); Hong Kong flu in 1968 (one million deaths); and the H1N1 pandemic in 2009 (200,000 deaths). High population densities, travel and poverty are thought to have been the primary contributing factors to the spread of these diseases. By 2050, more people will be living in cities and travelling further and more frequently. As the number of animals being farmed rises, the risk of animal diseases mutating to infect people (as happened with bird flu and swine flu) is also likely to increase. Advancements in health surveillance, preparedness and medicine

13 United Nations (UN), (2017), *World Population Prospects: 2017 Revision*, United Nations, page 6.

14 Hsieh, Y. C., *et al.*, Journal of the Formosan Medical Association, Volume 105, (2016), 'Influenza Pandemics, Past, Present and Future'.

could, however, mitigate the risk of pandemics. Growing antimicrobial resistance will exacerbate the threat from infectious diseases. Over time, microorganisms that are exposed to antibiotics can develop a tolerance, meaning that medication stops working. This is exacerbated by the overuse of antibiotics in both people and animals. In 2016, it was estimated that 700,000 people died after being infected by resistant bacteria, so unless mitigation measures are put in place, by 2050 there could be over ten million fatalities annually.[15] Without working antibiotics (or a similarly-functioning alternative), post-surgical infections could make major surgery extremely risky.

Deaths attributable to antimicrobial resistance (AMR) in 2050 could surpass that of other common diseases in 2016



Source: AMR Review

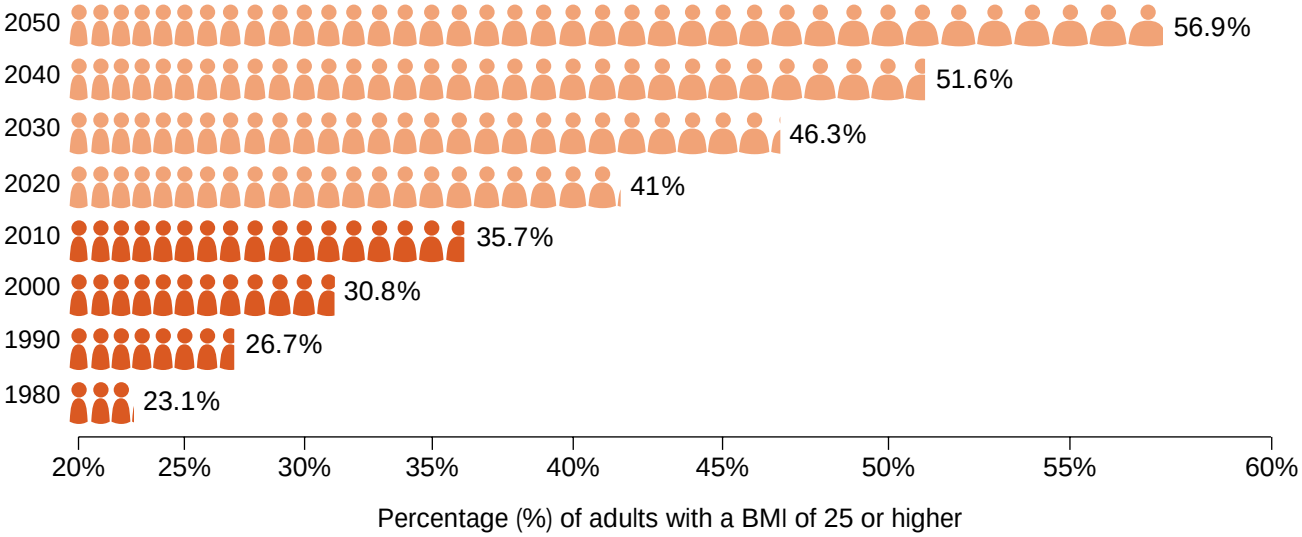
Non-communicable diseases. In 2000, 60% of worldwide deaths were caused by non-communicable diseases such as cancer, diabetes and heart conditions, rising to 69% in 2015.[16] This increase is partially due to reductions in deaths from other causes as treatment for infectious diseases has improved. However, lifestyle factors are also a substantial cause of the rise in deaths from non-communicable diseases, particularly obesity, which could be the world's most pressing health issue by 2050. Between 1975 and 2016, obesity levels almost tripled to around 650 million, with child obesity increasing from 4% in 1975 to 18% in 2016. In Africa, the number of overweight children under five has increased by nearly 50% since 2000, and in Asia, approximately 20 million children under five were overweight or obese in 2016.[17] Rising levels of obesity, along with ageing populations, could lead to recruitment problems for some armed forces. However, better access to health care, changes in lifestyle and advances in medicine may reverse these trends.

15 Marlieke, E. A., *et al.*, (29 November 2016), 'Will 10 Million People Die a Year due to Antimicrobial Resistance by 2050?'.

16 The World Bank, (2016), 'Cause of death, by non-communicable diseases'.

17 World Health Organization (WHO), (16 February 2018), 'Obesity and Overweight'.

Adults with a body mass index (BMI) of 25 or higher



Source: World Health Organization

Nutrition. Malnutrition is a multifaceted condition affecting 50% of the global population. Some malnourished people have a comparatively high-calorie diet with low nutritional value, whilst others still struggle to get enough to eat. There has recently been an increase in the number of people who are chronically undernourished, up from 777 million in 2015 to 815 million in 2016.[18] It is unclear whether this is a short-term, reversible effect or an early sign of a worsening long-term situation. In addition to hunger, around 30% of the world's population suffer from vitamin and mineral deficiencies and this could worsen in the coming decades.[19]

Mental health. Mental health disorders (such as schizophrenia, dementia and depression) were estimated to affect over 700 million people in 2014, and are likely to remain a significant issue.[20] Mental illness and suicide can be closely linked, but numbers of suicides seem to be declining. Between 2000 and 2012, suicides decreased by about 9%, from 883,000 to 804,000 globally. A better understanding of, improvements in, and greater spending on mental health care are likely to lead to a continued reduction in the number of suicides. However, some forms of mental illness, such as anxiety disorders, may increase in the coming decades. This is partly because of the harassment, scrutiny and bullying resulting from greater use of social media, and as more of our social lives are lived online, real-life interactions may dwindle, increasing loneliness.

> Spending on 'digital health care' grew twelvefold between 2009 and 2016.

Digital medicine. The use of technology in health care is likely to accelerate. Spending on 'digital health care' grew twelvefold between 2009 and 2016 (from US $500 million to US $6 billion).[21] Increasing computing power and bigger data sets are allowing more accurate diagnoses of disease to be made, for example, scanning chest x-rays for signs of cancer or drawing on a range of data to identify patterns that indicate a propensity

18 UN Food and Agriculture Organization (FAO), *et al.,* (2017), *The state of food security and nutrition in the world: Building resilience for peace and food security.*

19 Tulchinsky, T. H., *Public Health Reviews*, Volume 32, (2010), 'Micronutrient deficiency conditions: global health issues', pages 243-255.

20 Mnookin, S., World Bank Group and WHO, (2016), *Out of the Shadows: Making Mental Health a Global Development Priority.*

21 CB Insights, (1 March 2017), 'Digital Health Funding Sees Record year 2016'.

Advances in sensor technology may allow earlier and more accurate diagnosis

for diabetes. Advances in sensor technology are likely to further improve our capacity to diagnose disease accurately and early. Present-day examples of health care sensors include the automated monitoring of physical activity and blood pressure.

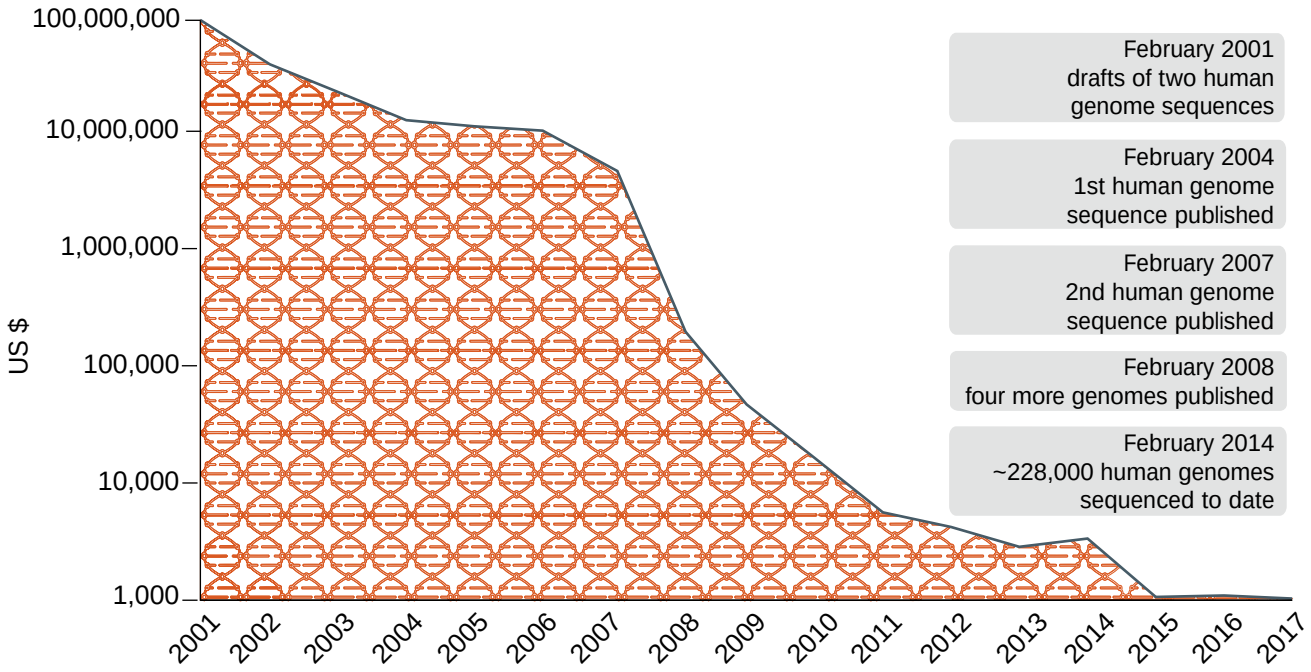
Regenerative medicine. Regenerative medicine is an umbrella term for restoring damaged tissues and organs by using advances in a range of medical sub-disciplines, including stem cell biology, biomaterials and genetics.[22] Regenerative medicine is already helping growing numbers of people, as seen in the use of stem cells to treat diseased bone marrow. Between 2006 and 2016, the number of patients receiving this treatment increased by over 46%. Regenerative medicine has the potential to help cure problems such as spinal injuries and heart defects, and may eliminate the need for organ donation.

Personalised medicine. In 2001, the cost of sequencing a human genome was around US $100 million, falling to just over US $1,000 by 2017.[23] As technology improves, this figure is likely to reduce dramatically. Being able to 'read' a patient's DNA (deoxyribonucleic acid) is, however, only a first step. Designing or identifying an effective treatment for that patient (or group of patients) is the next essential step, and the number of drugs designed in this way increased from five in 2008 to 132 in 2016 with oncology seeing the greatest benefit. As medical databases grow, the computers and algorithms that search those databases improve, and advances take place. Health care is, therefore, likely to become much more personalised and effective.

22 Huimin, X., *et al.,* nature.com, (19 June 2018), 'Tissue and regeneration with endogenous stem cells'.

23 Keshavan, M., STAT, (9 January 2017), 'Illumina says it can deliver a $100 genome – soon'.

Declining cost of DNA sequencing per genome



Source: National Human Genome Research Institute

> Gene editing can precisely, reliably and efficiently make changes to targeted DNA.

Gene therapy. A new technique known as gene therapy has recently been used to modify or replace genes that cause illnesses, and has significant potential to eradicate some currently incurable conditions. For example, in 2015, a boy with a rare genetic skin condition was successfully treated using a combination of stem cell techniques and gene therapy.[24] Between 1989 and 2017 the number of approved gene therapy trials increased from one to over 132. Recently, a new method of gene therapy, called 'gene editing', has been developed: the CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) and Cas9 (CRISPR associated protein 9) enzyme process. Gene editing can precisely, reliably and efficiently make changes to targeted DNA. The technique is expected to lead to the development of treatments for a wide range of conditions ranging from congenital blindness to cancer. Gene editing has also been used to create the first stable semi-synthetic single cell organism.[25] Gene editing could lead to signi□cant improvements in medicine, but also enable rogue actors to develop deadly biological weapons.[26] In addition, the technique may, in future, allow DNA to be modi□ed so that selected traits can be enhanced, potentially giving people extraordinary abilities.

Prosthetics. The use of 3D printing is already allowing prostheses to be individually tailored, including printed skin for burn victims, dental crowns and components for facial reconstruction. New types of composite materials are likely to be developed that will be stronger, lighter and more durable. Carbon-fibre sport prosthetics have already allowed disabled athletes to compete with, and in some cases outperform, able-bodied athletes.[27] Robotic limbs are used today, although they are at the early stages of

24 Hesman Saey, T. H., Science News, (8 November 2017), 'Scientists replaced 80 percent of a 'butterfly' boy's skin'.

25 Scrips Research Institute, (23 January 2017), 'First stable semisynthetic organism created'.

26 Regalado, A., MIT Technology Review, (9 February 2016), 'Top U.S. Intelligence Official Calls Gene Editing a WMD Threat'.

27 Greenemeier, L., Scientific America, (5 August 2016), 'Blade Runners: Do High-Tech Prostheses Give Runners an Unfair advantage?'.

development, are expensive and have significant limitations, but by 2050 they could be stronger, faster and more dextrous than the limb they replace. Similarly, exoskeletons could be routinely used by both the able-bodied and disabled to enhance performance, including in extreme environments.

Neurotechnology. Brain-to-machine and brain-to-computer interfaces have seen significant advances in recent decades. The first human neural prosthetic was used in the mid-1990s, and there are now 450,000 implanted hearing aids worldwide, as well as implants that treat Parkinson's disease. Brain-to-machine interfaces are already used to control robotic limbs, and improvements in this technology should lead to an increasing array of operable devices. In the nearer term, neural prosthetics could help with conditions including chronic pain and spinal injuries and by 2050, this could include interface-controlled technology such as cars and phones.[28] Although the technical barriers are formidable, by 2050, brain-to-computer interfaces may allow people to augment their mental abilities with automatic access to the memory and processing power of computers. This could include remotely operated military vehicles.

flickr_by_Mario_Sixtus-F

Neil Harbisson is the first legally recognised cyborg

Education and employment

Enrolment. The proportion of children being formally educated is likely to increase, with levels of primary school enrolment approaching 95% and secondary school education 89%. As more people in a society are educated, economic performance and quality of life improves. However, countries experiencing poverty, conflict, humanitarian emergencies and rapid population growth (particularly in sub-Saharan Africa) may struggle to achieve 100% enrolment in the next 30 years. Nevertheless, by 2050, only five countries (Burkina Faso, Ethiopia, Guinea, Mali and Niger) are likely to have more than 20% of children out of school.[29] Although improving, the education of girls, particularly in sub-Saharan Africa and South Asia, is still likely to lag behind that of boys.

Standards and access. Despite growing rates of enrolment, the quality of education around the world is often poor. The number of children attending school in Latin America has doubled, but the quality of education has not kept up. In the 2015 Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA), an assessment of 72 nations in reading and science, Latin America and the Caribbean nations ranked the lowest in quality.[30] However, advancements in technology could lead to a revolution in education, driving global improvements. By 2050, virtually anyone (including those living in poor and remote regions) is likely to be able to cheaply and easily access online education. Technology will probably also raise the quality of education, for example, a system called ALEKS uses artificial intelligence to determine the student's knowledge of a topic, then targets learning to address the gaps. In India, a system called Mindspark has already led to substantial gains in mathematics and reading.[31] Turning learning into a game or simulation (such as Minecraft: Education Edition) is likely to become more widespread, with better engagement likely to raise standards.

28 Varrasi, J., ASME, (January 2014), *The Next Generation in Heural Prosthetics*.

29 The World Bank, (2 October 2017), 'Data Education Statistics'.

30 Bobak, A., School of International Futures, (2017), *The Future of Latin America and the Caribbean out to 2050,* a research paper commissioned by DCDC.

31 *The Economist*, (22 July 2017), 'Together, technology and teachers can revamp schools: How the science of learning can get the best out of edtech'.

Despite online learning, traditional schools will endure

izusek / iStock.com

Literacy rates. Globally, literacy rates for those 15 and over are continuing to improve, from 81% in 2000 to 86% by 2016.[32] By 2050, they are likely to be around 95%, but some regions (particularly sub-Saharan Africa) could still have significant numbers of people who are illiterate. Developments in technology, such as voice recognition technology, however, may reduce the impact of being illiterate.

Schools. Although technology may mean that high-quality education can be delivered online, traditional schools and universities will endure. As well as providing education, schools play an important role in developing social skills, providing childcare, fostering social cohesion and allowing governments to impart shared values. Teaching children the skills to differentiate between true and false information could also make societies more resilient to manipulation. Universities not only impart information, but also provide a 'rite of passage' offering rich personal and social experiences, features that are likely to remain attractive (for those who can afford them). Nevertheless, the link between a traditional degree and securing a higher-paying job is likely to further weaken, and alternative models of higher education will evolve.

Through-life learning. The linear path from education and training, to work and then retirement looks unlikely to endure.[33] Increased life expectancy and higher state pension ages mean that people are likely to work for longer and will need to more frequently update their knowledge and abilities. Partnerships between universities and industry can be expected to strengthen in the coming decades, as businesses encourage, and even require, their staff to continuously improve their skills. Some governments are also likely to support individuals who wish to re-train, for example, the Government of Singapore provides vouchers for students to spend on any of 500 approved courses. Businesses, particularly large organisations (including militaries) will need to invest in through-life training and education if their employees are to remain competitive.

Recruitment. Businesses will probably rely less on academic attainment to select employees, with aptitude tests and simulations likely to be more important than formal qualifications. For example, in 2013, a leading financial services firm in the UK abandoned

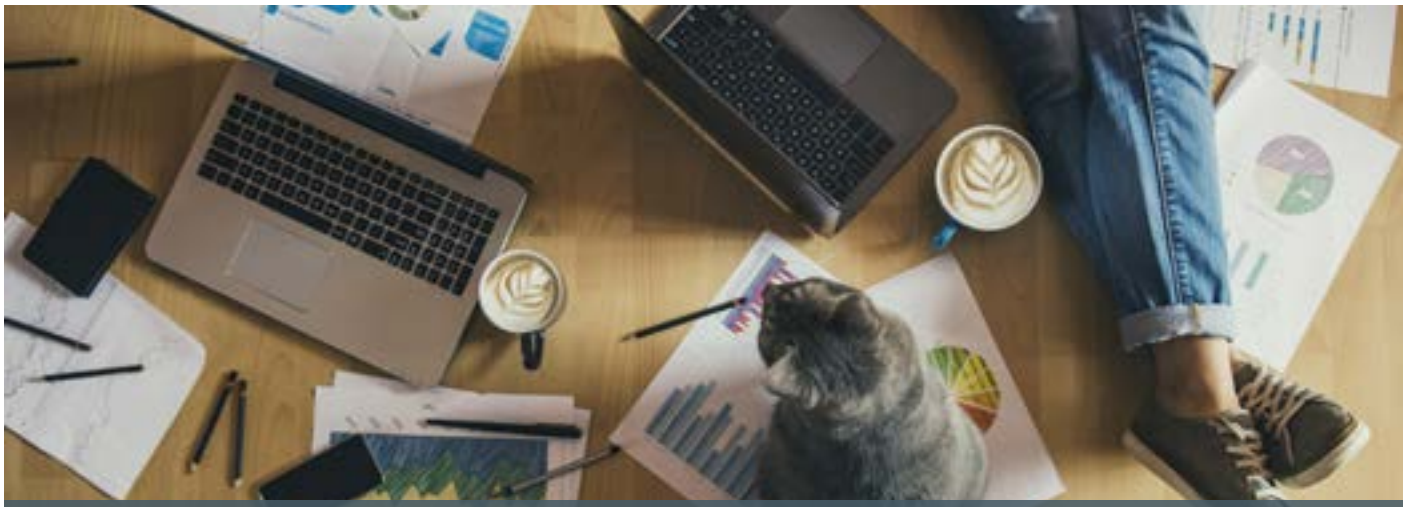
32 The World Bank, *Data Education Statistics*.

33 Daheim, C., *et al., (2017), The Future of Work: A Meta-Analysis on Disruptive Perspectives*, a research paper commissioned by DCDC.

academic qualifications as a recruiting metric.[34] Formal education may, therefore, become less important, but increasing automation in the workplace is likely to make high skill-levels even more critical, as people strive to compete in the future job market.

Flexibility. Advances in technology have allowed many people to work remotely, reducing the need for office space and travel. Although technology and a less-rigid working structure means people can balance their employment and other commitments (such as childcare) more effectively, it also means that they can be continuously connected to the demands of work, potentially increasing stress levels and adversely affecting health.[35] Further technological developments are likely to make working remotely, at any time, even easier. Many employees are also becoming more independent and autonomous, being assessed on their outputs rather than on time spent at work. The number of people working as freelancers, independent contractors and temporary staff (known as the 'gig economy') looks likely to increase. Freelance work is, however, often low-paid, lacking the benefits and security of formal employment and, therefore, the growth of the gig economy could increase inequality.

Diversity. The number and proportion of women in paid work is likely to continue to increase. In OECD countries, the percentage of working-age women in paid employment increased from 37% in 1971 to 63% by 2013 (although this is still 17% lower than men).[36] Whilst global figures are likely to lag behind those of the OECD, in the next 30 years job opportunities for women are expected to improve markedly across the world. Women are, however, more likely than men to be employed in low-wage, part-time and temporary work. This suggests that, despite improving employment prospects, women are likely to remain economically disadvantaged in the coming decades. As well as including more women, the workforce of 2050 will almost certainly be older and include workers on a variety of employment terms. The shift towards more diversity and inclusion is expected to accelerate and broaden to include more people with physical impairments or cognitive differences such as autism.[37] Future employers, including militaries, will therefore need to adopt more inclusive styles of leadership and management and adapt organisational structures and working practices.



Technology developments will make remote working, at any time, even easier

34 Hellen, N. and Griffiths, S., *Sunday Times*, (5 March 2017), '*We can work it out: exam 'failures' beat graduates at top firm'*.

35 Eurofound and International Labour Organization, (2017), *Working anytime, anywhere: The effects on the world of work*.

36 Organisation for Economic Co-operation and Development (OECD), (2016), *Trends shaping Education 2016*.

37 Deloitte University Press, (2017), *Rewriting the rules for the digital age: 2017 Deloitte Global Human Capital Trends,* page 118.

Virtual and augmented reality will become much more widely used

Communication

Communication technology. Communication technology has become increasingly portable, accessible and high speed, perhaps most clearly seen in the changes to mobile phones. Today's mobile phone has multiple sensors and functions. Future mobile devices are likely to be much more capable, and by 2050 the vast majority of the world's population will routinely use digital devices to communicate. Between 2010 and 2017, the number of social media users more than doubled,[38] and there are likely to be further substantial rises in the coming decades. Greater public demand, declining costs and improving utility will mean that digital communications networks will continue to increase in importance. The comparatively simple voice and text messages of today are likely to be replaced by more complex constructs, potentially using virtual and augmented reality.[39] As digital communication becomes more dominant, those not connected are likely to be increasingly isolated and disadvantaged, which is reflected in the United Nations' (UN's) declaration that access to the Internet is a fundamental human right.

Volume of information. The volume of data per consumer is currently growing exponentially. While in 1986 the daily amount of information available to one person (from all media sources) equalled 40 newspapers with 85 pages, today's consumer receives information equating to 174 newspapers (the equivalent to 34 gigabytes of data). It is likely that this upward trend will continue, and possibly increase. The human ability to process information remains limited, with the conscious mind only able to process approximately 50 bits (units of information) of factual information per second, a small fraction of the overall volume of information received daily.[40] As a consequence,

38 Statista, (2018), 'Number of social network users worldwide from 2010 to 2021 (in billions)'.

39 Marr, B., Forbes, (31 July 2017), 'The Amazing Ways Companies Use Virtual Reality for Business Success'.

40 BK101, 'Human Brain – Neuroscience – Cognitive Science'.

people will increasingly be required to manage, filter and select from this huge and increasing volume of information, running the risk of selection bias. Even with extremely well-developed techniques to handle the constant stream of information, the volume of information will still exceed our capacity to process it, potentially impacting on physical and mental health. This growing information overload could place excessive demands on the individual, hindering concentration and the development of critical thinking skills.[41]

Echo chamber. As individuals become exposed to ever greater volumes of information, they are more likely to focus on sources that reflect their existing preferences and prejudices. This can create an 'echo chamber' effect (where people only see and hear the views of those with similar opinions, leading to positions being reinforced and hardened), which can make people more susceptible to manipulation. As technology improves, it is likely to become easier to filter information so that people are further screened from facts and opinions they dislike or disagree with. This could lead to social fragmentation and a weakening of community values.[42] As the volume of information increases and people get more of their information from social media (as well as advances in mixed reality technology), it may become harder to tell what stories are real, potentially making people easier to manipulate. The relatively light regulation of the Internet in the West may mean it is especially vulnerable to external manipulation.

Virtual and augmented reality. As technology improves and costs fall, video and livestreaming are likely to take over from text and static images as the dominant form of electronic communication. The influence of radio, television and cinema, however, is likely to reduce, as increasing numbers of people directly disseminate their content to a wide audience.[43] As information technology further develops, augmented reality (where one's physical view of the world has virtual data superimposed upon it) is likely to become mainstream. For example, information could be provided by wearable smart-glasses or contact lenses to help people navigate and locate services, similar to the way smartphones are used today. Mixed reality (where virtual objects are presented as though they were real) may also become so advanced that it will become increasingly difficult to easily determine what is real. Virtual and augmented reality will become much more widely used, with some experts predicting an annual growth rate of 82% over the next few years.[44]

> "Mixed reality may also become so advanced that it will become increasingly difficult to easily determine what is real."

Language. The number of languages is likely to decline, 25% are currently spoken by fewer than 1,000 people, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) has identified 2,500 languages at risk of extinction. By contrast, speakers of the world's dominant languages are likely to increase. In 2017, 1,284 million people spoke a version of Chinese as a first language; 437 million spoke Spanish; 372 million spoke English; and 295 million spoke Arabic. The global reach of the Internet and social media are likely to reinforce the dominance of the most commonly-used languages, and English is expected to remain highly influential.[45] English is also the most commonly studied foreign language in the world, although Chinese, Hindi and Urdu are likely to take on increasing importance. Amid rising migration and international communication, languages will evolve, including incorporating foreign words, for example, 'Konglish' is a variety of English that has evolved amongst South Koreans. An increasing number of countries are, however, using legislation to protect national languages and dialects.[46]

41 Tech 21 Century, 'The human brain is loaded daily with 34 GB of information'.
42 Lance Bennet, W., (2016), *News: The Politics Of Illusion.*
43 Wenger, J., (2017), *The Future of Art, Expression and Design*, a research paper commissioned by DCDC.
44 Cisco, (2017), 'Cisco Visual Networking Index: Forecast and Methodology 2016-2121'.
45 Kaufman, S., The Linguist, (13 October 2015), 'English Will Remain The International Language'.
46 Baratta, A., (2017), *Putting an Accent on the Future*, a research paper commissioned by DCDC.

The young appear to be adopting liberal values more readily than the old

Culture, belief and identity

Liberal and traditional values. The increasing ease, and reducing cost, with which ideas and information can be spread globally, particularly due to the widespread use of the Internet, combined with increasing travel by unprecedented numbers of people have had significant effects on culture. Groups of people separated around the globe can now choose to exchange ideas, read the same books, watch the same films and eat virtually identical food. Whilst this has led to an increasing number of people across the world with shared values, it does not appear to be leading to a universal convergence of culture. Instead, while some societies are adopting more liberal attitudes, others are seeing their traditional, more conservative values reinforced.

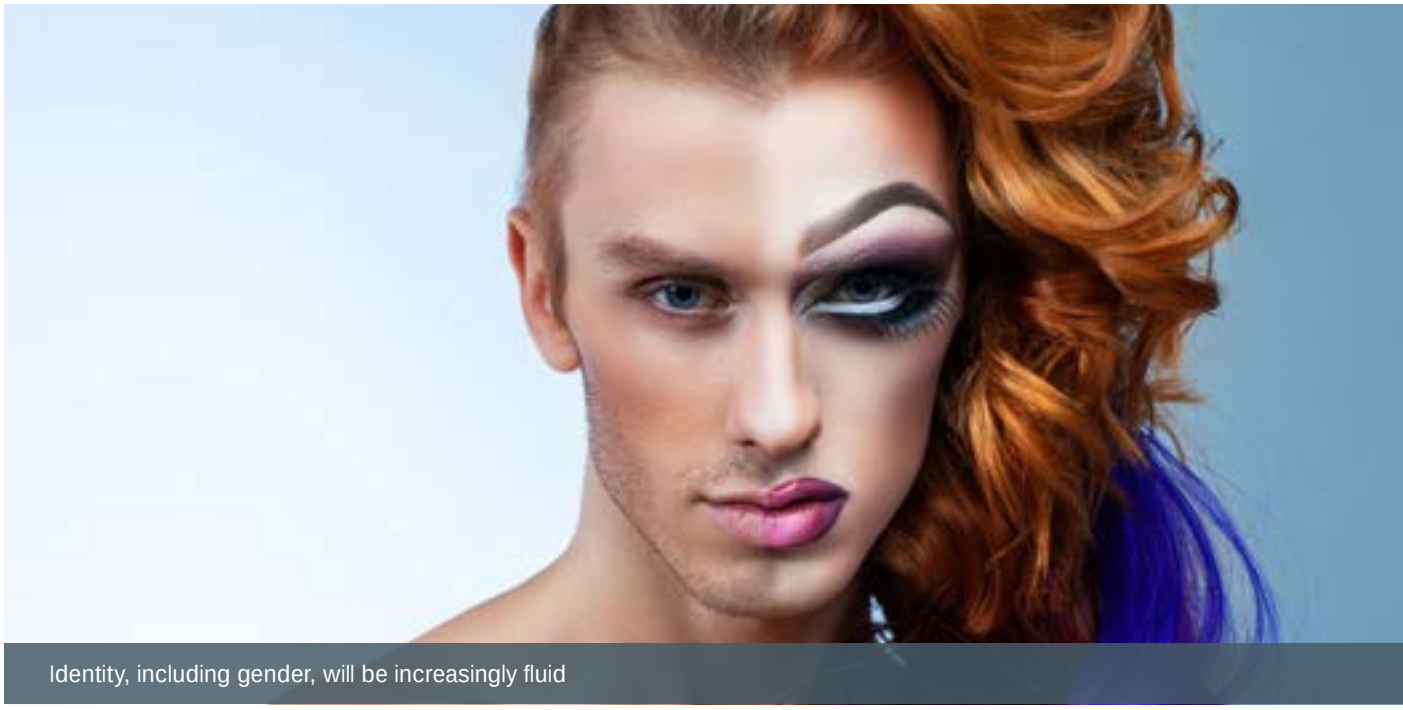
As societies become more prosperous, wealthier and more educated, they tend to be more liberal and accepting of difference (for example, being more welcoming to foreigners or removing legislation criminalising homosexuality).[47] These trends are not universal. Some Middle Eastern countries, for example, continue to embrace more traditional values despite increasing prosperity. Regardless of societal wealth, however, the young appear to be adopting liberal values more readily than the old. Rising prosperity is also linked to growing 'individualism' (personal empowerment through access to information, participation, accountability and economic development), including in India and China, suggesting that, over time, most societies will probably become more liberal.

47 Chatterje-Doody, P., (2017), *Self-identification in a global age: influences on the development of cultural identity*, a research paper commissioned by DCDC, page 5.

Intra-societal differences. Whilst there have always been differences between the wealthier, better educated and the less privileged, these differences appear likely to widen in the coming decades, at least in the West. Mobility is often crucial. Those who are willing (and able) to move in the pursuit of better education or employment often become richer, more liberal and more accustomed to mixing with those from different cultural backgrounds. Those unwilling (or unable) to move are often less well educated, poorer and more likely to have their existing traditional values and beliefs reinforced. This appears to be leading to a growing division within many countries that could result in a backlash by the less liberal who perceive they are being disadvantaged. Digital communication platforms and social media could also exacerbate divisions within societies because of the echo-chamber effect. The increase in the number of people living in gated communities might also lead to further polarisation. The effects of automation could lead to widespread job losses, lower pay and inequality, driving further discontent and division between the wealthy and the disadvantaged[48] and this could result in violent protest.

Internationally, cultural differences will continue to affect attitudes and beliefs. The Chinese, for example, think and look at society differently to the West. Whilst the West focuses more on the rights of the individual, the Chinese have traditionally prioritised those of the collective. As global economic power shifts to the East this difference in outlook may lead to a clash between Western and Eastern perspectives and values.

Gender equality. Whilst the idea that there should be equality between the sexes is gaining ground, it is unlikely to be a universally-held view by 2050. In the Middle East and North Africa only one in four men support gender equality, and 70% of Egyptians of both genders believe that a woman should tolerate violence to keep the family together. Nevertheless, women and men are becoming more equal based on the World Economic Forum's four criteria of: health and survival; educational attainment; economic participation and opportunity; and political empowerment. However, the rate of improvement is slow and possibly decreasing, it could take a century to eliminate the gender gap.[49]



Identity, including gender, will be increasingly fluid

48 Goodhart, D., (2017), *The Road to Somewhere: The Populist Revolt and the Future of Politics.*

49 World Economic Forum (WEF), (2016), *The Global Gender Gap Report 2016*, page 7.

More people are likely to identify as religious: religious parents have more children, children usually retain their parents' religion

> Total surveillance by some governments might stifle difference and lead to widespread conformity.

Internet identity. Most of the world's population already has access to the Internet (to some extent) and by 2050 access is likely to be almost universal. As people spend more time online, their identity will increasingly be defined by their digital presence, such as their involvement with networks, projects and communities of interest.[50] **In the coming decades, every facet of one's life is likely to be recorded by the ubiquitous presence of wearable devices, smart sensors and the Internet of things. Left unchecked, this could mean unparalleled levels of surveillance and the end of privacy.** People would know that everything they do can be viewed and judged. What sort of society this may lead to is unclear. Societies might become almost crime free and tolerant, or oppressed and fearful. Total surveillance by some governments might stifle difference and lead to widespread conformity,[51] reinforcing and strengthening existing cultural values. The Chinese social credit system, (a system that uses government data to score citizens' economic and social status and trustworthiness, with a low score attracting various penalties, for example, being prevented from obtaining a credit card or travelling abroad) although still in its early stages of development, may be a forerunner of such a society.

Gender identity. Some non-Western cultures have traditionally viewed gender as a more complex concept than a binary choice between male and female, and this more ambiguous approach is likely to be increasingly accepted, especially in Western cultures. Behaviours, roles and aspects of appearance are less likely to be seen as either 'masculine' or 'feminine'. In the US, the number of people identifying as transgender grew between 2007 and 2015,[52] and this is likely to increase due to greater awareness, social acceptance and legislative change. While in many ways a positive development, this could pose complex challenges, for example, deciding who is entitled to use women's prisons or refuges.

National identity. As people travel more and form relationships with those from other countries, including through online communities, nationality is likely to become less important to our sense of identity. People may begin to identify more strongly with those in other parts of the world due to shared values and beliefs. Those who live in

50 Verdon, J., (2017), *The Emerging Constraints of the Digital Environment and the Future of Identity*, a research paper commissioned by DCDC, page 5.

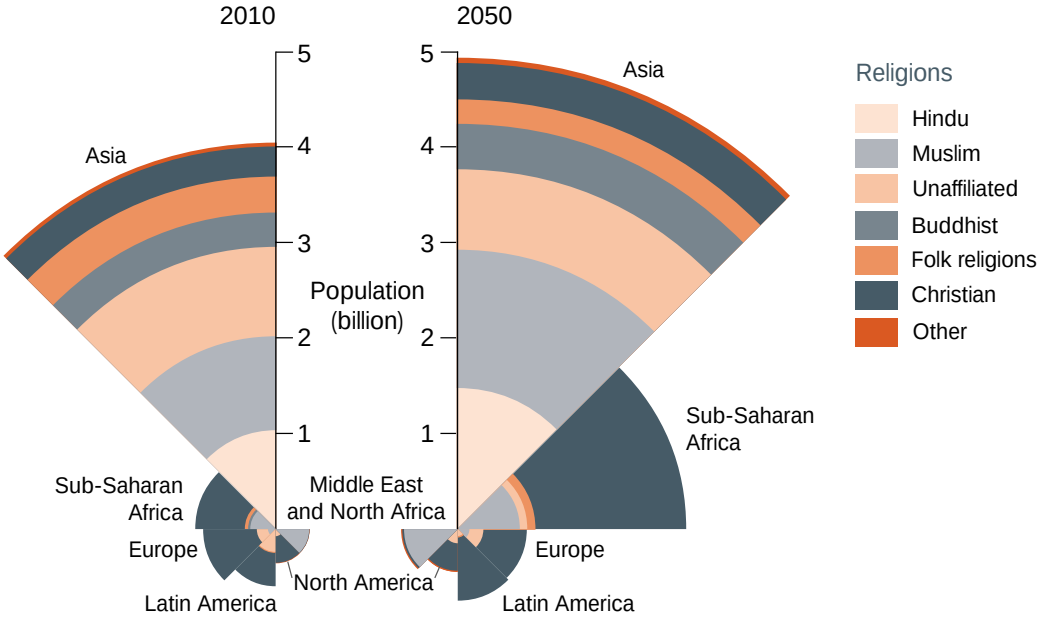
51 Watson, R., (2016), *Digital vs Human: how we'll live, love, and think in the future*, page 24.

52 Meerwijk, E. and Sevelius, J. M., PMC, (2017), *Transgender Population Size in the United States: a Meta-Regression of Population-Based Probability Samples*.

cities (characterised by ethnic and cultural mixing) are particularly likely to become less nationalistic.[53] Nevertheless, national identity will almost certainly remain a potent force in the coming decades, especially for many of those who are poor, less well educated and living in small towns and rural areas. National identity will continue to be used by political leaders to galvanise their populations, including to divert attention away from a government's failings.

Religion. More people are likely to identify as religious, due to demographics:[54] most of the world's population are religious; children usually retain the religion of their parents; and religious parents tend to have more children. As societies get richer, however, they typically become more liberal and the social pressure to retain one's parental religion diminishes. This could mean that the proportion of people who are not religious increases. Globally, there is a decline in the time devoted to formal religious activity.[55] Therefore, whilst the number of people who are religious is likely to increase, many will commit less time and may become less devout. Hence, the importance of religion to identity and communities may reduce. Increasing numbers of people (particularly the young) are, however, looking for spiritual inspiration on the Internet, making them prone to radicalisation by unscrupulous actors. The tendency of younger people to seek spiritual information and guidance online may further undermine ties to institutional religion. Such Internet-based engagement may not be mediated by contact with an established member of a religious organisation, increasing the likelihood of changes in the form, practice and content of religion.

Global religious adherence



Note: Evolution of global religious adherence with forecasted increase in global population.

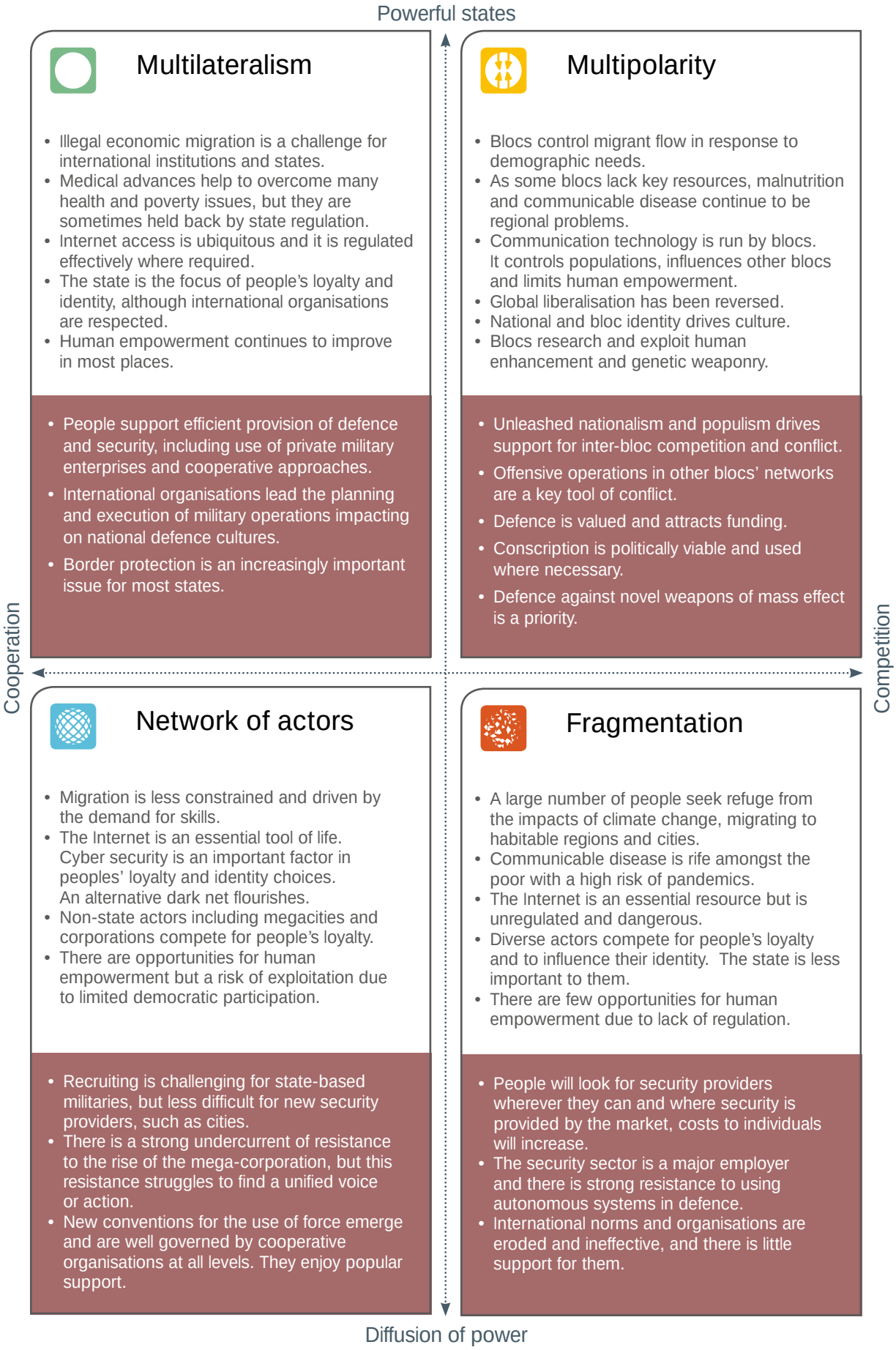
Source: Pew Research Center

53 Chatterje-Doody, P., (2017), *Self-identification in a global age: influences on the development of cultural identity*, a research paper commissioned by DCDC, page 2.

54 Pew Research Center, (2015), 'The Future of World Religions: Population Growth Projections, 2010-2050'.

55 Hart Group Oxford XXI, (2018), *GST – Future of Beliefs: Final report,* a research paper commissioned by DCDC, page 21.

Future worlds: Human development



Watch points

- Changes in the scale, drivers and patterns of migration.
- An increasing divide of wealth and outlook between urban and rural populations.
- Cities start to behave more like states.
- (Enhanced) life expectancy is perceived as a 'human right'.
- Development, regulation and use of human augmentation.
- Increasing adoption of Internet-based education spreading new values.
- Increasing numbers of people forming non-traditional allegiances as an alternative to national identity.

Discontinuities

- A medical advance that significantly increases life expectancy.
- The emergence of a pandemic that causes widespread loss of life.
- Creeping crises, such as obesity, mental health, antimicrobial resistance, are not tackled.
- The Internet becomes too 'unsafe' to use.
- Emergence of a new communication tool which enables the creation of defensible sovereign cyber territory.
- Major changes to a religious belief system similar to the Christian Reformation.

Implications

- A large proportion of migration is rural to urban leading to increasingly large and dense urban agglomerations. In many cities, the rate of urban growth will outpace the capacity of governments to implement sound urban management practices leading to a failure to provide secure basic human living conditions and sufficient security to avoid instability.
- Cities are likely to increasingly become nodes of global interconnectivity. Integration of cities into the rules-based international system may provide appropriate representation of the cities' population, reducing tensions and enhancing global harmony.
- Management of societal inequalities and expectations resulting from improvements in medical science, may prove a particularly challenging area for the state, especially if these advances are exploited for defence and security purposes.
- Timely investment in understanding the applications and risks for how human enhancement technologies may progress will generate competitive advantage and enable global leadership in the development of governing frameworks.
- There may be a moral or legal imperative to use performance-enhancing technologies to ensure the highest performance on the battlefield and in other 'life and death' professions.
- Technology will change jobs and skills and could even challenge people's sense of human purpose. Education and training will need to change to match these developments.
- An expanded and unregulated information space could make individuals more susceptible to misinformation and/or radicalisation.
- Defence and security exploitation of cyberspace and autonomy will be influenced by, and have an influence on, societal approaches to these technologies.
- Governments should prepare to function in a world where states, organisations and individuals hold diametrically opposing values and attitudes. Some may increase nationalist sentiment, while others become increasingly liberal, looking beyond borders to form communities with people of similar values. It may be increasingly difficult to predict how democratic influences will affect the actions of traditional allies, partners and competitors.
- If properly managed, migration might release pressures from areas with fast growing populations, providing benefits to receiving societies, especially those that are aging. However, if unmanaged or managed badly, integration is likely to fail, causing social unrest, negative sentiments towards migrants and drive fragmentation of the society.

Economy, industry and information

Synopsis

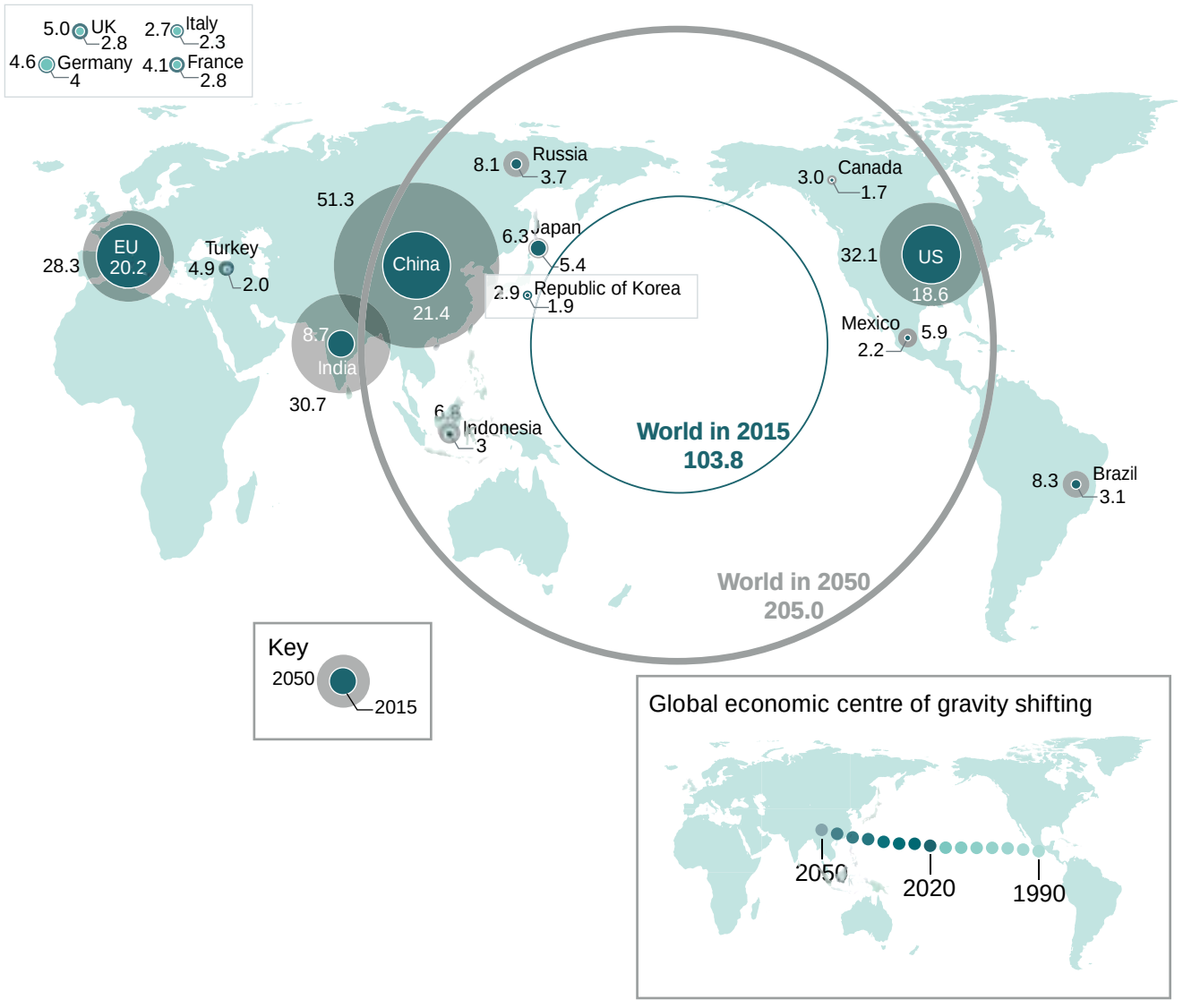
By 2050, the combined size of the Emerging 7 (E7) economies (Brazil, China, India, Indonesia, Mexico, Russia and Turkey) are likely to have surpassed the Group of Seven (G7) (Canada, France, Germany, Italy, Japan, the United Kingdom (UK) and the United States (US)). As the centre of economic power shifts eastward, Asia will become an increasingly important centre for not just commerce and finance but also accountancy, insurance and commercial law. Such a shift will reduce the economic and soft power of the West. The capacity of international trade and financial institutions to accommodate this transition will be vital in ensuring that international markets are effective and competing trade blocs are avoided. Digital trade will grow and could become the dominant form of trade by 2050. The economies in most developing countries are likely to grow significantly and workers' wages are likely to rise, although inequality could also increase. In developed countries, however, growth may remain low leading to low wages, resentment, social division and possibly internal conflict. Low growth will also restrict governments' spending, including on welfare, which is likely to exacerbate inequality. The rising costs of new military equipment could become unaffordable, hence military interventions could become prohibitively expensive for developed countries. The high levels of debt in many developed economies, combined in many cases with a financial sector substantially bigger than national gross domestic product (GDP), could make them particularly vulnerable to future financial crises.

Improvements in sensors, data analysis/decision-making and actuation (mechanical motion) will drive the automation of industry. Sensors will allow every facet of a factory's operation to be monitored and controlled, allowing products to be produced precisely in optimum conditions. This could reduce cost and pollution, and improve performance. Motors are becoming smaller, more powerful and more efficient, with controls so precise that machines can conduct microsurgery. The use of technologies such as computer-aided design and 3D printing will significantly reduce the time needed to develop new products and allow them to be tailored to individual customers. Transport will become cheaper, faster and possibly cleaner as electric vehicles become more commonplace and fuel efficiency improves. By 2050, virtually everyone is likely to have access to the Internet, mobile devices and virtually limitless information. The volume of data and processing power will grow exponentially and quantum computing could be realised. These improvements will accelerate artificial intelligence development, which will be used to solve increasingly complex problems, leading to improved productivity and generating substantial economic growth, although its effect on jobs could be highly disruptive.

Economy and finance

Changing economic balance. By 2050, the world economy is likely to have doubled, although the rate of growth will probably have slowed. The seven largest emerging economies, the E7 (Brazil, China, India, Indonesia, Mexico, Russia and Turkey) are likely to have increased their share of the global economy from around 35% to almost 50% by 2050, surpassing the G7 (Canada, France, Germany, Italy, Japan, the UK and the US).[1] China's GDP (at market value) could overtake that of the US by 2020, and by 2050 it is likely to be around 40% larger, accounting for 20% of global GDP. India's economy is also expected to grow substantially in the coming decades, with some estimating that by 2050 its GDP (at market value) will be about 85% the size of that of the US.[2]

Gross domestic product (adjusted for purchasing power parity) expressed in US $ trillion at 2016 values



Source: DCDC internal analysis based on PwC, Goldmansachs; OECD and Centre d'Etudes Prospectives d'Informations Internationales

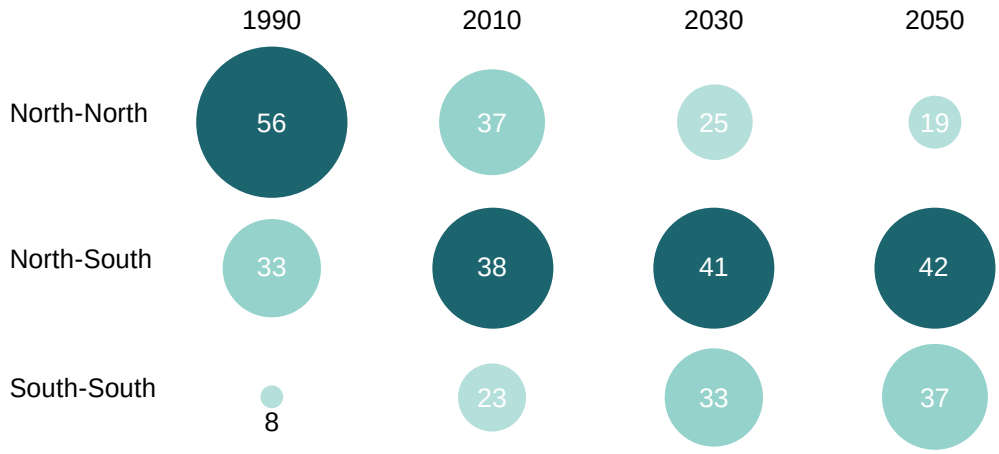
1 PwC, (February 2017), *The Long View – How will the global economic order change by 2050?*

2 Organisation for Economic Co-operation and Development (OECD) Data, OECD, (2017), 'Real GDP Forecast'.

Europe's share of the global economy is likely to decline in the next 30 years, with the European Union 27 countries (EU27 – although there are currently 28 EU members, EU27 refers to the 2018 membership minus the UK following Brexit) expected to have a combined share of around 10% of world GDP by 2050, less than India's share. If Asia achieves the economic, industrial and commercial dominance that is forecast, it could also become the centre of political and military power.

As increasing numbers of people (particularly in Asia) escape poverty and become consumers, the global economic centre of gravity is likely to continue to shift eastwards with Bangladesh, India and Vietnam likely to be the fastest growing economies. The share of trade between developing economies (known as South-South trade) is also expected to increase. Demands for a greater variety of products, improved communications and better customs arrangements have seen increases in trade between and within Africa, Asia, the Middle East and South America that can be expected to endure. Although the value of trade between developed economies will probably continue to grow, their share of world trade is likely to decline from approximately 30% today to around 20% by 2050. A similar pattern is occurring in intra-regional trade, where the Asia-Pacific's proportion is expected to grow from 17% today to around 27% by 2050, while Europe's and North America's share is expected to reduce from around 23% to 14%.

Global percentage (%) share of intra-regional trade



Source: Trade Winds, *Shaping the future of international business*

Governance of trade. Between 1990 and 2016, the number of trade agreements rose tenfold.[3] If this trend continues, it will lead to an increase in international trade, although protectionist policies could also prevail. Trade agreements give access to new markets and provide regulation through measures such as technical standards, labelling and packaging requirements. While protectionists may seek to define new standards to limit imports, emerging economies are increasingly likely to meet the standards set in trade agreements. This will probably lead to higher levels of international trade and may contribute to greater compliance with safety and environmental regulations. Many of the consumer and industrial products of 2050 are likely to depend on the ability to exchange information without restrictions.[4] The desire of many governments to protect data and prevent cyber fraud could also lead to new standards, trade agreements and, possibly,

3 Dubai Multi Commodities Centre (DMCC), *The Future of Trade*, pages 7-8.

4 Khanna, P., (2016), *Connectography – Mapping the Global Network Revolution*, pages 32-33.

Automated markets may be more efficient but they risk algorithm-driven flash crashes

new institutions. Technological advances should also make global value (or supply) chains more effective, allowing processes to be carried out in the most cost-efficient locations in the world.[5] These developments are likely to increase connectivity, further driving globalisation. Without agreed rules and effective institutions, however, trade disputes and protectionism will increase, possibly leading to the formation of competing trading blocs.

Intercity trade. Cities are likely to play an increasingly prominent role in world trade over the next 30 years. In 2014, the world's 20 largest cities were home to 75% of the largest global companies. As cities grow wealthier and job opportunities improve, attracting young workers and entrepreneurs, universities and colleges are likely to secure more funding. In turn, this will attract students, some of whom are likely to stay and set up their own companies, creating a virtuous circle. Consequently, today's leading cities look likely to strengthen their position in the global economy, and could replace states as the most important economic entities.[6] In the coming decades, many of the wealthiest emerging cities are likely to be in Asia, contributing to the shift of the economic centre of gravity eastwards.

Financial markets. By 2030, the Chinese bond market is expected to have grown more than tenfold, from around US $3 trillion to US $32 trillion, and by 2050, Asia's financial sector is likely to be four times the size of the West's.[7] As the global economic centre of gravity moves towards Asia, a shift in financial markets may follow. Although Western financial centres such as London and New York could remain pivotal (because of their time zones, levels of expertise and, possibly, standards of probity), those in Asia (for example, Beijing, Hong Kong, Jakarta, Mumbai, Shanghai, Singapore and Tokyo) will almost certainly grow in significance over the next 30 years. As well as banking, Asian cities are likely to become increasingly important hubs for accountancy, law and insurance. As Asia becomes an increasingly important centre for □nance, banking, accountancy, law and insurance, the West's importance is likely to reduce, leading to a decline in its soft power.

5 World Trade Organization (WTO), *World Trade Report 2013 – Factors shaping the future of world trade*, page 54.

6 Khanna, P., (2016), *Connectography – Mapping the Global Network Revolution*, page 51.

7 *Financial Times*, (2015), ''Asian century' will dominate financial markets'.

International financial institutions. The World Bank and the International Monetary Fund (often known as the Bretton Woods Institutions) were established at the end of the World War 2 and have since been joined by a variety of international banks including: the African Development Bank; Development Bank of Latin America (CAF); Asian Development Bank; Asian Infrastructure Investment Bank; the European Bank for Reconstruction and Development; and the Inter-American Development Bank. It is widely accepted that international financial institutions, whether global or regional, have played an important role in facilitating worldwide economic development and, as long as they have the capacity to adapt, they are expected to continue to do so.[8] However, the dominance of the World Bank and the International Monetary Fund is likely to decline in the coming decades, with other institutions becoming increasingly significant. For example, by 2050, the Asian Infrastructure Investment Bank could become as powerful as the World Bank, particularly if the potential of the Chinese Belt and Road Initiative (an initiative seeking to expand maritime routes and land infrastructure networks connecting China with Asia, Africa and Europe, boosting trade and economic growth) is realised.

Banking. Despite lessons from the financial crisis of 2008, which identified the risks of having banks that are 'too big to fail', the banking sector is now even more concentrated. For example, in 1990, the five largest banks in the US controlled 9.7% of the industry's assets, but, by 2015, that figure had increased to 45%.[9] As in many industries, a rising number of financial service activities are being automated and conducted online. In the next few years, 30% of jobs in both investment and retail banking are likely to be automated, with significantly more jobs likely to automated by 2050. While automation will probably lead to greater efficiencies, it is also likely to increase the risk of unintended consequences, such as the algorithm-driven 'Flash Crash' of 2010, where the Dow Jones index suffered its largest single-day fall. Malicious manipulation of digital systems is also a threat. By one estimate, the cost of cybercrime quadrupled between 2013 and 2015 and is expected to reach US $2.1 trillion a year by 2019. An alternative estimate is that the cost of cybercrime will increase at the rate 15% per year.[10] As cybercrime grows in sophistication, banks are likely to devote increasing levels of resource to keep their systems and information secure.

"As cybercrime grows in sophistication, banks are likely to devote increasing levels of resource to keep their systems and information secure."

Currencies. The US Dollar is currently the world's principal 'reserve currency' (a currency commonly used in international transactions and investments, and held by banks in substantial quantities). It currently makes up around 64% of global reserves, with the Euro accounting for 20%, Sterling and the Yen making up around 5% each and the Renminbi around 1%. Owning a reserve currency reduces the cost of international transactions, and by 2050 several developing countries (such as India and Brazil) will probably have taken steps to have their currencies adopted as reserve currencies. The dominance of the US Dollar will probably reduce in the coming decades, with China's Renminbi likely to become a more significant reserve currency, although the Renminbi is unlikely to have replaced the US Dollar by 2050. Digital currencies are also likely to increase in number and importance. Without the cost of printing cash, digital currencies are relatively cheap to administer and should, in theory, be impossible to counterfeit or steal, although it is not clear who (if anyone) is liable should their underpinning technology fail.[11]

Governments may adopt and regulate digital currencies

8 García, E., Center for International Relations and Sustainable Development, (2016), 'Regional Multilateral Banks in a New Global Context – The Experience of CAF – Development Bank of Latin America'.

9 Cox, J., CNBC, (15 April 2015), 'Biggest banks now own almost half the industry'.

10 Ponemon Institute, (October 2016), *2016 Cost of Cyber Crime Study & the Risk of Business Innovation.*

11 Leising, M., Bloomberg.com, (13 June 2017), 'The Ether Thief'.

Quantitative easing is likely to be an enduring feature of developed countries' economies

Governments have been wary of digital currencies because widespread use could limit their capacity to enact monetary policy, thwart illegal transactions and collect taxes. In the future, digital currencies could be more regulated and may even be adopted as fiat currencies (a government-backed legal tender). However, the involvement of governments in digital currencies might undermine their appeal for some users, who enjoy their unregulated aspect. States may also dilute the value of digital currencies through measures such as quantitative easing.

Quantitative easing. In modern times, quantitative easing was first used by the Bank of Japan in 2001 to tackle falling growth rates.[12] The process works by buying government debt (for example, bonds or treasury bills) from commercial organisations such as banks or pension fund managers, using electronic money created by central banks. The aim is to boost the economy by encouraging commercial borrowing and consumer spending. Quantitative easing has also helped governments (and other borrowers) by keeping interest rates low, although it has penalised savers. The central banks of most developed countries have few other options for stimulating economic growth because: interest rates are already low (and hence there are limited opportunities for further cuts); most are heavily indebted (so could find it expensive to borrow more); and there are few opportunities to raise taxes without economic damage. In the coming decades, therefore, quantitative easing is likely to be an enduring feature of developed countries' economies and it may be used to fund infrastructure investment projects.

Debt. Debt will be an ongoing (and perhaps increasing) feature of developed economies. Public, private and financial sector gross debt has grown to reach around 385% of GDP for developed economies, far exceeding real economic growth.[13] Such a level of debt is unprecedented in peace time. Most economists agree that there will probably be at least one major financial crisis before 2050, and that governments' attempts to boost growth by more borrowing might further reduce states' financial resilience. The level of debt

12 Cavallo, E., Market Mogul, (22 February 2015), 'A Brief History of Quantitative Easing'.

13 International Center for Monetary and Banking Studies, (2014), Geneva Reports on the World Economy 16, *Deleveraging? What deleveraging?*

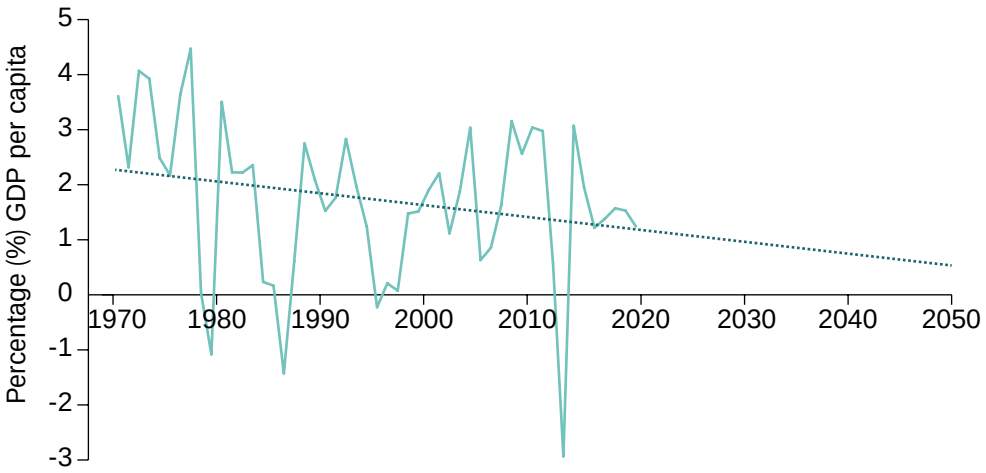
in developing countries, excluding the financial sector (which is generally far larger in developed countries), is around half that of developed countries. Due to low global interest rates and high state borrowing, national decision-makers in developed countries are running out of options for boosting economic growth. Innovation remains one of the few areas that might stimulate growth in the future.

Economic resilience. Several developed countries have financial institutions that collectively own derivatives ('contracts' based upon the value of assets such as stocks or shares) worth more than the nation's GDP. For example, in 2017, the value of EU derivatives was estimated to be €282 trillion,[14] 16 times the EU's GDP. The value of the UK's banking system is estimated to be 4.5 times the size of its GDP and could be 9.5 times the size by 2050. Countries (like the UK) whose financial sector is much bigger than the national economy may be particularly vulnerable to the effects of an economic crisis, and possibly malicious financial manipulation.

> "Several developed countries have financial institutions that collectively own derivatives worth more than the nation's GDP."

Per capita gross domestic product. Globally, per capita GDP is growing and many workers in developing countries have seen their wages increase substantially. The worldwide rate of growth has, however, been declining over the last 50 years (if the field of view is limited to the last 30 years the rate of growth appears to be increasing, reflecting the uncertainty of future growth rates). On current trends, it will have fallen to 0.7% a year by 2050. In the economically developed countries of the Organisation for Economic Co-operation and Development (OECD) the decline is even more pronounced (although in the last five years it has started to recover). Falling growth rates may have several drivers, for example, many developed countries have ageing populations and as people grow older, particularly if they retire, they tend to spend less. Developed countries frequently have high levels of both consumer and government debt and money is often spent on servicing those debts rather than on growth-boosting consumption and infrastructure investments. High levels of investment in financial products and property, another feature of developed economies, can reduce economic growth since money is, in effect, being hoarded[15] and since money can be made from buying and selling money (or other financial assets), investment in financial assets has increased, taking money out of the 'real' economy.

World percentage growth rate, gross domestic product (GDP) per capita



Source: World Development Bank

14 European Securities and Markets Authority, (2017), *EU derivatives markets – a first-time overview*.

15 Rognlie, M., Brookings, (Spring 2015), Papers on Economic Activity, *Deciphering the fall and rise in the net capital share: accumulation or scarcity?*, pages 1-69.

The growth dilemma. If the rate of economic growth remains low, or stalls completely, it could pose a strategic risk to governments in developed countries[16] because their citizens expect regular rises in living standards and political legitimacy has partially come to depend on it. **Low economic growth and increasing inequality may lead to resentment, social division and possibly con□ict, although this is not inevitable.** Japan, for example, has sustained low levels of growth but remained stable. Without growth, however, governments (particularly in countries that have ageing populations) are likely to find it increasingly difficult to fund rising welfare costs, service public debt and keep investing in public services, especially those that need to keep pace with rapidly improving technology, for example, defence. Spending on defence is likely to be especially squeezed since the cost of new hi-tech military equipment is frequently much more expensive than the cost of the equipment it is replacing, a phenomena known as 'defence inflation'. **If economic growth remains low, governments will struggle to afford the rising costs of new military equipment and, hence, conventional con□ict could become prohibitively expensive.**

Further challenges. In addition to the challenges already described, there will be others, including novel issues that are difficult to imagine. Innovation could unleash a wave of productivity that might boost national incomes and create jobs. Alternatively, artificial intelligence and automation might boost productivity, and hence economic growth, but without creating jobs. Some skills that have taken years to build (for example, a taxi driver's knowledge of a city) are already being rendered obsolete. Attempts to reduce greenhouse gas emissions will put stresses on the economy. Coal, and in time oil, could be abandoned as sources of energy, upturning industries that have been mainstays of many economies. Technology-driven social change could lead improvements without increasing consumption (and GDP). For example, self-driving vehicles might lower transport costs whilst also reducing the number of cars bought, and services such as Airbnb (which allows people to rent out spare rooms) could reduce the costs of accommodation and the need for hotels and hotel staff.

Industry and work

Automation. A key industrial trend is the increasing automation of industry. Automation is based on three areas of technology: sensors; data analysis/decision-making; and actuation (mechanical motion). Significant advances are expected in all three areas, and many facets of industry are likely to be affected by automation. Sensors have recently become increasingly capable, for example, smartphones can often capture images of a quality that only used to be produced by the most sophisticated and expensive cameras. On current trends, future cameras might be able to provide images at microscopic levels of detail from far away. Already some of today's most powerful satellites can produce images in fine detail.[17] Increases in processing power are allowing information from multiple sensors to be fused together, meaning that images of extraordinary fidelity can be produced. Improvements in pattern recognition and machine learning will allow machines to operate independently in increasingly complex environments. For example, driverless cars could re-route to avoid congestion, and heating systems could automatically adjust to account for changing weather and numbers of occupants. Motors are being developed that are smaller, more powerful and more efficient, with controls that allow for ever more precise and meticulous movements, for example, the robot da Vinci assists surgeons to carry out microsurgery. In future, machines are likely to be able to operate in increasingly hazardous and inaccessible locations. A worm-like machine is currently being developed which can change shape, allowing it to squeeze through small gaps when searching for survivors in collapsed buildings.[18]

"Increases in processing power are allowing information from multiple sensors to be fused together, meaning that images of extraordinary □delity can be produced."

16 Drezner, D., Brookings, (May 2016), Project on International Order and Strategy, *Five Known Unknowns about the Next Generation Global Political Economy*.

17 Bump, P., The Washington Post, (21 April 2017), 'Here's why the resolution of satellite images never seems to improve'.

18 Horchler, A. *et al.*, Biomimetic and Biohybrid Systems, (2015), *Worm-like Robotic Locomotion with a Compliant Modular Mesh*.

Microsurgery: machines are being developed which allow increasingly precise movements

Manufacturing. Many of the technologies that will transform manufacturing are already established or clearly emerging. For example, in 2014 a US car manufacturer, Local Motors, designed and built a car almost entirely using 3D printers, in just one year (compared with an industry average of six years). The car produced by Local Motors also used a design that was influenced by potential consumers and enthusiasts, suggesting a future where manufactured products are more customised, even personalised to individual consumer demands. Use of computer-aided design and 3D printing may rapidly reduce development and production times, cutting the time and cost of making military equipment. While traditional mass production techniques are currently the cheapest way to make goods, by 2050, 3D printing and distributed manufacturing (networks of small production facilities) may have largely replaced assembly lines. This will allow manufacturing to be both dispersed (conducted at multiple locations) and localised (near the consumer), potentially making it more difficult for law enforcement to prevent illegal production of weapons and for military targeting of manufacturing facilities.

The use of sensors is likely to have a transformative effect on manufacturing, for example, General Electric Company (GE) owns a battery factory in New York, where there are estimated to be over 10,000 sensors spread across 180,000 square feet.[19] These sensors are connected to a network which monitors almost every facet of the factory's operation, including local weather. Combining this data allows GE to ensure that every battery is made in precisely the same way, and that the amount of energy required is precisely controlled, reducing cost and pollution, and improving performance. An Austrian logistics company, KNAPP, has equipped its warehouse staff with a headset that uses augmented reality to help them locate items. The device presents relevant information on a see-through display, while an integrated camera captures serial numbers for real-time stock tracking. This process has reduced error rates by nearly 40%.[20]

Steve Lagreca / Shutterstock.com

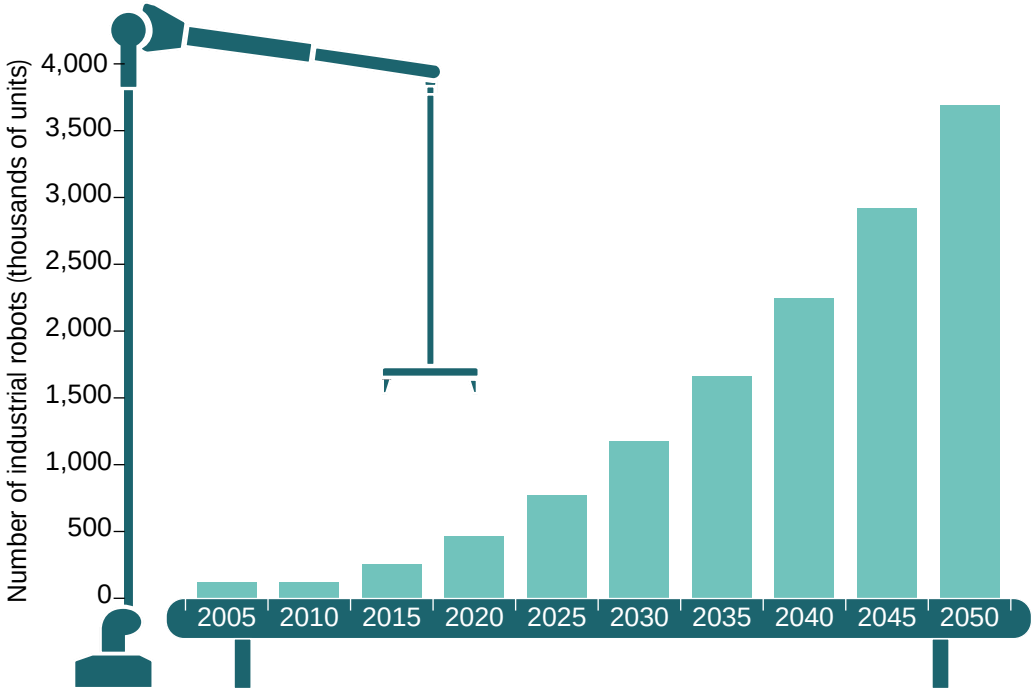
The first entirely 3D-printed car

19 Fitzgerald, M., MIT Technology Review, (28 January 2013), 'An Internet for Manufacturing'.

20 Baur, C. and Wee, D., McKinsey & Company, (June 2015), 'Manufacturing's next act'.

Industrial robots. Although industrial robots have been a feature of advanced manufacturing for years, their use will become much more widespread. Between 2010 and 2015, the number of industrial robots in use increased by 59% to around 1.5 million worldwide.[21] By 2050, it is likely that there will be tens if not hundreds of millions of industrial robots in operation. Some of the world's most advanced factories are already mostly automated, for example, in a factory operated by Siemens in Germany, machines and computers handle 75% of operations autonomously. South Korea currently has the highest density of industrial robots (with 630 per 10,000 workers), followed by Singapore and Japan, although China is now the largest market for industrial robots. In 2016, China purchased more industrial robots than Europe and the Americas combined (a total of 87,000 units, 30% of the total world supply).[22]

Estimated global annual supply of industrial robots



Source: International Federation of Robotics

Work and automation. The number of jobs that machines can do more effectively than people appears to be growing inexorably. Today's technology can (to an extent) drive trains, pick fruit, fly aircraft and drive taxis, and machines will get better and cheaper. Automation has, in part, been responsible for the lack of job creation in the US in the last 20 years, although forecasts for jobs in the US over the next decade show positive net change in every area of employment except manufacturing.[23] The impact of automation will affect regions differently over the next 30 years.[24] More than 50% of jobs are at risk of becoming automated in many countries in Asia, Africa and the Middle East, with China potentially being the hardest hit (because of the country's high number of manufacturing jobs). In developed countries, fewer roles are likely to be vulnerable, although the proportion of jobs that will be automated could still be between 20%-40%.[25]

21 International Federation of Robotics, (2017), *Executive Summary World Robotics 2017 Industrial Robots*.

22 *Ibid*.

23 World Economic Forum (in collaboration with The Boston Consulting Group), (January 2018), *Towards a Reskilling Revolution: A Future of Jobs for All*, page 8.

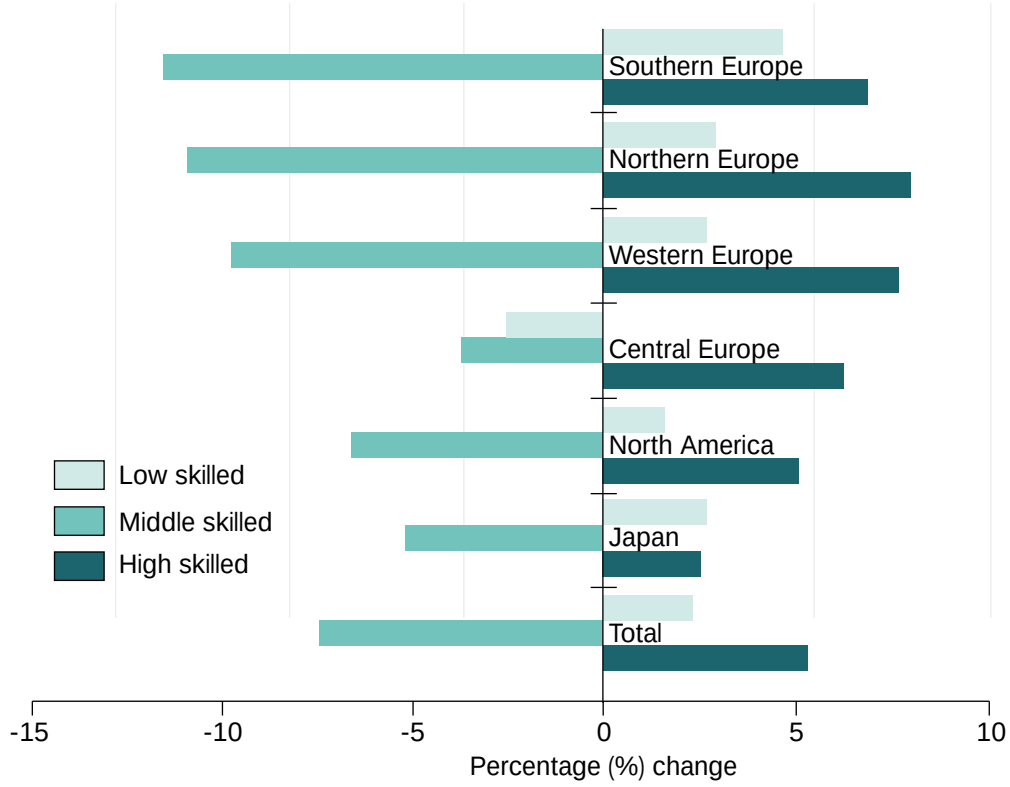
24 Daheim, C., *et al*., ((2017), *The Future of Work: A Meta-Analysis on Disruptive Perspectives*, a research paper commissioned by DCDC.

25 PwC, (March 2017), *UK Economic Outlook*.

Human-machine interaction. The most advanced of today's machines use 'assisted intelligence' to help workers with tasks, such as autopilots for aviation and computers that carry out pattern-identification in large data-sets. The next major development in automation, which is expected in the coming decades, is likely to be 'augmented intelligence', where humans and machines collaborate to make decisions. This will significantly affect how we work in the coming years, favouring those with skills such as emotional intelligence, creativity, persuasion and innovation. Many researchers believe that 'autonomous intelligence' (where machines think for and act by themselves) will be developed by 2050.[26] Autonomous intelligence will further reduce the amount of work that humans are best-placed to do. So far, though, the greatest impact of automation has been in middle-income jobs, such as those in factories. Since the early 1990s, the labour market in many industrialised nations has seen a rise in high-income, high-skill jobs and low-income, low-skill jobs, with a loss in middle-income and middle-skill jobs.[27] This polarisation is likely to lead to a widening income divide.[28]

> "Many researchers believe that 'autonomous intelligence' will be developed by 2050."

Percentage change in skilled employment due to automation (1995-2015) in Organisation for Economic Co-operation and Development (OECD) countries



Source: OECD

As businesses increasingly use automation (including artificial intelligence), they will become more efficient, driving down costs. In time, however, profit margins will also be squeezed, leading to a business model where profit on individual items and services is so small that the only way of generating a meaningful profit will be to sell in very large numbers (as has already happened with many commodities). This would drive companies to grow and absorb rivals, reducing competition and creating the conditions for monopolies, which could lead to economic stagnation and fewer jobs and increasingly concentrate wealth in the hands of a few. For market economies to work, however, consumers are needed, and consumers need an income. So, the economies should,

26 Barrat, J., (2015), *Our Final Invention: Artificial Intelligence and the end of the Human Era.*

27 Ford, M., (2016), *Rise of the Robots*, page 51.

28 OECD, (2016), *Automation and Independent Work in a Digital Economy.*

More than 50% of jobs are at risk of becoming automated in some countries

eventually, rebalance. Previously unconsidered jobs have emerged throughout history and the middle of the 21st Century might be no different.[29] Jobs where human input (rather than technical competence) is considered the most valuable component (for example, sport, artisanal crafts and, arguably, politics) could see significant growth. Alternatives of offering a universal wage, payable whether a person works or not (as in Finland), nationalisation of industries, or a tax on capital, may all be features of the future economy.

The speed of transition from the current model of work to one where machines do so much more could, however, be critical. The industrial revolution resulted in considerable upheaval and the loss of many livelihoods, yet the transition took several decades. The change to a signi□cantly more automated world is likely to happen faster than previous transitions, thus increasing the risk of societal upheaval, grievance and violent protests by the disadvantaged. If well-managed, however, automation could lead to more leisure time, less drudgery and reductions in poverty.

Industrial biotechnology. Industrial biotechnology aims to make biochemical processes useable for manufacturing and wider industry. Uses of biochemistry are often more energy-efficient and less polluting than conventional industrial processes. Biotechnology can use renewable biomass to make materials such as bioplastics, which reduce greenhouse gas emissions during production and can be fully biodegradable.[30] Although bioplastics currently make up a relatively small percentage of the world's plastics (about 0.5-1%) this proportion may expand. The chemical industry currently uses biotechnological fermentation to make a variety of substances, such as citric acid and propane. An increasing range of chemicals could be produced cheaply, effectively and cleanly using biotechnology. Biofuels might also play an important role in replacing fossil fuels in the future, although they are currently expensive and, because they are derived from crops such as sugarcane, wheat or corn, they will compete with food production.[31]

29 World Economic Forum (in collaboration with the Boston Consulting Group), (2018), *Towards a Reskilling Revolution: A Future of Jobs for All*, page 8.

30 Biotechnology Industry Organization, 'Consumer Products Made with Industrial Biotechnology'.

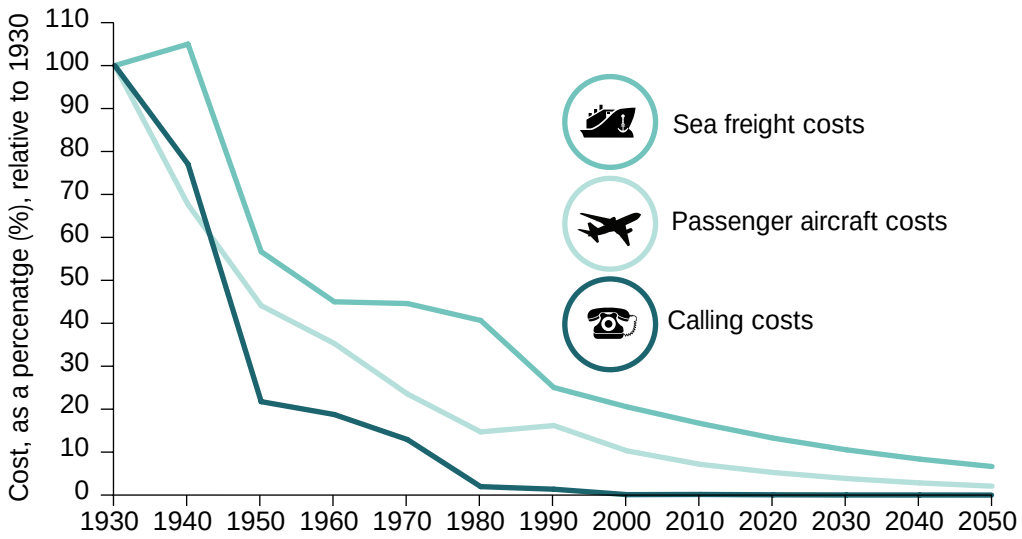
31 Biofuel.org.uk, 'Disadvantages of Biofuel'.

Transport

Rail and cars. By 2050, transport and communication costs will probably have fallen substantially, and the number of kilometres travelled per year is likely to more than double. In some parts of the world, recent transportation growth has been rapid, for example, there were almost no rail passengers in China in 2000, but by 2014, 2.9 billion journeys had taken place on China's trains. With 20,000 kilometres of track, China already has the largest high-speed rail network in the world and this is expected to expand to 80,000 kilometres by 2035.[32] Between 2015 and 2016, 23 million private cars were purchased in China, taking the overall number owned to 172 million, along with estimated totals of 50 million scooters and 20 million rural vehicles.[33] If India's economy grows as predicted over the next 30 years, it is likely to see similar increases in vehicle ownership. On current trends, the number of private vehicles could double to around 1.6 billion by 2050. By then, however, attitudes to car ownership worldwide may have changed, particularly for people in areas where 'on demand' transport services are available. This trend may already be in evidence in the US where the proportion of 16 to 24 year olds holding a driving licence dropped from 76% in 2000 to 71% in 2013 (although other factors such as increasing costs may be the cause).[34] Improved public and 'on demand' transport may, therefore, lead to a slowing, or even a reduction, in the number of privately-owned vehicles.

> "By 2050, attitudes to car ownership worldwide may have changed, particularly for people in areas where 'on demand' transport services are available."

Global transport and communication expenditure relative to 1930



Source: Our World in Data, University of Oxford

Transport infrastructure. To support increased demands for transport infrastructure, spending is projected to increase by 5% per annum worldwide in the coming years. While there will probably be strong growth in sub-Saharan Africa, the Asia-Pacific region is likely to remain the largest infrastructure market globally. Investment in 'gateway infrastructure', such as ports and airports, will be a crucial part of meeting rising requirements for transportation in the coming decades as current infrastructure will be unable to support future demand.[35] New national and regional transport hubs are likely to be established or improved to support the world's cities, as good transportation links are often essential components of economic prosperity.

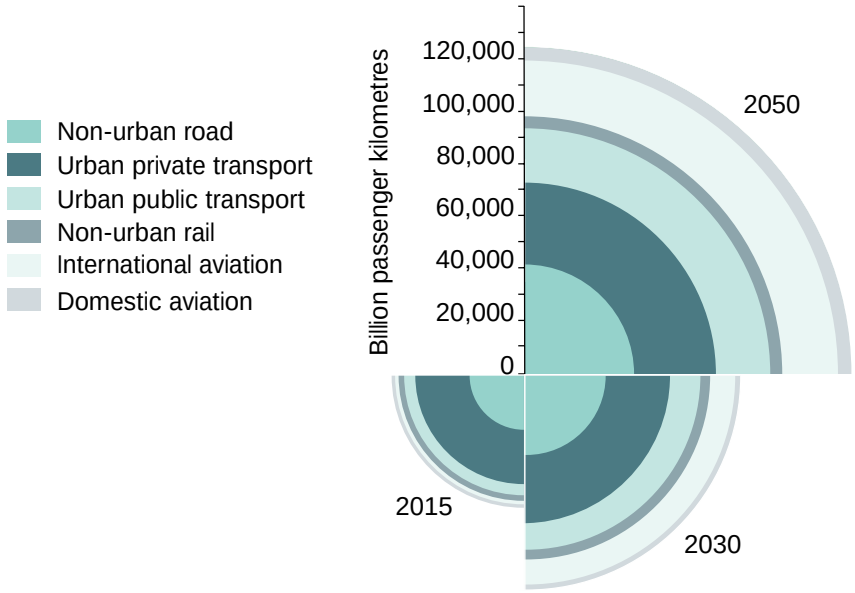
32 Ollivier, G., *et al.*, World Bank, (2014), *High Speed Railways in China: A Look at Traffic*.

33 Shaohui, T., Xinhua, (2016), 'China's car ownership reaches 172 million'.

34 McKinsey & Company, (2016), *Automotive revolution – perspective towards 2030*.

35 OECD International Futures Programme, (2011), *Strategic Transport Infrastructure Needs to 2030*.

Growth in global travel



Source: Organisation for Economic Co-operation and Development

Major cities, particularly those in developed countries, which are constrained by their layout, buildings or nearby geographical features could find adapting their transport infrastructure challenging and costly. Cities are likely to get bigger, leading to longer average commutes, increased congestion, and greater environmental problems. However, advances in technology may provide solutions to these issues. One study (that took place in economically developed countries) suggested that replacing privately-owned cars with shared-use autonomous vehicles could reduce car use by between 23-65% for peak periods, and almost completely remove the requirement for parking facilities.[36] Improved public transport will be vital to the quality of urban life and those cities that can afford to are expected to invest heavily in transport in the coming decades. The ability to work, socialise and shop remotely, however, could lead to a significant decrease in the number of journeys people make. For example, between 1998 and 2014, the number of home workers in the UK increased by 44%, comprising 2.8% of the total workforce.[37] If working patterns change substantially in the next 30 years, this will have a major effect on transport, particularly in cities.

> “Improved public transport will be vital to the quality of urban life and those cities that can afford to are expected to invest heavily in transport.”

Power and efficiency. Transport as a whole is likely to use 45% more energy by 2040 compared with 2010 figures, despite probable improvements in fuel efficiency. Most personal vehicles are expected to be powered by hybrid and electric engines from around 2025 onwards, but the majority of commercial vehicles are likely to run on heavy duty fuel, such as diesel, unless batteries become significantly cheaper and more powerful. Substantial increases in the number of electric vehicles would require major infrastructure investment, particularly in providing significantly more charging points; the current forecast of availability will not meet likely future demands. Designed intelligently, changes in infrastructure could help develop ‘smart grids’, where electric vehicles act as ‘batteries’, providing energy back to power grids during peak usage, and absorbing

36 OECD International Transport Forum, (2015), *Urban Mobility System Upgrade How shared self-driving cars could change city traffic*.

37 Office for National Statistics, (4 June 2014), ‘Record proportion of people in employment are home workers’.

VanderWolf Images / Shutterstock.com

Shared autonomous vehicles could dramatically reduce car use

excess capacity when demand is lower. Electric propulsion systems could offer many advantages in military vehicles, but it may not be practical to □eld expeditionary charging infrastructure. Military vehicles may need bespoke, and therefore expensive, power storage and generation capabilities.

Solely electrically-powered ships or large aircraft may not be in common usage by 2050. It is not currently technologically or economically feasible to store electricity in the quantities such vehicles would need. Ships' exposure to extreme weather also means that renewable energy is not a viable power source for commercial shipping in the short term. However, hybrid systems such as tri-fuel diesel electric propulsion ships are currently just entering service, with an electric propulsion system that runs on natural gas, marine diesel gas or heavy fuel oil. Hybrid engines may become an established way of powering shipping in the coming decades.[38] Widespread electrification of aircraft is also unlikely before 2050. Despite the success of the Solar Impulse 2 solar-powered aircraft (which circumnavigated the world in 2015), there are problems scaling the concept for commercial use.[39] The next generation of electric aircraft is likely to be primarily used for training and recreation, involving much shorter trips than commercial transportation flights. Electrically-powered drones may, however, operate as air taxis and deliver goods to individual customers (particularly in urban areas), while more intelligently coping with traffic.

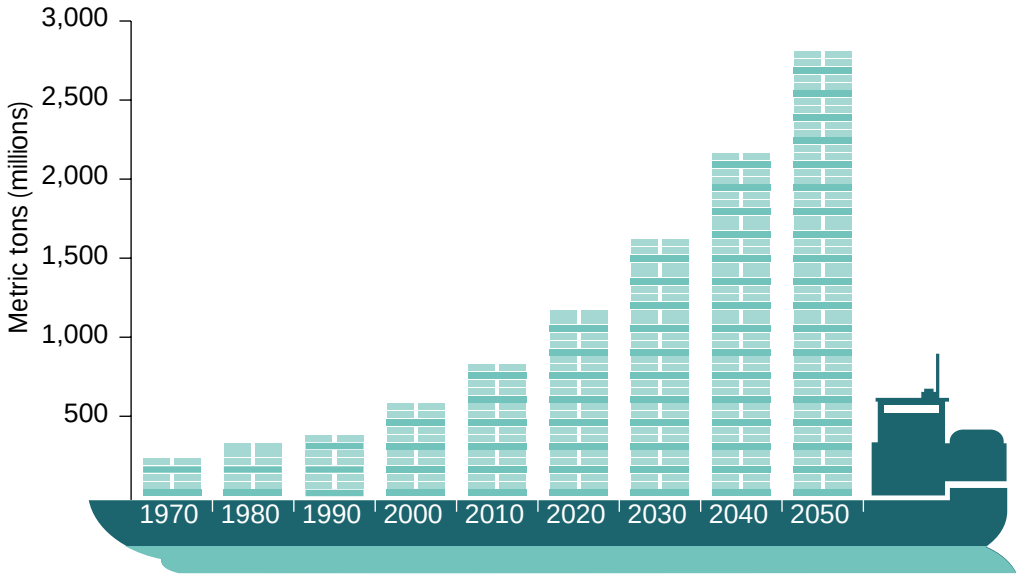
Improving efficiency will play a crucial role in reducing pollution from transport. Refinements to standard ship, vehicle and aircraft design may further reduce drag and, therefore, provide a better rate of energy consumption, but they are only likely to provide a limited amount of efficiency savings. More significant gains may be delivered by using technologically-advanced surfaces (such as diamond-like carbon materials and

38 Ship & Bunker, (4 July 2013), 'Tri-Fuel LNG Carrier to enter service this month'.

39 Gleave, J., (2017), *The Future of Transport 2050*, a research paper commissioned by DCDC, page 103.

nanocomposites), which could reduce friction by between 10% and 50%.[40] Rail travel could see significant increases in speed and efficiency if prototypes currently in operation come to fruition. For example, a US company (Hyperloop One) has successfully tested the propulsion of electromagnetically-levitated pods through underground tubes containing lowered air pressure, which substantially reduces drag and could allow travel at speeds of up to 600 mph. New aerodynamic and propulsion systems are being developed, which may mean aircraft could fly at Mach 5 to Mach 9, and adoption of space technologies for commercial use might generate even more impressive speeds. For example, German researchers are developing a reusable spaceplane (called SpaceLiner) which aims to fly at Mach 25, transporting up to 50 passengers. This could mean, for example, that you could fly from the UK to Australia in 90 minutes. Commercial application of these technologies could be up to 30 years away, although widespread military adoption might bring this forward. There may be significant environmental benefits by using hypersonic technology, for example, SpaceLiner would be fuelled solely by liquid hydrogen and oxygen, meaning that water vapour is the only by-product.

Volume of global surface freight shipped



Source: United Nation conference on trade and development

Information

The Internet. Over the last 25 years, Internet use has transformed industries, economies and trade worldwide. The Internet has become the conduit for a vast amount of commerce, and allows billions of people to talk, collaborate and share ideas almost instantaneously to and from almost anywhere. In 2001, only 9% of the world's population were using the Internet and by 2016 this had risen to 48%. Today, more people access the Internet via mobile devices, a trend that is likely to continue. In 2001, there were 18 mobile phone subscriptions per 100 people and by 2017 there were 103.5.[41] By around 2040, virtually everyone is likely to have access to the Internet, and probably through a mobile device. The Internet has led to the development of a multibillion-dollar trade in digital devices and services, which is likely to grow.[42] Digital trade is also expected

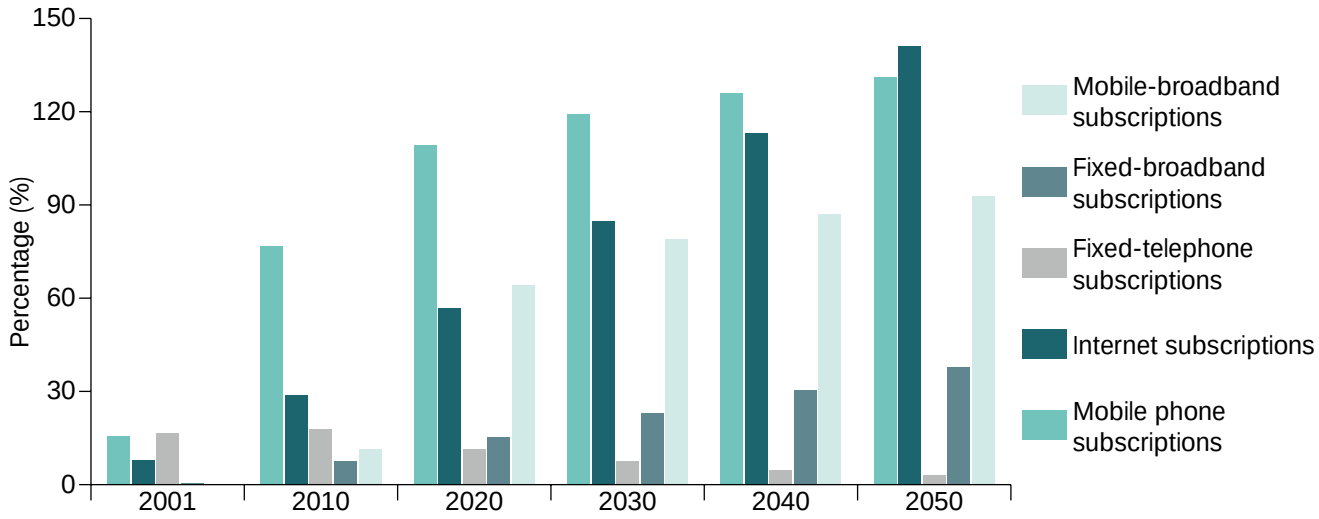
40 Gleave, J., (2017), *The Future of Transport 2050*, a research paper commissioned by DCDC, page 104.

41 International Telecoms Union, (2017), 'ICT Facts and Figures 2017 – supporting data'.

42 WTO, (2013), *World Trade Report 2013 – Factors shaping the future of world trade*, page 54.

to surpass the value of traditional commerce.[43] In the coming decades, rather than purchasing finished goods, consumers are more likely to buy a product design or blueprint, particularly if 3D printing becomes widespread. If more customers buy finished products at source, there could be a reduction in transportation requirements, although high volumes of raw materials and fuels will continue to be moved. Even without a substantial rise in 3D printing, the trade in digital services is likely to surpass the traditional global economy by 2050.[44] There has already been a substantial rise in digital products, for example, the number of applications available via the Google Play store rose from 16,000 in 2009 to over 3.5 million in 2017. On current trends, the volume of information flowing across national boundaries will grow substantially. It increased by 45 times between 2009 and 2014.[45]

Global information communication and technology development



Source: International Telecommunications Union

Data. The volume of the world's digital data continues to grow rapidly. There was a tenfold increase between 2010 and 2017, from approximately 1.7 to 18.3 zettabytes (a trillion gigabytes or 10^{21} bytes). By 2025, global data is expected to rise to over 163 zettabytes, and on that trend, there could be over 10,000 times more data in 2050 than there is today. The largest source of this new data is likely to be generated by machine-to-machine communication, for example, an engine providing automatic updates to the manufacturer on its usage. As the volume of data has grown, storage costs have reduced. Storing a gigabyte of digital data cost US $0.11 in 2009, but fell to US $0.02 in 2017. The energy and space needed to store data has also fallen, and dramatic improvements could be generated by new technologies, such as encoding information using the DNA (deoxyribonucleic acid) of bacteria. It has been estimated that less than a kilogram of DNA would be needed to store all the digital information in the world today.[46]

43 Tyson, L. and Lund, S., World Economic Forum, (21 February 2017), 'Globalisation isn't in retreat. It's just gone digital'.

44 Schwab, K., World Economic Forum, (2016), 'The Fourth Industrial Revolution: what it means, how to respond'.

45 McKinsey & Company, (2016), *Digital globalization: The new era of global flows*.

46 Extance, A., Nature, (2 September 2016), 'How DNA could store all the world's data'.

The largest source of new data is likely to be machine-to-machine communication

> Advances in processing power will continue to drive improvements across all aspects of human endeavour.

Processing power. The processing power of computers will continue to improve. A supercomputer made in 2017 could perform 750,000 times more calculations per second than a supercomputer from 1993. If this trend continues, the computers of 2050 could be hundreds of thousands of times more powerful than today's, although physical limitations on the capacity of microchips may slow future increases.[47] It is thought a silicon transistor cannot have a width of less than seven nanometres due to interference effects, and that limit is approaching. In 2017, manufacturers made a transistor 14 nanometres wide. If chips are made from an alternate material, however, this limitation might be overcome, for example, tests are underway to develop a chip two nanometres wide made from molybdenum and carbon nanotubes.[48] Advances in processing power will continue to drive improvements across all aspects of human endeavour. For example, distributed ledger technology (blockchain), which is already being used when cryptocurrencies are traded, will be able to validate transactions on an increasingly large scale. As processing power increases, it will fuel developments in artificial intelligence.

Quantum computing. Quantum computers could allow substantial advances in processing power and, in certain tasks, could be much more powerful than conventional computers. Traditional computers rely on binary 'bits' that are either one or zero to provide computational solutions to a calculation. Quantum computers, however, rely on 'quantum bits' (qubits) that can have values between one and zero, a superposition of states and in combination they represent every combination (with some probability) at the same time. This curious property is expected to allow massive calculations to be performed simultaneously, allowing certain problems to be solved far more quickly than conventional computers could. For example, molecular-level behaviour could be modelled to make better medicines or explosives and codes could be strengthened

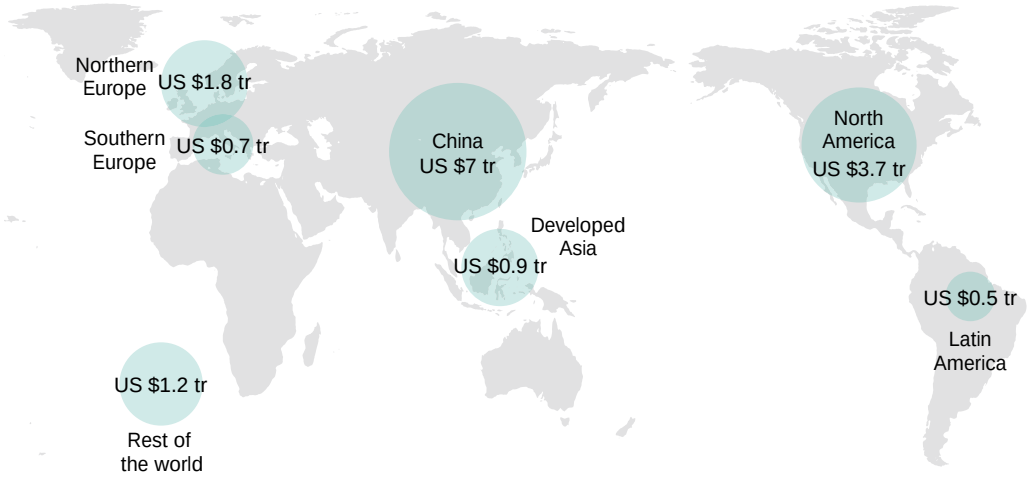
47 *The Economist*, (12 March 2016), 'Technology Quarterly: After Mores Law'.

48 Desai, S. B., *et al.*, (7 October 2016), 'MoS2 transistors with 1-nanometer gate lengths'.

or cracked. Already there are quantum computers that can perform calculations with a 72-qubit chip, but, the rate of error (qubits not holding their quantum state) is high, thus reducing performance and effectiveness.[49] By 2050, these problems are likely to be resolved and quantum computing could be a mature technology. China has already set up the world's first quantum-cryptographic network (the Jinan Project) and is well-positioned to become the front-runner in the field.[50]

Artificial intelligence. By 2050, artificial intelligence is likely to be an integral part of the global economy. Funding of artificial intelligence startup companies increased from US $0.1 billion in 2009 to US $1.2 billion in 2015, and if the trend continues, hundreds of billions (perhaps trillions) of US Dollars of funding could be secured by 2050. In recent years, the technique known as 'reinforcement learning' (modelled loosely on the neurons of human brains) has led to notable advances in artificial intelligence capability. For example, artificial intelligence systems outperformed humans when identifying faces in a series of images;[51] beat the world champion at the game Go;[52] and defeated leading poker players over an extended run of games. Artificial intelligence is likely to have more practical applications, such as identifying the most efficient route for delivering goods shipments or establishing which consumers are likely to be interested in (and able to afford) new products. As ever more data is generated over the coming decades, artificial intelligence will probably be brought to bear on highly complex problems, improving productivity and generating substantial economic growth. By 2030, artificial intelligence could add almost US $15.7 trillion (14%) to the global economy, with China (which hopes to be a world leader in the technology) benefiting most significantly. While artificial intelligence is likely to bring many benefits, there are risks to embracing the technology. The effect of artificial intelligence on jobs may be disruptive, at least in the short term, and it could be used maliciously by rogue actors.

Projected artificial intelligence contributions to economic activity by 2030 in US $ trillions (tr)



Source: Visual Capitalist

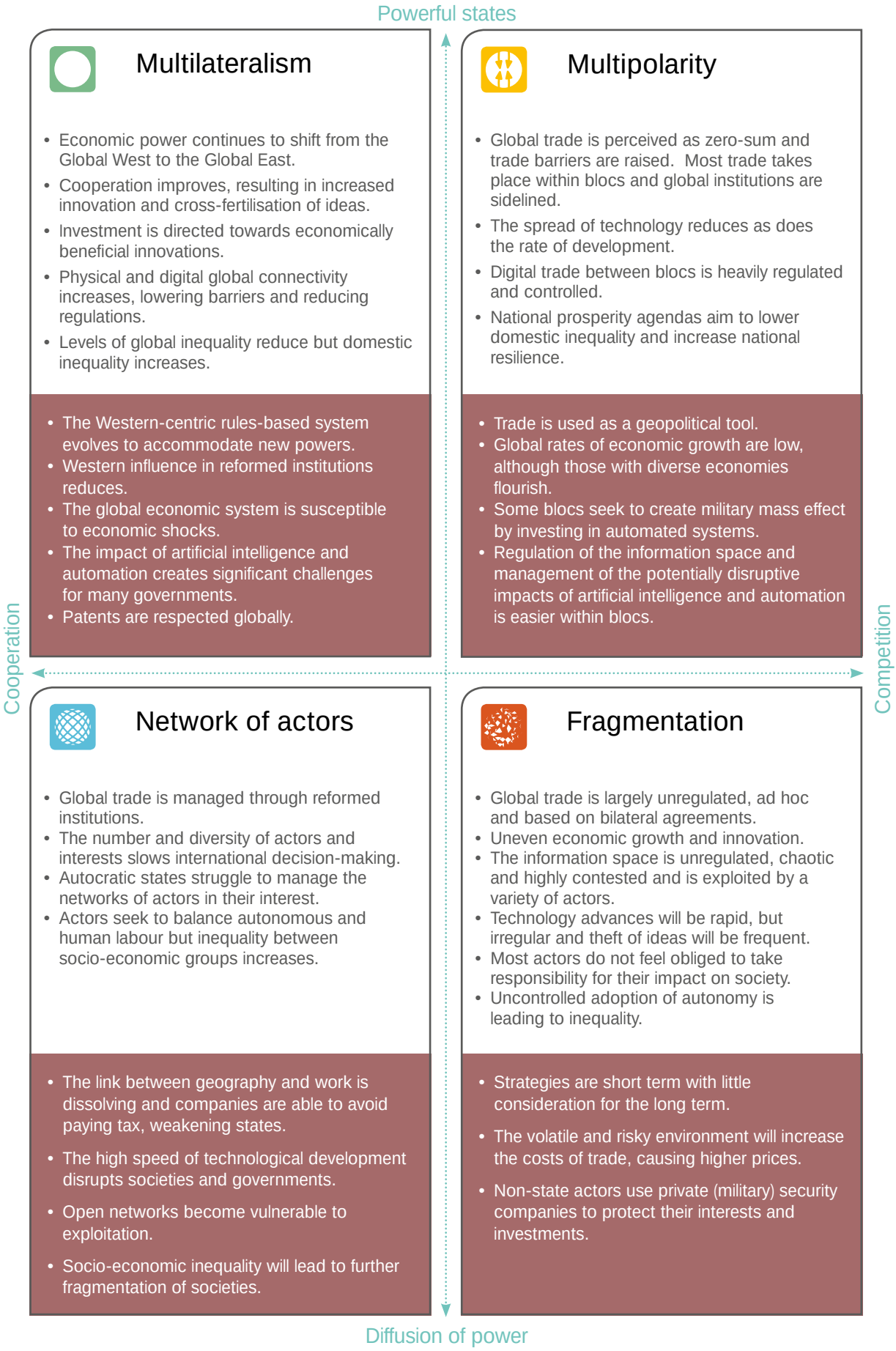
49 New Scientist, (6 March 2018), 'Google's 72-qubit chip is the largest yet'.

50 Ricks, T., Foreign Policy, (28 November 2017), 'The Quantum Gap with China'.

51 Gershgorn, D., Quartz, (26 July 2017), 'The data that transformed AI research – and possibly the world'.

52 Silver, D., *et al*., Nature, (28 January 2016), *Mastering the Game of Go with Deep Neural Networks and Tree Search*.

Future worlds: Economy, industry and information



Watch points

- The number of jobs being automated.
- Levels of debt.
- Size of China's and India's gross domestic product compared to Europe's and the United States'.
- Levels of inequality both within and between states.
- Changes to the balance of globalisation and isolationism.
- Geopolitical positioning of military assets in support of economic interests.
- Impacts of technological change on society and the economy.
- The evolution of mature economies and credible alternatives to capitalism.
- Increased human-machine teaming.

Discontinuities

- New economic paradigms.
- Move to post-consumerism.
- New reserve currency.
- The next major economic or financial crisis.
- Shifts in allegiances and alliances.
- Sudden closure of trade choke points.
- Natural disaster involving a global financial/ economic centre.
- Sudden change of regime in major power.
- Automation-driven fiscal collapse.
- Development of singularity.

Implications

- The use of artificial intelligence and automation could transform economies and have a fundamental impact on societies. States may need to change models of taxation, wealth distribution and education. To manage the inevitable tension of such a transition, clear and consistent strategic communication will be required. The management of this process might be particularly difficult for political systems with short election cycles.
- Global and domestic inequality could result in political instability and potentially violent conflict.
- The unconstrained growth of the information space will require a whole of society approach to manage inherent risks and exploit opportunities. It may be necessary to develop virtual space within national or regional control, not dissimilar to borders in the physical world. By reducing the free flow of data there is likely to be an adverse economic impact.
- The shift eastwards of the global economic centre of gravity will likely lead to a decline in Western soft power and competitive advantage.
- Economic growth could become evermore elusive for developed economies. Economic paradigms and assumptions need to be carefully considered and planning considerations need to be realistic.
- To exploit the opportunities of fast developing technologies, governments may need to accept an increased level of partnerships and decentralisation with a range of actors.
- As the economic value shifts from physical goods to ideas and data, control of networks will be important and states will need to find evermore sophisticated ways to protect intellectual property.
- Competing priorities, such as technological change, health, welfare and defence costs, will make the affordability challenge ever starker and may require harsh political choices.
- In a fiscally-constrained environment, investing in science and technology is necessary to identify and realise opportunities to gain asymmetric or offset advantage over competitors.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Governance and law

Synopsis

As the economic power of Asia increases, the political power of China (and to a lesser extent India) will grow, potentially rivalling that of the United States (US), and while Russia and Europe are likely to remain important political actors, their influence is likely to diminish. A crucial question is whether the current institutions, mechanisms and norms of the international system can adapt to accommodate the shifting balance of power. If it cannot, the system could fail and disputes will be more difficult to resolve, potentially escalating and leading to conflict. As political power becomes more dispersed and contested it will become harder to forge internationally binding treaties, and non-compliance and subversion of international laws are likely to increase. The transition of power between states is occurring alongside the diffusion of power within states, as they face an increasing number of problems that they cannot solve alone. Challenges such as climate change and international terrorism will require cooperation internationally, but also with non-state actors such as large corporations and local governments. The economic, demographic and political power of many cities (and some regions) is likely to grow relative to the state and this may lead to demands for devolution, or at least accommodation. Some countries may not exist in their current form by 2050. Some multinational corporations could become much bigger and more powerful, providing vital services that states are dependent upon, and some may use their power to demand accommodation from the state. The sovereignty of the state is, therefore, likely to continue to be eroded, resulting in a more complex, hybrid system of governance.

Paradoxically, the capacity of governments, particularly those in developing countries, is likely to increase as their ability to raise taxes and deliver services is enhanced by digital technology. Digital technology will also increase states' capacity to police effectively, which should make societies safer, but the risk of repression will increase. Criminals will, however, also exploit technology and cybercrime is likely to be a growing menace. The proportion of people living in absolute poverty is likely to reduce and virtually everyone is likely to have far greater access to information, empowering citizens who will demand more of their government. But, whilst most people's economic circumstances will improve, their sense of satisfaction may not. Instead, grievances could increase and nationalism, religious intolerance and antipathy towards immigrants could rise. If automation leads to widespread unemployment, the risk of widespread dissent will increase.

International order

A multipolar world. Over the next 30 years, an increasingly multipolar world is likely to develop, in which the current liberal international order and its institutions will come under increasing strain. Relative economic power will move from the Atlantic to the Pacific, and by 2050 the economies of China, and potentially India, are likely to have surpassed that of the US. Brazil, Indonesia, Mexico, Nigeria, Turkey and Vietnam might also become much more economically and politically influential in the coming decades and, if so, they can be expected to demand better representation in global institutions.[1]

Multilateral institutions. As global political and economic power becomes increasingly diffused, the challenge of securing agreement between member states may hinder the effectiveness of global multilateral institutions. While such institutions will probably endure, they are also likely to be modified to accommodate the interests of rising powers. Countries with growing economic status are also likely to develop their own institutions, as has already been seen with the creation of the New Development Bank and the Asian Infrastructure Investment Bank.[2] If current international institutions do not accommodate the interests of rising powers a breakdown of the international order could occur, possibly resulting in greater instability.

> “In recent years, countries such as China and Brazil have entered the list of the top ten contributing states.”

The United Nations. The United Nations (UN) will continue to face significant challenges, with increasing calls for reform from several member states as the disconnect between its power structures and the realities of where global power actually sits in the world system increases. Nevertheless, the UN is likely to survive, so long as the majority of countries continue to regard it as essential to international peace and security. While the US and other Western states are currently the largest contributors to the UN budget, the balance is shifting. In recent years, countries such as China and Brazil have entered the list of the top ten contributing states. In addition, the presence of emerging powers such as Brazil, India, Nigeria and South Africa in the top 20 troop-contributing states will probably add to the strength of their demands for greater decision-making powers within the institution, including reform of the UN Security Council. The desire of existing permanent members to protect their own influence is, however, likely to remain an obstacle to any meaningful reform.

The changing balance of power. In the next 30 years, the relationship between China, India and the US (and to a lesser extent, Europe and Russia) will be pivotal to the international order. An increasingly powerful China is likely to adopt a more authoritative and assertive stance on the world stage, whilst Europe, Russia and the US might find it difficult to accept their relative decline. Russia is likely to remain a vociferous opponent of the US (finding support from many countries around the world) and can be expected to push hard for a multipolar order that allows Russia to act as a key player. Russia and China will continue to cooperate on a range of issues, but there are also likely to be points of friction, not least in Central Asia.[3] India will continue to be wary of China and may look to establish alliances with other powers.

It is impossible to forecast the balance of power in 2050, as it will be dependent not just on trends, but also shocks and surprises, including natural disasters, financial crises and, potentially, war. Given the economic and political interdependencies between countries, cooperation could flourish, but recent years have seen a considerable rise in populist and nationalist sentiment, particularly among the poor and disenfranchised in many parts of the world. These political movements could lead to the election of protectionist

1 Dorman, A. and German, T., (2017), *How will the overarching global political order change over the next 30 years?*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC), page 14.

2 *Ibid.*, page 14.

3 *Ibid.*

Ankor Light / Shutterstock.com

The global legal environment is likely to experience competing local and regional understandings of international norms

governments that undermine the international system of trade. While the current shift of the US towards a more protectionist stance may be a short-term phenomenon, if it were to endure the international system of trade might not survive. If the international system of trade were to unravel, interdependencies between countries would reduce, and it is plausible tensions could increase. Con□ict between major powers, therefore, cannot be ruled out.

The international legal order. Over the next 30 years the redistribution of global power will challenge the universalist approach to international law and human rights.[4] The global legal environment is likely to become increasingly pluralist in character, with competing local and regional understandings of international norms likely to prevail. However, if the world economy continues to become more closely integrated, as is expected, the internationalisation of some aspects of law will probably continue. Furthermore, as the range of issues requiring a global response increases (such as climate change, cyber regulation and transnational crime), they too could encourage the adoption of international legal frameworks and institutions.[5] It is therefore likely that there will be a convergence around existing norms and rules in some respects, such as trade, but probably not in others, such as the application of universal human rights. For example, Russia and China are likely to continue to support the UN Convention on the Law of the Sea (UNCLOS), viewing it as an important mechanism to uphold order in regions such as the High North. Both countries see UNCLOS as a vehicle through which to further their own political and economic national agendas. Likewise, China and Russia are members of the World Trade Organization, however, Russia has not ratified its membership of the International Criminal Court, and China is not party to it (neither is the US).

Legal fragmentation. Although a universalist approach is likely to prevail in some areas of law, a multipolar world consensus is, in general, likely to be more difficult to achieve. With more actors, common ground between countries is likely to reduce, making it harder to deliver large-scale international law-making projects. In addition, the international legal environment is likely to use an increasing number of informal mechanisms, thereby undermining its effectiveness as a universal regulatory framework and increasing its vulnerability to non-compliance and subversion. This process could reduce the influence of states, potentially resulting in the adoption of new legal principles

4 Peerenboom, R., *The Law of the Future and the Future of Law*, (2011), 'The Future of Law in a Multi-Polar World: Toward a Global New Deal', page 43.

5 Muller, S., *et al.*, (2011), *The Law of the Future and the Future of Law*, page 2.

City Hall, London: national and local governance will become more complex

that exceed the parameters that individual countries would accept.[6] Nevertheless, leading powers will continue to shape international law, with China likely to play a more influential role in future worldwide legal development. For example, it is already taking steps to enhance its international law capabilities and to lead in emerging areas such as cyber law. China has also developed a training programme to share its growing legal expertise with less developed countries.[7]

The state, nationalism and politics

Challenges. Governments will face an expanding array of threats and issues over the next 30 years, including terrorism and international crime, migration, automation and climate change, that they will not be able to solve alone.[8] Countries that enjoy strong, effective and trusted state institutions and a stable economy are more likely to have the capacity to address these challenges effectively. However, weak and ineffective governments may be overloaded by the scale of future problems, exacerbating state fragility. Some countries are likely to face opposition to their system of government as other actors increase in power and influence, both nationally and internationally. The rise of new political movements (such as those based around populism and nationalism) will probably also challenge existing regimes. Although the next 30 years are very unlikely to see the end of the state system, it may signal the erosion of state sovereignty.

Capacity of governments. Paradoxically, the capacity of many governments, particularly in developing countries is likely to increase. In the coming years, developing countries are likely to expand their domestic tax base through the professionalisation of their tax authorities and digitisation of their economies. Providing banking and payment services online and using mobile phones has, particularly in developing countries, brought large sections of the informal economy into the formal economy where it can be regulated and taxed. As increasing numbers of people move into the formal economy, the governments' tax income will increase, allowing them to devote more resources to revenue collection and, thus, leading to a virtuous circle. By paying taxes the citizens' relationship with their government is thickened and they are likely to demand better services, which governments are increasingly able to afford. A growth in domestic economic activity is also likely to increase many governments' revenues in the coming

6 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, a research paper commissioned by DCDC, page 2.

7 Sceats, S., Chatham House, (4 July 2016), 'China's Fury Over South China Sea Belies Its Legal Insecurities'.

8 Dorman, A. and German, T., (2017), *How will governance within current state boundaries change over the next 30 years?*, a research paper commissioned by DCDC, page 2.

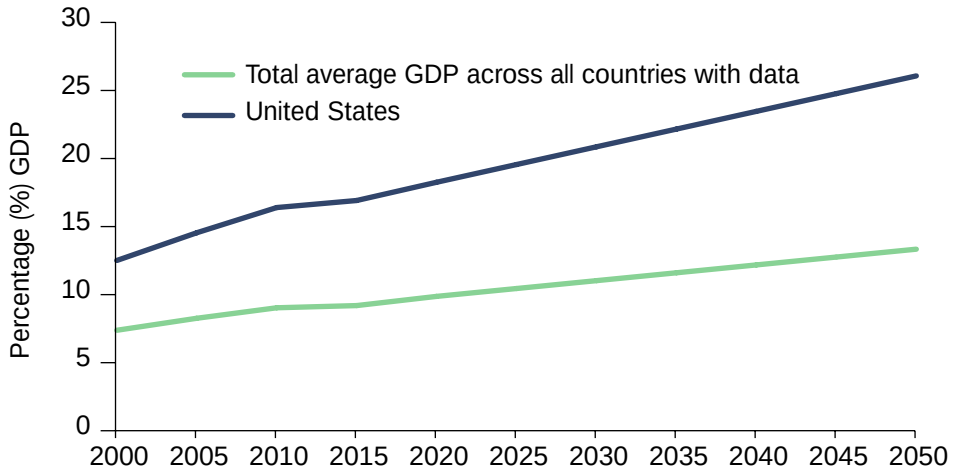
decades.[9] An increasing range of services are likely to be available through the Internet over the next 30 years, giving access to large sectors of the world's population, including many who previously would have been unable to access government services. In remote areas, technological advancements will improve health care and overcome critical skills shortages. Artificial intelligence may even be used to develop better governmental policies, assist with their implementation and help evaluate their effectiveness.[10] New technology could also improve citizens' safety and security, but in some authoritarian countries, a more capable state security apparatus is likely to stifle individual freedoms.

Automation and jobs. Current employment models are likely to be significantly altered by advances in automation and artificial intelligence. While new jobs are likely to emerge at some point, it is not clear if they will be created quickly enough to avoid significant disruption, or that there will be enough to provide mass employment. In many developed countries, citizens have come to expect a steady growth in living standards and if these expectations are not met, governments may face a backlash. Without sufficient numbers of people in work, traditional taxation will not generate sufficient revenue to fund government services.

> "Current employment models are likely to be significantly altered by advances in automation and artificial intelligence."

Welfare provision. In many parts of the world (particularly in Europe and parts of Asia), pension schemes are likely to be unaffordable as populations age and tax bases decline. This issue could be further compounded by medical advances that prolong life. Health care might also become unaffordable in many places, for example, spending in Organisation for Economic Co-operation and Development (OECD) countries is likely to double to around 15% of gross domestic product (GDP) by 2050. If US spending on health care continues to grow at current rates, it could reach around 30% of GDP over the same period. Ageing populations and the increasing cost of health care are likely to make current levels of welfare provision unaffordable, reducing funds available for defence and security. However, developing countries could see greater access to health care as their economies improve. Better governance should also expand health care provision, for example, over 90% of Rwanda's population have access to health care, despite a comparatively low GDP of around US $750 per person.[11]

Average percentage (%) of gross domestic product (GDP) spend on health care



Note: GDP spend on health care includes government spending and health insurance contributions.

Source: Organisation for Economic Co-operation and Development

9 Cheeseman, N., *How will governance within current state boundaries in Africa change over the next 30 years?*, a research paper commissioned by DCDC.

10 Tito, J., Centre for Public Impact, (21 September 2017), 'Destination unknown: Exploring the impact of Artificial Intelligence on Government Working Paper'.

11 *The Economist*, (28 April 2018), *Special Report, Universal Health Care*, page 4.

Discrimination will remain a block to prosperity for some

Donald Yip / Shutterstock.com

Hybridisation of government. If government-funded services reduce, those who can afford to do so will probably find commercial providers or seek support from their employers. People without these options may look to non-state actors (potentially including militant groups), some of who may offer low cost or free service provision in exchange for political support. We may therefore see a growing 'hybridisation' of government, where state responsibilities are delegated into more complex public/private networks, organised on a transactional basis according to the task in question. The concept of state sovereignty may become ever more blurred, with the relationship between public and private actors increasing in complexity. In less developed countries, there may be a 'governance leapfrog' to a networked system where the state is only one of many actors providing a range of services between them.

Inequality. Over the past 30 years, economic inequality between countries has reduced, mostly because of the fast growth seen in Asian countries. By contrast, economic inequality within countries has increased in Central Asia, Europe and North America. It has remained consistent in South Asia, and fallen slightly in Latin America, North Africa, Southwest Asia and sub-Saharan Africa.[12] Economic inequality will be shaped by rapid population growth in developing countries and rising wage inequality within developed countries (probably compounded by a scarcity of jobs caused by greater automation). If economic inequality within countries continues on current trends, global income inequality will continue to rise steeply. The share of the world's wealth owned by the richest 1% of the population could increase from nearly 20% today to almost 25% by 2050, and if all countries were to follow the trajectory of the US since 1980, that figure would rise to 28%.[13] Crime may become more socially acceptable in some communities if inequality within countries increases.[14]

12 Lea, N. and McGowen, J., Department for International Development (DFID), Chief Economist's Office, (2015), *Income Inequality And The Distribution Of Opportunity*, internal discussion document shared with DCDC.

13 Alvaredo, F., *et al.*, World Inequality Lab, (2018), *World Inequality Report 2018*.

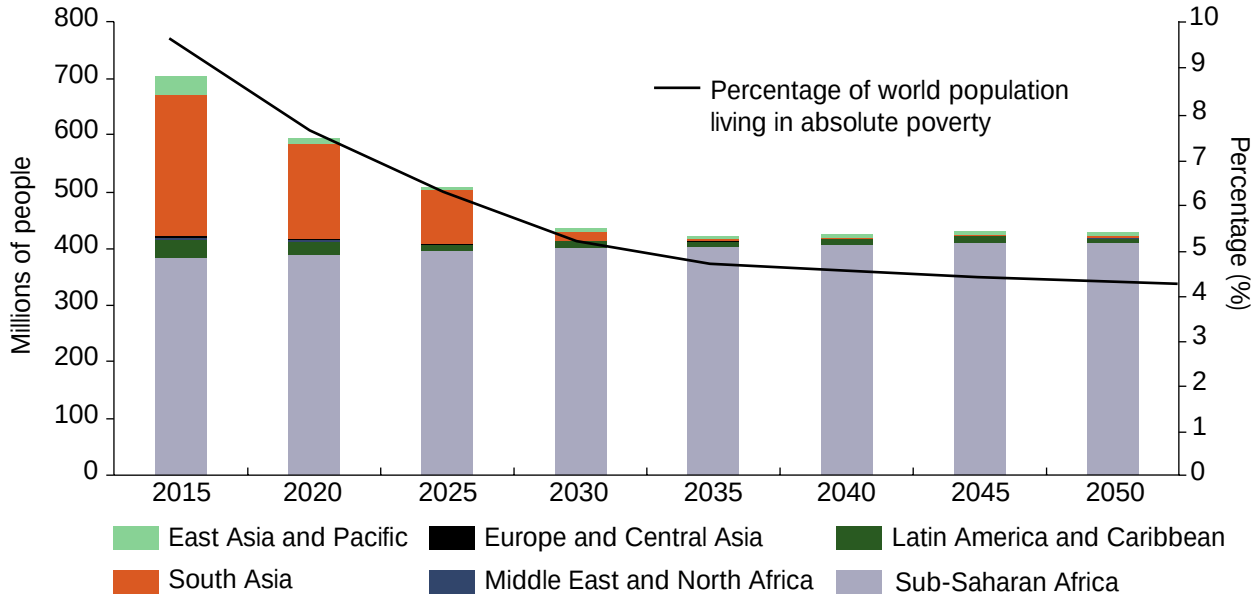
14 European Police Office (EUROPOL), (2015), 'Exploring tomorrow's organized crime'.

In the coming decades, the very highest earners will almost certainly remain rich, entrenching the power of a small elite. Vested interests could reduce the prospect of economic reforms that would benefit the poorest. Even in Asia (where absolute poverty is likely to be eradicated over the next 30 years), some ethnicities, genders, sexualities, castes and religions are likely to remain as barriers to prosperity, as well as employment and social opportunities. Economic growth will probably be concentrated in cities, resulting in urban residents enjoying opportunities and increasing prosperity not seen by rural residents, creating further inequality. Urban inhabitants who own property are likely to be especially fortunate. Many urban residents in the rapidly growing cities of Asia and sub-Saharan Africa are likely to live in slums, characterised by limited governance and services.[15] In these areas, criminal groups might fill the gap left by governments to an increasing extent. For example, drug gangs already provide welfare services, protection and job opportunities in the favelas of Rio de Janeiro and São Paulo.

> “Vested interests could reduce the prospect of economic reforms that would bene□t the poorest.”

Security, fragility and poverty. Security, fragility and poverty are highly intertwined and can be drivers of discontent. The proportion of the world's population living in poverty (on less than US $1.90 a day at purchasing power parity 2015) is likely to decline from around 10% in 2015 to approximately 4% (roughly 420 million people) by 2050. On current trends, absolute poverty is likely to be almost eliminated in Asia, Latin America and most of East and North Africa by 2030, with India joining this list by 2035. Poverty is, however, likely to endure in much of sub-Saharan Africa.[16] Although absolute poverty will reduce, there are still likely to be substantial numbers of people who are very poor. These populations will have substantial material wants and remain particularly vulnerable to shocks. The trend towards a reduction in the number of people living in absolute poverty could be reversed, particularly if populous states (such as the Democratic Republic of the Congo) descend into conflict. While not all fragile countries will have substantial impoverished populations, most poverty will be linked to fragility, and the poorest countries are likely to remain especially vulnerable to natural disasters and other humanitarian crises.

Projected decline in absolute global poverty



Source: Department for International Development, Chief Economists Office

15 UN Department of Economic and Social Affairs (DESA), Population Division, (2014), *World Urbanization Prospects: The 2014 Revision*, CD-ROM Edition.

16 Dissanayake, R., *et al*, (2017), DFID, Chief Economist's Office, *Three Worlds In 2050: Scenarios for Poverty and Development*, a research paper prepared for DCDC.

Some governments appear to be aligning the state with a particular religion

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Political pressures

Religion and nationalism. While the latter half of the 20th Century saw governments take more secular positions, many now appear to be going in the opposite direction, aligning the state with a particular religion. Examples can be found across the world. Viktor Orban, Hungary's prime minister, gave a speech arguing that Europe as a civilisation would die unless it re-discovered its Christian heritage. Vladimir Putin has tied the Russian Orthodox Church to Russian identity and Turkey is taking an increasingly Islamic-nationalist position. In India, Hindu nationalists and Muslims are adopting harder viewpoints, and both Pakistan and Bangladesh have been moving towards religious nationalism. Even the Chinese Communist Party has incorporated Confucian and Buddhist narratives into the new Chinese national narrative.[17]

Rising religious nationalism, particularly when combined with intolerance for other religions, increases the risk of conflict both between and within countries. For example, sub-Saharan Africa could see an arc of conflict from Nigeria via Ghana to Sudan between Christians and Muslims.[18] Similarly, the Sunni-Shia divide, alongside Saudi-Iranian competition, is likely to drive, and be driven by, conflict in the Middle East. **Rising religious nationalism could exacerbate existing tensions in flashpoints around the world, increasing the risk of conflict both within and between countries.** There are, nevertheless, some parts of the world where religious difference appears to be reducing in importance. In North America and western Europe, for example, the increasing ethnic and religious diversity of their populations may force politicians and policymakers to adopt a 'religion-neutral' approach to avoid alienating potential voters. Similarly, South Korea, which had experienced an upswing in Christianity, also appears to be becoming more secular.[19]

Populism and nationalism. Support for populist and nationalist movements could grow in the coming decades. The world is experiencing unprecedented levels of population movement, facilitated by significant improvements in technology (which have dramatically reduced the time and cost of travel), and these trends are likely to continue. This unprecedented movement of people and ideas has brought a greater degree of understanding and tolerance in some circles, but in others it has led to tension and the erection of barriers (both physical and virtual) through fear of increased competition over jobs and resources, as well as perceived threats to cultural identity. If job numbers are

17 Hart Group Oxford XXI, (2018), GST Future Beliefs, page 14, a research paper commissioned by DCDC.

18 *Ibid.*, page 40.

19 *Ibid.*, page 41.

reduced, wages are lowered by automation and levels of migration also remain high (which seems likely), widespread dissatisfaction can be expected. In the West, feelings of disenfranchisement have led to support for more radical political groups. In countries such as South Africa, India and Pakistan, higher levels of urbanisation, together with an increase in the number of foreign migrants, are leading to the emergence of a new wave of nationalist and populist leaders.[20]

Information and politics. As the amount of information being produced and disseminated grows, information technology will become an increasingly important political tool. The availability of real-time user analysis to measure trends in public opinion might also allow state and non-state actors to manipulate or control political views and voting behaviour.[21] The threshold between publicising a political agenda and swaying the views of the public with misleading information is not clearly defined and leaves a grey area, which could be increasingly exploited.[22] There are already signs that social media platforms are being used to mobilise people on the basis of discontent, making them a valuable tool for populist and nationalist movements that seek to feed on fear and insecurity. Digital communications are likely to be increasingly powerful tools for political mobilisation, potentially facilitating political power transitions.

Art and politics. Throughout history the arts have played a role in the world's social, political and ideological struggles, and there is no expectation that this will cease. Artists will continue to use their work to engage in criticism, or to act in defence of a cause. Recently, the way in which art is disseminated has altered with the Internet and social media allowing art to be seen by a wider audience, including protest and activist art. For example, the Chinese dissident artist Ai Weiwei gains public exposure through his WeChat channel and through his hundreds of thousands of followers on Instagram, with whom he shares images that not only criticise the Chinese regime but also provide more general social and political comment.[23]

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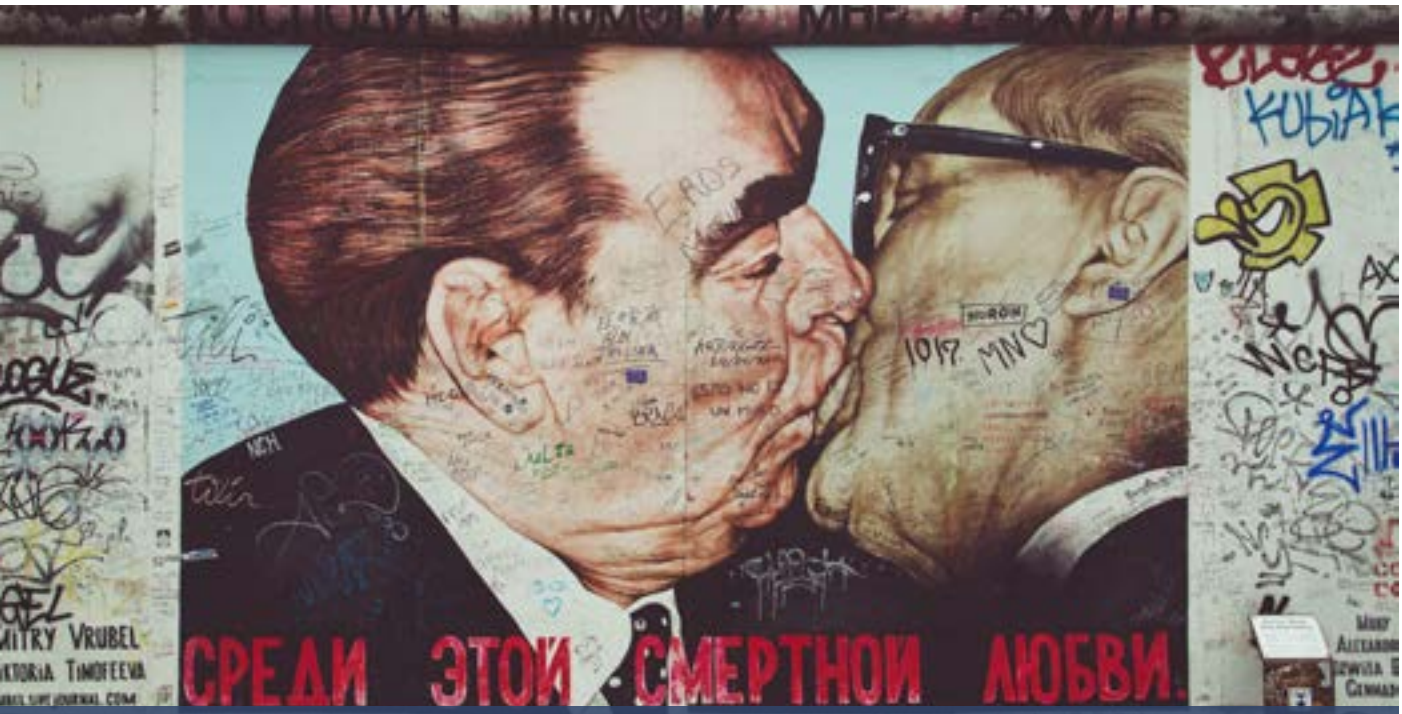
Art will still play a role in ideological and political struggles: life jackets draw attention to the plight of drowning migrants

20 Cheeseman, N., *How will governance within current state boundaries in Africa change over the next 30 years?*, a research paper commissioned by DCDC.

21 Dutton, W., (2009). Prometheus, Volume 27, (2009), *The Fifth Estate Emerging through the Network of Networks*, page 3.

22 Bennet, W. L., (2016), *News: The Politics of Illusion,* pages 209-210.

23 Lesser, C., Artsy, (7 November 2016), 'Ai Weiwei Returns to New York with Powerful Shows at Deitch Projects, Mary Boone, and Lisson'.



Artists may take on a greater role in shaping societal opinion and decision-making

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> The ability of the arts and cultural heritage to bring together divided communities and build trust is likely to become more widely recognised.

As the ability to publish art via social media and other forms of online dissemination increases, artists (both professional and amateur) may take on a greater role in shaping societal opinion and decision-making, expanding the role of art as a political influence tool. For example, Daesh digitally published traditional Islamic poetry in support of their cause, presumably as an attempt to influence hearts and minds. At the same time, the arts may increasingly be used as a tool for reconciliation in post-conflict environments. An example is David Best's temple in Northern Ireland, built to symbolise and promote healing between Catholic and Protestant communities. The ability of the arts and cultural heritage to bring together divided communities and build trust is likely to become more widely recognised,[24] whilst digital media may also facilitate projects aimed at building trust and reconciliation both internationally and within fragmented communities.

Online gaming will become ever more realistic, immediate and interactive, creating large Internet communities with increasing social and political relevance.[25] The potential for these virtual worlds to develop into a space for political activism should not be underestimated. In particular, where repressive regimes seek to clamp down on other forms of public protest (such as physical rallies or online social media campaigns), activists might seek to exploit these less obvious channels as a way of mobilising dissent. It is not inconceivable that a virtual equivalent of the Arab Spring will occur, where an uprising which begins within an online gaming community expands into the real world.

Political transitions. The increased weight of urban voices could undermine the hold on power of ruling parties. In several countries, incumbent regimes depend on their rural constituencies to remain in power, and in Africa, urban areas appear to be more likely than rural constituencies to back opposition parties. Most recent transfers of power have resulted, at least in part, from influential urban constituencies swinging behind an opposition party.[26] Because of short-term electoral pressures, democratically elected governments may find it more difficult than authoritarian regimes to balance competing

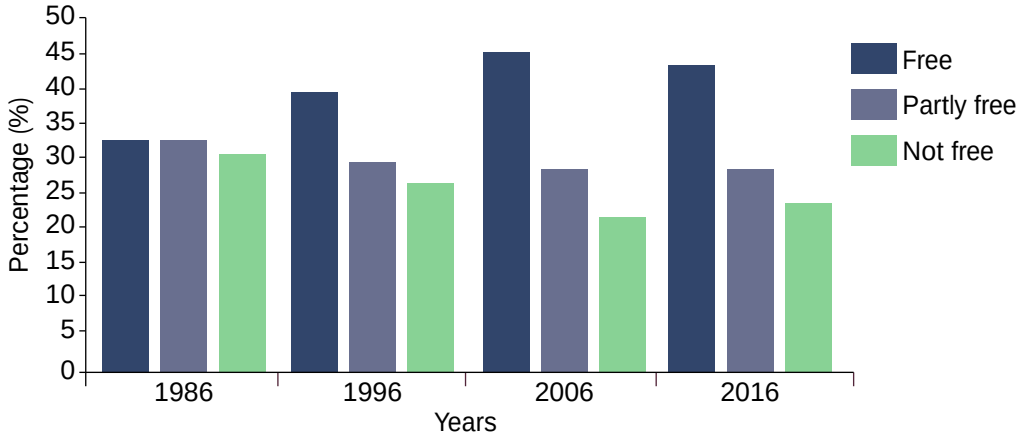
24 British Council, (2016), *Art connects us: our strategy for the arts*.

25 Wenger, J., (2017), *The Future of Art, Expression and Design*, a research paper commissioned for DCDC.

26 Cheeseman, N., *How will governance within current state boundaries in Africa change over the next 30 years?*, a research paper commissioned by DCDC.

demands and make difficult and unpopular decisions to prepare for the future. Authoritarian governments are, however, less likely to manage transitions of power as peacefully as established democracies, and so may be more at risk of violence and revolution, although young democracies are also vulnerable. Nevertheless, despite the optimism surrounding the Arab Spring uprisings in 2011, authoritarian systems are proving to be extremely resilient. Illiberal and authoritarian forms of governance may be on the rise. Although the number of 'free' countries in the world has slightly increased over the last 20 years, the last decade has seen a decrease in global freedoms with Freedom House identifying 105 countries that have become less free during the period.[27]

Changing percentage of countries classified as free



Note: Free defined by Freedom House, Freedom World 2018.

Source: Freedom House

State fragmentation. Devolutionary pressures and continued separatist demands mean that some countries may not exist in their present form by 2050. Greater globalisation and advances in technology may lead to the fragmentation of some states as sub-regions are able to deal directly with counterparts in other countries, effectively bypassing governments. In other cases, while there may not be pressure for national borders to be altered, there could be increasing calls for devolution of power to the local level, particularly as cities gain greater economic, demographic and political weight.

Today's megacities have bigger economies than many countries, and their economic weight is likely to grow. This will increase their ability to act independently of their national government. For example, the decision of several US cities, states and technology firms to sign up to the Paris Agreement on climate change, in response to the US Federal Government's decision to withdraw from it, may in the future be replicated by other cities on different issues. As urban areas grow, the capacity and mandate of municipal authorities is also likely to increase, not least to handle the challenges of developing and expanding new urban infrastructure. If the power and influence of major global cities expand in the coming decades, they (and their populations) may have more in common with other cities around the world than with their national government.[28] Those multinational corporations that thrive in the coming years are also likely to become bigger and more powerful, and they too may be increasingly able to act independently from the state.

27 Dorman, A. and German, T., (2017), *How will governance within current state boundaries change over the next 30 years?*, a research paper commissioned by DCDC, page 8.

28 Dorman, A. and German, T., (2017), *How will the overarching global political order change over the next 30 years?*, a research paper commissioned by DCDC, page 21.

Evolution of the state system. Despite the many challenges that the state is likely to face in the coming decades, it has proved remarkably resilient and will remain a key component of the international system. It is, however, likely to occupy a less central role by 2050, since the capacity of individual states to single-handedly deal with the array of challenges they face is likely to diminish. Instead, governments may increasingly exercise their power through accommodation with other actors. From a global perspective, political power and authority may be based on a networked governance system, which may not sit neatly within the borders of a particular country.

Crime and corruption

Organised crime and corruption. In 2017, transnational crime was estimated to have generated between US $1.6-2.6 trillion of illicit profit, threatening peace and security, and undermining the economic, social, cultural and political development of societies around the world.[29] Since 2010, organised crime has expanded dramatically in size, scope and influence, and it has diversified, globalised and reached macroeconomic proportions.[30] Organised crime will probably continue to influence local, national and (in some cases) international governance.

Corruption. Corruption (the abuse of public positions of trust for private gain) is closely related to organised crime and drives state fragility by weakening the social contract between state and its citizens. Corruption also increases inequality and is a major obstacle to development and poverty reduction. By some estimates, businesses and individuals worldwide pay between US $1.5-2 trillion in bribes every year.[31] Technology could, however, reduce the opportunities for corruption in the coming decades; for example, using the Internet to apply and pay for government licences (possibly using distributed ledger (or blockchain) technology to record transactions) thereby reducing opportunities for corrupt officials to demand bribes. Increasing levels of education and a growing lack of tolerance of corruption from businesses, including international investors and insurance companies, may make it more difficult to get away with corrupt behaviour in the future.

Technology may reduce opportunities for corruption

29 May, C., Global Financial Integrity, (27 March 2017), *Transnational Crime and the Developing World*.

30 UN Office on Drugs and Crime, (2010), *The Globalization of Crime: A Transnational Organized Crime Threat Assessment*.

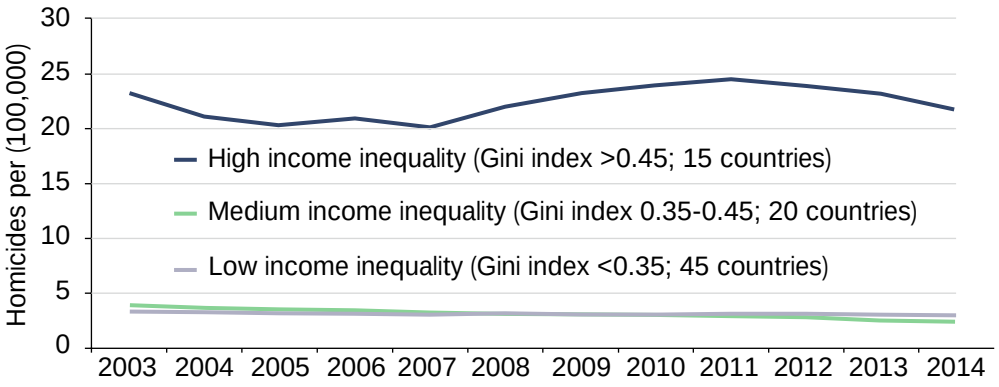
31 Kaufmann, D., International Monetary Fund, (September 2015), 'Corruption Matters'.

Organised crime and conflict. Corruption and organised crime are strongly correlated with politically instability, violence and extremism.[32] Organised criminal groups will probably remain an integral part of conflict, particularly civil wars, where they are likely to compete with states for power and profit, or establish alliances with corrupt or fragile governments.[33] **Organised crime (or state actions disguised as such) will continue to be used as an instrument in hybrid or covert warfare.** For example, the Russian government is believed to have used criminal networks to conduct assassinations, coercion and cyberattacks. Due to their different objectives, most historical examples of cooperation between a state and criminal groups have tended to be counterproductive for the state, and this is likely to hold true in future. State actions disguised as organised crime, however, may well be part of future hybrid (or grey zone) warfare.

> “Markets for illicit goods and sex will remain important sources of revenue for criminal groups.”

Criminal violence. Between 2003 and 2014, homicide rates fell in high and upper-middle income countries, while remaining steady in low and lower-middle income countries. Central and South America, the Caribbean and Southern Africa have all suffered from particularly high rates of homicide, especially in urban areas.[34] For example, in 2015, El Salvador's homicide rate surpassed one murder per thousand people, and for comparison there was approximately one murder per one hundred thousand in the UK in 2017.[35] Homicide victims were overwhelmingly young and male, and homicide rates were closely related to income inequality. With increasing urbanisation, growing populations and rising inequality, there is a substantial risk that many cities in developing countries, particularly sub-Saharan Africa and South Asia could experience very high murder rates, similar to those seen in Latin America today.

International homicides by level of income inequality



Note: Gini index is a measure of income inequality.

Source: United Nations Office on Drugs and Crime, Homicide Statistics (2016)

Smuggling, vice and trafficking. Markets for illicit goods and sex will remain important sources of revenue for criminal groups, but technology is likely to have a significant impact in future, for better and worse. Criminals will continue to obtain weapons, but traditional arms smuggling could be replaced as criminals (particularly in developed countries) find it cheaper and easier to use 3D printing to make guns and to create homemade explosives from Internet-sourced recipes. Synthetic substances may come to dominate the global drugs market, overtaking cocaine and heroin. This shift would cause significant disruption to current trafficking routes and reduce the importance of existing growing sites in countries such as Afghanistan.

32 Chayes, S., Fragility Study Group, (September 2016), *Policy Brief Number 1: Corruption and State Fragility*.

33 Cockayne, J., (2016), *Hidden Power: The Strategic Logic of Organized Crime.*

34 Cockane, J. and Roth, A., United Nations University, (2017), *Crooked States*, a research paper commissioned by DCDC.

35 *The Economist*, (7 April 2018), 'Latin America's homicide problem is a harbinger for the developing world'.

By 2050, it may be easy to download recipes for synthetic drugs, rendering some smugglers and low-level drug dealers obsolete. Legalised synthetic recreational substances might also be produced that are less harmful, allowing governments to reduce the toxicity of drugs, generate revenue and starve criminal dealers of profit.

If rapid population growth in Africa and Southern Asia is not followed by economic development, the appeal of illegal migration is likely to increase, providing greater opportunities for people traffickers. Gender imbalances in some countries may add to the profitability of sexual exploitation. Other illegal markets are also likely to become more entrenched. For example, the trade in illegal wildlife products is already one of the world's largest illicit markets, involving nearly 7,000 different species and generating between US $5 billion to US $23 billion in revenue annually.[36] Asia is likely to remain the major market for these products, although the Gulf, Latin America and Africa may also become important destinations.

> "Gender imbalances in some countries may add to the profitability of sexual exploitation."

Fraud and counterfeiting. Ageing populations, particularly in Europe and East Asia, may offer greater opportunities for criminal groups to exploit elderly people.[37] In particular, acts of fraud against pension and social benefit schemes are likely to increase, as is targeting of the health care industry, which could offer criminals lucrative profits. Where food and water supplies are scarce, counterfeit goods may be sold by organised criminal groups, making buyers vulnerable to health and safety risks.

Illicit financial flows. Between 2005 and 2014, illicit financial flows grew at an average rate of between 8.5% and 10.1% a year, with a total value of US $1 trillion in 2014.[38] As a share of total global trade, it has remained relatively constant. Illicit financial flows are closely tied to high levels of systemic corruption, which may in turn perpetuate inequality, lead to sociopolitical insecurity and harm economic progress, particularly in developing countries. Sub-Saharan Africa has been the region most severely affected by the illegal movement of money due to high levels of fragility and poor governance. Digital currencies and peer-to-peer payment networks may provide significant new opportunities for criminal organisations to move their funds, thus weakening affected states' control over revenues and their economies. However, technology is also likely to provide opportunities to monitor payments and identify illegal transactions. International cooperation to control financial flows, seize illicit assets and curtail tax avoidance among major corporations is likely to become increasingly important in the coming decades.

Synthetic substances may come to dominate the global drugs market, overtaking cocaine and heroin

36 May, C., Global Financial Integrity, (27 March 2017), *Transnational crime and the developing world*.

37 EUROPOL, (2015), *Exploring tomorrow's organized crime*.

38 Global Financial Integrity, (April 2017), *Illicit Financial Flows to and from Developing Countries: 2005-2014*.

Algorithms could even predict criminal activity before it occurs

Cybercrime. The number of cybercrimes has expanded significantly in recent years, as has their financial impact. A variety of different methods are used to estimate the cost of cybercrime and, hence, figures vary widely.[39] By one estimate, between 2013 and 2015, the cost of cybercrime quadrupled, and is expected to quadruple again by 2019 to US $ 2.1 trillion a year.[40] Advances in information technology, automation and artificial intelligence will have profound implications for the future of crime. In a world where almost every instruction, process, transaction and secret is located in cyberspace, there could be a wealth of opportunities for criminals. Cybercrime is likely to have an increasingly severe impact in the coming decades, and will require law enforcement agencies to collaborate internationally and with private companies to combat the threat.

With relatively low start-up costs and potentially huge profits, cybercrime will appeal to people in countries with limited economic opportunities. For example, most cyberattacks against targets in the European Union primarily originate outside the region.[41] This presents challenges for law enforcement organisations, although by 2050, technological advances may make it more difficult to conduct cybercrime. Over the next 30 years, cyberspace will also provide a new venue for competition and collaboration between states, criminal groups and other aspiring governmental actors. The ability to subjugate and control cyberspace and data might become the most effective way of exerting economic, military and political power for both state and non-state actors.[42]

Law and justice

Law enforcement. As crime becomes more sophisticated, so will policing. In addition to keeping the streets safe, police forces (at least in developed countries) are also expected to police inside the home, preventing domestic abuse and coercive control, and police cyberspace. This will require new policing models supported by an unprecedented degree of specialisation and expert knowledge. A high level of cooperation between governments, private businesses and non-governmental organisations will also be

39 Levi, M., Crime, Law and Social Change 67 (1), (2017), *Assessing the trends, scale and nature of economic cybercrimes: overview and issues*.

40 Morgan, S., Forbes, (17 January 2016), 'Cyber Crime Costs projected to reach $2 Trillion by 2019'.

41 EUROPOL, (2014), *The Internet Organised Crime Threat Assessment 2014*.

42 Cockane, J. and Roth, A., United Nations University, (2017), *Crooked States*, a research paper commissioned by DCDC.

Technology will play a growing role in surveillance and policing

needed. If cyberspace retains its transnational nature, law enforcement in cyberspace will need substantial international collaboration, with private firms likely to play a crucial role in protection, prevention and detection. For example, providing online identity and verification services is primarily provided by commercial organisations. The probable growth in the cybersecurity industry, both domestically and internationally, may, however, further erode states' monopoly on law enforcement.

Surveillance. Technology will play a growing role in surveillance and policing. Facial recognition technology could monitor a suspect's every move in public, and the use of algorithms may predict some kinds of criminal activity before it occurs.[43] Evidence extracted from Internet-connected devices, including those used in the home, will be used in future criminal prosecutions. These kinds of technological advancements could have profound implications for citizens' right to privacy, and developments in this area are likely to be contested, at least in some countries. Chinese authorities are developing a social credit system, which uses government data to grade citizens' 'worthiness'. While purportedly aimed at tackling corruption and poor-quality goods, the system demonstrates governments' increasing power to monitor every aspect of their citizens' lives. Similar developments may also take place in other countries.[44]

The development of legal practice. Technological advancements are also likely to change the practice of law. Artificial intelligence and big data analytics will allow huge quantities of material to be rapidly sifted and analysed, while other routine and less complex legal tasks are likely to be automated. Over time, developments in artificial intelligence could mean that machines take on ever more complex tasks. In remote areas where lawyers are scarce and expensive, online legal services may open up access to justice. Digitally-delivered justice is likely to be cheaper and could be more consistent,

43 Ng, Yi Shu, Mashable, (24 July 2017), 'China is using AI to predict who will commit crime next'.

44 Hawkins, A., Foreign Policy, (24 May 2017), 'Chinese Citizens Want the Government to Rank Them'.

objective and impartial, although it could also be blunt and harsh, for example, it might fail to recognise extenuating circumstances. Technology is also likely to play a greater role in punishment and offender management. For example, Global Positioning System (GPS) tagging (already used to monitor some offenders) could be used to prevent travel on public transport. Technology could also be used to deny access to certain areas of the Internet and prevent the purchase of prohibited materials such as alcohol. This could reduce the size of the prison population, lowering costs for governments.[45] In the coming decades, technology could also be used in criminal rehabilitation, for example, virtual reality simulations could help offenders develop and practice coping strategies for situations that may lead to criminal behaviour.

Regulation of new technologies. Advances in technology will have far-reaching legal implications that could test governments' abilities to adapt the law quickly enough to mitigate any disruptive effects on society. Many technologies are likely to have applications outside their country of origin, which may have implications for international law. However, it is unlikely that a multilateral consensus would be achieved rapidly. As a result, much of the regulatory response to new technologies is likely to initially take place at the national, or even local, level before happening at a transnational level. In some cases, regulation and standard-setting will probably be driven by non-governmental organisations (including industry and insurers) rather than countries, potentially seeing states ceding leadership on international standardisation.[46]

> “Virtual reality simulations could help offenders develop and practise coping strategies for situations that may lead to criminal behaviour.”

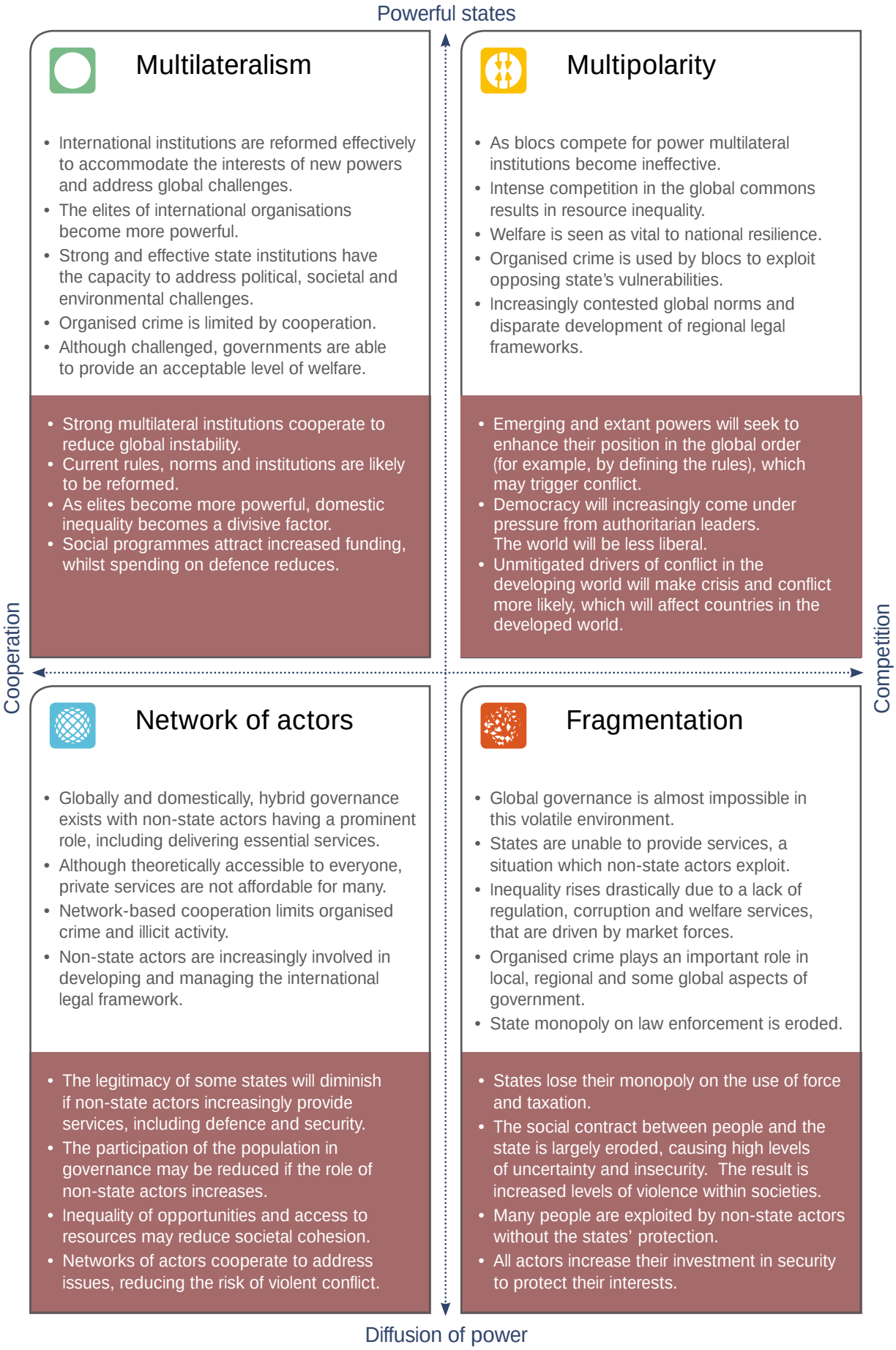
The development of new technologies could pose challenging ethical questions. For example, technologies could be developed that substantially boost physical and cognitive capabilities. Those who hold a professional duty of care towards the public (such as military or medical personnel) may have an obligation to use those technologies to ensure the highest performance. Advancements in fields such as genetic engineering, artificial intelligence and creating synthetic life forms will pose moral questions where an international consensus could be difficult to obtain,[47] particularly if sentient (conscious) intelligence is developed. Perhaps more plausibly, machines will be developed that many people believe are sentient and some people could form strong emotional attachments to their machines, especially to robots with appealing features, such as those used in a caring role.

45 Moody, G., techdirt.com, (18 August 2017), 'Welcome To The Technological Incarceration Project, Where Prison Walls Are Replaced By Sensors, Algorithms, And AI'.

46 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, a research paper commissioned by DCDC.

47 Parasidis, E., (2011), 'The Essence of Being Human', in Muller, S., *et al.*, *The Law of the Future and the Future of Law*, page 523.

Future worlds: Governance and law



Multilateralism

- International institutions are reformed effectively to accommodate the interests of new powers and address global challenges.
- The elites of international organisations become more powerful.
- Strong and effective state institutions have the capacity to address political, societal and environmental challenges.
- Organised crime is limited by cooperation.
- Although challenged, governments are able to provide an acceptable level of welfare.

- Strong multilateral institutions cooperate to reduce global instability.
- Current rules, norms and institutions are likely to be reformed.
- As elites become more powerful, domestic inequality becomes a divisive factor.
- Social programmes attract increased funding, whilst spending on defence reduces.

Multipolarity

- As blocs compete for power multilateral institutions become ineffective.
- Intense competition in the global commons results in resource inequality.
- Welfare is seen as vital to national resilience.
- Organised crime is used by blocs to exploit opposing state's vulnerabilities.
- Increasingly contested global norms and disparate development of regional legal frameworks.

- Emerging and extant powers will seek to enhance their position in the global order (for example, by defining the rules), which may trigger conflict.
- Democracy will increasingly come under pressure from authoritarian leaders. The world will be less liberal.
- Unmitigated drivers of conflict in the developing world will make crisis and conflict more likely, which will affect countries in the developed world.

Network of actors

- Globally and domestically, hybrid governance exists with non-state actors having a prominent role, including delivering essential services.
- Although theoretically accessible to everyone, private services are not affordable for many.
- Network-based cooperation limits organised crime and illicit activity.
- Non-state actors are increasingly involved in developing and managing the international legal framework.

- The legitimacy of some states will diminish if non-state actors increasingly provide services, including defence and security.
- The participation of the population in governance may be reduced if the role of non-state actors increases.
- Inequality of opportunities and access to resources may reduce societal cohesion.
- Networks of actors cooperate to address issues, reducing the risk of violent conflict.

Fragmentation

- Global governance is almost impossible in this volatile environment.
- States are unable to provide services, a situation which non-state actors exploit.
- Inequality rises drastically due to a lack of regulation, corruption and welfare services, that are driven by market forces.
- Organised crime plays an important role in local, regional and some global aspects of government.
- State monopoly on law enforcement is eroded.

- States lose their monopoly on the use of force and taxation.
- The social contract between people and the state is largely eroded, causing high levels of uncertainty and insecurity. The result is increased levels of violence within societies.
- Many people are exploited by non-state actors without the states' protection.
- All actors increase their investment in security to protect their interests.

Watch points

- Transnational issues are, increasingly, addressed through multilateral cooperation.
- Emerging powers begin out-competing the established powers.
- Changes in the ability of multilateral institutions to accommodate relevant actors' interests.
- The number of autocracies compared to democracies.
- The prevalence of organised crime.
- The support for, and success of, multilateral institutions.
- Ability of states to collect taxes and enforce the law.
- The capacity of states to operate in a social media-driven environment.

Discontinuities

- War, disaster or financial crisis leads to a sudden change in the global order.
- Unexpected development (collapse or change in approach) of one of the current major powers.
- Regime change in one or more of the major powers.
- Role of multilateral organisations is undermined by societal disapproval.
- Widespread adoption of collective values and rejection of universal human rights.
- Emergence of a new, and successful, political ideology.

Implications

- The current global order will increasingly come under pressure. Changes to the global distribution of power will necessitate adaptation of the existing governance architecture within the international system. If insufficient effort is made to accommodate the interests of rising powers, a breakdown of the international order is highly likely.
- States will need to shape the change in international order and proactively respond to the influence of non-state actors if they are to remain the primary actors in the global system. The social contract between a state and its citizens will need to evolve to maintain social cohesion.
- Global and domestic inequality will need to be addressed to maintain social cohesion and avoid rifts between the state and the people.
- The current global legal framework will be increasingly challenged, possibly giving rise to more informal mechanisms, which will in turn undermine the extant regulatory framework and increase its vulnerability to non-compliance and subversion.
- Technological advances could fundamentally change the relationship between people and the state as education, health care, lifestyles, labour markets and taxation models are altered. This change could occur over an extended period of time and therefore require strategic choices that endure beyond election cycles.
- Alternative models for providing state services and functions could emerge, resulting in a competition for peoples' allegiances. Agile states that are able to make a consistently better offer, and develop a strong narrative, are more likely to succeed in this competition and may better manage internal inequalities.
- Global cooperation will be needed to address organised crime. If it is not, it will become an increasing threat to governments and communities, fuelling conflict and violent extremist organisations.
- States will increasingly need to work in partnership with a range of actors. Those that do so effectively will gain a substantial competitive advantage.

Conflict and security

Synopsis

The world order is changing and current norms and institutions are being challenged. If the current institutions fail to adapt, a period of volatile transitions could follow. As the balance of power shifts from West to East, competition between states and other actors is likely to intensify and become ever more persistent. Whilst the risk of a war between states is likely to remain low, but not implausible, sub-threshold conflict is likely to become increasingly common. The number of intra-state and non-state conflicts has been increasing and this is likely to continue. Inequality and a sense of injustice, religious intolerance, nationalism and intolerance of immigrants are on the rise and could mutate into violent ideologies. Continuing instability in the Middle East and South Asia are also likely to perpetuate the activities of Islamic violent extremist organisations. Some actors are likely to exploit these and other grievances using misinformation (fake news) and propaganda to erode trust in governments and provoke conflict. The boundary between war and peace will become blurred and actors will, increasingly, use a hybrid approach to warfare, going beyond military and economic activities and opening-up new arenas of conflict, including in cyberspace, augmented and virtual reality. The rules-based international system has not evolved to deal with these challenges and is likely to struggle to respond effectively. Arms control regimes, already under stress, are also likely to struggle to cope with new challenges such as cyber, directed energy weapons and hypersonic weapons, and the use of artificial intelligence in conflict.

The oceans, polar regions and space have all seen increased levels of activity and are likely to become the focus of increasingly intense competition, and possibly conflict, as states compete for resources and influence. Cyberspace is already an active battleground and as more people spend more time conducting an ever-widening range of activities, it could become the vital ground of the future. Similarly, as more people live in cities they too are likely to become more central to conflict. States are likely to remain the central actors in future conflicts but violent extremist organisations, irregular actors and private security companies are likely to play an increasing role. The state will increasingly need to work in partnership with a range of actors, particularly technology firms. Those that do this most effectively will have a substantial advantage over their opponents. The number of nuclear-armed states is likely to rise and increasing investment in tactical nuclear weapons will increase the risk of nuclear weapons being used. Weapon systems such as rail guns, directed energy weapons and hypersonic missiles will allow possessors to strike rapidly, practically anywhere in the world. As machines and artificial intelligence become more capable, they will play an increasing role in conflict and combat. Technology will continue to change the character of conflict, and possibly its nature.

Context

The global context. As global power is redistributed, current norms and institutions will be challenged,[1] and new stresses will emerge. The international legal environment is likely to become more fragmented, with competing local and regional interpretations of international standards increasingly prevalent.[2] As populations and economies grow, competition for resources is likely to intensify and, in a more fragmented, multipolar context, could increase the risk of conflict. If the world trading system breaks down, a less integrated and less globalised economic system may also mean that, for some countries, the cost of military action could reduce. Therefore, the risk of war between states in the coming decades cannot be ruled out.

Great power rivalry. Historically, when great powers emerge and alter the world's geopolitical balance, conflict often follows. Change to the global order is likely to create several opportunities and incentives for great powers to challenge one another. For example, China's growing economic, military and diplomatic capability could equal, or even surpass, that of the United States (US) in the coming decades. Potential developments in North Korea and disputes over maritime territory in the East and South China Seas all provide potential flash points between China, the US and their respective allies. India's economy is also growing rapidly, and it may emerge as a great power during the next 30 years. India and China's shared 3,000 kilometre border has already seen clashes, and the two countries are likely to increasingly vie for influence and control, not least in the Indian Ocean. Russia has also become more assertive in recent years and, though unlikely to want a major conflict with the West, is likely to use sub-threshold conflict (activity that remains below the threshold of armed aggression to avoid reprisal), and the threat of it, to pursue its aims. In addition to great power rivalry, many regional power struggles will also endure and some could turn violent. The Middle East is one theatre where an enduring regional power contest has become more violent since the end of the Cold War. Iran and Saudi Arabia will continue to vie for influence and both sides are engaged in regional conflicts. Outside the Middle East, multiple territorial disputes remain unresolved, particularly in Africa and Asia, many of which could lead to conflict.

Regional power struggles will endure and some could turn violent

HomoCosmicos / iStock.com

1 Peerenboom, R., (2011), 'The Future of Law in a Multi-Polar World: Toward a Global New Deal', in Muller, S., *et al.*, *The Law of the Future and the Future of Law*, page 43.

2 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, page 6, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC).

Evolving nature of power. Globalisation and technology have combined to create complex interdependencies and more ways and means for nation states to influence each other. The terms 'soft power', 'smart power' and 'sharp power' were all coined to describe how influence can be achieved beyond using simple military and economic power. Increasing numbers of actors are likely to have the ability to influence events across the globe.[3] Technology such as cyberspace, augmented and virtual reality will open up new arenas within which human desires can be met more reliably and efficiently than in the 'real world'. Although the extent to which power and influence in these arenas will translate to traditional domains is not clear. Citizens may increasingly seek allegiance to forms of authority beyond the nation state. For example, citizens could owe their allegiance to corporations that make it their business (literally) to reliably understand, predict and fulfil the needs and wants of citizens. The driving forces of future conflicts may involve corporations seeking resources, or civil conflicts involving large numbers of disenfranchised or excluded citizens confused about where their allegiances lie and being dissatisfied with systemic changes. Corporations may be able to 'discipline' citizens on their own terms by disconnecting offenders from vital electronic systems such as medical care, navigation, education or employment. Security in domains such as cyberspace could be outsourced to selected 'tech-savvy' individuals or sub-contractors. Conflict is most likely to occur where the relative power differentials are greatest and where power is contested or redistributed.

> "Citizens may increasingly seek allegiance to forms of authority beyond the nation state."

Defence spending. Defence spending has been declining globally since 1960 as the level of violence has dropped and, on current trends, defence spending is likely to continue to fall. Currently, the US spends more on defence than any other country, although the proportion of its gross domestic product (GDP) spent on defence has declined from 4.7% in 2010 to 3.3% in 2016. In 2017, China spent the second largest amount on defence, using around 2% of its GDP (approximately a third of what the US spent). However, when China's GDP surpasses that of the US, as is expected, it could become the global leader in defence expenditure. The proportion of GDP that India spends on defence has been declining in recent years (in 2017 it used around 2.5% of its GDP, compared to a high of 4.2% in 1987). If its economy grows as forecast, it will be the third biggest spender on defence by 2050.

France, Russia and the UK currently spend similar amounts on defence, but different proportions of their GDP, around 2% by France and the UK, and an estimated 5% by Russia. A large part of Russia's defence and security expenditure is classified or hidden under other budgets. Along with 'open' spending on national defence and security, the share of defence spending could be at a post-Soviet high.[4] Although Russia is likely to sustain this level of defence spending in the next few years, whether it can be maintained in the longer term is less clear. Across Europe, the average proportion of GDP devoted to defence is currently around 1.5%, although this has fallen recently, despite general economic growth, which is similar to the situation in Canada and the US.[5] Eight of the eleven countries with the highest military expenditure (as a percentage of GDP) are in the Middle East and North Africa, with Pakistan, Iran and Russia recently increasing the proportion of government revenues spent on defence. High levels of military spending indicates that the potential for conflict in these regions will probably endure, as countries facing an external threat (or the possibility of major internal unrest) are likely to devote a high level of their GDP to defence.[6] There are, however, alternative explanations for this expenditure, such as the desire to play a more significant international role.

3 Moyer, J., *et al*, Atlantic Council, (January 2018), *Power and Influence in a Globalized World*.

4 Stockholm International Peace Research Institute (SIPRI) *Military Expenditure Database*.

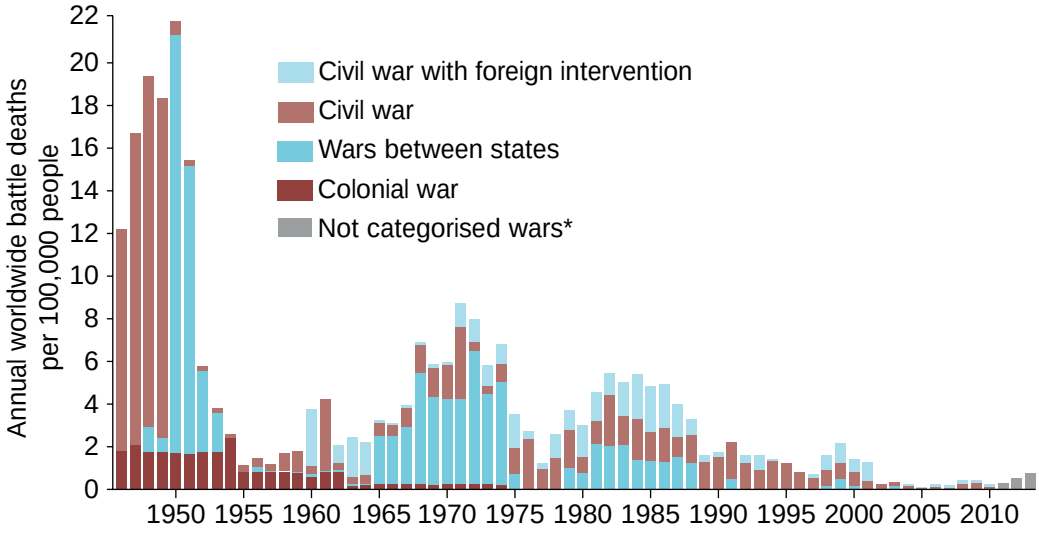
5 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II: Future Defence and Security,* a research paper commissioned by DCDC.

6 *Ibid.*

> As trade between countries has increased, so have the ties between them, and as mutual dependency increases, so does the cost of conflict.

Trends in conflict. Globally, the proportion of lives lost due to armed conflict is at its lowest level since at least the end of the Middle Ages.[7] Western Europe has never enjoyed such a long period of peace, state-on-state conflict in North America and Oceania is almost unimaginable and it has also been over 20 years since there was an international conflict in Latin America. As trade between countries has increased, so have the ties between them, and as mutual dependency increases, so does the cost of conflict, suggesting that the risk of state-on-state conflict will reduce if trade becomes more globalised. The risk of being killed in an armed conflict has also declined considerably since 1946 (although there has been a slight increase since 2005). This is almost certainly due to: a reduction in the number of state-on-state conflicts (the deadliest type of conflict); more precise weapons (causing fewer unintended casualties); better medical care; and effective humanitarian aid.

Global battle death rates in state-based conflicts



* For the period 2011-2013 wars are not designated by type.

Source: Our World in Data, University of Oxford

Intra-state conflict. While the incidence of state-on-state conflict has been declining, the number of armed conflicts is increasing, particularly intra-state conflicts. There are several explanations for this increase, including improved communications leading to more conflicts being recorded. Conflicts are also being more tightly classified, for example, the conflict against Boko Haram in West Africa was described as one conflict in 2014, but in 2015 was split into six separate conflicts depending on the country and allegiance of the armed group. As well as greater reporting of conflict there are other reasons to think the incidence of conflict may continue to increase. For example, today, fewer people are caught in the trap of absolute poverty and, freed from poverty, impotent grievance can turn into conflict. The increasing activity of Islamic violent extremist organisations accounts for a significant proportion of the recent increase in intra-state conflicts, a trend that is likely to endure, not least because of continuing instability in the Middle East and South Asia. The number of intra-state conflicts with at least one external country intervening to support one side has also increased. These conflicts tend to last longer and become more violent, suggesting that the death toll from intra-state conflict is likely to rise.[8]

7 Roser, M., Our World in Data, (2018), '*War and Peace*'.

8 Dupuy, K., *et al.*, Center for Security Studies, for the Peace Research Institute Oslo (PRIO), (2017), 'Trends in Armed Conflict, 1946-2016'.

RuralAfricaClips / Shutterstock.com

Governments will be challenged by the consequences of climate change and population growth

Grievances and inequality. Many parts of the world have recently seen increases in nationalism, intolerance between religious groups and intolerance for immigrants. In most cases these sentiments have not led to armed conflict but there is an enduring, possibly worsening, risk that some may mutate into violent ideology. Income inequality is likely to increase within countries,[9] which may lead to growing resentment and a sense of grievance in many populations. Social media's echo chamber effect (where people only see and hear the views of those with similar opinions, leading to positions being reinforced and hardened) could further drive division within societies. If mass job losses occur because of automation, severe intra-state rifts could develop. While large numbers of unemployed people do not necessarily become violent, they do create a potential for mass-mobilisation,[10] potentially by unscrupulous actors. In addition to inequality within countries, the Internet and social media will lead to groups becoming aware of their relative inequality compared to people around the world and this could also fuel a sense of grievance. Taken together, growing inequality, the risk of mass unemployment and fragmentation of societies, exacerbated by social media, means that the risk of intra-state and non-state conflict looks likely to increase.

Many governments are likely to be challenged as the effects of climate change start to be realised, and populations continue to grow, mainly in developing economies. Limited resources and limited (albeit in many cases improving) capacity of governments, combined with the likely impact of climate change, means that parts of Africa, Central and South America and Central, South and Southeast Asia may all experience conflict in the coming decades. Rapid population growth and enduring poverty means that Africa will be at particular risk. Poverty is a key driver, and there is a strong correlation between corruption, organised crime and violence.[11] A gender imbalance is also associated with higher levels of violence, and many Asian countries are likely to have significantly more men than women in 2050.[12]

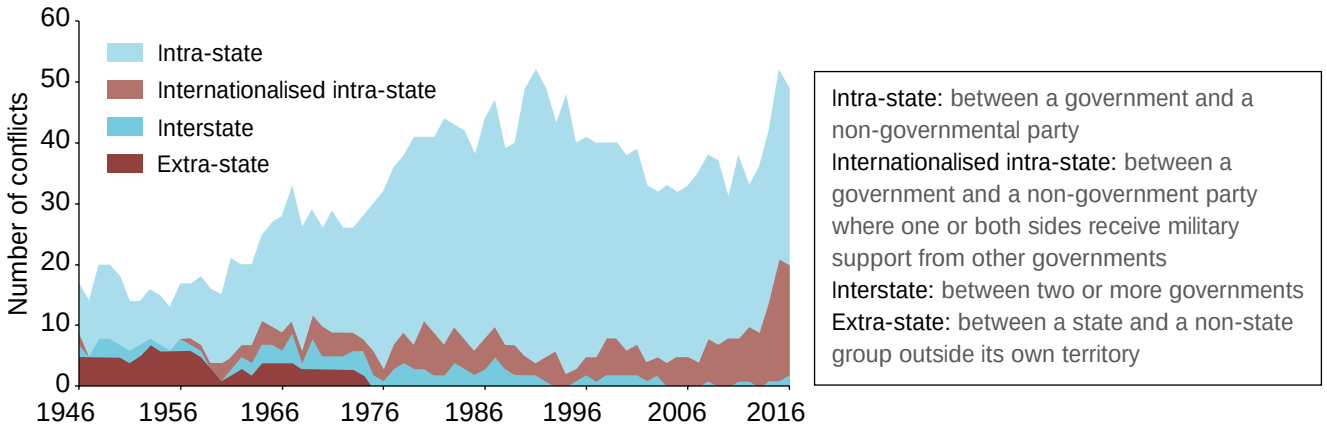
9 Alvaredo, F., *et al.*, World Inequality Lab (2018), *World Inequality Report 2018*.

10 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II: Future Defence and Security,* a research paper commissioned by DCDC.

11 Chayes, S., Fragility Study Group, (September 2016), *Policy Brief Number 1: Corruption and State Fragility.*

12 Schacht, R., *et al.*, New Scientist, (October 2014), *Does a surplus of men really mean more violence?*

Global armed conflict by type



Source: Uppsala Conflict data Program

> “Countries are likely to adopt an increasingly broad understanding of what constitutes an ‘armed attack’.”

Law of Armed Conflict. The norms and mechanisms of the rules-based international system have largely been shaped by state-centric approaches of assessing security threats and determining thresholds for when, where and how to respond to them. They have not yet evolved to deal with the diffusion of power, proliferation of actors below state level, threats in cyberspace, exploitation of information, and political and economic warfare. States and international institutions are therefore not well equipped to respond to these threats. Changes to laws governing the use of force in international relations are, however, expected over the coming decades. For example, countries are likely to adopt an increasingly broad understanding of what constitutes an ‘armed attack’ by a state or non-state actor, within the context of offensive cyber activities. This could result in the threshold for the use of military force in self-defence being lowered. The general prohibition on the use of force is almost certain to remain in place, but it may be progressively challenged and narrowed in scope. This could in turn lead to increased tensions and a greater tendency to resort to military action to settle disputes. New developments in battlefield technology will probably also require careful re-interpretation, and in some cases adaptations, of existing rules. For example, if artificial intelligence becomes so advanced that it can be used in warfare, legislation will be needed to govern the behaviour of such entities and to allocate responsibility for any breaches of law committed by them.[13]

Laws and norms. The inherent difficulty of renegotiating and reformulating international rules and norms to take account of technologies such as cyber weapons and artificial intelligence, particularly regarding sub-threshold activities, is illustrated by the practicalities of drafting the first and second Tallinn Manuals on the International Law Applicable to Cyber Warfare. The process involved producing non-binding, academic studies by a group of international experts, observed by members of the International Committee for the Red Cross, the North Atlantic Treaty Organization (NATO) and US Cyber Command. It demonstrated that when states are exploiting a new technology they will usually be prepared to show that they intend to use that technology (broadly) in accordance with international humanitarian law, but not how they will use it. The process also showed that different actors are likely to use very different conceptual models when exploiting a new technology, and that it may be impossible (for operations security reasons) for them to discuss how they envisage international humanitarian law to be applied. This illustrates how difficult it is to agree how international humanitarian law should be applied, even if the approaches to using the new technology are shared. In addition, by allowing non-governmental organisations and scholars to lead on the

13 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, a research paper commissioned by DCDC.

development of how international humanitarian law is applied to a new technology, states ability to influence the development and application of international humanitarian law has (arguably) been diminished.[14]

Human rights law. In recent years, international human rights instruments have been applied more frequently to the activities of states operating outside their own territories, including during military operations. Such norms may increasingly be used as a yardstick against which the legality and legitimacy of armed interventions are measured.[15] Some, though not all, governments will find themselves coming under more scrutiny and pressure from their citizens, affording them less freedom of manoeuvre and potentially leading to a divergence in international standards for the conduct of military operations.

Arms control treaties. Attempts to ban or limit possession of proscribed weapons are likely to become increasingly challenging as the ability to draft comprehensive, binding international treaties becomes more difficult. Recent events, such as the use of chemical weapons by Syria (a Chemical Weapons Convention signatory) during its civil war, or the attempted development of nuclear weapons by Iran, highlight some of the difficulties associated with implementing current arms control regimes. States can use technology workarounds, loopholes or misrepresentation to create the appearance of compliance whilst continuing to develop prohibited weapons. The different views on imposing sanctions between the US and European Union in 2018 illustrate the challenges with both verification of, and acting against, a breach. Finally, the withdrawal of North Korea from the Nuclear Non-Proliferation Treaty in 2005 demonstrates that states will remain prepared to endure sanctions if it is assessed that an overt breach is in its strategic interest.

Nickolay Vinokurov / Shutterstock.com

Some governments will be more closely scrutinised by their citizens

14 Schmitt, M. N., and Watts, S., *Texas International Law Journal*, Volume 50, (August 16, 2014), '*The Decline of International Humanitarian Law Opinio Juris and the Law of Cyber Warfare*'.

15 Sari, A. and Jachec-Neale, A., (2018), *The Future of the Domestic and International Legal Environment out to 2050*, a research paper commissioned by DCDC.

Limiting possession of proscribed weapons may become more challenging

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The arms control system will be further challenged by future weapons and weapon manufacturing technologies. It is plausible, given advances in technology and the availability of information, that states will be able to construct a new nuclear weapon with such a high degree of assurance that they will not need to conduct a confirmatory detonation. Without a detonation, and hence a seismic signature, the capability is likely to remain covert. Advances in technology, such as microlabs, may also make it easier to secretly create chemical and biological weapons. The diffusion of power to non-state actors may also provide a challenge to the (essentially) state-based framework for arms control treaties. It is possible that new technologies, for example, artificial intelligence, automated systems and offensive cyber, will be the subject of attempts to control proliferation and limit numbers. Treaty negotiations are likely to be hindered by the absence of a clear concept for using these systems, and the unwillingness of actors to give up an advantage in an emerging technology. Such technological developments could, however, undermine the norms and conventions under which current treaties operate, for example, by creating the ability to destroy nuclear missiles in flight, thus limiting their deterrence effect.

Approaches and arenas

Hybrid con□ict. Actors, both state and non-state, seeking to challenge the current international order have developed a series of techniques that allow them to neutralise the conventional strengths of Western powers. This occurs in two main forms. First, 'sub-threshold conflict', which is hostile activity that remains below the threshold of armed aggression to avoid reprisal. Secondly, 'hybrid warfare', which combines conventional warfare with unconventional activity, usually by non-state actors, to offset conventional military strength. These approaches have been given the label 'hybrid' due to the mixture of military and non-military means, the combination of warfare types, and the dual nature of many of the actors involved.

Sub-threshold conflict (known as 'hybrid threats' in Europe[16] or 'Gray zone' in the US[17]) is likely to become more frequent in the coming decades as states compete for power within the international system while avoiding full-scale conflict. At the global level, rising powers will seek to expand competition beyond traditional diplomatic, military and economic activities into new areas, including technology, information and cyber, where they can seek relative advantage to secure their interests. At the regional level, dissatisfied states will also use all available means across all domains to improve their status.[18] At all levels, a wide range of levers will be employed to conduct disruptive activity, from proxy actors in cyberspace to criminal gangs operating across borders.

Hybrid conflict and warfare are challenges that are likely to persist and evolve.[19] The strategic environment will present state and non-state actors with an array of new, more cost-effective means that can be employed in combination against an opponent's vulnerabilities. In the short term this could range from information operations in cyberspace to the proliferation of cheap military technology. The evolution of hybrid warfare in the longer term will be driven by actors motivated to develop and employ new modes of conflict. The most likely developments will continue to be with non-state actors given their higher appetite for risk and incentive to generate asymmetric advantage over more powerful adversaries. The evolution of hybrid warfare by state actors should, however, not be ignored as it provides an effective way of escalating confrontation. Hybrid warfare can offer protection through ambiguity in the early stages of conflict, for example, using proxy actors to commit arms-length aggression, or inciting uprisings.[20] Similarly, simply brute effectiveness through complexity an be achieved by combining cyberattacks, urban warfare and biological and chemical attacks.

> "Hybrid conflict and warfare are challenges that are likely to persist and evolve."

A key feature of hybrid conflict and warfare is using misinformation (fake news) and propaganda. It is designed to erode trust in adversaries' governments and institutions, create uncertainty and stir up grievances. The increasing reach and penetration of information technology, including social media, could allow these activities to be undertaken on a vast, potentially global, scale. Using proxies and militias will also be favoured, because the sponsoring country can plausibly deny responsibility for their agents' actions. Similarly, some states are likely to disguise their actions as the activities of organised crime, for example, the Russian government is believed to have used criminal networks to conduct assassinations and cyberattacks.[21] Cyberattacks and information operations, particularly on social media, are a key part of hybrid warfare because they can often be deployed without revealing the aggressor's (or sponsor's) identity. The past ten years have seen an almost continuous stream of cyberattacks and there is no evidence to suggest that this will change in the coming decades. Hybrid warfare is likely to be a pervasive feature of future conflict, occurring simultaneously across multiple geographical regions.

16 For more information see European Union (EU), (2016), *Joint Communication To The European Parliament And The Council: Joint Framework on countering hybrid threats a European Union response*.

17 For more information on the 'grey zone', see Dubik, *et al.*, Institute for the Study of War, (February 2018), *America's Global Competitions: The Gray Zone in Context*.

18 Puri, S., *Journal of Global Security Studies*, 2(4), (2017), *The Strategic Hedging of Iran, Russia, and China: Juxtaposing Participation in the Global System with Regional Revisionism*, pages 307–323.

19 DCDC, (2017), Joint Concept Note 1/17, *Future Force Concept*.

20 Johnson, R., (2017), *Hybrid War and its Countermeasures*, a research paper commissioned by DCDC.

21 Galeotti, M., European Council on Foreign Relations, *CRIMINTERN 'How the Kremlin uses Russia's criminal networks in Europe*.

An increasing number of pipelines creates new vulnerabilities

The global commons. The oceans, polar regions and space have all seen increased levels of activity (such as shipping, tourism, military activity and satellites in orbit) and are likely to become the focus of increasingly intense competition, and possibly conflict. In the oceans, deep sea mining is already technologically feasible and vast deposits of minerals and precious metals have been identified. Competition to claim the rights to these deposits can be expected. An increasing number of pipelines and cables are being laid across the seabed, creating new vulnerabilities. The oceans will also continue to be vital conduits for international trade with global freight trade forecast to grow by between 330% and 380%.[22]

While the United Nations Convention on the Law of the Sea (UNCLOS) will continue to provide an effective framework of governance, it is also likely to be challenged in some areas, not least in the South and East China Seas. As Arctic sea ice melts, resources will become easier to extract and shipping routes will open up. Competition to control both the resources and shipping routes will increase and could lead to tension. Activity in the Antarctic is also increasing and the Antarctic Treaty System is likely to come under increasing pressure. With a review of the Antarctic Treaty System not due until 2048, some countries (particularly non- and late-treaty signers) may see this as an opportunity to renegotiate the Antarctic Treaty System, potentially leading to tension.

Space is also the site of increasing activity and dependency on spaced-based capabilities is increasing. The numbers of satellites, particularly small satellites nanosats), in orbit is increasing rapidly, as is the number of actors involved, both state and non-state. The main governance framework, the Outer Space Treaty of 1967, however, has not been updated since 1979. The risk of the treaty breaking down, possibly leading to conflict and/or weapons basing in space cannot be ruled out. As reliance on the global commons increases, maintaining freedom of access will be a vital objective for governments.

Cyber. Cyberspace is already an active battleground, with state and non-state actors continuously searching for adversaries' vulnerabilities, trying to obtain secret information, developing weapons and occasionally deploying them. For example, cyber attacks can be used to disable industrial facilities or shut down public services. Those countries with open cyber borders are likely to benefit economically, as well as being able to analyse the data flowing into their territories and to distribute their own information more easily. However, such countries are also likely to be more exposed to cyber hazards than those that control their cyber borders, so states may need to carefully balance openness and control. Algorithms are likely to be used increasingly by some countries to analyse data from civilian populations, including that harvested from social media, thereby enabling actors to develop effective strategies for manipulating public opinion.

22 Organisation for Economic Co-operation and Development (OECD), (27 January 2015), '*IFT Transport Outlook 2015*'.

Urban conflict. As more people live in cities, urban areas are likely to become more central to conflict. The governments of developing countries that experience rapid urbanisation, many of which will be in coastal regions, may be unable to provide essential services to their growing populations, leading to grievance and possibly conflict, including terrorism. In failing or fragile states, criminal-insurgent groups may takeover cities, controlling the population through intimidation and low-intensity terror.[23] **The dense, multidimensional nature of urban environments means that military and police tactics are likely to require modification over the coming decades.** For example, the value of high ground may be eroded by the lack of manoeuvrability entailed by operating at the top of high-rise buildings. The vast underground network created for transportation, sewage and utilities infrastructure could become the vital ground of urban operations. Similarly, large numbers of people and electronic devices with their associated emissions (such as heat, light and radio waves) are likely to challenge today's surveillance systems. Conversely, using the embedded surveillance systems likely to be found in the smart cities of the future could confer an overwhelming advantage to the possessor. The connectivity and density of cities are likely to leave them vulnerable to devastating attacks (whether by cyber or conventional means) from irregular actors, criminals or hostile states. The capacity and technical competence of civil defence organisations is, therefore, likely to have to grow significantly to meet these challenges.

The complex, crowded nature of cities already makes it easy for insurgents to hide, and difficult for government forces to use air power and artillery effectively without causing unacceptable numbers of civilian casualties. Military and security forces are likely to be increasingly required to fight within cities, including going into buildings and clearing them room by room. Machines could play a more important role in this process in the future, moving ahead of troops to see what is in a room, clearing booby traps and explosives, and firing weapons either at the command of a remote operator or automatically.

Diy13 / iStock

Urban areas will become even more central to conflict

23 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II: Future Defence and Security*, a research paper commissioned by DCDC.

States will continue to form or maintain traditional alliances, but alliances may also diversify

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Actors

States. Although state governments will face an increasing number of threats and challenges, they are likely to remain the key security actor. States will continue to be the principal organisations that set and shape laws, both domestic and international, collect taxes and determine relationships with other states. The capacity of many governments, particularly in developing countries where they are likely to significantly expand their domestic tax base, are likely to increase. New surveillance technology is likely to strengthen the hand of states in ensuring domestic security, although this could lead to repression. There is, however, likely to be an increasing number of actors delivering services that are (in many cases) currently the preserve of the state. For example, in most countries Internet services, including Internet security, are delivered by private companies. Private companies are also putting satellites into orbit and, particularly in Western countries, running critical national infrastructure. Many governments could, therefore, adopt a federated approach to delivering services.

Alliances. The norms of the rules-based international system are currently shaped mainly by a state-centric approach and have not yet evolved to deal with the diffusion of power and proliferation of actors below state level. As a result, states will probably continue to form or maintain traditional alliances, such as NATO, and partnerships at the state level that will help them sense, attribute and respond to threats. In addition, states' alliances may diversify. In future they may partner with multinational corporations or private security companies and even powerful regional or global institutions, gaining advantage from the collective capabilities they possess. This may allow close coordination of cyberspace, exploitation of information, and political and economic warfare, for which expertise and resources, particularly at scale, may primarily exist outside the state. Some contemporary alliances may realign if the global power dynamic rebalances. Some alliances, such as the US and Canada's bilateral cooperation, including the North American Aerospace Defence Command, will remain geographically based. Others may evolve as a global network in response to new threats to which distance is only a limited defence. If regional organisations such as the European Union remain strong, they may increasingly develop common security policies to be better able to share the burden

of military and security costs. Access to technology may become a new influence on alliances. States that can form successful partnerships with private industry, especially with technology firms, are likely to derive a crucial advantage in future conflicts.

People's identities will become more layered and complex as the forces of globalisation contribute, simultaneously, to both increased cosmopolitanism and retrenchment. As citizens' identity becomes more complex and the number of actors with whom they associate (for example, religious organisations, online gaming communities, political groups, football clubs and celebrities) demand varying degrees of allegiance, states are likely to find maintaining the support of their citizens increasingly challenging. The ability of governments, and competing non-state actors, to build alliances across this increasingly broad array of actors will be essential for the power of a state. States will therefore have to work with an increasingly diverse set of partners, including, non-governmental organisations, commercial organisations and, for some, criminal organisations. Private security companies are also likely to play an increasingly important role, possibly at a far greater scale than currently.

People's identities will become more layered and complex as the forces of globalisation contribute, simultaneously, to both increased cosmopolitanism and retrenchment.

Private security companies. Organised crime, including piracy, and the threat from cybercrime have led private companies to increase their investment in security in recent years. If, as expected, the threat from terrorism endures, companies are likely to seek to enhance, and invest in, their own security, rather than relying on protection from the state.[24] Some of these funds could be spent internally, but much will also be paid to private security companies. Private security companies range from those supplying computer antivirus software to businesses providing armed personnel for a multitude of tasks.

Private security companies offer several advantages that are likely to make them attractive in the future, particularly if (as seems probable) the currently high numbers of minor conflicts and multinational missions continue. For example, private security companies only have to be paid for when they are needed (as opposed to being expensively maintained whether used or not); the employing organisation can, with varying degrees of credibility, deny they are using them; and, if killed, private security employees rarely attract the same degree of sympathy from an employing state's citizens. Private security companies are also often used without being subject to the full range of governance limitations that a state's armed forces are held to, making them more politically convenient. There are, however, several disadvantages associated with the use of private security companies, not least the risk of companies failing to meet their contractual obligations or engaging in behaviour that discredits the employing state. Nevertheless, the advantages of using private security companies are likely to endure, and possibly increase, meaning that they could be an increasingly important feature of future conflicts.

Private companies. Recent decades have seen the growing use of private companies to provide support to military operations, such as supplying bottled water, communication facilities and logistics. Governments are also increasingly replacing state-run security services with provision from private companies, for example, delivering diplomatic protection. Private companies, particularly in Western militaries, are already used to build, maintain, repair and even operate military vehicles, ships, aircraft and other complex capabilities. As industry continues to develop advanced capabilities in artificial intelligence and robotics, private companies will play a more important role in many countries' ability to use military force. Since several companies that produce military capabilities sell to multiple governments, it is conceivable that in future conflicts, a single private company could be providing essential capabilities to both sides.

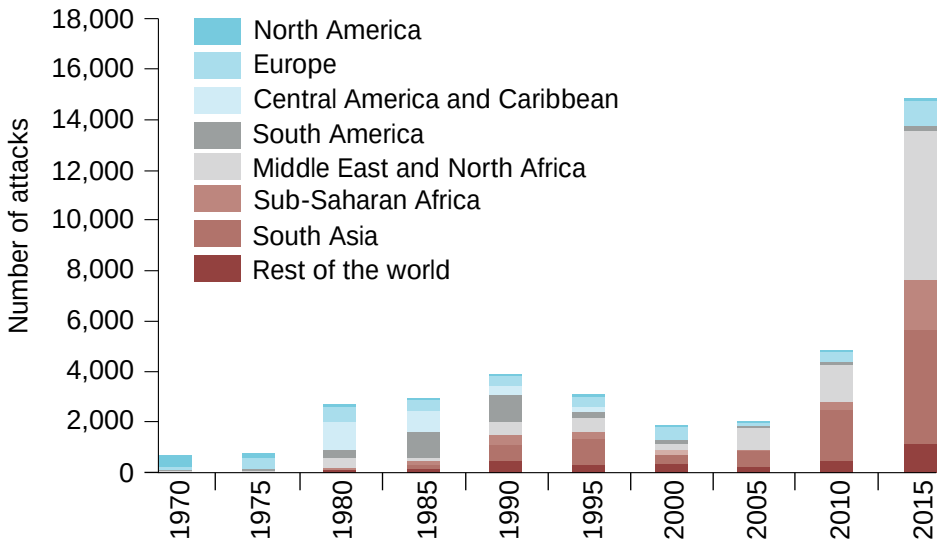
24 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II: Future Defence and Security*, a research paper commissioned by DCDC.

Commercial cyber actors. In many parts of the world, cyber security and Internet services (such as social media and online banking) are provided by private organisations. Cyber security companies are likely to benefit from significant rises in funding during the coming decades, and will probably become increasingly capable. While a cyber company's focus is likely to be protecting corporate, and clients' networks and capabilities, developers will almost certainly understand how to conduct cyberattacks, if only to learn how to better defend against them. It is likely, however, that at least some cyber security companies (or individual employees) will provide offensive cyber capabilities for hire.

> The likelihood of violent extremist organisations acquiring and using a nuclear weapon remains low but plausible.

Violent extremist organisations. The number of attacks by violent extremist organisations increased sharply in 2008, reaching their highest recorded level in 2014, with over 16,000 attacks.[25] The Middle East and North Africa region has experienced the highest number of attacks by far, followed by South Asia and sub-Saharan Africa, while North and South America have seen significant reductions. In Europe, the frequency of violent extremist organisation attacks is currently approaching levels similar to those seen in the 1970s.[26] The global number of attacks by violent extremist organisations is likely to rise, partly because weapons and explosives (or the means and information needed to make them) are becoming more readily available, but also because the grievances and stresses that give rise to conflict are likely to increase. While separatist nationalism has been the most common ideological motivation for violent extremist organisations, violent jihadism has become the most potent ideology and it shows no sign of diminishing. Anti-immigration and anti-Islamic sentiments are also on the rise and they too could become driving motivations.

Number of terrorism attacks per region



Source: Datagraver

The likelihood of violent extremist organisations acquiring and using a nuclear weapon remains low but plausible, particularly for groups with sufficient funds to suborn those with legitimate access to such technology. All known instances of planned or actual theft of nuclear or radiological material have been facilitated by insiders who stated their motivation was financial gain. Violent extremist organisations are also likely to try to develop or obtain chemical and biological weapons, although the majority of attacks will probably continue to involve small arms and explosives when they can be obtained, and vehicles and knives when they cannot. While some violent extremist organisations might develop highly capable abilities equivalent or close to NATO soldiers, most are likely to remain ad hoc, drawing on the society from which they originate.

25 Datagraver, (2016), '*Worldwide Terrorism 1970-2015*'.

26 Roser, M., *et al.*, (2018), '*Our World in Data: Terrorism*'.

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Nuclear-armed states are in the process of modernising their arsenals

Most violent extremist organisations will continue to depend on cheap, readily available equipment, and this could continue to provide an asymmetric advantage against a more technologically-advanced foe. For example, in 2017, it was established that Houthi rebels in Yemen had employed low-cost drones to disable Patriot missile systems in Saudi Arabia.[27] Asymmetries of this sort are likely to remain favoured techniques in the coming decades, as they allow violent extremist organisations to cause heavy financial losses at a relatively low cost to themselves.

Capabilities

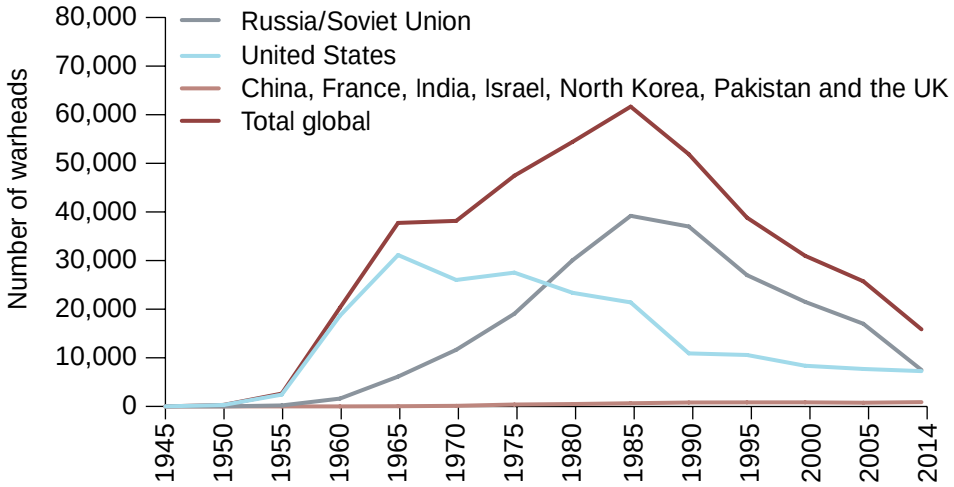
Nuclear weapons. While the overall number of nuclear weapons in the world has declined, nuclear-armed states are in the process of modernising their arsenals. Moreover, the destructive power of each nuclear warhead has increased significantly since the first atomic weapons were used in World War 2.[28] Countries with nuclear weapons are unlikely to relinquish them in the foreseeable future. Indeed, on current trends, the number of nuclear-armed states is likely to continue to rise in the coming years, at the rate of roughly one or two nations per decade, with North Korea the latest confirmed country in 2006. However, a nuclear arms race could occur, for example, if one Middle Eastern country develops nuclear weapons, others are likely to follow suit. While Russia and the US account for more than 90% of the world's nuclear warheads,

27 Defense News, 'Report: Houthi rebels flying Iranian-made 'Kamikaze drones' into surveillance radars'.

28 Stockholm International Peace Research Institute, (2017), '*Global nuclear weapons: modernization remains the priority*'.

China has the resources to substantially increase its nuclear capability, should it choose to do so. While more-powerful nuclear weapons might be developed in the coming decades, the current focus is on building smaller, more accurate, faster missiles with multiple warheads.

Estimated global number of nuclear warheads



Source: Federation of American Scientists

Russia's growing emphasis on tactical nuclear weapons could heighten the likelihood that they will be used, perhaps to compensate for gaps in conventional capability.[29] Because the use of tactical nuclear weapons is not expected to result in mutually assured destruction, the threshold for their use may be lower than that of strategic nuclear weapons. Therefore, although impossible to quantify, the risk that nuclear weapons are used looks likely to increase. It is also probable that nuclear weapons are being developed for the specific purpose of delivering electromagnetic pulses to destroy electronic devices and networks across wide areas.[30]

Strategic and tactical nuclear weapons. Strategic nuclear weapons are designed to inflict massive damage and prime targets are cities, particularly capitals. The owners of strategic weapons also have the capability to fire back if they are subject to a nuclear attack, allowing them to cause substantial retaliatory harm to their attackers, a deadly balance known as mutually assured destruction. The intention of some of those who hold strategic nuclear weapons is to deter potential attackers, so that they never have to be used. Tactical weapons, however, are designed not to deter but to create military effect, such as destroying a hardened command and control centre or an aircraft carrier. Their use is intended to be calibrated so as not to lead to escalation and retaliation with strategic nuclear weapons.

29 Goliath, M., *et al.*, Granholm N. (red), Rydqvist J. (red), *Kärnvapen för slagfältsbruk och europeisk säkerhet – en strategisk faktors regionala betydelse* [Translation – *Nuclear arms for the battlefield and European Security*].

30 Kristensen, H. and McKinzie, M., *International Review of the Red Cross*, 97, (2015), 'Nuclear arsenals: current developments, trends and capabilities', pages 563-599.

Electromagnetic pulses. A high-altitude nuclear detonation generating an enhanced electromagnetic pulse would instantaneously shut down numerous satellites, most of a country's electric power grid and severely damage national telephone lines, communication systems, other electrical installations and even diesel generators for weeks, possibly years. While military equipment might be hardened, civilian capabilities would be badly affected. Data would be corrupted, broadcast stations would go off air and the effects on automated systems could be catastrophic. Much of modern society has forgotten how to survive for long periods without electricity, meaning that there could be disastrous follow-on consequences from a large electromagnetic pulse, such as shortages of food and water, as well as a breakdown in law and order.

Potential methods of reducing the effects of an electromagnetic pulse detonation (such as using optical fibre or protecting transformers and other vital equipment) already exist in principle, but would require significant investment to be implemented on a large scale. The detonation of a small nuclear weapon designed to deliver an electromagnetic pulse wave could be an effective asymmetric option. Non-nuclear electromagnetic pulse technologies could also be fielded by developed militaries, less powerful states and even non-state actors. Although the effect of a non-nuclear electromagnetic pulse is likely to be much smaller than a nuclear electromagnetic pulse, this also makes the effect more precise. For example, terrorists could have a disproportionate disruptive (but non-lethal) effect by initiating a non-nuclear electromagnetic pulse outside a facility containing important electrical equipment or data storage.[31]

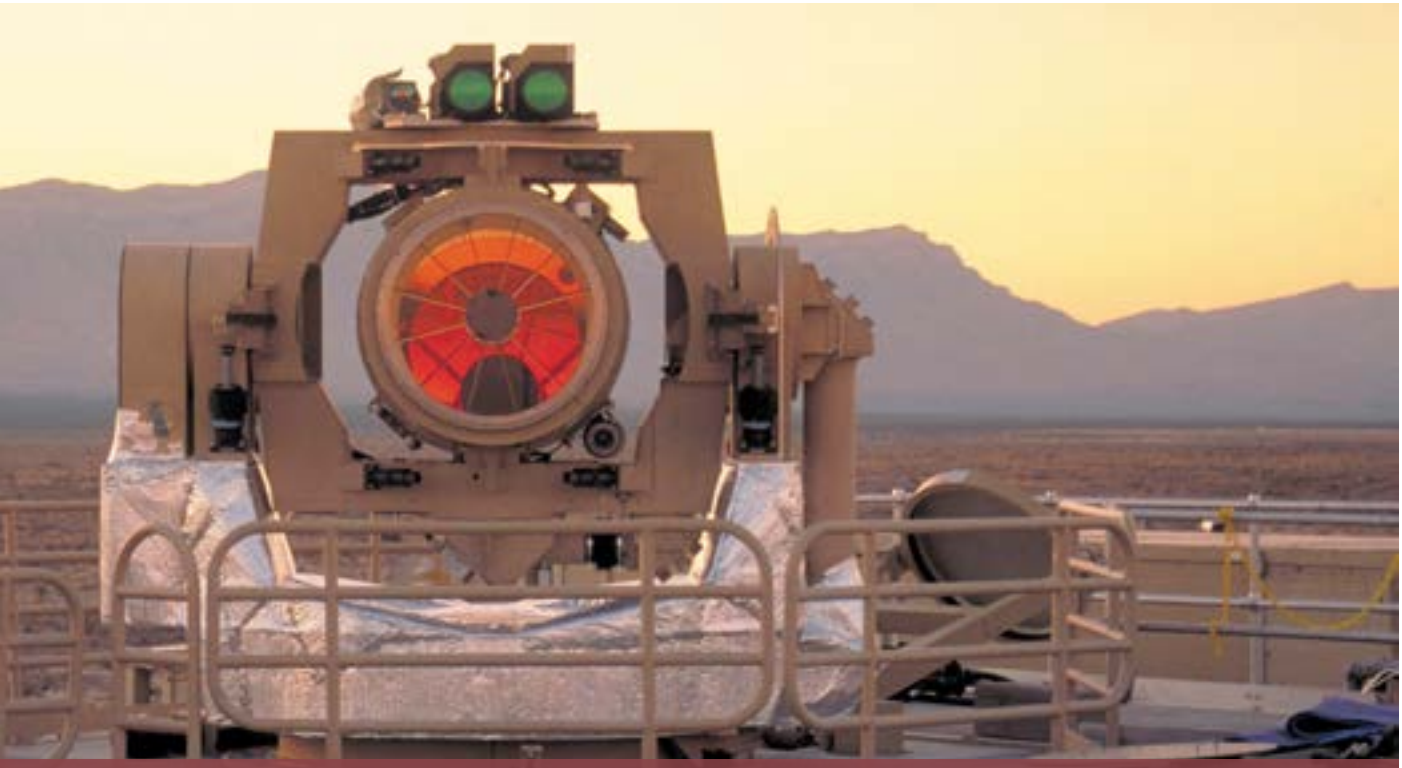
Chemical and biological weapons. Although banned under international law, it is likely that some states and non-state actors will continue to develop, stockpile and use chemical and biological weapons.[32] Syria has repeatedly used chemical weapons in recent years and, similarly, Iraq deployed chemical weapons against Iranian troops in the Iran-Iraq war of the 1980s, and against its own population in 1988. Chemical weapons have also been used by non-state actors in recent decades (for example, by insurgents in Iraq and by Daesh), as has anthrax. Developments in biology and chemistry could allow weapons to be developed that can be precisely targeted and are more lethal, or possibly with specific non-lethal effects, making them more attractive to potential users. Genetic engineering could allow bacteria and viruses to be developed that only target victims with selected genetic traits.

Kovalenko Alexander / Shutterstock.com

Some states will continue to develop, stockpile and use chemical and biological weapons

31 Emanuelson, J., '*Non-nuclear Electromagnetic Pulse Generation*'.

32 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II: Future Defence and Security*, a research paper commissioned by DCDC.



Directed energy weapons could offer unprecedented levels of accuracy and variability of effect

Reproduced from GST 5

Precision strike. Weapon systems will become more accurate and have longer ranges. Rail guns that use electromagnets to fire projectiles at speeds of 4,500 miles per hour have already been developed.[33] Directed energy weapons, including lasers, could offer unprecedented levels of accuracy and variability of effect, potentially including non-lethal results such as immobilising vehicles or temporarily incapacitating individuals. Hypersonic missiles that can fly faster than five times the speed of sound are under development, as well as improved cruise missiles and glide vehicles which could be launched to the edge of space before attacking their targets. Such weapons might be used to strike practically anywhere in the world in a matter of hours, and their ability to change direction in flight will probably make it hard to predict their targets or deploy appropriate responses. They are also likely to make air and sea lines of communication increasingly vulnerable, and mean that distance will become increasingly irrelevant as a security buffer or defence.

Future weapons could be deployed much more rapidly, reducing the amount of time available to determine if an attack is underway and what the appropriate response should be. This could heighten the risk of miscalculation, such as retaliation in response to a false alert. Since it may be harder in future to distinguish between a conventional or nuclear attack, the risk of a nuclear response is also likely to increase. Space could develop as a theatre of war in the coming decades. Weapons that can destroy satellites and other human-made space objects are likely to be created, and it is even possible that armaments designed to be fired from space onto the Earth's surface will be manufactured.[34] In parallel, methods of denying space capability without generating large amounts of debris, such as cyber weapons, are being developed. At the same time, some major powers are preparing for wars without access to space, for example, by training without Global Positioning System (GPS) navigation.

33 *The Economist*, (27 January 2018), 'Power Projection', page 12.

34 Johnson, R., (2017), *The Future of Conflict, Violence and Security: A study in support of the Global Strategic Trends research – II*: Future Defence and Security, a research paper commissioned by DCDC.

Remote and automated systems. Remotely-operated air vehicles are a common feature of many of today's battlefields, and some automatic systems (such as those that allow manned aircraft to operate if the pilot is injured) are already in service. Such systems are less familiar in the land and maritime environment, but are likely to become commonplace. For example, automated submarines are likely to be used to conduct reconnaissance missions against enemy coasts to seek and destroy mines, and possibly used to automatically attack submarines or ships that enter a defined area. Similarly, on land, vehicles are likely to be developed that automatically deliver supplies, conduct reconnaissance, and clear obstacles, including mines and booby traps.

Increasingly, machines capable of combat are likely to be used on the battle□eld under close human supervision, but as con□dence in the machines capabilities grow, they could be employed further away from human supervision. In time, for those who can afford them, machines will be used □rst, before putting people in harm's way. Automated systems need not be expensive. Cheap mass-produced swarming devices could be used to conduct attacks, overwhelming defensive systems.[35] Armed machines are also likely to be developed, some of which might be able to automatically engage targets without human intervention. Removing the operator from danger should reduce the occurrence of instinctive, adrenalin-fuelled decision-making, influenced by fear, fatigue and anger and thus, an automated response could be more rational, possibly strengthening compliance with international humanitarian law. Alternatively, poorly designed and insufficiently supervised machines might dogmatically follow poorly-designed rules that lead to unjustifiable deaths. The (apparently) inexorable improvements in the capability of machines suggest that the physical component of □ghting power could overshadow the conceptual (perhaps also done by machines) and moral components, at least at the tactical level.

Chesky_W / iStock.com

Cheap mass-produced drones could overwhelm defences

35 Hammes, T. X., War on the Rocks, (2014), 'The Future of Warfare: Small, Many, Smart VS. Few & Exquisite?'.

Sensors. The growing number of sensors monitoring the physical world will give machines vast amounts of data to analyse and draw conclusions from. Sensors are becoming more powerful, capable of exploiting a broad array of the electromagnetic spectrum and seeing ever further with increasing fidelity. In the coming years, however, the sheer volume of devices that emit signals and other forms of energy are likely to overwhelm some surveillance and reconnaissance systems. Although in the longer term more powerful computers, enhanced by developments in artificial intelligence, are likely to weave information from multiple sources (including from secondary signals, such as changes in air temperature and trace emissions from engines) into comprehensive pictures of future battlefields. Theoretically, the oceans might be rendered virtually transparent and hostile aircraft could be identified before they take off, although capable adversaries will almost certainly use deception and false signals to camouflage their activities. Actors with the best sensors, data and algorithms will probably be able to identify the positions of combatants and non-combatants with a high degree of accuracy and thus achieve an important competitive advantage.

> “The oceans might be rendered virtually transparent.”

Artificial intelligence. The very nature of cyberspace makes it the ideal environment for artificial intelligence to be deployed. In future, artificial intelligence could be used to provide automatic defences, evolving rapidly to counter changing threats, as well as for dynamic cyberattacks, constantly probing for weakness and developing new ways to attack opponents at lightning speed. Outside cyberspace, the use of artificial intelligence to mine data and fuse information from sensors should help leaders to be better informed, and in time, artificial intelligence will probably be used to automatically make decisions. Indeed, some systems are already automated, such as those on ships designed to shoot down incoming missiles, because a response is needed before human calculations could be made. However, allowing artificial intelligence to decide to kill a person without human oversight is a step many find horrifying. In particular, some fear that, if any kind of permission is given to machines to kill, a rogue artificial intelligence might decide to exterminate or enslave humanity. While attempts are being made to ban the development of autonomous machines that can kill, it is difficult to see such restrictions being wholeheartedly accepted (let alone enforced) by all countries or actors.

Attracting suitably skilled personnel to work in artificial intelligence for military purposes is likely to be a strategic challenge for many countries, partly due to the multimillion-dollar salaries that the best developers can obtain.[36] Moreover, some programmers are likely to refuse to work on military artificial intelligence, although these decisions are unlikely to be respected everywhere. For example, the Chinese and Russian governments are likely to insist that technology firms operating in their countries develop military capabilities (as artificial intelligence is a national priority for both nations), and this could deliver a significant military advantage for them.[37]

36 Bughin, *et al*., (2017), McKinsey Global Institute, ‘*How artificial intelligence can deliver real value to companies*’.

37 *The Economist*, (27 January 2018), ‘The Future of War’, page 11.

K_E_N / iStock.com

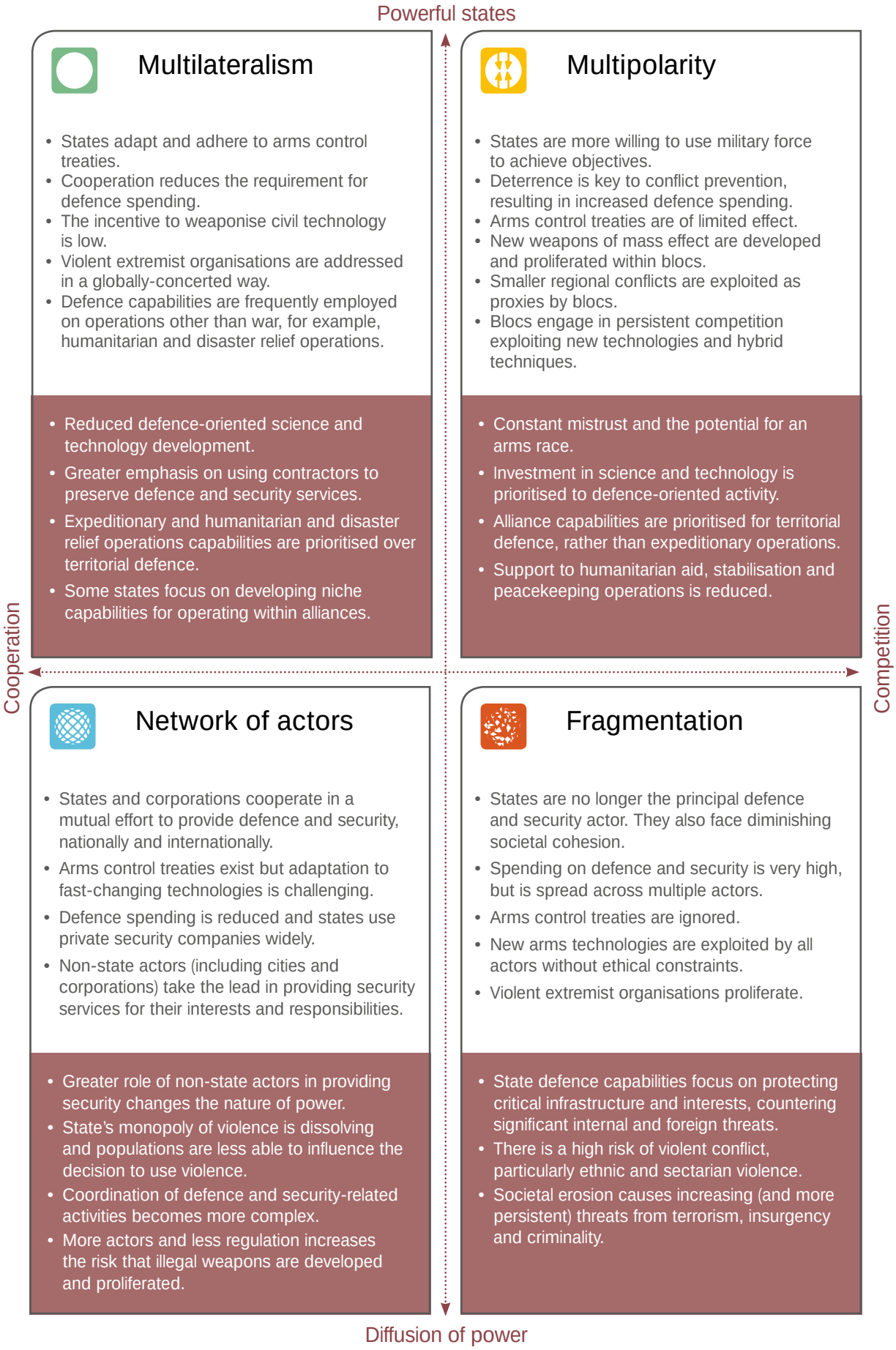
Actors that most effectively integrate man and machine may derive a decisive advantage

Nature and character of warfare

As already described, weapons such as hypersonic missiles are being developed that will almost certainly reduce decision-making time. It is plausible therefore that some countries may decide to delegate defence against such weapons to an artificial intelligence. Others might go further, calculating that using an artificial intelligence to command and control wider military operations (perhaps using automated ships, aircraft and land systems) could deliver an overwhelming advantage. The ethical consequences of the militarisation of artificial intelligence could be profound. A machine may take no account of human suffering and might all too readily resort to violence. Alternatively, free from ego, hubris and nationalistic sentiment, an artificial intelligence might more rationally calculate the probable costs of conflict, thus preventing states from making rash decisions.

If artificial intelligence and machines carry out an increasing number of combat functions and decisions, the impact will be profound. Courage, fortitude and valour have been synonymous with the military ideal, yet in a future where machines do most of a professional military's fighting and key decision-making, from where will personnel draw their values and inspiration? The potentially cool, hyper-logical calculations of machines could remove passion from war and if the digital exertions of cyberspace are the vital battles of future wars, violence too might become a diminishing part of conflict. Those that most effectively integrate the capabilities of machines and people may derive a decisive advantage. Historians will be the judges, but it is plausible that by 2050 (or perhaps before) automation and artificial intelligence will have altered not just the character, but the very nature of war.

Future worlds: Conflict and security



Watch points

- Level of cooperation in conflict prevention and international responses to conflict and disaster relief activities.
- Degree to which international law and ethics constrain the use of novel technologies, such as human enhancement and artificial intelligence, for defence and security.
- Adherence to arms control treaties.
- Increases in confrontational nationalistic politics.
- Changes in global defence spending.
- Rise in unregulated, privatised defence and security providers.

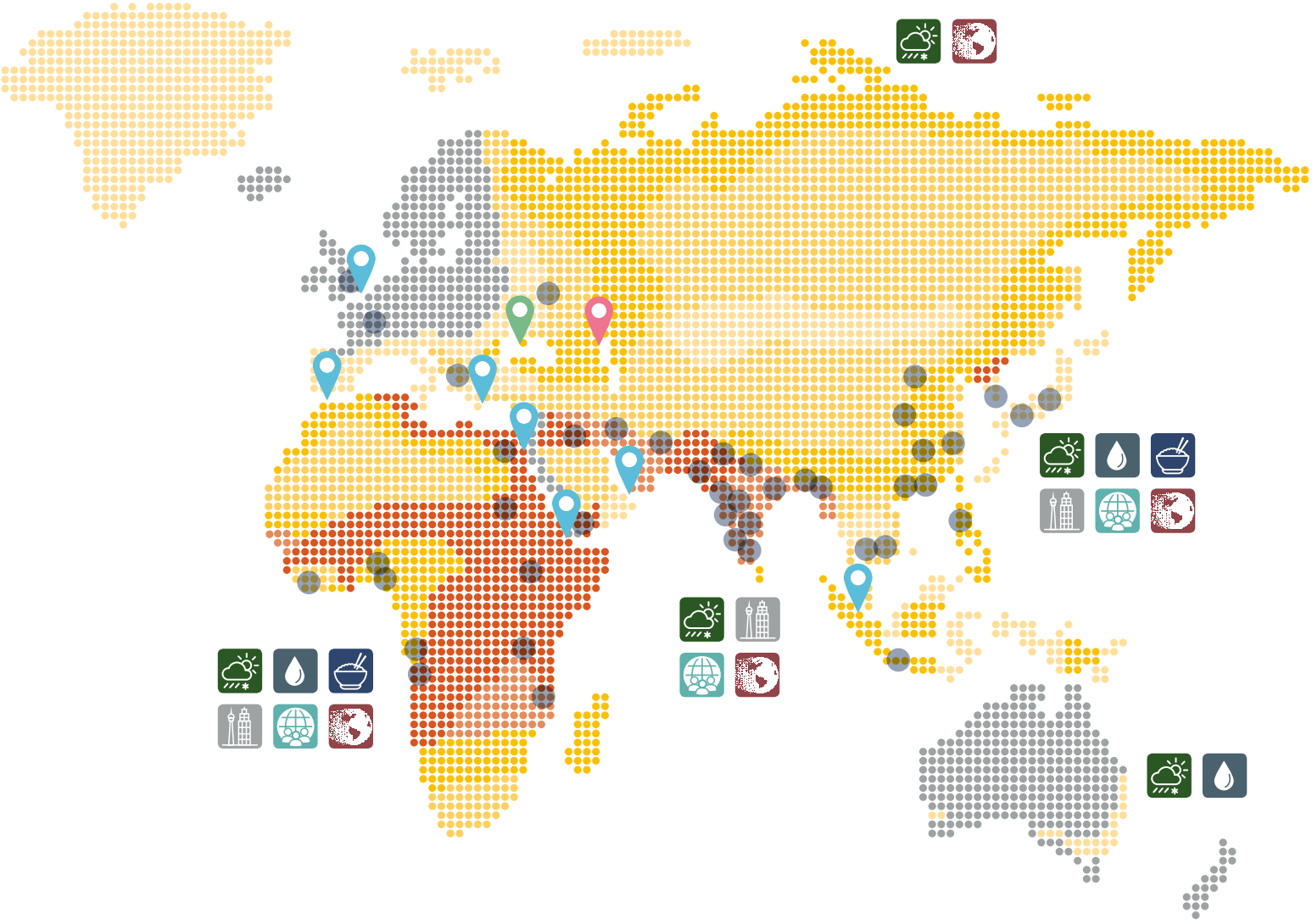
Discontinuities

- Global conflict (i.e., a 'World War').
- Shifts in the membership of alliances.
- Declining military pre-eminence of US.
- Rapid proliferation of weapons of mass destruction.
- Collapse of key multilateral organisations, for example, United Nations, North Atlantic Treaty Organization, European Union, and so on.
- Ideological/religious revolution within a major state.
- Major cyberattack resulting in the breakdown of a country/region.
- Disruptive technologies.
- Changing nature of war.

Implications

- In a complex interconnected world, an understanding of the causes of crises and conflicts is critical and requires a whole-of-government approach and response.
- States will need to be prepared for state-on-state warfare, including through collective defence alliances, whole-of-government approaches and strengthening of homeland resilience. Deterrence strategies need to adapt to new and emerging weapons of mass effect and defensive capabilities.
- How to create mass effect and competitive advantage, either by few very expensive advanced capabilities or by large numbers of cheaper capabilities, will need careful consideration.
- The variety and influence of non-traditional security actors will make it necessary to think differently about defence alliances and partnerships. New forms of cooperation will be required to achieve viable, legitimate and equitable rules, norms and institutions.
- Arms control regimes, already under stress due to differing interpretation and application, will need to be robustly enforced to restrict proliferation of weapons of mass effects, and modified to cope with a new range of challenges such as cyber weapons and the use of artificial intelligence in conflict.
- Actors who develop the capabilities and framework to exploit the expanding competitive space will derive a significant advantage.
- Artificial intelligence and robotics could be as transformational to warfare as radio and aviation. The pace of technological change will necessitate changes in policymaking, norms, permissions and authorities otherwise there is a risk of ceding the initiative to competitors.
- Despite sustained downward trends in defence spending, states will need to ensure they match investment with their level of ambition. A clear understanding of the value defence offers as a national insurance policy is needed, and this may require a narrative with the public.
- Distance will become less relevant as a security buffer as weapon systems will be faster, more accurate and have greater range/reach. The homeland can no longer be considered a sanctuary, with obvious need for resilience. Warfare will become ever more personalised as individuals and their families are targeted in novel ways.
- Tackling transnational criminal and violent extremist organisations will require global cooperation and a whole-of-government approach.

Global stress map

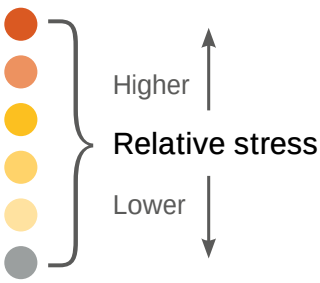


These stress maps are an illustrative visualisation of the potential impact of seven stress influences: water security, food insecurity, population, state fragility, impact of climate change, megacities and choke points.

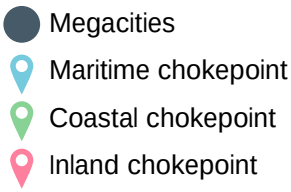
The maps illustrate expected impacts on people and their activities rather than physical attributes in 2050.

These maps are based on analysis completed as part of this edition of Global Strategic Trends, and made particular use of:

- Human Dynamics of Climate Change, Met Office;
- Global City Populations, UNDP;
- City Population 2050, University of Ontario;
- 2018 Fragile States Index, Fund for Peace; and
- Chokepoints and Vulnerabilities in Global Food Trade, Chatham House, 2017.


Higher
Relative stress
Lower


Water security
Food insecurity
Population
State fragility
Megacities
Climate change


Megacities
Maritime chokepoint
Coastal chokepoint
Inland chokepoint


1 Kazakhstan
2 Kyrgyzstan
3 Tajikistan
4 Turkmenistan
5 Uzbekistan
1
2
3
4
5

Central Asia

Having only gained their independence in the 1990s, the countries of Central Asia are still adjusting to the changed geostrategic environment. The region will become more closely integrated into the global economy, particularly the markets of China and Europe. Through its Belt and Road Initiative, China is making substantial investments in infrastructure in Central Asia, enhancing the land route to Europe. This is likely to boost and lead to diversification of the economy. Whilst China is the largest trading partner and investor in the region, Russia will seek to retain its influence, not least through its indigenous ethnic Russian populations. Many of the region's governments are authoritarian and corruption is endemic, but a better educated and increasingly globally connected population could force improvements. Governments will also seek to balance their relationships with China, Russia and the West. The risk of ethnic and religiously motivated violence is likely to endure, and could be exploited by organised crime groups and terrorists. Climate change and unsustainable practices are likely to result in water shortages that could lead to conflict. There are several unsettled border disputes in the region and local skirmishes across these borders are likely to endure. Whilst armed conflict between Central Asian states cannot be ruled out, the transnational nature of security challenges and the influence of outside powers should drive regional cooperation.

Environment

The effects of climate change in the region will be mixed. Although a rise in average temperature may increase the agricultural output in northern and eastern Kazakhstan, it will probably worsen droughts and desertification and increase water demand in western Kazakhstan, Uzbekistan and Turkmenistan.[1]

Both water use and availability varies amongst Central Asian countries and water is likely to remain an important and contested resource.[2] Whilst increased glacier melting might increase flows of water in the medium term, higher temperatures will increase water loss due to evaporation. Water management is as significant as water scarcity. Obsolete and unsustainable infrastructure and practices, particularly in the agricultural sector, are highly wasteful, which could threaten the water-intensive economies of Central Asia. However, they may also provide strong incentives for regional cooperation and for investment in new technologies in the agricultural sector and in water management in general.

1 Intergovernmental Panel on Climate Change (IPCC), *Fourth Assessment Report*.

2 International Crisis Group, (11 September 2014), *Water Pressures in Central Asia*.

Central Asia is a seismically active region. The Fergana Valley, a particularly vulnerable area, is home to 20% of the region's population. More than half of the inhabitants live in houses that were not built to withstand strong earthquakes. Due to the many built and planned dams, earthquakes could cause significant damage, including severe flooding.

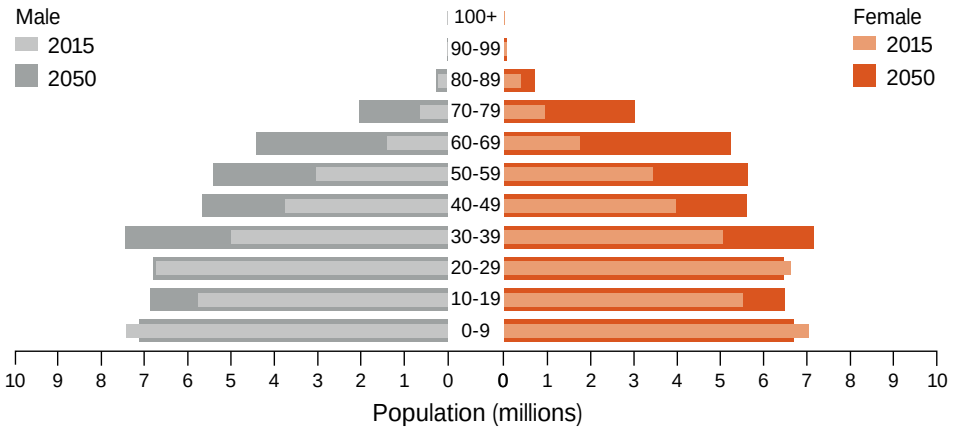
Human development

Central Asia's population is likely to grow by approximately 40%, from about 68 million in 2015 to an estimated 94.5 million in 2050.[3] Growth will not be uniform, for example, Tajikistan's population is projected to grow by 68%. As a result, the difference in size of the population between Russia and Central Asia will reduce. Most of Central Asia's population growth will occur in and around the Fergana Valley, putting pressures on economies, infrastructure and food production.

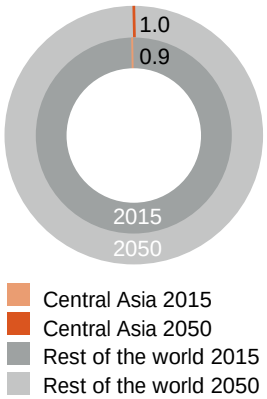
Population growth will drive greater urbanisation. The share of Central Asia's population living in urban areas is likely to grow from 44% in 2015 to 54% in 2050, an additional 20 million people. Rapid urbanisation could pose problems for Central Asian countries because urban governance is poor, with limited resources and ill-defined divisions of responsibility between local, regional and national authorities. Infrastructure is largely obsolete and employment opportunities may be insufficient to support urban populations.[4] However, potential domestic and foreign investment in technologies such as renewable energy, electric cars and automated service provision could lead to major urban improvements in the region.

As people move from poorer rural to wealthier urban areas, comparatively well-educated and cosmopolitan people are likely to mix with the more religious, traditionalist and less educated.[5] Combined with interstate migration patterns, this may increase social integration but could also lead to a rise in tensions. In addition to the internal movement of people, external labour migration and remittance flows may also increase, depending on economic opportunities abroad, particularly in Russia.

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

3 United Nations (UN) Department for Economic and Social Affairs (DESA), (2017), *The World Population Prospects: 2017 Revision*.

4 Center for Economic Research, UN Economic and Social Commission for Asia and the Pacific and UN Development Programme (UNDP), (2013), *Urbanization in Central Asia: Challenges, Issues and Prospects*.

5 Central Asia-Caucasus Institute, Silk Road Studies Program, (2016), *The Silk Road to 2050: Key Trends*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC).

Education in Central Asian countries is based on the Soviet system, which brings both strengths and weaknesses. Some fundamental indicators are positive as there is almost universal literacy and high enrolment rates in both primary and secondary education. However, there is also a mismatch between education provision and the needs of the labour market, which may hamper economic growth, modernisation and diversification. Education systems in Central Asian countries still reflect the effects of Soviet emphasis on technical and vocational training over university education. As a result, the labour force is not optimised for a modern economy. This is exacerbated by limited access to tertiary education in some countries.[6] However, increasing numbers of students are seeking higher education abroad. International investments and cooperation with the European Union, the United Kingdom and others are likely to bring novel ideas and skills to a new generation.

Since gaining independence from Russia in the early 1990s, Central Asian countries have increased spending on health care. Improvements, including a greater focus on primary care, have led to an increase in life expectancy equivalent to lower-middle income countries. However, the number of HIV/AIDS cases in the region continues to grow, and health care expenditure as a share of gross domestic product (GDP) remains far below the average of former Soviet countries. It may take decades of sustained reform to ensure that health care professionals are highly qualified and equipped, preventative medicine receives sufficient attention, and health care is sustainably financed.[7]

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Central Asian literacy and enrolment levels are high but Soviet-style education may not match future labour market needs

6 Riboud, M., *Global Journal of Emerging Market Economies*, (2016), 'Investing in Inclusive Human Development'.

7 *Ibid.*

China's investment in infrastructure, such as the railways, brings increasing influence

Leonid Andronov / Shutterstock.com

Economics

Central Asia has good rates of economic growth, largely due to commodity exports. Turkmenistan, Uzbekistan and Kazakhstan export hydrocarbons, cotton and minerals, while Kyrgyzstan and Tajikistan also export some commodities, but have a greater dependence on remittances from emigrant workers in Russia and Kazakhstan. Energy exports from Central Asia to China are likely to decrease, as countries in the region diversify their economies and use their resources for high value domestic production. Greater diversification is likely to help achieve sustainable economic development and provide employment. The revolution in communications technology could offer new opportunities for Central Asian countries to realise productivity gains. However, there are some obstacles to diversification. Central Asian countries may need to improve their attitudes to business and investments by strengthening institutions, improving property rights and the rule of law, and carrying out structural reforms. They will also need to address corruption and tackle infrastructure shortcomings, while overcoming resistance among influential elites with vested interests in maintaining the status quo.[8] Regional integration could also become increasingly important, as countries seek to reduce trade costs. The city of Tashkent has the potential to regain its old role as a regional trade hub.

Central Asia's geostrategic position between China and Europe may lead to significant development following Chinese investment as part of the infrastructure programme of the Belt and Road Initiative (an initiative seeking to expand maritime routes and land infrastructure networks connecting China with Asia, Africa and Europe, boosting trade and economic growth). The land corridor between China and Europe allows faster but more expensive transportation compared to sea lanes, and China has earmarked large sums of money to improve the route.[9] This would present Central Asia with greater economic opportunity, with the region likely to become a more mature market for China in the future.

8 International Crisis Group, (15 March 2017), *Uzbekistan: The Hundred Days*.

9 PwC's Growth Market Centre, (February 2016), *China's New Silk Route: The long and winding road*.

Governance

Central Asian countries continue to develop their national identity nearly 30 years after the dissolution of the Soviet Union. For example, Kazakhstan is changing from the Cyrillic to the Latin alphabet and using Kazak as the national language, as well as promoting local culture and history. However, through its extensive control of the media in most countries, Russia may continue to have a significant influence on public opinion. Secularism and tolerance are generally accepted norms in the region's ethnically diverse societies, but religion is growing in importance in parts of Central Asia. Islam is the largest religion in the region, practised by 70%-90% of the population.

The countries of Central Asia are predominantly authoritarian and suffer from corruption, weak institutions and parallel power structures. As a result, the peaceful transition of power is likely to be challenging and will probably be a source of great interest for external powers, particularly Russia. The next generation of leaders, representing new values and ideas, may struggle to establish influence over politics and the economy. A variety of actors with competing interests, including criminal organisations, are likely to resist change.[10] Governance challenges may also occur at the sub-national level due to an increased demand for devolution of some central authority, despite political qualms about ceding power to local and regional levels of government.[11]

There may be increasing pressure on Central Asian countries to address governance issues, due to: a greater awareness among a digitally and globally connected new generation; population growth; increased urbanisation; fluctuating commodity prices; and international influences. There are some indications that reforms may be successful. For example, Kyrgyzstan has recently attempted to foster a pluralistic parliamentary system. After two civil wars in the space of five years, the country has had trouble-free parliamentary and presidential elections, and is seeing initial consolidation of an open political system. Similarly, Uzbekistan's new president has pushed for greater transparency and openness, and Kazakhstan may see a new president elected in 2020.

Central Asia's geostrategic position between China and Europe may increase development: Samarkand lay on the old Silk Route

10 International Crisis Group, (15 March 2017), *Uzbekistan: The Hundred Days*.

11 Central Asia-Caucasus Institute, Silk Road Studies Program, (2016), *The Silk Road to 2050: Key Trends*, a research paper commissioned by DCDC.

Monument of Victory in Biskek, capital of Kyrgyzstan: Russia remains a major influence in post-Soviet Central Asia

MehmetO / Shutterstock.com

Geopolitics

Russia remains a major influence in the post-Soviet countries of Central Asia, despite their efforts to form ties with the wider world after gaining independence.[12] Central Asian countries tend to avoid making foreign policy choices on ideological grounds. Instead they engage with multiple actors (with a variety of political philosophies) based on cost-benefit analysis. As a result, Central Asian countries have: joined Russian-led security and trade blocs (the Collective Security Treaty Organization (CSTO) and Eurasian Economic Union (EAEU)); engaged with the North Atlantic Treaty Organization (NATO) (through the Partnership for Peace programme); and become part of the Shanghai Cooperation Organization (a political, economic and security group). Kyrgyzstan, for example, has Russia as a key partner (providing trade opportunities, direct investments and even security equipment), but also hosted a United States (US) air base until 2014.

In the future, Central Asia's geopolitical focus may shift and there are already some signs that a change of emphasis has begun. Trade between China and Central Asia has risen dramatically since 2000, and China is now the region's leading trade partner, providing investments and financing for large infrastructure projects. Chinese investment in Central Asia surpassed that of Russia in 2009. While China's stated aim is to boost trade by improving regional infrastructure, increasing regional economic policy integration and removing trade barriers, security arrangements are likely to follow to protect their investments.

Although anti-Chinese sentiments are currently strong among the Central Asian public, as China's investments in the region grow, its influence is likely to rise. In response, Russia will seek to maintain its own influence through the EAEU, an organisation modelled roughly on the European Union. Russia's aspiration to reclaim so called 'lost territories' is likely to persist, particularly as some Central Asian countries have Russian minorities, hence the spectre of a Crimean-style annexation will endure in the near term. While the European Union is expected to play an important role in a number of fields, particularly education, the US has recently lowered levels of aid to Central Asia, arguably reducing its soft power influence in the region.[13]

12 Hanks, R. R., in *Journal of Balkan and Near Eastern Studies* 11(3), (September 2009), 'Multi-vector politics' and Kazakhstan's emerging role as a geo-strategic player in Central Asia', pages 257-267.

13 Ayres, A., Forbes, (4 May 2017), 'Trump to Cut Foreign Aid Budgets, Opening South and Central Asia's Door to Chinese Influence'.

Security

Ethnic tensions are a looming threat to security in Central Asia. Major ethnic violence flared up in Kyrgyzstan in 2010 with hundreds killed and many wounded, and tensions continue to run high.[14] Similarly, there is an ethnic dimension to border disputes between Uzbekistan, Kyrgyzstan and Tajikistan in the fertile and densely-populated Fergana Valley.[15] The borders, initially drawn up when the countries were part of the Soviet Union, are not yet settled and ethnic enclaves dotted around the area complicate the situation in a time of rising nationalism. Violent clashes are common among locals, the borders are militarised and security forces have used force to interdict one another in the borderlands. Existing tensions between neighbouring Uzbekistan, Kyrgyzstan and Tajikistan over access to water could be worsened by the effects of climate change since all three countries rely heavily on water for agriculture or hydroelectric power.[16] This could even lead to armed conflict in the region, particularly as populations grow and demand for water and power increases further.

Terrorism and organised crime will continue to threaten security in Central Asia. Over recent years, mainly as a result of external influence from the Middle East and South Asia, radical fundamentalist groups (affiliated with the Taliban, al-Qaeda, and ISIS) have emerged, recruited and maintained a presence in the region, although government crackdowns have led many to seek refuge in Afghanistan and Pakistan.[17] Without stability in the Middle East, Afghanistan and Pakistan, there is unlikely to be an end to problems from religious extremism and crime in Central Asia. Terrorists often receive at least part of their funding through the illicit drug trade and organised crime. There are a number of synergies between the tactics, logistics and organisational structures employed by both types of actor.[18] Given the transnational character of security problems likely to affect the region, as well as the need to balance the interests of competing great powers, there is likely to be a strong drive for regional cooperation in the future. China is likely to have an increasingly prominent role in matters of security cooperation.

Tensions about water could be worsened by climate change

14 Malashenko, A., Carnegie Moscow Centre, (31 March 2012), 'Kyrgyzstan: A White Ship Amidst the Ice of Post-Soviet Authoritarianism'.

15 Borthakur, A., *Asian Affairs*, 48:2, (2017), 'An analysis of the conflict in the Ferghana Valley', pages 334-350.

16 International Crisis Group, (11 September 2014), *Water Pressures in Central Asia.*

17 Zenn, J., Hudson Institute, (2013), 'On the eve of 2014: Islamism in Central Asia'.

18 Reyes, L. and Dinar, S., *Studies in Conflict and Terrorism*, 38:5, (2015), 'The Convergence of Terrorism and Transnational Crime in Central Asia', pages 380-393.

1 Armenia
2 Azerbaijan
3 Bahrain
4 Georgia
5 Iran
6 Iraq
7 Israel
8 Jordan
9 Kuwait
10 Lebanon
11 Oman
12 Qatar
13 Saudi Arabia
14 State of Palestine
15 Syrian Arab Republic
16 Turkey
17 United Arab Emirates
18 Yemen

Southwest Asia

Southwest Asia will remain a volatile region with many actors competing for influence and several conflicts likely to endure. Although the United States' (US) presence may reduce, it will remain an important actor and other powers, including China (not least investing in infrastructure as part of the Chinese-led Belt and Road Initiative), India and Russia, are likely to play a greater role. Southwest Asia will remain the world's largest producer of oil and gas but, on current trends, energy consumption will rise dramatically with some countries becoming net importers. Climate change will drive summer temperatures even higher, droughts will become more frequent and water scarcity will increase. Religion will remain a defining issue for the region. The loosening of social rules in Saudi Arabia, and the increasing empowerment of women (albeit from a low starting point), could mean that the region adopts an increasingly moderate interpretation of Islam, although it is also plausible that the sectarian divide between Sunnis and Shia could intensify. Across the region, access to health care and education is likely to improve and illiteracy and extreme poverty could be virtually eliminated.

Environment

Southwest Asia already endures considerable extremes of climate and this is likely to increase in the future, with varying effects across the region.[1] Overall, Southwest Asia will experience a warmer and drier climate that will generate further water stress and impact agricultural production. By 2050, parts of the region may become so hot that they are uninhabitable, dramatically increasing the number of people migrating due to climate change. Sea level rise, increased flooding risk and water scarcity are likely to be major issues. Demand for fresh water could increase by about 50% due to population growth, rapid urbanisation and the impact of climate change. However, this may be ameliorated by advances in technology and more efficient water management, particularly in the agricultural sector (the region's biggest consumer of water). Reducing the cost of desalination, eliminating reliance on fossil fuels, and mitigating environmental impacts will all be crucial. Food security will also be a challenging issue as Southwest Asia (apart from Turkey) will be increasingly reliant on food imports.[2] Water stress and fluctuations in food prices may even drive large-scale migration and conflict.

1 Rance, H. and Bradshaw, C., The Met Office, (2017), *Climate change in South West Asia: A review of trends out to 2050*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

2 INRA and Pluriagri, (October 2015), *Addressing agricultural import dependence in the Middle East – North Africa region through the year 2050*.

Renewables may allow continued oil and gas exports

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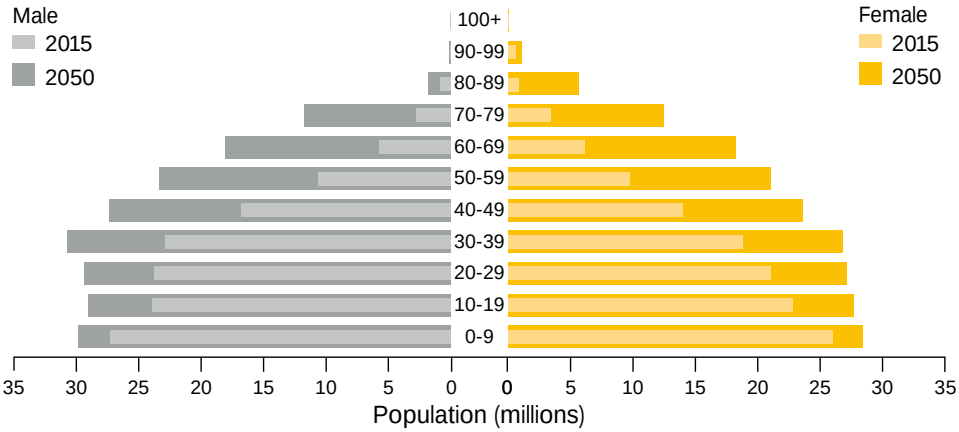
Southwest Asia is likely to remain the world's largest hydrocarbon-producing region in the coming decades, with energy consumption likely to rise dramatically.[3] Some of the region's biggest energy producers, such as Saudi Arabia, are likely to become net importers well before 2050.[4] With a high proportion of the world's proven natural gas reserves, the case for using expanding gas where possible as a substitute for oil is relatively straightforward. Liquid natural gas is expected to become a key part of the energy export. Investment in renewable energy sources is increasing, but it is unclear when output will be able to meet the region's energy demands. Nuclear energy use is also on the rise in Southwest Asia, and nuclear energy cooperation agreements with countries around the world are likely to be an increasingly important part of energy policies. Investments in renewable and nuclear energy may be a way to enable continued hydrocarbon exports. However, environmental concerns and technological developments are driving a transformation of the energy markets towards renewable energy. This, together with the US becoming a major oil exporter, may lead to a downward pressure on oil prices. Competing suppliers of natural gas and a more flexible market are likely to keep gas prices low. As a result, Southwest Asian countries are highly unlikely to build their economies purely on energy exports in the future.

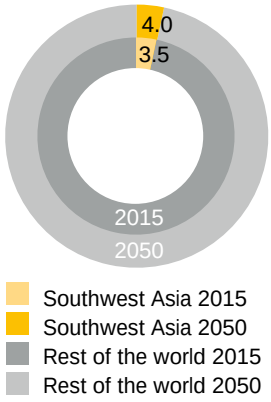
Human development

Southwest Asia's population will increase by approximately 50% over the next 30 years, from 322 million in 2015 to 485 million by 2050. Population growth will probably be highest in the region's most unstable and undeveloped states, for example, the populations of Iraq, Palestine and Yemen are likely to double in size. Global trends towards smaller families and ageing populations are evident in Southwest Asia,[5] but a number of countries may still have substantial youth populations by 2050. If these young people do not have access to the opportunities they expect, greater migration or rising tensions could occur.

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

3 BP, (2016), 'BP Energy Outlook, Regional Insights – Middle East'.

4 Hino, Y., Brookings, (2 July 2015), '*Saudi Arabia field report: Another potential oil crisis in the Middle East*'.

5 United Nations (UN) Population Division, (2017), *World Population Prospects 2017.*

The urban population of Southwest Asia will increase over the next 30 years, with an estimated 70% of the population living in cities by 2050 compared to 61.5% today. Future urban habitats will probably be a mixture of highly developed, technologically-enabled areas (such as Tel Aviv, Dubai and Beirut) and big cities surrounded by unplanned sprawls. The region will contain some of the biggest urban agglomerations in the world by 2050, including Istanbul, Tehran and Baghdad. Emigration will continue to be driven by conflict, the effects of climate change, political disruption, a lack of economic opportunities and youth unemployment.[6] The historic trend of inward migration to the Gulf States, as people look for work, is likely to decrease as more attractive employment appears elsewhere.

Levels of human development vary considerably in Southwest Asia, with Israel having the highest human development ranking and Yemen the lowest. Although high population growth in conflict zones is a continuing barrier to rapid poverty reduction, the region could see a total elimination of absolute poverty well before 2050. Women's rights and opportunities are likely to remain limited by discriminatory inheritance laws, child marriage and deep-seated cultural norms, particularly for those living in poverty and rural areas.[7] However, significant progress is expected in areas such as access to health care, education and political participation.

There was a significant increase of non-communicable diseases, such as heart disease (44%), strokes (35%) and diabetes (87%) in Southwest Asia between 1990 and 2010. This trend is likely to continue as it is often related to lifestyle choices.[8] The response of countries in the region to the rise in non-communicable diseases is variable. Richer countries are investing heavily in health care provision, but demand for services is increasing. Curbs on government spending could increase the importance of private health care.

Women's rights will improve, although progress could be slow due to cultural norms

6 International Organization for Migration (IOM), (2017), *IOM Middle East and North Africa: Regional Strategy 2017-2020*, pages 10-11.

7 UN Economic and Social Commission for Western Asia (UNESCWA), (2016), *Equality in the New Global Agenda, Integrating a Gender Perspective in the Implementation of Sustainable Development Goals 1 and 2 in the Arab Region*, page 3.

8 The World Bank, (4 September 2013), '*In Middle East and North Africa, Health Challenges are Becoming Similar to Those in Western Countries*'.

The influence of religion on politics will remain, but a more moderate Islam may develop

Education provision has greatly improved in the region over the last few decades with literacy rates rising from 59% in 1990 to 78% in 2010, and by 2050, rates of illiteracy may no longer be a concern in Southwest Asia. Despite entrenched attitudes towards women, there is almost complete gender parity in primary education,[9] and female university graduates outnumber men in many countries. The region is seeing increasing participation of women in the paid labour market, which is likely to drive further economic growth. However, some countries lag behind these positive educational trends, mainly as a result of conflict. A key issue will be whether higher education adequately prepares young Southwest Asians to enter high-skilled employment.

Economics

Saudi Arabia and Iran are likely to be the major regional economies by 2050, although Turkey could substantially outperform them all if it is able to implement structural reforms.[10] Iran's gross domestic product (GDP) is likely to grow if the economy diversifies and a more business-orientated environment takes hold. However, reforms progress slowly in Iran and (as in the region as a whole) prospects for long-term economic growth are directly connected to the political environment and wider governance issues. The region's reliance on oil exports and the escalation of conflicts could hamper significant economic growth. Many countries have acknowledged the need for economic diversification, but actions to achieve this vary considerably (there are some positive examples, such as the United Arab Emirates, where oil now accounts for a third of the country's GDP). Southwest Asia (apart from Israel) also has poor rates of technology adoption, contributing to economic underperformance.[11] The Gulf States in particular will face the challenge of balancing the use of foreign labour to drive economic growth, versus providing opportunities for their citizens.

China, and increasingly India, will play an important role in the region's economic development, with trade between China and Southwest Asia increasing fiftyfold in the past 20 years.[12] The Horn of Africa will also be a key area of economic and political interest for the region, where rising investments are likely to be followed by broader cooperation, including on security. Intra-regional commerce is also likely to increase, with Turkey reorientating towards its immediate neighbours (which currently account for around 25% of overall trade). As part of a long-term strategy for economic and political cooperation between Turkey and the Arab world, the Turkish government has set a goal to achieve US $100 billion of annual trade with the six countries that make up the Gulf Cooperation Council by 2023.

9 The World Bank, (2014), '*Education attainment in the Middle East and North Africa: success at a cost*'.

10 PwC, (February 2017), *The Long View: How will the global economic order change by 2050*.

11 Stansfield, G. and Ranharter, K., (2017), *The Middle East to 2050: Key trends*, a research paper commissioned by DCDC.

12 Kane, F., The National, (27 May 2014), 'China blazes a trail as trading partner for Middle East'.

Governance

The political culture in Southwest Asia has been dominated by 'strong men' and authoritarian governance resulting in personality-based politics that are sensitive to disruptions. It is therefore doubtful whether political, cultural and religious pluralism can be improved and inclusive prosperity achieved. There are a number of challenges to creating stable democratic systems in the region, however, it is plausible that limited democracies could be established.[13]

Religious, national, ethnic and tribal affiliations will continue to play important roles in identity-building in Southwest Asia. In Iran, the only theocracy (a form government in which priests rule in the name of God) in Southwest Asia, most people define themselves along nationalistic or ethnic lines (as either Iranian or Persian), depending on their support for the regime. The recent increased influence of religion in politics in Turkey and a number of other countries in the region could persist over the next 30 years. However, the authoritarian and violent character of some religious movements is likely to weaken public support for political Islam and, in combination with social reform, drive a long-term trend towards greater religious moderation.[14] If more moderate Islam takes hold in countries such as Saudi Arabia, strict social rules may be loosened, with corresponding improvements in gender equality, transparency, state accountability and economic structures.

Persistent discrimination against Sunnis or Shia (depending on the country) and the current struggle for influence between Saudi Arabia and Iran has led to sectarian identity becoming increasingly important.[15] While it is plausible that the sectarian divide could be bridged (Shia and Sunnis live in peaceful coexistence in countries such as Kuwait), current trends suggest there will be a growing divide. This is particularly significant in Iraq where the survival of democracy largely depends on political leadership that manages to unify both Sunnis and Shia.

Governmental legitimacy will increasingly depend on prosperity, with economic growth, fiscal sustainability and job creation for an ever-growing youth population constituting major challenges. State expenditure has already overtaken revenue, as countries seek to use expansionary monetary policies as a means of resolving political problems, as opposed to concentrating on economic development. Major public sector employment schemes reflect tribal, ethnic and sectarian pressures, while security and defence expenditure as a proportion of government spending is the highest in the world.[16] Food and energy subsidies (key methods of suppressing inflation and avoiding public discontent) have grown dramatically in response to consumption habits and rapid population growth. The social contract may be affected by: jobs moving from the public to the private sector; higher income tax; and significantly reduced subsidies. Most governments in Southwest Asia will seek to retain power by gradual reform rather than major systemic change, which could cause political instability if public expectations are not met. Those with competing political and personal interests are also likely to oppose far-reaching reforms.[17]

13 Muasher, M., (2014), *The Second Arab Awakening: And the Battle for Pluralism*.

14 Pollock, D., Washington Institute, Policy Watch 2572, (25 February 2016), 'Polls Show Most Muslims Reject Both Extremism and Islamic Reform'.

15 Kinninmont, J., Chatham House, (6 January 2016), '*Middle East's Sectarian Divide Threatens to Overwhelm a Generation*'.

16 Stockholm International Peace Research Institute (SIPRI), (2016), 'Trends in the world military expenditure, 2016'.

17 Kinninmont, J., Chatham House Report, (2015), 'Future Trends in the Gulf'.

The legitimacy of the theocratic regime in Iran may be increasingly challenged with growing demands to modernise from a highly-educated citizenry, increasingly influenced by women. The government will endeavour to hold on to power at any cost, but gradual reform is probable. Abrupt regime change is unlikely if the security apparatus remains loyal. Reimposed sanctions are, however, likely to strengthen the more conservative elements of Iranian society.

Geopolitics

Influenced by nationalist rivalries and religious sectarianism, the struggle for influence between Iran and Arab states, led by Saudi Arabia, is likely to be a long-term theme in regional geopolitics. Non-state actors may continue to play a role as proxies, but also in their own right challenging the established state structures. Turkey's strategic interests appear to be moving away from Europe in favour of greater influence through intra-regional cooperation with countries in Southwest Asia. Nevertheless, Turkey is unlikely to develop lasting relationships with its historic rivals, Iran and Russia.[18] Modernisation of Saudi Arabia and Iran could dramatically change regional geopolitics, although power dynamics in Southwest Asia will continue to be characterised by a high degree of pragmatism, and personal relationships.

The US will remain an important regional actor, but will probably reduce its presence in Southwest Asia as its energy dependence on the region declines. This could create an opening for other powers. For example, Russia's involvement in the Syrian civil war may be the start of a renewed long-term presence in the region, serving Russian security interests and reinforcing its role as a global power. China may also become a more active player in the region, as it implements its Belt and Road Initiative, a massive programme of infrastructure investment. A significantly more capable Chinese navy (supported by base facilities in the region) could help secure its access to the Gulf, protecting trade and national interests. China may even become a serious competitor to Western countries over arms deals and form bilateral security arrangements with countries in the region.[19]

Due to demographic changes, Israel is likely to become more conservative, affecting its economic and political landscape,[20] and its influence in the region may decline. It is unlikely that US backing will cease, but the type and extent of support provided to Israel will be largely dependent on the priorities of the incumbent US president. Egypt is likely to remain closely connected to the politics, economics and security of Southwest Asia. However, the financial support to Egypt from some of the Gulf States is likely to decrease, due to increasing fiscal pressure. It may result in a reduction of Egypt's political support to those countries and its capacity to provide internal stability. Internal instability in Egypt or a major humanitarian crisis, such as flooding of the densely populated Nile delta, could also have major ramifications in Southwest Asia. Further fragmentation of some countries in the region is possible and new states may emerge, such as an independent Kurdistan. However, internal divisions among the Kurds and competing interests among regional powers could constitute significant constraints.

18 Larrabee, F. S. and Nader, A., (2013), *Turkish-Iranian Relations in a Changing Middle East.*

19 Castilla, C., Institute for Security & Development Policy, (18 March 2016), '*China's Evolving Middle East Role*'.

20 Staff, T., *Times of Israel*, (19 May 2017) 'Half of Israel to be Arab, ultra-Orthodox by 2059 – projections'.

Security

Southwest Asia will remain a volatile region where the potential for conflict will be high. Security challenges will be driven by socio-economic issues, resource scarcity (particularly water) and discrimination. Such issues will mainly be internal, but with a transnational character. The impact of climate change is likely to exacerbate the drivers for conflict. Organised crime and corruption could continue to drive state fragility, and religious radicalisation will also continue to exist.[21] Countries outside Southwest Asia and non-state actors are likely to play an important role in determining the regional balance of power. The prospect of the conflicts in Syria and Yemen stabilising are limited in the short term. Syria is likely to remain an arena for strategic competition among external powers for the foreseeable future.

Due to its complex amalgam of political, economic, environmental and security factors, the Israel-Palestine conflict may remain unresolved. Although the conflict no longer has the same profile it once had (in regard to understanding how the region would develop), this may change.[22] With a rapidly growing Palestinian Arab population, frustrated over injustices and lack of opportunities, tensions could escalate again. Egypt will continue to have an important role in the Israel-Palestine conflict.

Southwest Asian militaries are likely to see continued major investment in conventional capabilities, however, asymmetric warfare will probably gain in importance.[23] The major military powers in the region will almost certainly be Turkey, Iran and Israel, along with Saudi-led coalitions. While the Gulf States have the greatest conventional military strength in Southwest Asia due to years of extensive defence spending, they have, in practice, limited influence on Iran.[24] Iran's credible conventional deterrent and use of asymmetric methods (including proxies) gives it major advantages in the struggle for regional dominance. Direct state-on-state conflict and further nuclear arms development cannot be ruled out in the next 30 years.

Rostislav Glinsky / Shutterstock.com

The Israel-Palestine conflict is expected to continue

21 Clarke, C., RAND Corporation, (2 November 2016), 'Al Nusra Is Stronger Than Ever'.

22 Stansfield, G. and Ranharter, K., (2017), *The Middle East to 2050: Key trends*, a research paper commissioned by DCDC.

23 Cordesman, A., Center for Strategic and International Studies, (4 January 2016), 'The [New-Old] Crises and Instability in the Middle East and North Africa in 2016'.

24 Cordesman, A. and Toukan, A., Center for Strategic and International Studies, (2016) 'Iran and the Gulf Military Balance'.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5 Maldives
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South Asia

The relationship between China, India and Pakistan will dominate regional geopolitics and drive, or thwart, regional integration and trade. Driven by a rising number of consumers, the economy is expected to grow rapidly, and India's economy could be the world's second largest by 2050. Absolute poverty is likely to have been virtually eliminated by 2050, although relative poverty and inequality will endure. Tensions between religious and ethnic groups are likely to be an enduring feature of the region, and governments' ability to manage that tension will be crucial. South Asia will be badly affected by climate change with high temperatures, droughts and flooding. Water shortages are likely and without mitigation food production will reduce by approximately 15-30%. South Asia's armed forces are likely to grow, with India's armed forces reaching over four million by 2050. Nuclear proliferation will remain a cause for concern, and regional rivalry and continued investment in tactical nuclear weapons could spark a nuclear arms race, with the possibility of nuclear conflict.

Environment

South Asia will be one of the regions most affected by climate change. Over the next 30 years, droughts, floods and other natural disasters could displace tens of thousands of people across the region. Sea level rises, bringing increased risk from tsunamis, cyclones, typhoons and flooding, could constitute an existential threat to island and coastal populations, and are likely to threaten a number of major South Asian cities, including Kolkata, Mumbai and Dhaka.[1]

Access to water has improved across the region in recent years. However, water availability is likely to become an increasing concern as populations grow, industrial activity increases and ground water sources are depleted. Some of South Asia's most valuable water sources pass through disputed territory, and although access to water alone is unlikely to trigger conflict, it will probably constitute an increasing source of tension between and within South Asian countries if not managed sensitively. South Asia is also expected to experience temperature rises of between 2° Celsius and 4° Celsius over the next 30 years, reducing food productivity by up to 15-30%, unless mitigation measures are put in place. Those most directly affected are likely to be the poor living in rural areas who currently account for 70% of the South Asian population.[2]

South Asia will witness a steep rise in regional energy demands, driven largely by India's growing energy needs. India is currently the world's fourth largest electricity consumer and will need to substantially increase its use to sustain its economic growth levels. Current estimates suggest that coal consumption will need to increase tenfold by

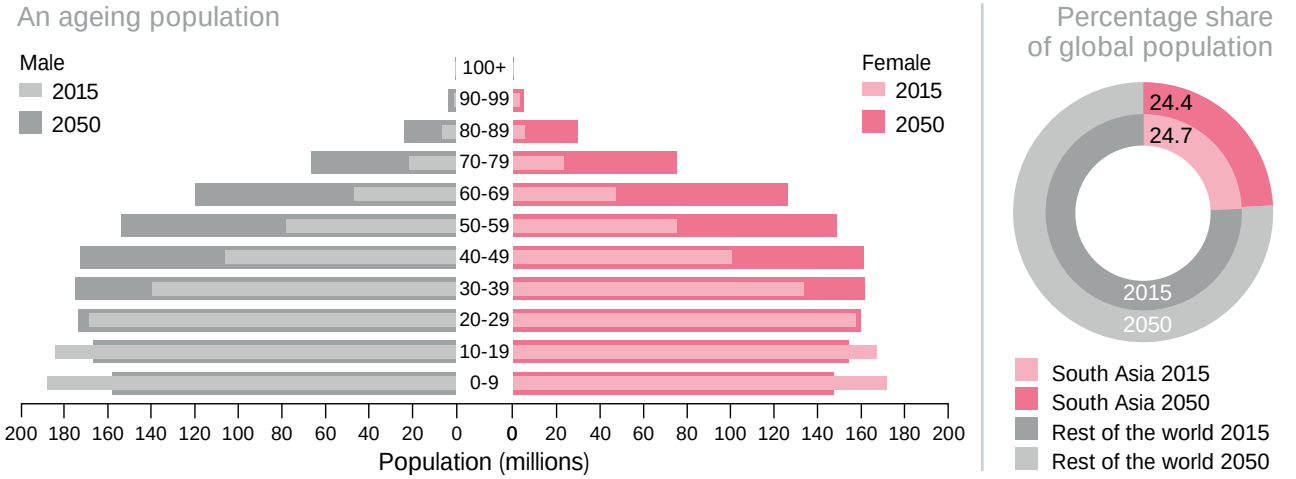
1 Asian Development Bank, (2011), *Asia 2050: Realizing the Asian Century*, page 79.

2 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC), page 12.

2050.[3] Pakistan's energy security will be highly dependent on the full implementation of the China-Pakistan Economic Corridor (CPEC), which includes 21 energy projects.[4] If successful, these could have a positive impact on Pakistan's social and economic development. Smaller countries in the region may also benefit from Chinese investment in regional energy projects, and China may increasingly be regarded as an alternative partner to India for energy cooperation.

Human development

It is expected that South Asia's population will grow to a little under 2.5 billion, representing approximately a quarter of the world's population and 46% of the total Asian population by 2050.[5] India's population alone is expected to increase from 1.35 billion today to 1.65 billion. On that projection, India will overtake China as the most populous country in the world around 2024. Importantly, South Asia's working age population continues to grow and is not expected to peak until around 2040, presenting a demographic window of opportunity that, if harnessed effectively, could boost economic growth and productivity in the region. Education and employment will be important priorities for South Asian governments. Rates of technical and vocational education and training remain low in South Asia, with 1.2% secondary enrolment in vocational programmes in India in 2014, compared with 27.1% in Europe and 21.7% in China.[6] Addressing this deficit will be crucial if South Asia is to provide adequate employment opportunities for its growing working age population and sustain current levels of economic growth.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

Much of the region's growing population is likely to live in cities. South Asia's urban population is expected to more than double over the next 30 years, resulting in over 50% urbanisation by 2050. A considerable amount of this development is likely to consist of informal, slum housing, lacking basic services and infrastructure. In addition, despite this increasing urbanisation, South Asia's rural population will almost certainly remain substantial, and governments may come under pressure to invest in rural infrastructure

3 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by DCDC, page 12.

4 *Ibid*., page 8.

5 Asian Development Bank, (2011), *Asia 2050: Realizing the Asian Century*, page 121.

6 The World Bank, (2017), 'World Bank Education Statistics 2017'.

and connectivity to maintain its political support. Concerns over food security, in combination with the projected increase in both droughts and flooding, could have a huge impact on rural India. If agriculture is not given the attention and investment it requires, it is likely to drive even more migration to urban areas, placing a strain on both urban and rural development.

Religious tensions in South Asia (across the region as well as within individual states) are likely to endure. India's Muslim population is projected to surpass Indonesia as the world's largest. However, the country will almost certainly remain majority Hindu, with Hindus comprising 76.7% of India's total population in 2050.[7] Sectarian violence could be exacerbated if one religion is perceived to be benefiting at the expense of another. Therefore, governmental ability to manage the relationship between religious groups will be a key determinant of national and regional stability.

Countries in South Asia are home to almost 37% of the world's poor, with 31% of the population currently surviving on less than United States (US) $1.25 per day.[8] However, despite the region's massive population growth, the number of those living in extreme poverty is likely to reduce substantially, and may be eliminated completely by 2050.

South Asia's health care priorities are likely to include managing the impact of climate change and non-communicable diseases. As a result of climate change, new disease vectors may emerge and the malaria season could lengthen, with more outbreaks. Higher incidences of flooding could increase the threat of waterborne diseases and diarrhoea, although some states, such as Bangladesh, are making efforts to mitigate this by improving sanitation.[9] At the same time, the probable rise in non-communicable and chronic diseases will mean that countries will face a 'double burden' of disease, which some will struggle to address. In 2010, 53% of all deaths in India were through non-communicable diseases,[10] but this figure is likely to grow, as life expectancy increases and improving living standards lead to the better management of communicable diseases.

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Much of South Asia's population growth will be in cities such as Mumbai

7 Hackett, C., Pew Research Center, (21 April 2015), 'By 2050, India to Have World's Largest Populations of Hindus and Muslims'.

8 United Nations (UN) Economic and Social Commission for Asia and the Pacific, (2016), *Achieving the Sustainable Development Goals in South Asia: Key Policy Priorities and Implementation Challenges*.

9 *The Economist*, (24 March 2018), 'Beating the Bugs'.

10 World Health Organization (WHO), (2011), *India: Non-Communicable Diseases*.

Some projections place India as the world's second largest economy by 2050

Economy

Prospects for economic growth remain promising. In 2015, South Asia was the fastest growing economy in the world, driven not just by India but also Pakistan, Bangladesh and Bhutan.[11] India's economy is already converging on that of the US and can be expected to continue to do so. Some projections place India as the world's second largest economy after China by 2050, by which time the two countries are expected to be contributing 15% and 20% respectively to global gross domestic product (GDP) levels (purchasing power parity adjusted). However, there are some challenges to economic growth, most notably, creating sufficient jobs. The Indian labour force will reach approximately one billion workers by 2050, 25% more than China.[12] This could act as a spur to economic growth, potentially resulting in India exceeding Chinese growth rates. Although current efforts to boost the Indian manufacturing sector show commitment to job creation, if historical trends are taken into account there is a very high probability that at least 150-175 million Indians will be unemployed by 2050. Given its increasing working age population, the pressure to reduce manufacturing costs through automation could prove problematic for India.

Continuing distrust and hostility between South Asian countries, as well as a lack of the necessary physical infrastructure, currently makes regional economic cooperation problematic. South Asia, therefore, remains one of the least economically integrated regions in the world.[13] At present, intra-regional trade represents less than 5% of total trade, compared with 35% in East Asia and 60% in Europe. However, intra-regional trade is increasing slowly from this low level, largely as a result of bilateral trade initiatives, but increasingly through wider sub-regional approaches. In particular, China's massive regional infrastructure programme, the Belt and Road Initiative, is likely to bring significant opportunities for South Asia. The Belt and Road Initiative may be one of the key drivers boosting regional economic integration.

11 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by DCDC, page 39.

12 Asian Development Bank, (2011), *Asia 2050: Realizing the Asian Century*, page 21.

13 Chaudhuri, R., (2017), *South Asia out to 2050,* a research paper commissioned by DCDC, page 41.

Governance

Although questions remain over levels of democratic development in much of South Asia, technological innovation, economic growth and the need for greater regional economic integration are likely to drive changes, shaping the character of regional governance. India in particular will continue to take pride in its status as the world's largest democracy and is likely to remain an important advocate of democracy in the region. The key governance challenge for South Asian countries will continue to be fragmentation within state boundaries, with pressure for greater devolution to the local level currently in evidence in India, Pakistan, Myanmar and Nepal. Although national governments may be forced to accede to such demands to a limited extent, they will almost certainly continue to oppose any moves towards actual secession, and it is unlikely that the region will see a shift in current state borders in the foreseeable future.[14]

Geopolitics

The triangular relationship between China, India and Pakistan will dominate regional geopolitics and drive the progress, or otherwise, of the wider region. The long-standing relationship between China and Pakistan is highly likely to endure, supported by the US $60 billion China-Pakistan Economic Corridor project. China will also seek to boost its relations with each of India's neighbours, through investment in infrastructure projects under the Belt and Road Initiative and free trade agreements. China is currently negotiating such an agreement with Sri Lanka, which could turn China into its major investor and trading partner by 2050.[15]

India's relationship with China, as geographic neighbour, trade partner and competing power, will almost certainly remain complex and problematic. India will continue to view China as a military threat and a geostrategic rival, particularly as Chinese activity in the Indian Ocean Region is increasing. India will remain suspicious of Chinese investment in South Asian infrastructure projects, such as the China-Pakistan Economic Corridor, which passes through disputed territory and which India views as having a military element. However, growing economic interdependence between the two countries may be a stabilising factor. Despite ongoing geopolitical tensions, levels of Chinese-Indian trade will remain substantial. In 2015, China was already one of India's largest trading partners. This relationship was heavily weighted in China's favour, with India's trade deficit at more than US $40 billion, but Indian exports to China have since risen sharply.[16] If this can be sustained, it may place the economic relationship on a more equal footing.

As China becomes more economically and politically dominant, India may seek to strengthen relations with the US, seeing it as a counterweight to Chinese power and influence in the region. The US is unquestionably already India's most important strategic partner, and India will almost certainly view any signs of a US disengagement from the region with concern. Fear of US withdrawal may result in India seeking greater regional cooperation. However, given tensions in its near abroad, and in particular in its volatile relationship with Pakistan, India may focus its efforts towards the wider continent. India's partnerships with Vietnam, Thailand and Cambodia are likely to deepen, whilst those with Japan and South Korea may also strengthen further.[17] India could be increasingly drawn towards East and Southeast Asia, and may pursue opportunities to invest in regional infrastructure in response to China's foreign infrastructure projects in the Indian Ocean Region. Other South Asian states may also

14 Chaudhuri, R., (2017), *South Asia out to 2050,* a research paper commissioned by DCDC page 47.

15 *Ibid*., page 42.

16 *Ibid*., page 45.

17 *Ibid*., page 41.

India will almost certainly remain majority Hindu

look outside the region for global partnerships, in an effort to balance and hedge against existing relations with India and China. The Maldives, Sri Lanka, Nepal and Bangladesh are likely to be increasingly mindful of the dangers of the Chinese debt trap (if China decides to call in its infrastructure loans) and will probably look to the US and the United Kingdom (UK) as a counterweight to the regional powers. Sri Lanka in particular may seek to forge closer ties with the UK, France and the US.[18]

Security

India-Pakistan and India-China tensions are likely to endure, although bilateral dialogue is expected to continue, and there are prospects that limited settlements will be reached on some disputed areas by 2050. As China develops transport networks as well as energy and communications infrastructure in its western border regions as part of the Belt and Road Initiative, this may test the strength of territorial agreements and heighten tensions over disputed claims. As the Belt and Road Initiative gathers pace, similar skirmishes to those seen on the Bhutan-China border in 2017 are possible and may escalate in some cases, although they are likely to stop short of conflict.

Although the number of fatalities caused by terrorism and insurgency in the region (excluding Afghanistan and Iran) has decreased steadily in recent years (from around 9,000 deaths in 2010 to under 3,000 in 2016),[19] terrorism will remain South Asia's major security challenge. However, improving state security and surveillance capabilities mean that some South Asian governments could succeed in containing the threat, even if they cannot remove it completely.

Between 1990 and 2015, the size of the armed forces of South Asia doubled from a little over two million to around 4.6 million. By 2050, India alone is expected to have increased the size of its armed forces to at least four million.[20] As well as boosting the size of its military, India may seek to enhance the sophistication of its technical

18 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by DCDC, page 54.

19 South Asia Terrorism Portal, (2017), *South Asia Fatalities 2005-2017*.

20 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by DCDC, page 52.

capabilities, sourcing cutting-edge technology from international partners such as the US and Israel, potentially through co-development initiatives with Indian firms.[21] India may also conduct joint military exercises in the region with countries such as Australia, Singapore, Japan, the US and Indonesia. As well as boosting its own capabilities, such exercises could be used as a strategic messaging tool towards China.

Nuclear proliferation will remain a cause for regional and international concern, particularly in the face of continued hostility between India, Pakistan and China. In particular, continued regional investment in tactical nuclear weapons might increase the probability of their use, whether by state security forces, after theft by non-state actors, or even as a nuclear retaliation.[22] At best, continued investment in tactical nuclear weapons could spark a nuclear arms race in the region, making deterrence in South Asia increasingly dangerous and risky to manage.

Joe Ravi / Shutterstock.com

India may seek to enhance its technical capabilities with international partners: the Tejas jet is 60% indigenous content by value

21 PwC, (2012), *Decoding the Indian Aerospace and Defence Sector.*

22 Chaudhuri, R., (2017), *South Asia out to 2050*, a research paper commissioned by DCDC, page 62.

1 China
2 China, Hong Kong SAR
3 China, Macao SAR
4 China, Taiwan Province of China
5 Democratic People's Republic of Korea
6 Japan
7 Mongolia
8 Republic of Korea

East Asia

East Asia is likely to account for 25% of the global economy by 2050, a larger share than any other region. China's investment in research and development could surpass that of the United States (US) within a decade, and China, Japan and South Korea are likely to remain leading investors in robotics and automation. The transition to a technology-driven economy will pose significant challenges for the region, and China will also have to concurrently manage the transition to a consumer based economy. The ability of China's government to manage these transitions will be pivotal for the region and the world, as will its relationship with the US. China will become an increasingly powerful military actor, potentially rivalling the US, while the militaries of Japan and South Korea are likely to operate globally. Increasing economic interdependency within the region will reduce the risk of conflict, although it cannot be ruled out. A rising sea level and increasingly intense storms will threaten many coastal cities, and prolonged periods of drought will result in water shortages. The region's population is likely to shrink and the median age will increase, making the affordability of welfare and pensions an acute challenge for governments, although access to, and the quality of, health care and education are likely to improve.

Environment

All countries in East Asia will be affected by climate change. Flooding and landslides already affect many parts of the region, and the frequency of such events is likely to increase due to more intense rains. Rising sea levels will worsen the effects of storm surges associated with cyclones, increasing the risk of severe impacts on densely-populated coastal regions.[1]

Overfishing, rising sea temperatures and ocean acidification will reduce fish stocks, possibly leading to tensions over fishing rights. Demand for water, particularly in the agricultural sector, is likely to increase. Northern China, parts of North Korea and northern Taiwan are likely to face severe water stress by 2050. If not adequately managed, water scarcity may lead to large-scale economic and social displacement. For example, northern China contains 20% of the country's water resources, but 41% of its population and 38% of its agriculture.[2] Although longer periods of drought may result in food shortfalls, rain-fed crop production is likely to increase by 2-10% by 2050.[3] Technological advancements are likely to improve the efficiency of food production and water management. Agriculture is likely to be part of urban development.

1 Westphal, M., *et al.*, Asian Development Bank, (2013), *Economics of Climate Change in East Asia*.

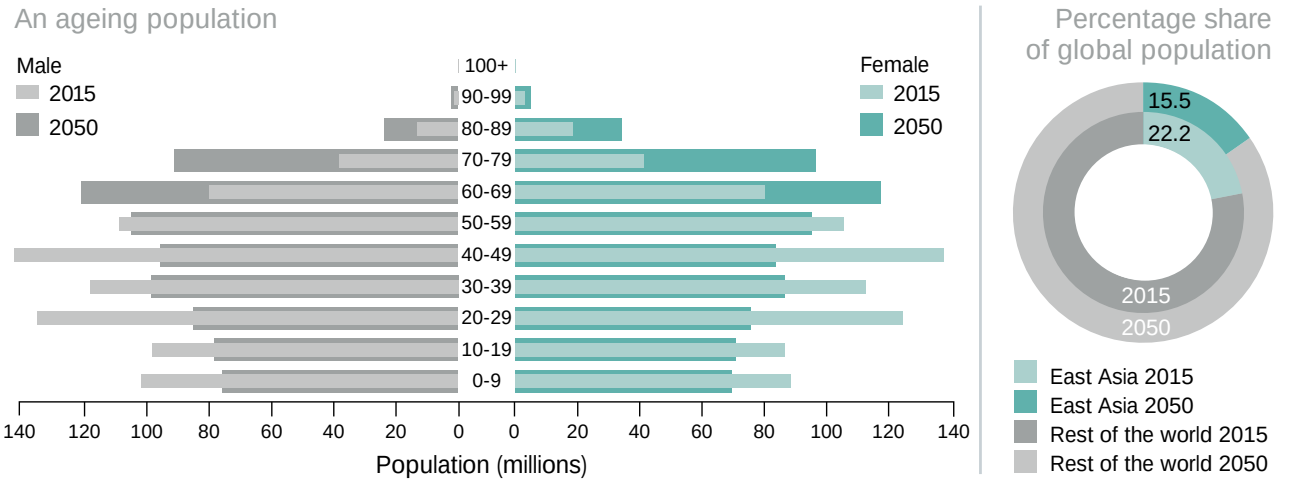
2 Du, T., *et al.*, in Food and Energy Security, Volume 3, Issue 1, (2014), 'China's food security is threatened by the unsustainable use of water resources in North and Northwest China'.

3 Conforti, P., (Ed), Food and Agriculture Organization of the United Nations, (2011), *Looking ahead in world food and agriculture: perspectives out to 2050*.

In East Asia, the demand for energy will grow, mainly driven by the modernisation of China. Due to the scale of demand, East Asia will continue to be dependent on imported energy. The US could become a major liquefied natural gas exporter to the region. Decades of heavy industrialisation has caused significant environmental damage, with air pollution, contaminated drinking water and damage to crops becoming major political issues in China. Greater investment in renewable and nuclear energy (which could account for 60% of China's energy consumption by 2050) is likely to have a major impact on the long-term regional energy mix.[4] Making economic and structural changes, including introducing electric cars, to create a lower carbon infrastructure will take time, meaning that in the short term there will be continued increases in emissions.

Human development

East Asia's population is projected to both increase in median age and decline in numbers, with profound effects on political frameworks, welfare systems and economies.[5] The region's population is likely to shrink by 3%, from 1.63 billion today to 1.59 billion by 2050.[6] Parts of the region may well be deserted by 2050, with the vast Russian Far East currently home to just six million people, 25% of whom are at retirement age. East Asia's population is ageing faster than any other region in the world, and is likely to comprise 434 million people over the age of 65 by 2050.[7] Accordingly, dependency ratios (the proportion of children and the elderly compared with those of working age) will increase dramatically in the next 30 years. The legacy of Chinese birth control policies is likely to prove particularly challenging, as each worker will need to support two parents and four grandparents, as well as their own children.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

Pension provision is likely to remain a long-term financial challenge, although policy interventions, such as increasing retirement ages and creating programmes to incentivise bigger families, are underway. If they are to be effective, such policies will probably need to address the cost of raising children and a lack of access to child care. Although immigration from outside the region could be a solution to East Asia's demographic

4 Institute for Security & Development Policy (ISDP), (2016), *Northeast Asia to 2050: Key Trends*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC).

5 *Ibid.*

6 United Nations (UN) Department for Economic and Social Affairs (DESA), (2017), *World Population Prospects: 2017 Revision*.

7 *Ibid.*

ChameleonsEye / Shutterstock.com

Ageing populations, urbanisation and environmental challenges may drive governance changes in East Asia

problem, societies in the area are comparatively conservative in this respect. However, intra-regional migration is significant, and is expected to continue to grow due to increased interconnectivity, economic opportunities and environmental challenges.

The urban population of East Asia is likely to increase from 982 million in 2015 to 1,250 million by 2050. In China, approximately 50% of the current rural population (269 million people) are expected to move to cities by 2050. While Japan, South Korea and Taiwan are already highly urbanised, the transformation of China into a predominantly urban country could be one of the most profound changes in Asia in the next 30 years, with immense social and political ramifications. Urbanisation in the region is unlikely to be uniform, with some cities being technology-driven and highly organised (such as those in Japan), contrasted with less efficient urban sprawls, as may occur in parts of China. Megacity regions are likely to change the economic and political dynamics in the region. Four of the major Chinese megacity regions already have status on par with the provinces and by 2050 this number is likely to have more than doubled.

Hong Kong, Japan, South Korea and Taiwan have very high rankings on the Human Development Index, but may face problems providing social security and addressing age-related inequality, due to economic slowdowns and ageing populations. China has recently seen a period of major progress in prosperity and providing public goods (with the state guaranteeing food, clothing, medical care, housing and burial expenses). However, income inequality is rapidly increasing and there may be rising public dissatisfaction at the lack of improvement in living conditions. North Korea will continue to have the lowest human development level in the region due to extreme political suppression and constraints to economic development. However, as a whole, East Asia is likely to see the elimination of absolute poverty well before 2050.[8]

The region will continue to see further investments and structural changes in education to address the technology skills gap. Private education, influences from students studying abroad, less rigid education systems and the introduction of apprenticeships are likely to mitigate skills shortages in the future, as well as addressing an innovation deficit between East Asian and Western countries.

8 Dissanayake, R., *et al.*, Department for International Development (DFID), Chief Economist's Office, (2017), *Three worlds in 2050: scenarios for poverty and development*, a research paper prepared for DCDC.

With Japan at the forefront, significant parts of East Asia are likely to have access to highly advanced health care. As life expectancy rises and the treatment of communicable diseases improves, the relative incidence of non-communicable illnesses (such as cancer and diabetes) will probably increase significantly. Rising health care costs will be burdensome, particularly for China, due to the scale of demand. However, state provision of services may drive economic growth by ensuring greater disposable income.

Economics

The coming decades will see continued economic growth as strategies of sectorial rebalancing take hold and regional trade links are strengthened.[9] Led by China, Northeast Asia is likely to account for about 25% of the global economy by 2050,[10] with a rapidly expanding middle class driving increased domestic consumption. Small, flexible, technology-driven companies are likely to comprise a larger part of the economy, replacing some state-owned enterprises or major conglomerates. China will likely transition to a market-based economy, and eventually deregulate interest rates and increase the flexibility of its exchange rate.

E-commerce and hi-tech businesses could contribute significantly to the East Asian economy. South Korea and Japan will remain among the top investors in research and development, while China's spending on research and development could eclipse the US within a decade. The region (especially China) already conducts substantial advanced research in artificial intelligence with deep pools of data, and has significant internal markets. East Asia also has the potential to play a leading global role in the space industry. However, the transition from labour-driven to technology-driven economies will pose significant socio-economic challenges for the region.

The East Asian share of the global trade is estimated to increase from 22% in 2015 to 29% in 2050.[11] A greater extent of the trade is expected to be with markets within the Indo-Pacific region. Although the US has strong interests in the region (with 11 million jobs dependent on trade with Asia), trade between the US and East Asia will continue to be a politically contentious issue. Protectionism or weak demand in the US, or elsewhere, may drive further regional cooperation on trade. Negotiations are already underway for a comprehensive trade agreement between China, South Korea and Japan (and could potentially include Taiwan in the future). A successful economic integration could give these countries significant influence on future financial markets. However, over-reliance on Chinese trade will be a cause for political concern among China's trading partners and Japan, South Korea and Taiwan are likely to remain major global trading nations in their own right.

Governance

Amidst a deteriorating regional security environment and lingering historical grievances, nationalism will continue to be a dominant factor in shaping the identity of the region. The Chinese Communist Party will continue to promote a strong historical Chinese identity, as well as emphasising its own role in China's strength and prosperity. In the next 30 years, Beijing may face a growing threat to its control from ethnic minority groups adopting increasingly violent tactics to promote their interests. Failure to address grievances and socio-economic disparities may drive future unrest.

9 Asian Development Bank, (2011), *Asia 2050: Realizing the Asian Century*.

10 ISDP, (2016), *Northeast Asia to 2050: Key Trends*, a research paper commissioned by DCDC.

11 HSBC Commercial Banking, *Trade Winds: Shaping the future of international business*.

Despite rising cross-border exchanges in East Asia, regional identity remains underdeveloped, but may mature in the next 30 years. One example of cultural cross-pollination can be seen in South Korea and Japan's music and film industries, which provide both countries with soft power throughout the Indo-Pacific region.

Christianity is growing in East Asia, with the largest increase in adherents seen in China, from eight million in 1991 to 67 million in 2010. Some Chinese academics project substantial growth of the population identifying as Christian by 2050.[12] Despite a recent decline in the numbers of religiously affiliated people in Japan, spiritual beliefs are likely to remain important in identity building in East Asia in the coming decades. However, greater individualism and departing from traditional collectivist norms may also become more important in identity building.

Ageing populations, urbanisation and environmental challenges may drive innovative and decentralised forms of governance throughout Northeast Asia in the coming decades. Better rates of education and greater interconnectivity, as well as a more demanding Chinese middle class, will also contribute to growing calls for more effective and responsible governance. It is unclear, however, whether China will become more democratic, or if the current system of government is adaptive enough to endure. Hierarchical social norms, increased surveillance and nationalistic sentiment in a tense regional security environment are powerful constraints to democracy. Democratisation in North Korea is only likely to happen should the current regime collapse.

Women's representation in politics remains low in East Asia, with women comprising 9.5% (Japan) and 23.6% (China) of delegates to national parliaments. It is likely, however, that women's representation in politics will increase significantly, due to policy interventions and women comprising a greater part of the paid workforce.

MAHATHIR MOHD YASIN / Shutterstock.com

Tokyo's first female Governor, Yuriko Koike, at the Tokyo Annual Public Disaster Drill in 2016

12 Pew Research Center, (2015), *The Future of World Religions: Population Growth Projections, 2010-2050*.

Economic and social reforms will be required to promote Chinese stability

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China 2050. China's economic, social and geopolitical future will have a significant impact on the rest of the world. There are a number of domestic constraints that will limit China's prospects of becoming the world's dominant superpower.[13] A key question will be how effectively China's one-party state addresses the country's broad range of social, economic and environmental challenges.[14] This will depend on developments in China's political system and its external strategic environment. Whether the Chinese Communist Party loosens, tightens or maintains its current controls over Chinese society, it is bound to have a defining impact on its future.[15] Hard authoritarianism is unlikely to deliver far-reaching socio-economic reforms, and hence could increase the risk of economic stagnation and exacerbate social problems. A softer authoritarianism is more likely to facilitate the economic and social reforms that will promote stability. In any event, it is unlikely that China will return to the totalitarianism seen under Mao Zedong, due to the economic importance of the private sector, global interdependencies, and a lack of support for such a position from the public, government and armed forces. On the other hand, Chinese society lacks the features that could lead to Singaporean-style democracy, and such a path is also unlikely to be tolerated by the Chinese Communist Party. If China fails to transition to a modern sustainable economy, there is likely to be internal instability that could have global ramifications. However, if the transition succeeds, China could have an affluent, urban middle class, and a population that benefits from a healthier environment and a more efficient welfare system. The Chinese Communist Party would probably still be in power under these circumstances, with China experiencing a more benign international environment and taking on a more proactive global role.

13 Fenby, J., (2017), *Will China Dominate the 21st Century?*

14 The World Bank and Development Research Centre of the State Council, the People's Republic of China, (2013), *China 2030: Building a modern, harmonious, and creative society.*

15 Brown, K., (2016), *CEO, China: The rise of Xi Jinping.*

Geopolitics

It is highly likely that regional cooperation in East Asia will continue to be impeded by historically-based distrust and nationalism, but pushed forward by desires for prosperity, regional stability, free markets and trade, and access to sustainable energy. This may well lead to parallel trends of cooperation and confrontation.

In the coming decades, China's economic, military and diplomatic strength will increase, making it a global power with the potential to compete with the US. China's aspirations and rapid progress towards achieving great power status could be one of the most important geopolitical factors shaping the region, and perhaps even the global world order. China is using (and is likely to continue to use) a number of economic, political and military strategies to generate regional influence and challenge US interests. For example, the Belt and Road Initiative is a massive trade and infrastructure programme, which is central to China's prosperity and stability, and is likely to boost regional economic integration.[16] The Belt and Road Initiative also includes a system of bases and security arrangements, as China seeks to protect its trade routes (particularly in the Indian Ocean and Central Asia). This expansion is likely to cause concerns to other actors (most notably India), who could drive countermeasures and competing projects.

The US will probably remain the strongest military power in the world and continue to have a significant military presence in East Asia, partly to preserve its deep and enduring economic and security ties to the region. The relationship between the US and China will be the key determinant of the regional security environment. Although the two powers will probably be increasingly competitive, they are also likely to see an ever-increasing degree of economic and social entanglement, and so they are likely to avoid direct military confrontation.[17]

Thana Thanadechakul / Shutterstock.com

Chiang Kai-shek Memorial Hall: The relationship between China and Taiwan could be a potential flashpoint

16 Bower, E. Z., *et al.*, Center for Strategic & International Studies, (CSIS), (June 2015), *Southeast Asia's Geopolitical Centrality and the U.S.-Japan Alliance*.

17 Shambaugh, D., (2016), *China's Future*.

The relationship between China and Taiwan could be a potential flashpoint in the coming decades. Taiwan's population is increasingly likely to self-identify as Taiwanese rather than Chinese, which may drive greater calls for independence. However, Taiwan's significant demographic decline, combined with a probable rise in immigration from China, and extensive 'brain drain' to China may provide a counterbalance to this trend.[18] By 2050, China is likely to have the capacity to establish military superiority in the western Pacific, and asymmetric approaches, including artificial intelligence and automated systems, are likely to play an important part.[19] If future Taiwanese governments make direct moves toward independence, China may respond with military threats and possibly action. The US position on Taiwan will remain an important part of China-US interactions.

In the next few years, it is likely that Japan will conclude its post-war 'normalisation', and implement a new constitution allowing it to play an independent part in Indo-Pacific power relations. Despite historical issues, closer cooperation between Japan and South Korea may develop over the coming decades. By 2050, both Japan and South Korea will almost certainly have the capacity to operate globally with small-scale expeditionary forces. Both countries' relationships with China will depend on a mix of economic opportunities and security concerns.

China-Russian relations will be based on a mutual fear of US-led containment, with a strategic partnership to counter US influence and promote economic growth. However, as the weaker partner in the relationship, Russia will probably continue to have concerns about China's strategic intentions and will pursue its own agenda in the region. Europe is likely to maintain a keen economic interest in East Asia, as its exports to the region have increased by 347% since 2000.[20] After the US, East Asia is Europe's biggest trading market, and commerce with the region may overtake trade with the US by 2050. As China is not seen as a potential existential threat, Europe is more likely to try and maintain a productive relationship with China.

Security

The East Asian security environment is a particularly complex and challenging one, particularly due to: the presence of some of the most powerful military forces in the world; great power competition; tensions on the Korean peninsula; maritime territorial disputes; transnational threats such as organised crime and terrorism; and the potential for natural disasters. The increasing military powers of Chinese and North Korean weapons of mass destruction are likely to lead to the strengthening of the military capabilities of Japan and South Korea, and ongoing demand for US presence. Economic entanglement is likely to deter full-scale conflict in the region, although the use of asymmetric means, such as cyberattacks, may increase. Although the East Asian security environment lacks shared security mechanisms, many of the regional security challenges will demand a collaborative response, and could therefore be a driver for regional security cooperation.

Complicated by historical controversies and grievances, nationalism, domestic politics and competition over energy resources, the East Asian maritime territorial disputes (Senkaku/Diaoyu islands are claimed by Japan, China and Taiwan; Takeshima/Dokdo are claimed by Japan and South Korea; and the southern Kurils is claimed by Japan and Russia) will persist. Whilst there has been increased militarisation and uncompromising rhetoric regarding the disputed islands, growing economic interdependence may lead to more pragmatic ways of handling these disagreements in the future.

18 Oxford Economics, (2012), *Global Talent 2021: How the new geography of talent will transform human resource strategies*.

19 Kania, E. B., The Strategy Bridge, (2018), 'Strategic Innovation and Great Power Competition'.

20 UN DESA, Statistical Division, 'International Trade Statistics Yearbook, Volume II, Annex D'.

It is plausible that Kim Jong-un will remain in power for a considerable period in North Korea by maintaining a level of domestic popularity, a loyal circle of officials and high levels of political repression. The future of the North Korean nuclear capability is highly uncertain. If it develops a more effective nuclear capability, the regional actors may have to adjust to containment of a nuclear-armed country. North Korea would be highly likely to use its nuclear weapons if it was attacked and believed the regime's survival was at risk. A North Korea with long-range missiles also changes the geostrategic conditions in East Asia as it will make it difficult for Japan not to be drawn into any future war on the Korean Peninsula. However, Kim Jong-un could craft a deal with both China and the US that may lead to the end of the Korean War and create a new, more stable status quo. The sudden death or resignation of the North Korean leader may trigger a regime collapse with significant ramifications. The longer-term outlook will be influenced by the political situation in the two Koreas and regional powers' strategies. China is unlikely to change its preference for the status quo and any potential regime change that is unfavourable to China's strategic interests may lead to Chinese military intervention.

Mattis Kaminer / Shutterstock.com

Long-term outlooks will be influenced by the political situation in the two Koreas and regional powers' strategies

1 Brunei Darussalam
2 Cambodia
3 Indonesia
4 Lao People's Democratic Republic
5 Malaysia
6 Myanmar
7 Philippines
8 Singapore
9 Thailand
10 Timor-Leste
11 Vietnam

Southeast Asia

Sitting between the rising powers of India and China, and astride the busiest shipping lanes in the world, geopolitical competition in Southeast Asia is likely to be intense. The region hosts some of the fastest growing economies in the world and future foreign investment is likely to further boost the region's economy. Corruption is, however, endemic and is likely to dampen economic growth, and whilst standards of governance could improve some governments, others could become more authoritarian. Climate change, in particular its impact on the monsoon season and rising sea levels, could lead to flooding, crop failures and water shortages. Absolute poverty may be virtually eliminated, although inequality will endure, and could increase. Although the region has been relatively peaceful over the past few decades, rising defence spending and an increasingly complex security environment with several potential flash points, including the South China Sea, could make the risk of conflict more likely.

Environment

Southeast Asia's annual mean temperatures will continue to rise, particularly inland. Along the east coast of Vietnam, northwest Sumatra and islands in the southern part of Indonesia, there have been recent increases in rainfall in excess of 50 millimetres per decade. Similar increases in rainfall are likely to continue, although projections for future rainfall vary, depending on the climate model used. The region relies heavily on monsoon rains for food production, meaning that any change in future monsoonal patterns could have a significant impact on food security. Food production may also be threatened by rising sea levels and salt water intrusion, which could reduce the availability of suitable arable land. Some projections suggest that countries that are currently net producers of rice (such as Vietnam) may become net importers by 2050 and coastal crop areas could routinely become submerged in salt water.[1] Poorer Southeast Asian countries will almost certainly be less able to adapt, and consequently will be harder hit by climate changes.

Coastal communities in Southeast Asia will experience sea level rise, with some areas at particular risk. For example, a projected one metre rise in sea level by 2100 could impact on 10% of the population of Vietnam and submerge 6% of the Philippines. All climate models suggest an increase in intensity of extreme weather events, with higher sea levels exacerbating their impact.[2]

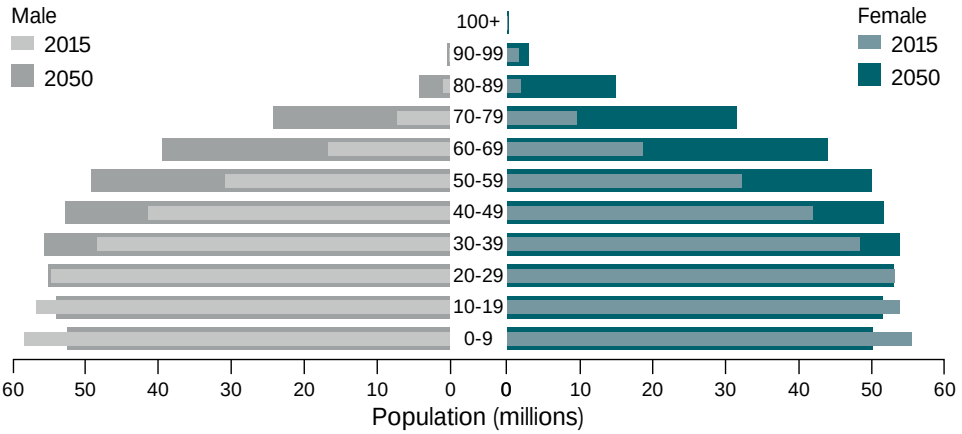
1 Rance, H. and Bradshaw, C., The Met Office, (2017), *Climate change in South West Asia: A review of trends out to 2050*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC), page 14.

2 *Ibid*., pages 15-16.

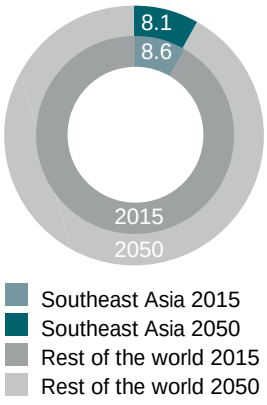
Human development

Southeast Asia is currently home to 649 million people, comprising 14% and 8.6% of the overall Asian and global populations respectively. By 2050, there may be 797 million people in the region, representing a growing proportion of the Asian population at 15% and a slightly reduced percentage of the world's inhabitants at 8%.[3] Despite this population growth, fertility rates across Southeast Asian countries will probably continue to decline with nine countries likely to fall below the replacement rate of 2.1 children per woman by 2050, although there will be significant disparities across the region. Thailand's population could begin to shrink by 2025 and Singapore's by around 2045.[4] Declining birth rates and longer life expectancies will probably mean that Southeast Asia's population ages, possibly leading to more problematic dependency ratios (the proportion of children and the elderly compared with those of working age). Social, financial and political structures will need to be implemented and resourced across the region, otherwise many elderly people will be at risk of poverty.

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

Across Southeast Asia, the level of absolute poverty has fallen significantly over the past 20 years, with the number of people living on less than United States (US) $2 per day reducing significantly. Absolute poverty has been eradicated in Singapore and Brunei; is below 5% in Malaysia and Thailand; but is above 40% in the rest of the region.[5] However, despite declining levels of poverty, inequality has increased between urban and rural regions within each country, reducing social inclusiveness. Climate-induced migration may erode advances in poverty eradication. Southeast Asia will likely maintain a net emigration rate in line with the broader Asian trend (three people per thousand emigrating annually), although there are countries within the region that will continue to see high rates of immigration over the next 30 years. The region's urban inhabitants are likely to increase in number. Today, rates of urbanisation vary significantly between countries, from 100% in Singapore to just over 20% in Cambodia.[6] An increase in the number of informal settlements lacking basic services and an inadequate police presence could lead to an environment in which criminal or terrorist groups prosper.

3 United Nations (UN) Population Division, (2017), 'World Population Prospects Interactive Data'.

4 UN Population Division, (2017), 'World Population Prospects Interactive Data'.

5 Cook, S. and Pincus, J., *Journal of Southeast Asian Economies*, Volume 31, Number. 1, (2014), 'Poverty, Inequality and Social Protection in Southeast Asia: An Introduction', pages 1–17.

6 The World Bank, (2017), 'World Bank Open Data'.

Inequality between rural and urban areas is likely to remain significant

Human development standards throughout Southeast Asia vary greatly. Singapore and Brunei have 'very high' human development levels (ranked 5th and 30th in the world respectively); Malaysia and Thailand have 'high' levels (59th and 87th, respectively); while all other countries have 'medium' levels, showing a decline over the last 30 years.[7] Educational standards vary across the region, but all countries demonstrate a positive trajectory. There are high levels of attendance at primary schools throughout the region, but greater diversity in the level of secondary education enrolments, ranging from over 95% in Brunei to below 75% for Myanmar. Over the past decade, Timor-Leste, Vietnam, Thailand and Malaysia have increased their investment in education, which will almost certainly have positive impacts on their economies. The value of investment in technical skills is recognised across the region, as each country transitions to increasingly digital economies, but critical thinking and creativity-based skills remain undervalued.

Key health indicators in all Southeast Asian countries have improved in recent decades, with a continuous increase in life expectancy since 1950. As the region's population ages, incidences of non-communicable diseases, such as cancer and diabetes, are also likely to rise. Changing weather patterns may lead to more outbreaks of infectious diseases, especially those linked to greater temperatures and rainfall. Although spending on health care is currently low across the region (around 4% of gross domestic product (GDP) compared to the Organisation for Economic Co-operation and Development (OECD) average of 9.5%), trends suggest that there will be significant increases in the future.[8] Health care quality and provision will continue to vary greatly across the region, possibly leading to increased pressure on governments to meet the needs of their population.

7 UN Development Programme (UNDP), 'Human Development Report 2016'.

8 Hashim, J., United Nations University, (2012), 'Health and Healthcare Systems in Southeast Asia'.

Educational, institutional, governmental and financial reforms will be required to achieve full potential

Economy

As an economic bloc, Southeast Asia currently has a GDP of nearly US $3 trillion, ranking as the seventh largest global economy (if considered as a single nation) and it will probably be the fifth largest within ten years. Vietnam could be the fastest-growing global economy over the next 30 years, with a projected average annual GDP growth of around 5%, closely followed by the Philippines (fifth fastest-growing at 4.3%), Indonesia (ninth at 3.7%), Malaysia (tenth at 3.5%) and Thailand (19th at 2.6%).[9] Within these countries, growth is being driven by both population increases (stimulating demand and capital investment) and technological integration that increases productivity. However, if the region is to realise its full economic potential, sustained financial reforms and strengthened commercial and governmental institutions will be required, alongside investment in education.

Southeast Asia has experienced a rapid growth in trade of merchandise and services since 2000 and this is likely to continue, albeit at a declining rate. However, despite the region's potential, most Southeast Asian countries (except Singapore and Brunei) are still developing economies, and may be unable to afford new infrastructure to support rapid urbanisation. Southeast Asia is a major destination for foreign direct investment, attracting 16% of such funds sent to developing economies worldwide in 2016.[10] China is also investing in infrastructure in the region as part of its Belt and Road Initiative, and this is likely to help the ease with which trade can be conducted within Southeast Asia. Nevertheless, an over-reliance on foreign direct investment may be problematic, since funding streams are volatile and are likely to remain so unless barriers to investment are addressed.

Governance

Southeast Asia currently contains five 'flawed democracies', three hybrid regimes, two authoritarian states and one absolute monarchy.[11] Although several democratic reforms have taken place over the last ten years, this trend may have stalled, with increased instances of dissent being suppressed across the region. As civil societies struggle

9 PwC, (2017), 'The long view: how will the global economic order change by 2050?'.

10 UN Conference on Trade and Development (UNCTAD), (2016), *ASEAN Investment Report 2016*.

11 The Economist Intelligence Unit, (2016), 'Democracy Index 2016', page 34.

to emerge from military power bases and as religious and secular forces clash, it may continue to be hard for democracy to flourish in the region. Without mitigation, it is plausible that some countries in Southeast Asia could see increasingly authoritarian forms of government in the future. Corruption is endemic within Southeast Asia and is estimated to cost the region 1% of its potential annual economic growth.[12] Most Southeast Asian countries rank highly on corruption indexes, and public office is widely seen as a means to acquire personal wealth. Anti-corruption organisations are often undermined by political elites, while activists are at increasing risk of attack and incarceration.[13] It is unlikely that anti-corruption efforts will gain significant traction by 2050, meaning that corruption could continue to be a constraint on the region's potential growth and broader influence.

Geopolitics

The Association of Southeast Asian Nations (ASEAN) has provided a framework for regional governance since its inception in 1967. It is central to how Southeast Asia engages with the broader Indo-Pacific region, giving member countries substantial collective bargaining strength. The forum has been lauded for its successes but also criticised for its inability to act decisively, which may lead to obsolescence in the future.[14] Historically, ASEAN has been based on balanced representation within the organisation, however, Indonesia may push to take a leadership role commensurate with its growing economic might. This may either provide the unifying leadership that is required, or fracture the organisation.

Ho Chi Minh City: Vietnam could have the world's fastest growing economy

12 Transparency International, 'Corruption Perception Index 2016'.

13 Welsh, B., ASEAN Studies Program, (2016), 'Corruption Trends in 2016: Southeast Asia's Governance Plight'.

14 Quah, D., *The Economist*, (2015), 'Is the ASEAN Way the Right Way?'.

Southeast Asia will grow in importance globally, in large part because much of the world's trade passes through strategic chokepoints within the Southeast Asian archipelago. All Indo-Pacific powers, including the US, China and India, are seeking to improve their influence within the region, and ASEAN can also expect an increasing level of engagement from non-regional partners, including the United Kingdom and the European Union. Even if its internal problems lead to ASEAN's dissolution or marginalisation, Southeast Asia will remain critical to the Indo-Pacific power balance.

Security

Over the last 50 years, Southeast Asia has experienced relatively low levels of conflict when compared with other regions. With the exception of several long-running insurgencies and sporadic intra-regional territorial conflicts, non-violence has become the norm. However, it cannot be assumed that (relative) stability and peace will persist. Many Southeast Asian countries were founded through violent struggle, and the region's military dynamics are influenced by elites, corruption, intra-regional economic inequalities and differing perceptions of extra-regional state actors.[15] The region has benefited from a strong US presence and security guarantees since the end of World War 2, but major global powers are increasingly vying for influence. As the security environment becomes more complex, the risk of conflict is likely to grow. This, along with growing economic power, has been driving increased defence spending within the region over the last 30 years.[16] This trend is expected to continue as economic circumstances improve and the geopolitical environment remains uncertain.

Open sea lanes will be critical to peaceful outcomes in the region and encourage international cooperation

Kyodo News / Contributor

15 Ak, H., Kyoto University, (2016), 'An Arms Race in Southeast Asia: The Claims and Realities'.

16 Stockholm International Peace Research Institute (SIPRI), (2018), 'SIPRI Military Expenditure Database'.

The complexity of the Southeast Asian security environment is exemplified by the South China Sea territorial dispute between Brunei, China, Indonesia, Malaysia, the Philippines, Taiwan and Vietnam. China views its claim as vital to its physical and economic security, and its reinforcement of military installations in contested territory is likely to continue, so that it can take control in a crisis. However, China may also seek to use diplomacy to appease other claimants by offering compromises that reflect its pre-eminent position in the disputed waterways. China's actions within the South China Sea are increasingly drawing international attention and are seen as a test case for how the country will function within a liberal rules-based world order. Although there is a risk of military incidents, the likelihood of full-scale war is limited as long as the sea lanes remain open.

People smuggling and human trafficking in Southeast Asia have been increasing since the Asian Financial Crisis of 1997. Some estimates suggest that the number of trafficked victims rose from around 5,000 people in 2009 to just under 14,000 in 2015.[17] However, the true extent of the problem is difficult to assess because there are porous borders between many countries and a lack of birth and citizenship records in some areas.

Piracy within Southeast Asian waters poses a significant threat to the region's maritime security, particularly as over 50% of global shipping passes through the region. While the number of piracy-related incidents has decreased, globally, between 2011 and 2015, there was a 71% rise within Southeast Asian waters, with the majority of incidents occurring around Indonesia.[18] Since 2015, there has been increased counter-piracy cooperation between Southeast Asian countries, which has led to some degree of stabilisation. However, piracy will continue to plague the region, particularly in areas such as the Southern Philippines, where the reach of law enforcement is limited. Local insurgencies, transnational organised crime and terrorist networks may seek to exploit opportunities provided by piracy-related activities.

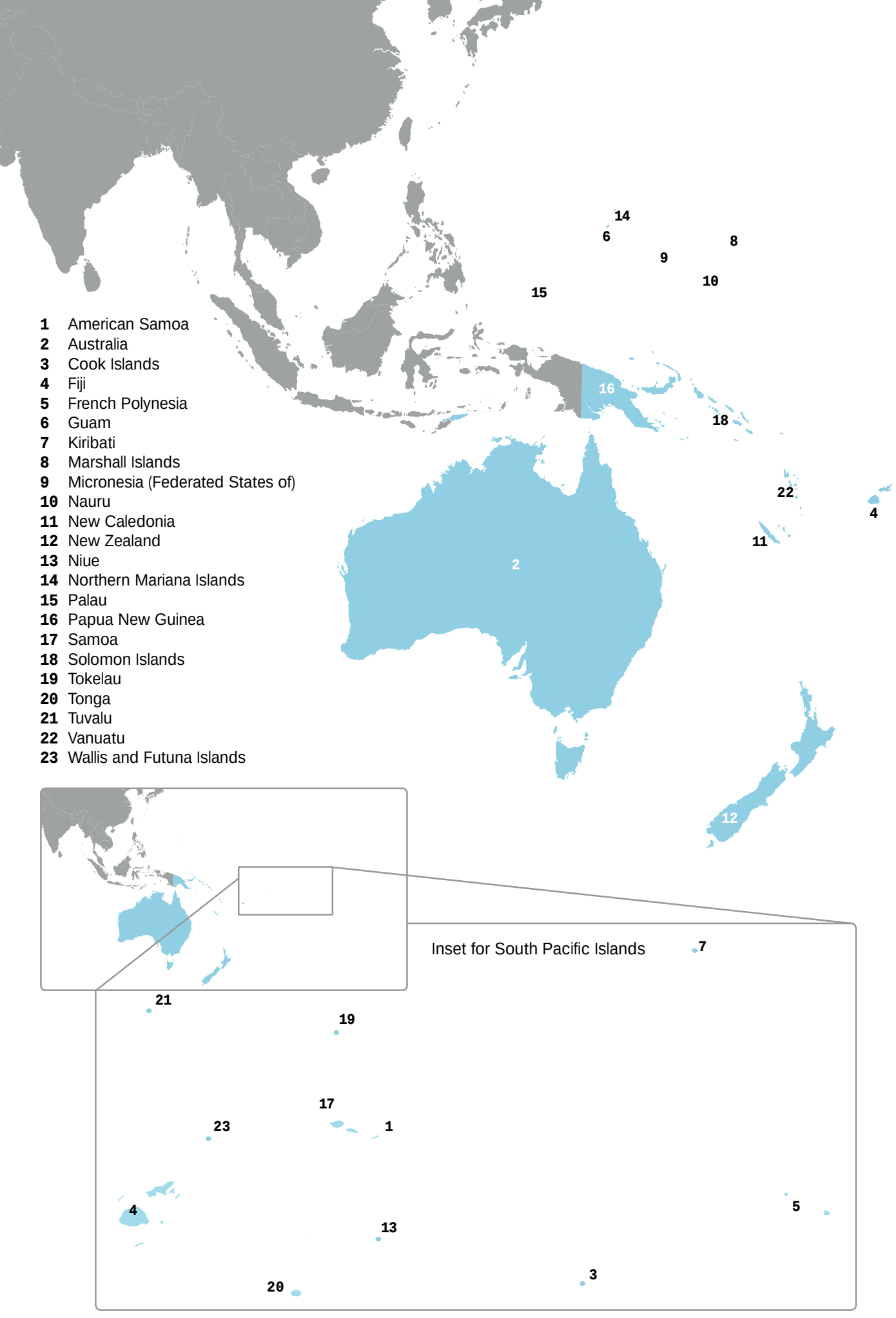
As Southeast Asian economies digitalise and as more people in the region have access to the Internet, there will probably be a corresponding growth in cybersecurity risks. Differing rates of modernisation within Southeast Asia is already creating a digital divide, presenting opportunities for exploitation by transnational cybercrime.[19] Collaborative efforts between ASEAN countries to date have focused on capacity building within member states, and have not established the legal framework necessary to combat trans-border criminal cyber activities. The development of a collaborative and credible multilateral cyber deterrence mechanism will be critical for ASEAN's continuing economic and geopolitical growth over the next 30 years.[20]

17 US Department of State, (2016), 'Trafficking in Persons Report'.

18 International Chamber of Commerce (ICC) International Maritime Bureau, (January 2016), 'Piracy and Armed Robbery against Seas: Report for the period 1 Jan – 31 Dec 2015'.

19 Thomas, N., Asian Security, Volume 5, (2009), 'Cyber Security in East Asia: Governing Anarchy'.

20 Chen, Q., The Diplomat, (2017), 'Time for ASEAN to Get Serious About Cyber Crime'.



1 American Samoa
2 Australia
3 Cook Islands
4 Fiji
5 French Polynesia
6 Guam
7 Kiribati
8 Marshall Islands
9 Micronesia (Federated States of)
10 Nauru
11 New Caledonia
12 New Zealand
13 Niue
14 Northern Mariana Islands
15 Palau
16 Papua New Guinea
17 Samoa
18 Solomon Islands
19 Tokelau
20 Tonga
21 Tuvalu
22 Vanuatu
23 Wallis and Futuna Islands

Oceania

Covering a vast area of the Pacific and stretching into the Southern Ocean, Oceania will act as a bellwether for humanity's impact on the oceans and the effects of climate change. Increasingly intense storms and rising sea levels will have a profound impact on small island communities, which could become trapped in a continuous cycle of environmental disasters that devastate local economies. Australia and the larger islands will also be adversely affected by climate change, but not to the same extent. Levels of health care, education and literacy are likely to improve as is access to information, although poverty and inequality could increase and some communities could be dependent on foreign aid. Both China and the United States (US) are likely to vie for influence in Oceania, although the US, with its close ties to Australia and New Zealand (who will remain the dominant actors), is likely to remain the most influential external actor. France and the United Kingdom (UK) will also remain active in the region (both having territories and strong historical links) and Russia has a developing relationship with Fiji. The risk of state-on-state conflict in the region, however, is low. Illegal maritime activity is increasing and is likely to become a focus for security cooperation.

Environment

Climate change will present growing economic and social challenges. Sea levels in the Pacific are expected to increase by 1.2 metres by 2100 and temperatures are likely to rise by between 1° Celsius and 4° Celsius.[1] Extreme weather events, such as cyclones, will also become more severe, although it is currently uncertain if they will become more frequent.[2] The effects of climate change are already stressing Pacific communities to the extent that migration is often seen as the only solution, for example, 70% of households in Tuvalu believe that they will need to move if farming becomes more difficult. However, it is unclear where climate migrants will live, and how they will fund this process. For example, the median monthly household income in Kiribati is US $12, meaning many would not have the financial means to relocate.[3]

1 Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO), (2011), *Climate Change in the Pacific: Scientific Assessment and New Research, Volume 1: Regional Overview.*

2 Global Change Institute, The University of Queensland, (September 2016), *Global Strategic Trends 6: Out to 2050 in Oceania, Key Ideas Paper*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC).

3 United Nations (UN) Economic and Social Commission for Asia and the Pacific (ESCAP), (2015), 'Pacific Climate Change Migration – Survey Fact Sheet'.

Effects of climate change will continue to drive migration in the region

ChameleonsEye / Shutterstock.com

Water supply security will be an increasing challenge for all Oceanian countries. While Australia and New Zealand have the means to develop climate-resilient water sources, such as desalination and recycling, many countries elsewhere in the region are reliant on a single type of water supply. As sea levels rise, salt water may contaminate more groundwater aquifers and at the same time rainfall will become more unpredictable, perhaps leading to reservoirs and surface flows drying up. Urban populations will probably increase, with inadequate sanitation infrastructure further contributing to water contamination as cities grow. Both Australia and New Zealand are currently assessed as being food secure, but Australia's agriculture may become more susceptible to the effects of climate change.[4] Elsewhere in the region, as many Pacific Island countries become more urbanised, their reliance on imported foods may increase, contributing to an insecure national food supply. Currently, all Pacific Island countries have either negative or highly-negative food trade balances.[5]

All Oceanian countries are subject to natural disasters (such as cyclones, tsunamis and earthquakes), with their effects sometimes worsened by human-caused deforestation or environmental degradation. The predicted increase in severity of extreme weather events[6] could be exacerbated by a growing population, as well as increasing urbanisation. Resilience to environmental disasters within Oceania is likely to remain low[7] and, by 2050, many nations in the region could be in a constant state of recovery. A severe weather event across multiple countries (or concurrent environmental disasters) could mean that relief efforts are significantly delayed, potentially resulting in a broad humanitarian crisis.

Human development

Australia will have approximately 31 million inhabitants by 2050 and New Zealand will have six million. Both nations' populations are currently ageing, and this is likely to continue. Fertility rates will remain below replacement-level and life expectancy is likely to increase, hence any population growth will mainly be due to immigration. Papua New Guinea's current population of around seven million people could reach over 20 million by 2050, with Fiji's 880,000 citizens increasing to 1.1 million. By contrast, Niue's population will probably shrink to around 1,050 by 2050, from approximately 1,600 today.

4 Di Nunzio, J., Future Directions International, (2014), *Consumption Patterns and Food Demand in Australia to 2050*.

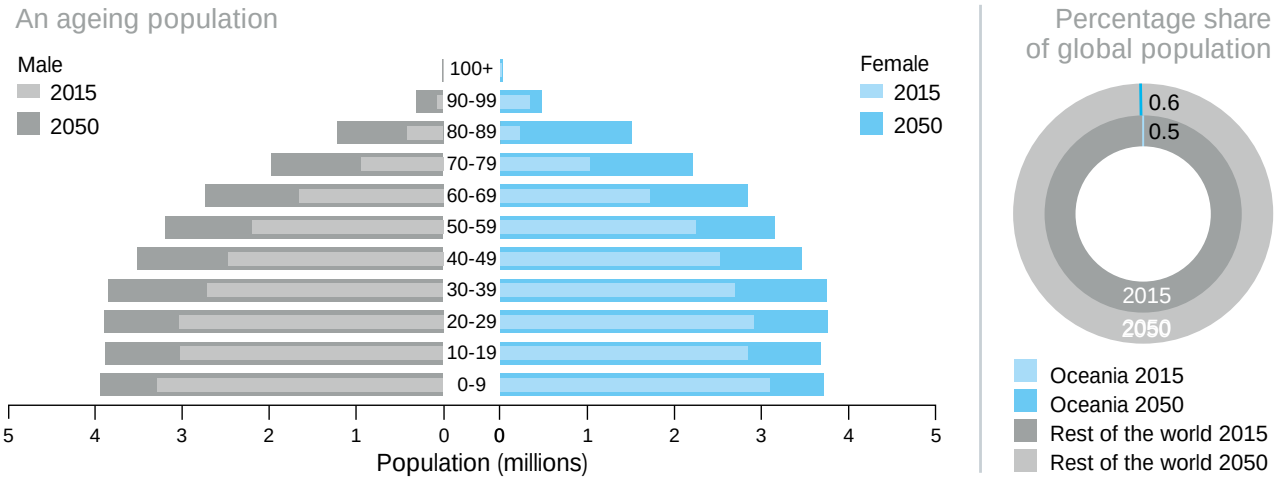
5 Global Change Institute, The University of Queensland, (September 2016), *Global Strategic Trends 6: Out to 2050 in Oceania, Key Ideas Paper,* a research paper commissioned by DCDC.

6 *Ibid.*

7 Boxall, S., New Zealand Defence Force, (August 2017), *Directorate of Future Force Development Publication: Foresight Report: Oceania.*

Fertility rates within the Pacific Island countries have declined in recent years, but remain high by world standards, contributing to a proportionately large youth population.[8] High fertility rates, combined with over 50% of Pacific Islanders currently under the age of 25, will mean that the region has a surging working-age population, but not enough education provision or employment. This opportunity gap could lead to increases in criminal activity, substance abuse and violence, if not addressed.

Across Oceania, it is estimated that 73.5% of the population will live in urban areas in 2050, compared with 70.8% in 2017, although there will continue to be substantial regional variations. On small islands such as Guam, everyone lives in cities, whereas only 20% of Papua New Guinea's population is urban. The existing trend of rural to urban migration in search of employment is likely to continue, which may lead to a rise in spontaneous informal settlements that lack basic services and government oversight.[9]



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

Prosperity (as measured by the United Nations (UN) Human Development Index) varies across Oceania, from 'very high' in Australia and New Zealand to 'low' in Kiribati, Papua New Guinea and the Solomon Islands. All Pacific Island countries in Oceania rely on external development assistance, which has been increasing over the last 20 years. However, due to global fiscal conditions, future aid flows are likely to remain at current levels or potentially decline in real terms.

Inequality and poverty are rising across the region, with recent economic growth failing to improve living standards. Papua New Guinea has the highest rate of poverty in Oceania with 40% of its population affected.[10] Inequality (as defined by the Gini coefficient: 'a measure of income inequality with higher values representing greater disparity within a given country'), is highest in the Melanesian countries, although it is not extreme by global standards. Levels of poverty and inequality are unlikely to improve, as governments are reluctant (or lack the capacity) to redistribute wealth.

8 UN Population Fund, (April 2014), *Population and Development Profiles: Pacific Island Countries*.

9 Mageto, A., *et al.*, UN Human Settlements Programme, (2010), *Papua New Guinea: Port Moresby Urban Profile*.

10 The World Bank, 'Poverty & Equity Data Portal'.

Fiji was Christianised in the 19th Century and Christianity will remain the most widely observed religion in the region

Most children in Pacific Island countries attend primary school, and there are high literacy rates (90% or better) in the region, with the exception of Papua New Guinea at 60%.[11] However, enrolment figures for secondary education are lower, while technical and professional training is insufficient to meet demand. Without investment to address current skills shortage in the extractive and hospitality sectors, future economic development potential will not be met.

Since the initiation of the Millennium Development Goals, most Pacific Island countries have seen improvements in health, including decreases in maternal and child mortality, and progress in eliminating vaccine-preventable diseases. However, rising global temperatures are increasing the incidence of some communicable diseases. Currently, 40% of Pacific Islander populations have non-communicable diseases such as cardiovascular problems, diabetes and hypertension, which are likely to increase due to an increasing Westernisation of diets. Such conditions are often worsened by a reliance on cheap imported food, which also contributes to dietary deficiencies. Waste management within the Pacific Islands will probably be a major threat to public health (and sustainable economic development) as populations grow and as landfill space decreases.

Religious adherence in many Pacific Island countries is over 80% and is likely to remain consistent with Christianity being the largest group.[12] Historically, other faiths have been tolerated in the region, although ethnic tensions in some communities (exacerbated by uneven economic development) may disrupt this trend over the coming decades.

In 2015, over 60% of Pacific Islanders had access to a mobile phone, up from 10% in 2006, a trend that is expected to continue.[13] Mobile Internet is enabling new solutions (such as telemedicine) to many of the challenges facing people living in remote communities. Increased access to telecommunications is also allowing greater political participation, and is already contributing to increased scrutiny and transparency of local governments. However, the cost of communications in the Pacific Islands will probably remain high.

11 Global Change Institute, The University of Queensland, (September 2016), *Global Strategic Trends 6: Out to 2050 in Oceania, Key Ideas Paper*, a research paper commissioned by DCDC.

12 Pew Research Center, (2015), *The Future of World Religions: Population Growth Projections, 2010-2050*.

13 Global Change Institute, The University of Queensland, (September 2016), *Global Strategic Trends 6: Out to 2050 in Oceania, Key Ideas Paper*, a research paper commissioned by DCDC.

Economy

The economies of Australia and New Zealand are likely to grow over the coming decades, although probably at slower rates than over the past 30 years.[14] Ageing populations in both countries will result in declining labour force participation and increasing dependency ratios, reducing productivity.

All Pacific Island countries have developing economies, each with different economic bases. Generally, the smaller islands have subsistence economies, the medium-sized islands focus on commercial tourism, and the larger islands are building extractive industries. The most significant challenge that Pacific Island economies face is their relative isolation from major markets, which increases the costs of providing services and doing business. Their limited economic bases also restrain diversity and opportunities for value creation, while high transportation costs and relatively poor commercial infrastructure hinders their ability to trade.[15] With the possible exception of Papua New Guinea, the economies of most Pacific Island countries are likely to remain small, narrowly-based and highly vulnerable to external financial shocks. Papua New Guinea has the largest economy of the Pacific Island countries, with the highest 30-year projected growth rate.

The Pacific Ocean contains a wealth of natural resources that could provide economic benefits if managed sustainably. However, rising sea temperatures, increasing acidification and poor regulation of fishing practices are eroding the economic benefit to nations in the region. More generally, the annual costs of environmental disasters are increasing Pacific Island countries' government debt.

Governance

New Zealand and Australia are well-established democracies and both rank highly in world democracy indexes. The Pacific Island countries are becoming more democratic, but poor governance will probably continue to hamper economic development and growth. Meeting internationally-accepted standards of transparency and public sector management is likely to be a slow process, due to entrenched nepotism and authoritarianism.[16]

Isolation from major markets will continue to challenge Pacific Island economies

14 Organisation for Economic Co-operation and Development (OECD) Data Portal, 'GDP long-term forecast'.

15 Asian Development Bank, (2015), *Corporate Evaluation Study: ADB Support to Pacific Small Island Countries*.

16 Global Change Institute, The University of Queensland, (September 2016), *Global Strategic Trends 6: Out to 2050 in Oceania, Key Ideas Paper*, a research paper commissioned by DCDC.

Regionalism is seen as a solution to many of the challenges facing Pacific Island countries, who formed an intergovernmental cooperation organisation in 1971 (the Pacific Islands Forum). However, in recent years nationalism has been more frequently prioritised above regionalism. The disparities in the economies of the richest and poorest countries will almost certainly create asymmetric relationships that may further challenge regional cohesiveness.[17]

Geopolitics

Oceania has historically been of particular interest to China and the US (the latter has close military ties to Australia and New Zealand), but recently it has also seen increased activity from non-traditional actors such as Russia and Indonesia. The two main Oceania powers see regional stability as critical to their national security as both are heavily engaged in capacity building and development programmes in the region. Australia is currently the most influential actor in Oceania. It contributes approximately two thirds of the region's aid, and seeks to be the principal security partner in the region.[18] Through aligned policies, New Zealand will probably continue to work closely with Australia, whilst also trying to retain its reputation for independence. However, growing Chinese economic involvement in Pacific Island countries is challenging Australia and New Zealand's influence.[19]

China will continue to be interested in Oceania so that it can gain access to fishing ports and maritime zones, secure rights to seabed mining and generate increased support in international bodies (particularly to counter pro-Taiwanese independence policies). Chinese aid to the region increased significantly between 2006 and 2016, and it was Oceania's second largest donor over that period, providing an estimated US $1.7 billion (of a US $9 billion total). However, Chinese aid can involve unconditional low interest or concessional loans for large-scale infrastructure projects, resulting in debt burdens that may be beyond the capacity of receiving nations to service. There is also speculation that Chinese aid may be funding infrastructure that will help with its longer-term military aspirations, such as developing large jetties capable of supporting naval operations beyond the South China Sea.[20]

The US' objectives in the region are focused on balancing Chinese influence. The US maintains several bases in the Pacific and entered into the Compact of Free Association with Micronesia, the Marshall Islands, and Palau. The US will remain a major donor of foreign aid to the region and is likely to operate in concert with Australia and New Zealand.

France has over 1.6 million citizens living in its territories in the Pacific, as well as several military bases and a sizeable maritime presence. It contributes to regional security frameworks including the Quadrilateral Defence Coordination Group, alongside the US, Australia and New Zealand. France has recently expressed concern over Chinese influence, implying that it will cooperate with other Western powers to help maintain the regional status quo and protect its economic interests. Australia's recent decision to buy submarines built by a French state-owned naval company has strengthened the strategic

17 Boxall, S., New Zealand Defence Force, (August 2017), Directorate of Future Force Development Publication: Foresight Report: Oceania.

18 Wallis, J., Australian Strategic Policy Institute, The Strategist, (27 September 2017), 'Do Australia's interest match its influence in the Pacific Islands?'.

19 Bately, J., Lowy Institute, (27 April 2018), *Review: Safeguarding Australia's security interests through closer Pacific ties*.

20 Dibb, P., Australian Strategic Policy Institute, The Strategist, (4 April 2018), 'If China builds a military base in Vanuatu, what are the implications for Australia's defence planning?'.

relationship between the two countries, and indicates France's interest in the region.[21] While French territories in the Pacific are likely to move to independence, this is not expected to have a significant impact on France's strategic interests in the region.

The UK's announcement that it will open three new diplomatic missions in Tonga, Vanuatu and Samoa means that the UK will have greater diplomatic coverage in the region than the US or France. Its strategic interests in Oceania are centred on maintaining the rules-based global order, but also positioning itself as an environmental leader and providing support to many Pacific Island countries that face significant challenges in managing climate change impacts over the next 30 years.[22]

Security

With the exception of civil wars in Papua New Guinea and the Solomon Islands, and political violence in Fiji, the region has experienced a relatively high level of stability. Defence expenditure has historically been low in the Pacific Island countries and some nations do not have militaries. Security forces in the region often work together, and New Zealand and Australia have helped to develop regional maritime protection capabilities in other countries, for example, by providing patrol boats, infrastructure and training. External military partners, particularly Russia and China, are also playing an increasingly important role in the region. Fiji and Russia signed a technology and military cooperation agreement in 2013,[23] and China recently gifted 14 military vehicles and a medical unit to Vanuatu.[24]

Illegal maritime activity has been growing in Oceania and is expected to continue to rise. Transnational criminal syndicates are exploiting the region's isolated and porous borders to traffic drugs, weapons and people,[25] and expanding their operations into other sectors such as fishing and mining. Illegal maritime activities could be a driver for greater regional cooperation. If left undeterred, however, these activities could undermine regional stability. Should the activities of extractive industries in remote areas increase, private security companies are likely to be used more frequently.[26]

pichitchai / Shutterstock.com

Deterring illegal maritime activity could drive greater regional cooperation

21 Wyeth, G., The Diplomat, (16 October 2017), 'France in the Pacific: Growing Strategic Ties with Australia'.

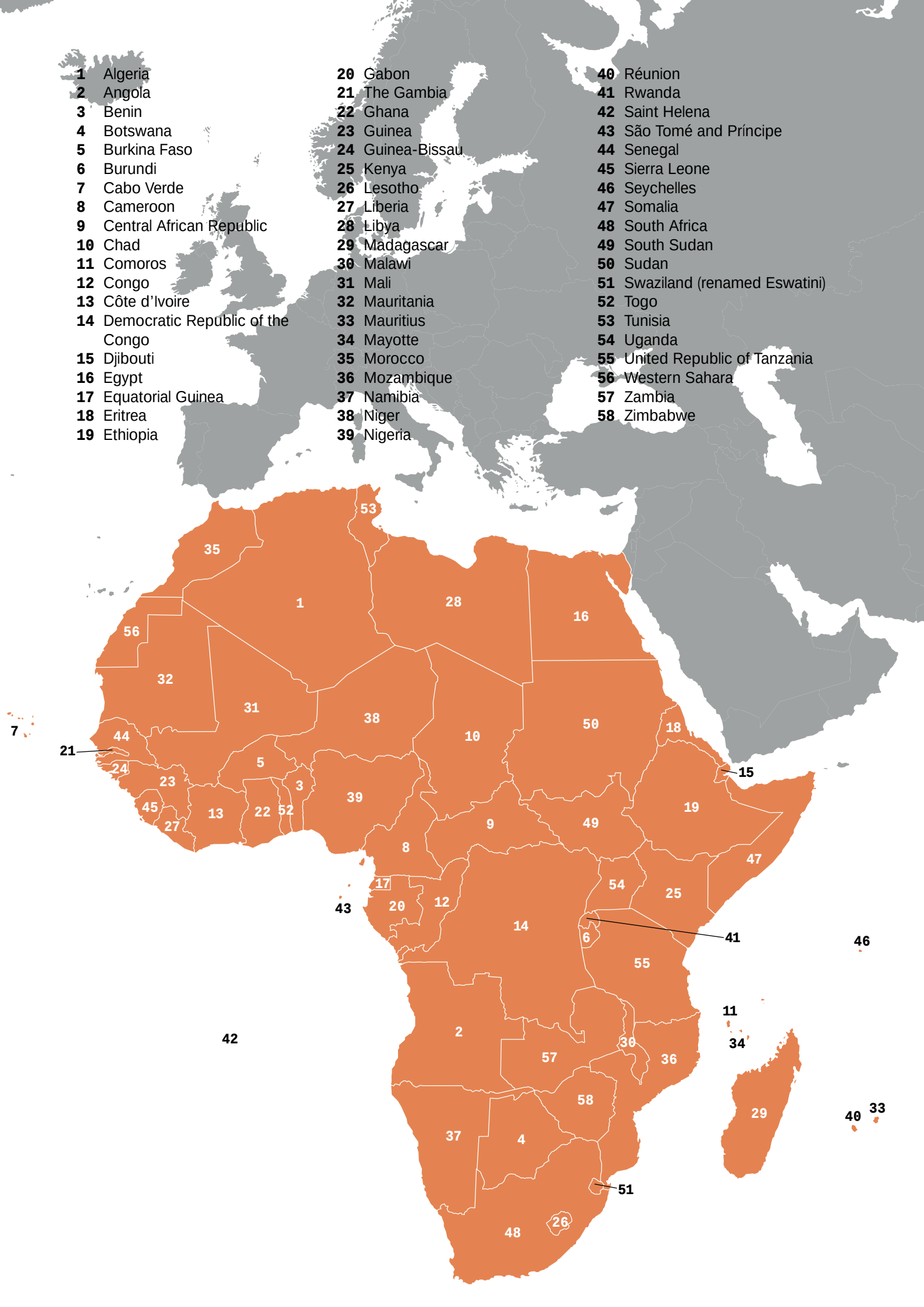
22 Paskal, C., Lowy Institute, The interpreter, (24 April 2018), 'Britain's new Pacific presence'.

23 The Fijian Government, (2013), 'Fiji Signs Landmark Agreement with Russia'.

24 Boxall, S., New Zealand Defence Force, (August 2017), *Directorate of Future Force Development Publication: Foresight Report: Oceania.*

25 UN Office on Drugs and Crime (September 2016) and Pacific Islands Forum Secretariat, *Transnational Organized Crime in the Pacific: A Threat Assessment.*

26 Pacific Islands Report, (2015), 'Security Services Fasted Growing Industry In Papua New Guinea'.


1 Algeria
2 Angola
3 Benin
4 Botswana
5 Burkina Faso
6 Burundi
7 Cabo Verde
8 Cameroon
9 Central African Republic
10 Chad
11 Comoros
12 Congo
13 Côte d'Ivoire
14 Democratic Republic of the Congo
15 Djibouti
16 Egypt
17 Equatorial Guinea
18 Eritrea
19 Ethiopia
20 Gabon
21 The Gambia
22 Ghana
23 Guinea
24 Guinea-Bissau
25 Kenya
26 Lesotho
27 Liberia
28 Libya
29 Madagascar
30 Malawi
31 Mali
32 Mauritania
33 Mauritius
34 Mayotte
35 Morocco
36 Mozambique
37 Namibia
38 Niger
39 Nigeria
40 Réunion
41 Rwanda
42 Saint Helena
43 São Tomé and Príncipe
44 Senegal
45 Sierra Leone
46 Seychelles
47 Somalia
48 South Africa
49 South Sudan
50 Sudan
51 Swaziland (renamed Eswatini)
52 Togo
53 Tunisia
54 Uganda
55 United Republic of Tanzania
56 Western Sahara
57 Zambia
58 Zimbabwe

Africa

Africa will remain one of the most economically and culturally diverse regions in the world, with substantial regional differences. By 2050, Africa's population is likely to have doubled to around 2.5 billion people. It will also have the most youthful population of any region, giving it a huge workforce, but providing sufficient education and employment opportunities to realise this potential will be challenging. In some countries unemployment is already around 50%. Climate change is likely to lead to extreme weather including droughts, floods and storms, and crop failures are likely to be increasingly common. Extreme poverty is likely to endure and could increase. Criminality, conflict and terrorism will be enduring challenges that could worsen substantially, although African security services should become increasingly effective. Partly driven by technology, many, perhaps most, Africans will have increased access to information and electricity, better health care and education.

Environment

Climate change will pose a huge challenge for Africa in the coming decades. Many countries will experience an increase in extreme weather events, including more severe and frequent droughts and floods, heatwaves, intense storms and tropical cyclones in coastal areas. A rising sea level could displace up to 1.4 million Africans by 2050.[1]

Africa is likely to see average temperature rises of 2° Celsius by 2050, with the drier regions of North and Southern Africa potentially increasing up to 3° Celsius.[2] Combined with the continent's rapid population growth, this could exacerbate existing water insecurity, potentially leading to high levels of water stress if not managed effectively. Widespread water shortages could lead to the spread of disease, a reduction in agricultural productivity, damage to industrial production and slower economic growth. Water stress could prove a significant source of social and political tension throughout the continent and may lead to conflict, particularly in areas of high population density and where shared water resources are disputed.

The effects of climate change will also have a major impact on agricultural production, and as Africa's population increases, there may be more frequent food shortages and famines. At present, despite having 24% of the world's agricultural land, Africa only produces 9% of global agricultural output.[3] The continent currently imports 30% of its food cereals and whilst food imports in themselves are not indicative of food security, reliance on food imports out of necessity is an issue for concern. Currently, 27 out

1 Brown, S., *et al.*, (2011), *Sea-Level Rise and Impacts in Africa, 2000-2100*, page 8.

2 Richardson, K., UK Met Office Hadley Centre Report, (2015), *Climate Change in Africa: a review to inform DCDC's Africa Regional Survey 2045.*

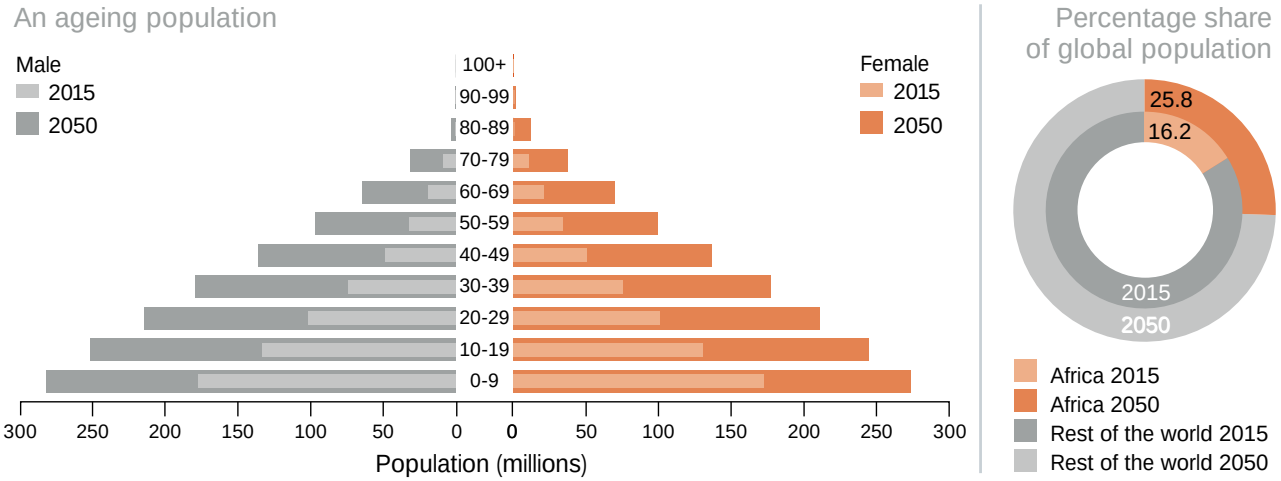
3 African Development Bank, (2014), *Tracking Africa's Progress in Figures.*

of 34 countries highlighted for their inability to produce their own food due to water and land limitations are in Africa.[4] High levels of population growth are likely to drive a growing dependence on food imports over the next 30 years. However, developments in biotechnology could have a positive impact on food security, and the adoption of high-yield, drought-resistant crops may help to mitigate the effects of climate change.[5]

Human development

Africa's population is projected to more than double to around 2.5 billion (a quarter of the world's population) by 2050. This would provide a huge boost to Africa's potential workforce, predicted to exceed China's by 2030 and India's by 2035,[6] with potentially significant benefits for African economies. However, some of the highest rates of population growth will occur in Africa's poorest regions such as the Sahel and the most densely populated areas such as Nigeria and the Great Lakes. This could strain inadequate resources and infrastructure, adding to the challenge of poverty reduction. Africa is expected to have the world's fastest growing rate of urbanisation, with 56% of the continent's population likely to live in cities by 2050. However, there are also likely to be increasing numbers of people living in rural areas, meaning that Africa will be the least urbanised continent in the world in 2050.

Where adequate opportunities are not available at home, population growth may act as a spur to migration, encouraging young Africans to leave their countries of birth in search of employment. Whilst some of this migration will be to other continents, possibly leading to an African 'brain drain', most African migration is likely to take place within the continent. Considerable numbers of people may also migrate because of conflict, insecurity and the impact of climate change, meaning that the movement of people will remain a significant economic and social challenge, potentially creating tension and higher levels of conflict on the continent.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

4 World Atlas, (2017), 'Countries Most Dependent On Others For Food'.

5 Ruane, J. and Sonnino, A., *Journal of Biotechnology*, 156, (2011), '*Agricultural biotechnologies in developing countries and their possible contribution to food security*', pages 356-363.

6 Cilliers, J., *et al*., Institute for Security Studies (ISS), Monograph 175, (2011), 'African Futures 2050', page 15.

As religion is very important to many Africans, religious tensions may be another driver of conflict in Africa. Christianity will remain the majority religion, but the proportion of the population who are Muslim will probably increase, largely due to higher birth rates.[7] Although religious tolerance has often been the norm in Africa, tensions may grow with the rise of less tolerant movements such as Salafism and evangelical Pentecostalism. In some areas, these groups may be manipulated for political purposes, resulting in religious persecution and potentially an increase in violence between adherents of different faiths.

Despite high levels of economic growth throughout the continent, wealth will continue to be unevenly distributed. Although the proportion of people living in extreme poverty in the region will decrease, Africa's rapid population growth means that the number of people living in extreme poverty (those living under the global poverty line of United States (US) $1.90 in purchasing power parity terms, set by the World Bank) may increase. By 2050, it is likely that extreme poverty will almost exclusively be concentrated in Africa.[8]

Government spending on education to boost economic development is likely to increase across many African countries. Although basic levels of literacy and numeracy are currently low, trends suggest they are likely to improve, with primary school enrolment having more than doubled between 1990 and 2015.[9] However, secondary and tertiary education provision (although improving) will require significant investment if sufficient numbers of African workers are to be equipped with the necessary technical, vocational and other specialist skills required to realise the continent's economic potential. At present, only 11% of secondary education students are enrolled in vocational programmes in Africa, in comparison with 21% in East Asia and 20% in Organisation for Economic Co-operation and Development (OECD) countries.[10]

mtcurado / iStock.com

Some of the highest rates of population growth will occur in Africa's poorest and most densely populated areas

7 Pew Research Center, (2015), 'The Future of World Religions: Population Growth Projections 2010-2050'.

8 Dissanayake, R., *et al*., (2017), Department for International Development (DFID), Chief Economist's Office, *Three Worlds In 2050: Scenarios for Poverty and Development*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

9 The Africa-America Institute, (2105), *State of Education in Africa Report 2015: A report card on the progress, opportunities and challenges confronting the African education sector.*

10 African Development Bank, Organisation for Economic Co-operation and Development (OECD), United Nations (UN) Development Programme (UNDP), (2017), 'African Economic Outlook 2017', page 209.

Primary school enrolment has more than doubled between 1990 and 2015

Adam Jan Figel / Shutterstock.com

Health care provision will probably improve in many African countries, with access to, and the quality of, medical services likely to get better for most. Recent years have seen significant advances in tackling diseases such as malaria and HIV/AIDS, as well as reducing child mortality, and further improvements are expected over the coming decades. However, African medical services will face new challenges. Climate change could cause the emergence of new disease vectors, resulting in longer transmission seasons and the spread of malaria to currently unaffected areas. The risk of epidemics will endure (despite better vaccination programmes), and it is plausible that the threat of a global pandemic could emerge from Africa. In addition, as life expectancy and living standards increase, Africa is likely to see an increase in non-communicable diseases, which could see these emerging as the primary cause of health-related deaths by 2025-2030.[11] In the next decade, Africa is expected to see the world's largest increase in deaths from non-communicable diseases. This problem could worsen as smoking and drinking trends amongst the youth of Africa are on the rise.[12]

Increasing urbanisation may act as a spur to economic growth, but could also create new challenges for some African countries. Many African cities have grown informally through rapid internal population growth and movement (from waves of inward migrants in search of temporary or seasonal employment, people escaping from civil war). Consequently, much of the continent's urbanisation is unstructured, with large slums, inadequate infrastructure and a lack of services. Many urban areas are likely to remain poorly planned and difficult to govern, leading to tension and possibly urban conflict. Nevertheless, where the necessary investments are made, Africa could see success stories, with cities such as Lagos developing into 'smart cities'.

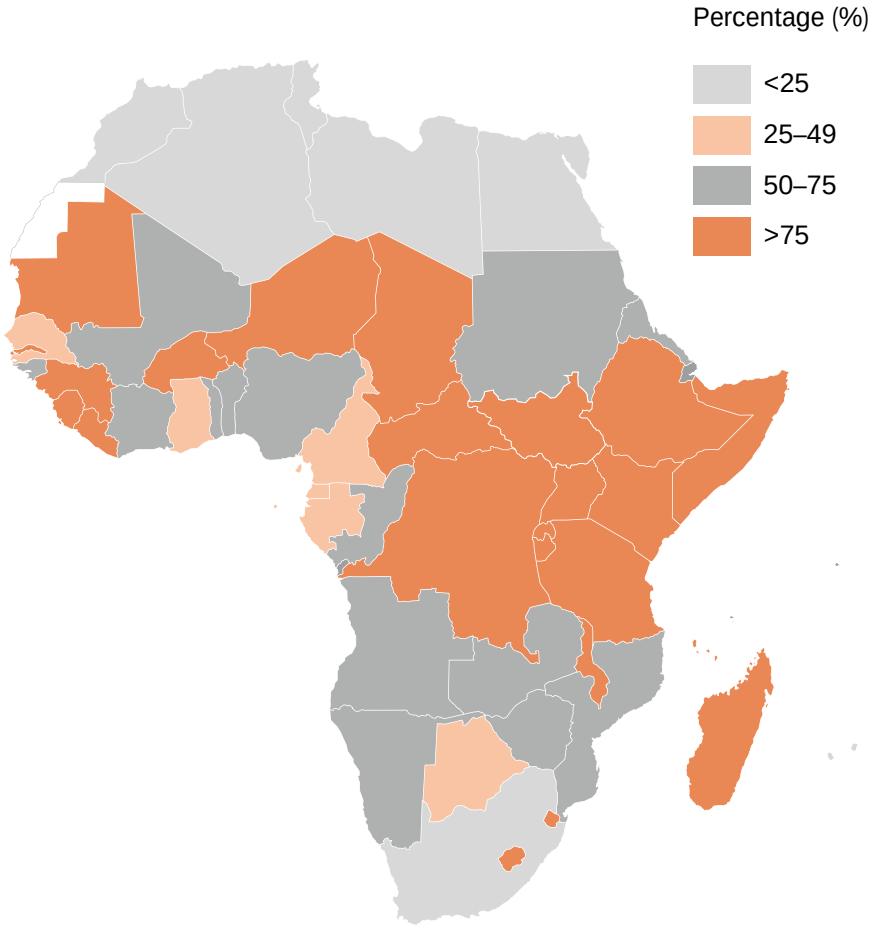
Greater investment in road and rail construction, both by government and foreign investors, will boost economic integration and dramatically improve transport links to many poorly-connected areas. Cheaper and more efficient air travel may provide alternative routes for goods and services to parts of the continent that are currently expensive and time-consuming to access.

11 Cilliers, J., *et al*., ISS Monograph 175, (2011), 'African Futures 2050', pages 15 and 25.

12 Naik, R. and Kaneda, T., Population Reference Bureau, (2015), *Non-communicable diseases in Africa: Youth are key to curbing the epidemic and achieving sustainable development*.

The next 30 years could also see a 'technology leapfrog' in the energy sector in Africa, currently the only region in the world where the majority of the population do not have access to electricity.[13] Some forecasts indicate that the percentage of sub-Saharan Africa's population with access to the energy grid could rise from 34% in 2010 to 71% by 2050, and an additional 8% could gain access to electricity through the creation of off-grid systems. Universal access to electricity could have a positive impact on poverty reduction strategies in Africa, with probable increases in gross domestic product (GDP) and business productivity.[14]

Share of African population without access to electricity (2012)



Source: The Economist

Internet penetration rates are currently low in much of Africa, with only 1% of the population having access to cable Internet, whilst 25% go online via their mobile telephones. However, technological advancements, rising incomes and cheaper forms of computing and electricity generation will drive a huge growth in Internet usage, with 90% of Africans able to use Internet broadband by 2050.[15] This could in turn provide a significant boost to economic growth and human development. An increasing range of government services may also be available through the Internet, dramatically widening access and potentially strengthening ties to the state.

13 International Energy Agency, (2014), 'Africa Energy Outlook Special Report: A Focus on Energy Prospects in Sub-Saharan Africa'.

14 Bössner, S. and Stang, G., European Union Institute for Security Studies, (2014), *The EU and sub-Saharan Africa: An energy partnership?*

15 African Development Bank Group, (2011), 'Africa in 50 Years' Time – The Road Towards Inclusive Growth', page 14.

Economics

If recent growth rates can be sustained, the African economy as a whole may quadruple in size by 2050, with some countries, such as Nigeria, growing at an even faster rate. Africa's share of the global economy will remain relatively small, although it will rise to around 6% of global GDP by 2050.[16] However, African economies currently face a number of challenges, including fluctuations in commodity prices, a sluggish performance in the global economy, protracted armed conflict in a number of countries and, in North Africa in particular, political instability in the wake of the Arab Spring.

Africa's rapidly growing population could give a significant boost to the continent's economies, providing a larger pool of potential workers as well as a growing domestic consumer market for African goods and services. However, unemployment currently remains high, at up to 50% in some countries, with Africa's youth population particularly adversely affected. Finding meaningful employment for young people will remain a challenge in the future.

Economic diversification will remain a key priority for African countries. The manufacturing sector is likely to grow, although it has made a slow start in Africa and currently provides only 5% of the continent's jobs. Service provision offers huge potential for growth and Africa's young and increasingly skilled youth population could play an important role in driving expansion.[17] Those countries that do not achieve sufficient levels of diversification will find themselves falling increasingly behind the continent's more successful economies.

High levels of unemployment in Africa particularly affect the youth population

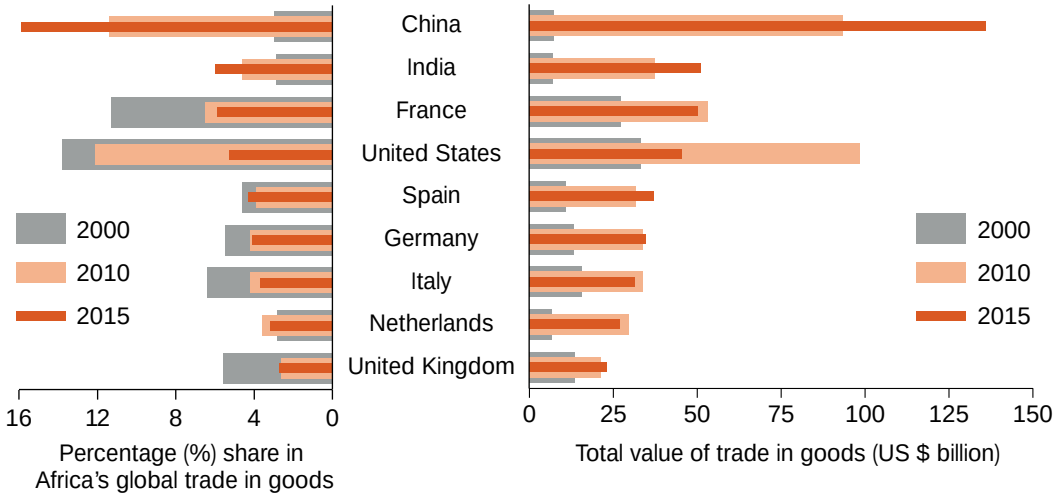
Anca Dumitrache / Shutterstock.com

16 The World Bank, (2006), 'The Road to 2050: Sustainable Development for the 21st Century'.

17 African Development Bank, OECD, UNDP, (2017), 'African Economic Outlook 2017', pages 82 and 209.

Although levels of regional trade are low compared to the rest of the world, they might grow due to technological developments and investments in transport infrastructure. However, political action to address high trade tariffs, lengthy customs procedures and other barriers to cross-border trade will be required if substantial growth is to be achieved. Although traditional trading partners such as Europe and the US are likely to remain important for African countries, they will face increasing competition from Asian markets. China and then India are currently Africa's largest trading partners, but India may surpass China by 2050. Although the European Union accounted for 30% of Africa's total global trade in 2015, more than half of Africa's interregional trade is now with emerging and developing economies, a share which may grow further in the coming years.[18]

Africa's main trading partners (2000-2015)



Source: African Economic Outlook

Foreign direct investment in Africa has increased fivefold since 2000, reaching an estimated annual total of US $56.5 billion in 2016. Foreign direct investment now regularly exceeds levels of aid to the continent, a trend likely to continue, with economic diversification spurring additional interest from investors. Africa's share of global foreign direct investment could double by 2050.[19] Increased foreign direct investments could mean increased diplomatic links but also reliance on external actors.

Africa's growing connection to the global information network has recently facilitated another type of external funding in the form of remittances (money that emigrants send home). In 2016, remittances to Africa (not including unreported flows), were worth an estimated US $64.6 billion, compared with aid levels of US $50.2 billion. Remittances from diaspora are likely to remain a major source of external finance for the continent and provide a vital lifeline for many African households through the next 30 years.[20]

18 African Development Bank, OECD, UNDP, (2017), 'African Economic Outlook 2017', pages 30, 74, 76 and 209.

19 Cilliers, J., *et al.*, 'ISS Monograph 175', (2011), 'African Futures 2050', pages 15 and 61.

20 African Development Bank, OECD, UNDP, (2017), 'African Economic Outlook 2017', pages 45 and 209.

Technology and enhanced professionalism should lead to an improvement in law enforcement and security

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Governance

Advances in democratic standards are evident in many African countries, with an increasing number setting term limits on their presidents and many peaceful power transitions following elections. This trend is likely to continue, although the path is unlikely to be free from setbacks. In some cases, particularly in the early years of a democracy, elections could be a major source of instability and tension, particularly where results are contested. Over time, however, there are likely to be increasing expectations of free and fair elections, which could provide a significant boost to democratic development. As urbanisation increases, the greater weight of urban voices may undermine the power of ruling parties in some countries. For example, Africa's urban areas are far more likely to back opposition parties than rural constituencies. Most transfers of power on the continent have resulted, at least in part, from influential urban constituencies supporting an opposition party.[21] If the proportion of Africans living in urban areas continues to rise, this may result in a higher rate of governmental turnover, demonstrating greater support for democratic processes, but it could also have a destabilising effect.

Rising standards of education could have a positive impact on African governance. Higher rates of literacy and greater use of social media will enable greater access to information and provide an effective platform to voice concerns over government policies. This could lead to calls for improvements in the quality of state governance and provision of services, as well as demands for an end to corruption. In addition, increasing levels of economic development will lead to a growth in the African middle class, which may play a pivotal role in driving improvements in state governance. As educational standards improve, the expanding middle class may provide a larger pool of Africans with the requisite skills and political awareness to staff government positions.

21 Cheeseman, N., (2017), *How will governance within current state boundaries in Africa change over the next 30 years?*, a research paper commissioned by DCDC.

Geopolitics

African countries could become increasingly engaged in global matters and may exert a growing influence on the international stage, particularly in partnership with others. Increasing dissatisfaction over the continued dominance of Western economies in international institutions such as the World Bank and the International Monetary Fund has led in recent years to the involvement in alternative structures, such as South Africa's membership of the Group of Twenty (G20) and the New Development Bank. These institutions, together with South-South initiatives, could grow in importance, meaning that the rest of the world may have to take greater notice of their actions.

Africa's strategic importance as a geographic centre of global trade is likely to become more significant as international trade increases. Ports on Africa's eastern coastline could grow in strategic importance as trade with Asia and the Middle East grows, and a similar trend emerging for the continent's west coast is possible given a developed interest in South American markets. However, the strategic importance of Africa's geographic location may be tempered by the opening of new trade routes through the Arctic.

The US, France and the United Kingdom will remain important influences in Africa over the next 30 years, but will be joined by other state and non-state actors. Growing powers, such as China, India and Brazil, all view Africa as an opportunity for trade and investment. Elsewhere, Middle Eastern countries, such as Qatar and the United Arab Emirates, will continue to compete for influence in the Horn of Africa, motivated by political and economic factors. Aside from state-led engagement, private multinational companies will attempt to secure a foothold on the continent, seeking access to African commodity reserves but also, increasingly, looking for investment opportunities in other African business sectors, such as financial services, construction and manufacturing.

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Movement of people throughout the continent will provide social and economic challenges

The African continent will continue to account for a large share of the world's armed conflicts

punghi / Shutterstock.com

Security

State fragility will continue to drive conflict and violence in a number of African countries, with North Africa, the Sahel, the Horn of Africa and the Great Lakes being particularly vulnerable to continued instability.[22] As the continent's population increases, competition over water, food, energy and land may result in heightened levels of conflict at the local level, particularly in southern and northern Africa, where the effects of climate change will probably be felt most keenly. A declining proportion of the African population is being affected by armed conflict, but, the continent still accounts for the largest share of the world's armed conflicts.[23] Since 2010, there has been an increase in the level of armed violence in Africa, largely due to the protracted conflicts in Nigeria, South Sudan, Sudan, Somalia and the Central African Republic.[24]

Terrorism will continue to present a challenge to African governments, with Islamic extremist groups posing an enduring threat. Such organisations are likely continue to mount foreign and domestic attacks, using African countries as a base for overseas operations, as well as striking foreign interests on the continent. The emergence of an Islamist Caliphate in the region within the next 30 years is plausible, although unlikely because of the diverse and often localised character of African extremist groups.

22 Cilliers, J. and Sisk, T., ISS Monograph 188, (2013), 'Assessing long-term state fragility in Africa: Prospects for 26 'more fragile' countries'.

23 African Development Bank, OECD, UNDP, (2017), 'African Economic Outlook 2017', pages 26 and 209.

24 Cilliers, J., ISS Paper 273, (2014), 'Africa's conflict burden in a global context'.

Poverty, inequality and a growing awareness of socio-economic imbalance will continue to drive high levels of crime in Africa. The effects of population growth and resource shortages could see rates of criminal activity (including violent crime) increase even further, potentially deterring tourism and foreign direct investment to some African countries. In urban areas, youth unemployment and poor service provision may cause a rise in crime rates,[25] in some cases resulting in urban areas becoming so dangerous that they are considered 'no go' areas for state security forces.[26] These ungovernable spaces are at risk of being taken over by belligerent non-state actors.

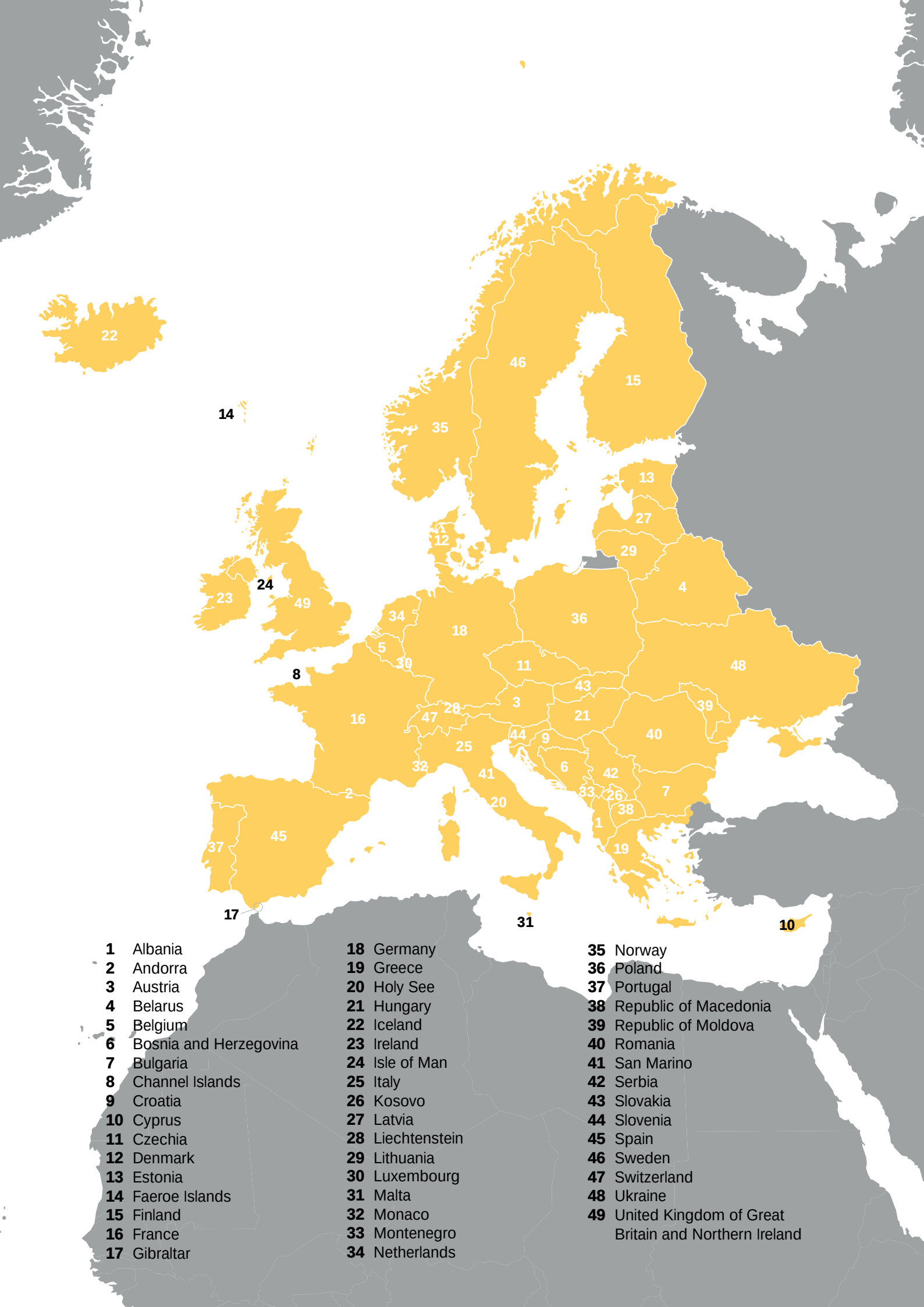
Weak state governance will provide space for organised crime to flourish in parts of Africa. Increasingly powerful criminal networks (some of which might have strong links to the state) may exploit developments in communications technology and Africa's growing integration into the global economy. The growing connection of Africa's criminals to global crime networks may also result in rising levels of illegal migration, the majority of which is facilitated by transnational criminal organisations as a source of finance. Europe is likely to remain an important destination for illegal migration due to its geographic proximity to Africa and higher levels of prosperity.[27]

The increasing professionalism of Africa's security providers and law enforcement agencies, together with investment in new technological capabilities, should lead to an improvement in law enforcement and security on the continent. While capabilities will continue to vary widely from country to country, many militaries and police forces are likely to see improvements in their capabilities and effectiveness, helping to tackle challenges such as terrorism, piracy and violent crime. Whilst the United Nations will continue to be a major actor in African security operations, the African Union should become increasingly influential, playing a vital role in maintaining peace and stability on the continent, diminishing the requirement for international involvement over time.

25 Cilliers, J., *et al*., ISS Monograph 175, (2011), 'African Futures 2050', pages 15 and 76.

26 Cheeseman, N., (2017), *How will governance within current state boundaries in Africa change over the next 30 years?*, a research paper commissioned by DCDC.

27 European Police Office (EUROPOL), (February 2016), *Migrant Smuggling in the EU*.



1 Albania
2 Andorra
3 Austria
4 Belarus
5 Belgium
6 Bosnia and Herzegovina
7 Bulgaria
8 Channel Islands
9 Croatia
10 Cyprus
11 Czechia
12 Denmark
13 Estonia
14 Faeroe Islands
15 Finland
16 France
17 Gibraltar
18 Germany
19 Greece
20 Holy See
21 Hungary
22 Iceland
23 Ireland
24 Isle of Man
25 Italy
26 Kosovo
27 Latvia
28 Liechtenstein
29 Lithuania
30 Luxembourg
31 Malta
32 Monaco
33 Montenegro
34 Netherlands
35 Norway
36 Poland
37 Portugal
38 Republic of Macedonia
39 Republic of Moldova
40 Romania
41 San Marino
42 Serbia
43 Slovakia
44 Slovenia
45 Spain
46 Sweden
47 Switzerland
48 Ukraine
49 United Kingdom of Great Britain and Northern Ireland

Europe

Europe will retain considerable soft power, despite its reducing influence on global issues and dwindling share of the global economy. Productivity growth is likely to remain low and unemployment could rise. Nevertheless, Europeans should remain relatively wealthy compared with people in most other regions of the world. Europe's neighbourhood is, however, likely to remain a challenging one, with the Middle East and Africa likely to experience rapid population growth and instability, forcing migration to Europe. Europe's relationship with Russia is also likely to remain difficult. The impact of these factors will hit southern and eastern Europe hardest, sub-regions that are the most affected by low economic growth, climate change and ageing populations. A divide between the wealthier, more competitive and climatically cooler northern and western Europe and the poorer south and east could challenge European cohesion. Furthermore, most governments will be challenged by ageing populations and increasing demands for greater spending on welfare. Despite these challenges, the European Union (EU) should survive, as without it, the challenges that some European countries will face may be beyond the capacity of their governments to manage.

Environment

Climate change will have far-reaching consequences across European countries. Climate projections show a marked increase in high temperature extremes, droughts and heavy precipitation events, albeit with variations across Europe.[1] Sea level rises and extreme rainfall are projected to increase coastal and river flood risk in Europe. Consequently, without adaptive measures, flood damage is expected to increase. There will also be an impact on human health in Europe. Heat-related deaths and injuries are likely to increase, particularly in southern Europe. Changes in the distribution and seasonal pattern of some infections and increased risk of new infectious diseases are plausible.

Southern Europe is particularly vulnerable to climate change, with multiple sectors likely to be adversely affected, including tourism, agriculture, forestry, infrastructure, energy and health care. Hot and cold weather extremes will have adverse effects in some areas, but benefits in others. For example, transport could face challenges of overheating infrastructure, but could also benefit from a reduction of maintenance costs in winter. Climate change could also increase cereal yields in northern Europe whilst decreasing yields in southern Europe. Furthermore, as temperatures increase, plants will need more water, potentially necessitating greater extraction from rivers and aquifers, and requiring

1 Intergovernmental Panel on Climate Change (IPCC), (2014), *Fifth Assessment Report: Europe.*

The risk of wildfires in southern Europe will increase

improved water management schemes. Rising temperatures will increase forest productivity in the north, although there will probably be more damage from fires and diseases throughout Europe, particularly in the south.[2]

Crude oil largely dominates EU energy imports with a share of 69% in 2017, followed by natural gas with 20%. In 2017, Russia was the largest supplier of oil and gas to the EU, ahead of Norway.[3] If energy dependence continues as projected, Europe will import 93% of its oil and 83% of its gas in 2030, predominately from Russia, Norway and the Middle East.[4] The EU and Russia have an interdependent energy relationship which is likely to persist for the next 20-30 years. Maintaining the current pace of renewable energy deployment throughout Europe would enable the EU to achieve its target of sourcing at least 27% of its gross final consumption of energy from renewable sources by 2030. Breakthroughs in energy production and distribution could bring even wider adoption of renewable energy sources, safer and cheaper nuclear power, and potentially even fusion technologies.[5] Regulatory changes could affect investors' confidence in renewables, and market barriers may continue to discourage new competitors from entering the renewable energy sector.

Human development

Urban development is projected to increase throughout Europe, particularly in the east. The development of super-cities, mega-corridors and mega-regions is likely to change the human habitat, but could also lead to greater polarisation within countries. There is an increasing Europe-wide concern about growing social and regional imbalances, which could lead to social and political instability.[6] Peri-urbanisation in Europe is also an increasing trend in which residents move out of cities to rural locations, whilst retaining a functional link to cities by commuting to work.

2 Intergovernmental Panel on Climate Change (IPCC), (2014), *Fifth Assessment Report: Europe*.

3 Eurostat, (2018), '*EU imports of energy products – recent developments*'.

4 Copenhagen Institute for Future Studies, (2017), *The Future of Europe 2050*, a research paper commissioned by the Development, Concepts and Doctrine Centre (DCDC).

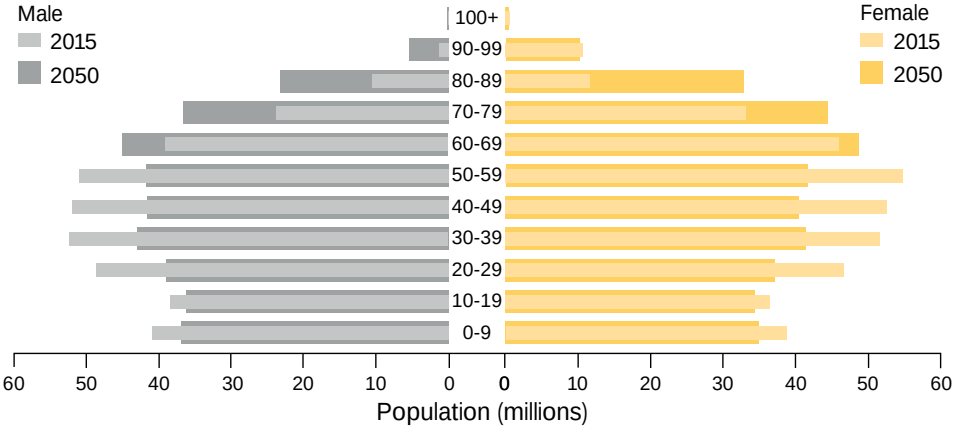
5 Pick, L., POLIS Journal, Volume 7, (Summer 2012), '*EU-Russia Energy Relations: a Critical Analysis*'.

6 Copenhagen Institute for Future Studies, (2017), *The Future of Europe 2050*, a research paper commissioned by DCDC.

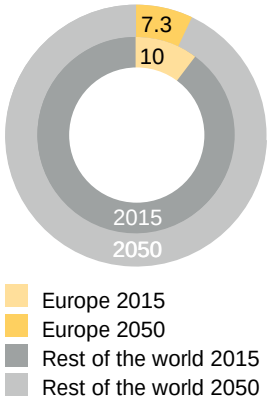
Health care and social welfare have improved everywhere in Europe, with reductions in adult and child mortality rates, but social inequalities both within and between countries persist. Despite declining fertility rates (fertility in Europe more than halved between 1950 and 2010),[7] the population of most EU countries has risen, primarily as a result of net immigration. With persistently low fertility rates, Europe's population is expected to decline in the next 30 years. Continued migration could, however, offset this decreasing trend if countries are willing to accept more immigrants.

Europe will have to deal with an ageing population and an increasing age dependency ratio. European welfare states may need to undergo fundamental structural reform to avoid crises and create lasting economic growth.[8] European governments will face increasing pressure to increase spending on health care, long-term care and pensions. This combination of higher spending commitments and lower tax revenues is likely to be a source of concern for all European countries, especially those with high debt levels and unfunded pension schemes. Economic necessity may mean that people cannot retire until they are 80, or possibly even older.

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

It is plausible that migration from sub-Saharan Africa, the Middle East and North Africa will accelerate in the future. Contributing push factors include demographic growth, conflict and climate change, whilst pull factors include the promise of a better life in a relatively wealthy Europe and the opportunities presented by its labour market. However, the greatest proportion of migrants will move within their region of origin.

Growing socio-economic inequality and increasing polarisation between some sub-regions in Europe has already generated substantial movement within the region. In 2014, internal migrants accounted for more than half of Europe's migrant population. As long as current inequalities among EU countries remain, this trend is likely to continue. By 2050, estimates indicate that the Muslim population in Europe will double and reach 10% of the population (70 million people), whilst the Christian population in Europe could decline by 100 million, constituting 65% of the population. These figures should be seen in the light of the worldwide secularisation trend.[9]

7 Bussolo, M., *et al.*, The World Bank, (2015), '*Golden Aging: Prospects for Healthy, Active and Prosperous Aging in Europe and Central Asia*'.

8 Copenhagen Institute for Future Studies, (2017), *The Future of Europe 2050*, a research paper commissioned by DCDC.

9 *Ibid.*

Immigration could offset population declines in Europe

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Overall, Europe may experience several social challenges: an increase of external and internal migration; an ageing population; increased income, wealth and employment inequality; declining innovation performance; and increased urbanisation. If not mitigated by collaborative action, underpinned by technological development and coherent policy, there is a risk of fragmentation and unrest within Europe.

Economics

Europe's global economic position shows signs of weakening. Since 2000, the EU's economy grew by 17% against a worldwide average of 47%. In the same period, China's economy grew by more than 100% and the United States (US) by 18%. BRIC countries (Brazil, Russia, India and China) currently rival Europe and the US Fortune 500 companies in terms of revenue.

Productivity has grown significantly less in the EU over the past 20 years compared to the US, although there are substantial regional variations. For example, most northern European countries have displayed rapid productivity growth, while other sub-regions have fallen behind. This divide in European income distribution reflects a global trend of income inequality that has been growing in most wealthy countries in recent decades. In the 1980s, the average disposable income of Europe's richest 10% was around seven times higher than that of the poorest 10%. Today, it is around nine and a half times higher. The unequal distribution of wealth in the region surpasses that of income. The top 10% of the wealthiest households hold 50% of the total wealth, whereas the bottom 40% own little over 3%.[10] Unless European governments or the EU are able to mitigate this disparity, a widening wealth and income divide could threaten not only the social, but also the political, stability of European societies.

Innovation is a key aspect of future growth in Europe. Current trends suggest a pessimistic outlook for the next decades with many European sub-regions showing declining innovation performance since 2008. Similarly, Forbes list of the 20 most innovative companies shows that only one came from Europe while 17 were in the US.[11] If innovative performance is measured in terms of higher education, scientific

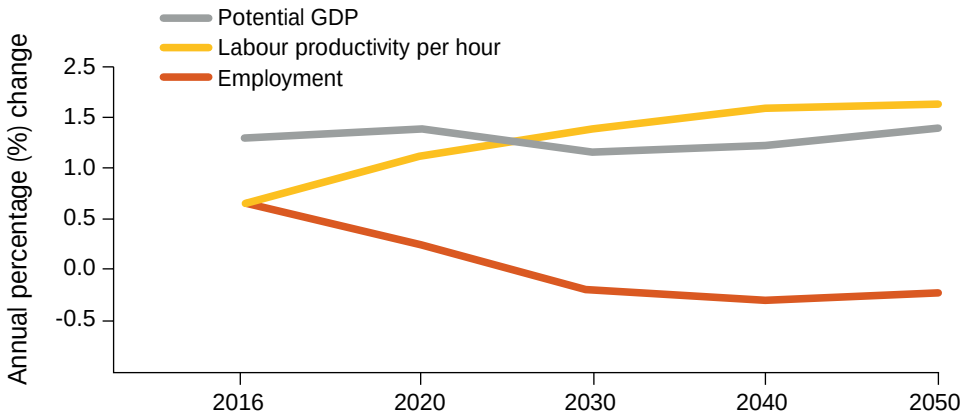
10 Organisation for Economic Co-operation and Development (OECD), Centre for Opportunity and Equality, (2017), *Understanding the socio-economic divide in Europe.*

11 Copenhagen Institute for Future Studies, (2017), *The Future of Europe 2050*, a research paper commissioned by DCDC.

publications, research and development, patents and export of knowledge-intensive services, the US outperforms Europe in almost all aspects. However, this gap is closing. The US performance lead was at 33% in 2007, but declined to 22% in 2014. China, on the other hand, is quickly strengthening its performance and is already outperforming the EU in many areas.

Long-term unemployment is likely to rise, as an increasing skills gap continues to dampen employment prospects.[12] Under-employment and a lack of job security may become increasingly problematic. Gender gaps in employment and earnings have declined in most countries in the EU, but they persist, and women remain disadvantaged in terms of the type of jobs they hold.[13] Substantial differences in productivity and competitiveness within and between nations and sub-regions in Europe could also lead to tensions and imbalances.

European Union gross domestic product (GDP), employment and labour productivity growth



Source: European Commission

Growing automation may have a profound impact on employment and service provision. Studies show that between half and two-thirds of jobs could be automated in the next 20-30 years. The cost of automation will probably decline rapidly, reducing the number of skilled jobs, whilst increasing quality.

China's influence in Europe is increasing. China is now the EU's second-biggest trading partner behind the US, while the EU is China's biggest trading partner. Chinese investments in the EU have grown from less than EUR 1 billion in 2000 to almost EUR 35 billion in 2016. Despite a decline in 2017, investment is expected to continue.[14] From 2005 to 2015, China's share of the EU's total trade rose, while the EU's proportion of China's trade volume fell.[15]

While Chinese investment could have a positive impact on the EU by increasing trade, investment, finance and flows of tourists and students, there is a risk that Europe will become dependent on Chinese investment. Chinese companies may even take over European strategic industries, particularly if there is an imbalance in respective levels of investment.

12 Hoorens, S., *et al.*, RAND Corporation, (2013), *Europe's Societal Challenges: An analysis of global societal trends to 2030 and their impact on the EU*.

13 OECD, Centre for Opportunity and Equality, (2017), *Understanding the socio-economic divide in Europe*.

14 Hanemann T. and Houtari M., Mercator Institute for China Studies, (2018), '*Chinese FDI in Europe in 2017*'.

15 Garcia-Herrero, A., *et al.*, (2017), *EU-China Economic Relations to 2025: Building a Common Future*.

Active separatism and demands for autonomy by cities could challenge national and EU cohesion

nito100 / iStock.com

Governance

Europe's future will be heavily influenced by the success of its dominant economic and political structure, the EU. Several forces are currently driving the EU towards fragmentation. Migration, increasing income inequality and growing regional imbalances have led to Euro-scepticism with anti-immigration parties gaining ground across Europe. The political challenges resulting from the growing divide between the public and the elites, as well as between liberal and authoritarian-minded groups, are likely to persist for many years.[16]

The factors driving EU fragmentation could also be replicated on the national level within EU member states. There are active separatist movements in many European countries and many leading cities are likely to seek greater autonomy. The challenge posed by a fragmented Europe could hamper the EU's future development, and provide an opportunity for external powers to exploit and further widen division.

While the EU's prospects appear uncertain today, this could be a transitory situation. Historically, the EU's development has not been smooth and transition has occurred with a series of setbacks. Despite increasing Euro-scepticism, there are parallel forces pulling the EU together, such as the newly established banking union. It is unlikely, however, that a federalised block will develop by 2050 as there appears to be little appetite for creating a 'United States of Europe'.

Geopolitics

By 2050, significant economic, political and military power is likely to have shifted from the US and Europe to other countries and regions, primarily China and India. Europe's influence on global issues will probably be tied to its ability to leverage hard and soft power, both of which are likely to be reduced by Europe's smaller share of global gross domestic product (GDP). Moreover, European states currently lack the ambition to act in a coordinated fashion or to project a strong EU globally.[17] These trends suggest that Europe's relative power in the world will decline. Being a wealthy region with global interests, Europe is, however, expected to continue to exert some leadership worldwide, primarily through soft power.

16 Raines T., *et al.*, Chatham House, (June 2017), *The Future of Europe: Comparing Public and Elite Attitudes.*

17 Copenhagen Institute for Future Studies, (2017), *The Future of Europe 2050*, a research paper commissioned by DCDC.

Although there are likely to be periods of tension between the US and Europe, the transatlantic relationship and the US' role in European security and the North Atlantic Treaty Organization (NATO) is likely to endure.[18] However, the EU's security priorities may differ from NATO's. NATO is likely to focus more on hard security issues (such as territorial defence) and the EU on soft security issues (such as migration and inequality), based on where EU member states have common security interests. Rather than forming an autonomous EU or European defence union, states with similar outlooks are likely to collaborate more closely to enhance security.

Turkish politics will preclude EU accession, at least in the next ten years. Because of this and existing interdependencies, a continuous dialogue between Turkey and Europe seems likely. However, against this background, Turkey's future role in NATO is uncertain.

Security

Europe will continue to be caught in an unstable geostrategic environment to its east and south, facing potential tensions with Russia. Russia is likely to continue, and possibly increase, its soft power and propaganda efforts in Europe, particularly in former-Soviet countries. The long-term outcome of the ongoing fighting in Ukraine and the frozen conflict in Georgia remains uncertain. Eastern Europe and the Caucasus will continue, however, to be part of a wider great power competition and an escalation leading to an armed conflict between Western countries and Russia cannot be ruled out. Meanwhile, stress and instability in Africa and the Middle East may spill over into Europe. As Europe's population stagnates and the populations of Africa and the Middle East grow, parts of Europe are likely to focus on the south, but these trends could also lead to a potential split within Europe, as different sub-regions focus on different security concerns.

Public support for a common EU foreign, security and defence policy has remained high for the past 25 years.[19] There is a clear trend in increased defence and security prioritisation and EU defence spending has increased in real terms over the past five years. Three European states remain in the top ten of the world (France, Germany and the United Kingdom), and 14 EU members have increased defence spending as a share of GDP since 2014.[20] However, unless there is a clear threat to the European states, this trend is less likely to continue, as Europe's share of global GDP reduces along with less tax income and increasing social costs. More money may also be allocated to fighting the effects of climate change. In general, trends show that countries are less willing to spend money on defence as a share of GDP.

While the threat from international terrorism and extremist violence will continue to be a security concern on the European continent, it is expected to remain at a comparatively low level. Although Europeans remain concerned about terrorism, especially Islamic extremism, only 0.4% of global attacks occurred in Western Europe between 2001 and 2014.[21] The overall trends concerning ideology and motivation behind terrorist action are changing. Violent jihadism is on the rise in Western Europe, as is right-wing terrorism motivated by anti-immigration and anti-Islamic sentiments. The old, but still most common, form of terrorism motivated by separatism is fading away, although a return of this form cannot be ruled out.[22]

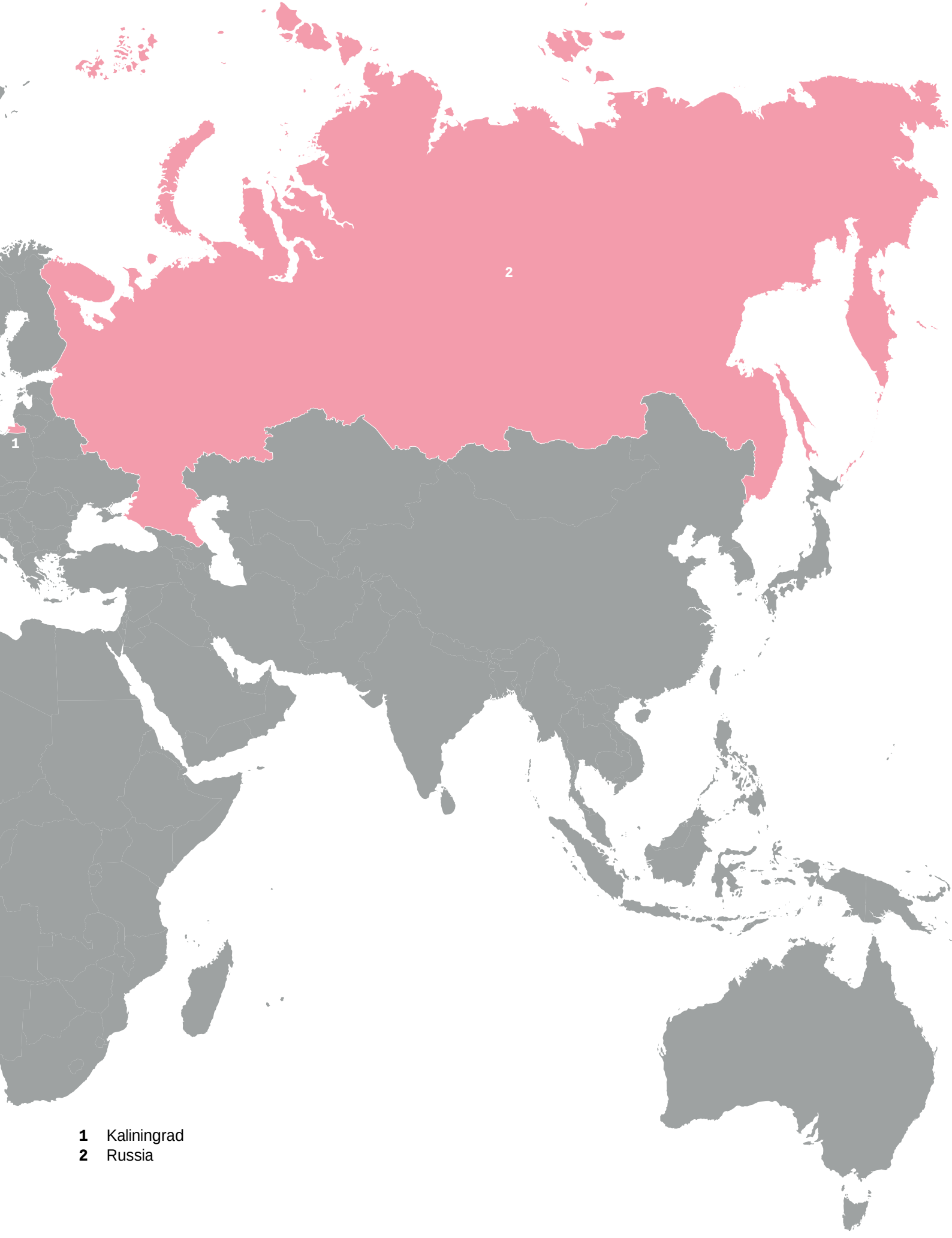
18 Salonius-Pasternak, C., Finnish Institute of International Affairs, (November 2016), *The Future of US-Europe Relations: Institutional Constraints and Public Opinion May Render Changes Smaller Than Expected*.

19 Iso-Markku, T., *et al.*, (Eds.), Finnish Institute of International Affairs, (2017), *The EU's Choice: Perspectives on deepening and differentiation.*

20 Stanley-Lockman, Z., European Union Institute for Security Studies, (1 March 2017), '*SMS – European defence 2016*'.

21 Roser, M., *et al.*, Our World in Data, (2013), '*Terrorism*'.

22 Iso-Markku, T., *et al.*, (Eds.), Finnish Institute of International Affairs, (2017), *The EU's Choice: Perspectives on deepening and differentiation*.



1 Kaliningrad
2 Russia

Russia

Stretching from Europe, across Asia to within 51 miles of North America, and with one of the largest nuclear arsenals in the world, Russia will remain a major global actor. By 2050, Russia's population is likely to reduce by around ten million and have concentrated in major urban centres, leaving much of the country almost uninhabited. Climate change will open up shipping routes along Russia's Arctic coast and increase the area of land suitable for agriculture in the north, but hotter and drier weather in the south and west will limit agricultural output. Russia's economy should be sustained by its huge reserves of oil and gas, but chronic underinvestment in other sectors will hamper growth. Russia will continue to maintain pressure and influence on countries in its near abroad and push for a multipolar world order. Its relationship with Europe and North America is likely to remain awkward, and whilst its relationships with Asian countries will become increasingly important, China's growing influence, particularly in Central Asia and the Far East could create tensions. Military spending will remain high and its capabilities can be expected to improve, although a declining number of healthy recruits may limit the size of its armed forces.

Environment

The northern territories of Russia will continue to be the area most affected by climate change. Melting Arctic ice, leading to the opening of the Northern Sea Route will create significant economic opportunities, and might reverse the exodus of inhabitants which began in the 1990s. Research suggests that the passage will be mostly ice free and navigable in the summer months by 2025-2030. However, the long northern coastline will be vulnerable to land erosion and thawing of permafrost. Legacy Soviet oil infrastructure on land and offshore will be increasingly vulnerable and require significant investment. Overall, precipitation across Russia is projected to increase slightly, particularly in winter, and extreme snowfall events may become more frequent.

Temperature increases will also be most pronounced in the north. Without significant internal and external pressure, the primary focus of Russia's environmental concern is likely to remain the clean-up of Soviet era legacy infrastructure and pollution rather than preventing climate change. There is unlikely to be substantial policy interest or investment in climate change prevention or mitigation from either government or business.

Food supply will remain a national security issue for Russia. In recent years, as much as half of Russian food has been imported, increasingly from European Union (EU) or North Atlantic Treaty Organization (NATO) countries, and there remain concerns about the strategic grain reserve. Although temperature rises could increase arable land availability in northern Russia, the Volga region (Russia's traditional breadbasket) could be adversely affected by climate change and may even become arid. Therefore, any gains in the north

are likely to be more than offset by losses in the south and west, where wildfires could also destroy crops and cause pollution. Since Russia is a major exporter of grains, particularly wheat (supplying 13% of total exports in 2015[1]), this may have an adverse effect on global food security. Russia holds 20% of the world's forests, however, economically accessible stocks are shrinking and may be exhausted before 2050, unless management strategies are improved. Although the availability of saltwater fish could increase due to warming oceans,[2] management of inland fish stocks and new, ice free, fishing grounds may prove essential if an enduring Russian demand for fish products is to be met.

Energy will remain pivotal to Russia's economy, due to its position as the world's largest natural gas exporter, and holds the world's largest reserves.[3] Internally, a shift away from coal and oil towards gas is already taking place and is expected to continue under Russia's 'Energy Strategy to 2035'. Outside European Russia, the transition will be slower. Strong regional demand from Europe, and increasingly Asia, will enable Russia to diversify its export markets and remain a leading exporter of hydrocarbons. A shift towards renewable energy is unlikely in the next ten years, but technological breakthroughs could change this in the longer term. The cost of gas production from Russian fields may rise in the longer term. Nevertheless, Russian oil and gas will remain competitive due to the size of its eastern onshore fields, output from which will increasingly replace falling production from the West Siberian fields. It is unlikely that the Arctic offshore fields will be developed systematically and on a large scale before 2030.

Energy supply will probably remain a tool for influence and even coercion

1 Salmon, K. and Davie, J., (2018), *Climate summary for Russia*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

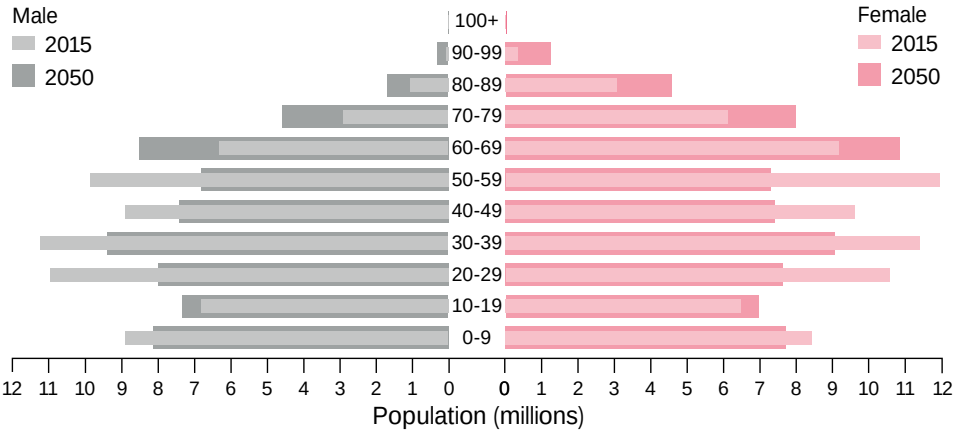
2 *Ibid.*

3 Organization of the Petroleum Exporting Countries (OPEC), (2013), 'World Proven Natural Gas Reserves by Country'.

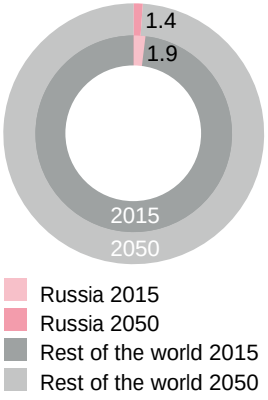
Human development

Russia's population will probably decrease from 146 million to around 143 million by 2030. However, by 2050, high rates of inward migration from Central Asia, as well as rapid population growth in some of Russia's southern regions, could stabilise the population to 130-140 million. High numbers of Muslims among these immigrants, and the higher fertility rates in Muslim populations, may change the ethnic balance in Russia substantially. By 2050, non-Slavic ethnic groups could account for approximately one third of the population, and Russia is projected to possess one of the highest dependency ratios (the proportion of children and the elderly compared with those of working age) in the world. Due to a relatively low rate of economic growth and high taxes, the resources to support Russia's dependent population will be spread thinly.

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

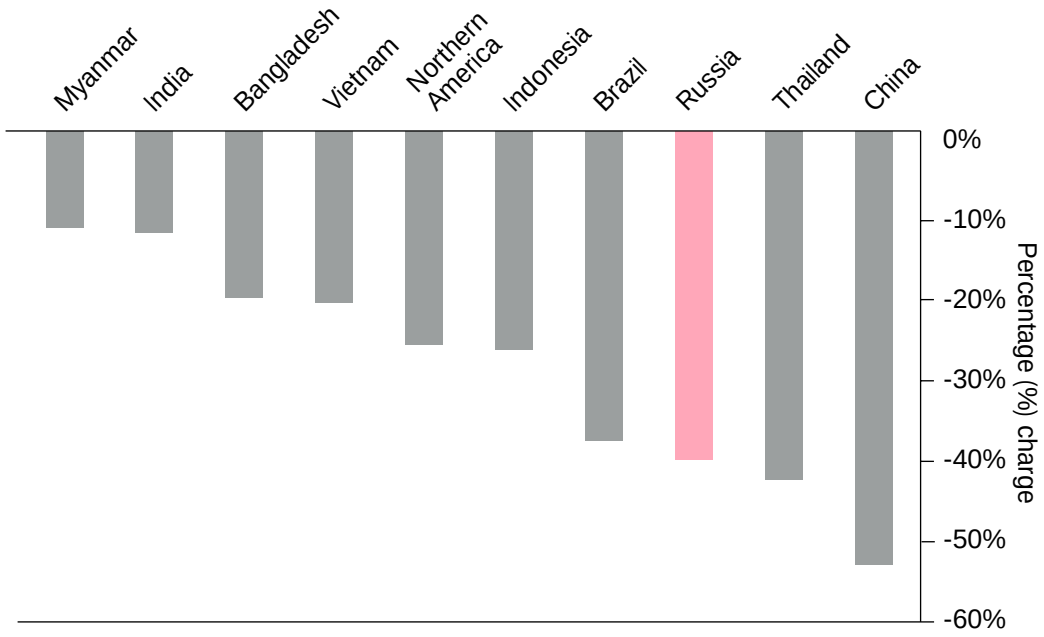
Policy interventions aim to repopulate Russia's agricultural regions and Far East but are unlikely to be fully successful unless additional resources are made available. As a result, degradation of these regions may continue and in the north, central and eastern regions, population density may decline to 1930s levels. Russia's plans to encourage Chinese industry in its Far East may increase population density, but could also change the ethnic balance. Associated Chinese economic migration could worsen inter-ethnic tensions. By 2050, most Russians will live in urban areas away from the most remote regions. Depopulation will leave many parts of the country unoccupied and without basic social infrastructure.

Russian budgets and spending increased in the period 2007-2014, primarily as a result of revenue from the export of hydrocarbons. However, the share of the population with incomes below the minimum subsistence level remained unchanged. During the same period, the state share of the economy increased from 35% to 70%. Between 2011 and 2016 federal expenditure increased from 13.9% of total spending to 19.6%, but spending on health care and education fell by more than 25% and may continue to drop.[4] Russian educational performance appears to have benefited from the increased investment in the 2007-2014 period, with attainment in almost all areas having improved to around the Organisation for Economic Co-operation and Development (OECD) average since the early part of the 21st Century.[5]

4 Domanska, M., Centre for Eastern Studies, (2017), *Crisis in Russia: The degradation of the model of economic governance*.

5 Organisation for Economic Co-operation and Development (OECD), (2017), 'PISA 2015 key findings for Russian Federation'.

Estimated projections of rural population change in Russia and selected other regions (2018-2050)



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

By 2016, Russia's per capita expenditure on health care was the eighth lowest among the 45 countries covered in an OECD health survey, and only one third of the OECD average (with purchasing power parity applied). Life expectancy at birth has improved significantly since the Soviet era but remained fourth lowest of the countries surveyed, at 71.3 years, in 2015.[6] Russia also had the greatest variance between male and female life expectancy. Low life expectancy levels are largely due to lifestyle choices. Russia had the eighth highest number of adult smokers, and above average number of drinkers.[7] However, Russian women were among the least likely to smoke, and Russian adolescents were significantly less likely to smoke than Russian adults and were among the least likely to drink alcohol globally.[8] If this trend continues into adulthood, health outcomes may improve.

Economics

The Russian economy will be sustained by its vast natural gas reserves and large population, and the country's economic performance will be shaped by global commodity demand and technological developments outside Russia. Measured by purchasing power parity, Russia could be a major economy by 2050. In per capita terms, however, Russia is likely to be poorer than its European neighbours, although there will be significant regional variation.

In the short term, some effort may be made to reduce Russia's dependence on extracting and selling natural resources. State policies to foster the development of new industries may be partially successful. However, unless a new political direction strengthens property rights, any significant rise in investment is likely to occur only in

6 OECD, OECD Indicators, (2017), 'Life expectancy at birth', *Health at a Glance 2017*.

7 *Ibid.*

8 OECD, OECD Indicators, (2017), 'Smoking and alcohol consumption among children', *Health at a Glance 2017*.

state-owned or state-influenced sectors of the economy. Such investment is likely to be confined to strategically-important sectors. Due to security concerns, as well as demographic trends, federal government spending will continue to be dominated by military and social welfare expenditure and, as a result, most available resources will be diverted to the defence industry, the extractive industry sector and welfare for the ageing population. Therefore, the Russian economy is likely to display only small pockets of globally competitive industry, particularly hydrocarbon extraction, defence equipment and other state-sponsored enterprises. These will exist alongside larger, uncompetitive sectors.

Russia will, however, be more closely integrated with the global economy, particularly the hydrocarbon market, and may shift its focus towards East Asia in line with the broader shift of global economic activity. Its hydrocarbon export market will broaden as non-OECD countries seek to diversify supply. Russia will be an increasingly important supplier of oil and gas to China and this will probably result in construction of denser overland energy supply infrastructure. This will help boost Russia's Far Eastern regions economically and promote a rising mutual dependence between China and Russia.[9] Russia's draft 'Energy Strategy for 2035' continues to emphasise the limited availability of gas, Europe's future demand and Russia's diversification of supply to Asia. This suggests that energy supply will remain a tool for influence and even coercion.

Exploitation of Arctic resources will accelerate: the Prirazlomnaya is the first production platform on Russia's Arctic shelf

9 OECD, OECD Indicators, (2017), 'Smoking and alcohol consumption among children', *Health at a Glance 2017*.

A large-scale, state-controlled project promotes patriotism, nationalism and Russian values to support President Putin

vlad_karavaev / iStock.com

Governance

Russia is likely to retain its current governance model of managed democracy, administrated corruption, directed media, and nepotism for at least the next decade. However, Russia will be unable to modernise without changing its network-based governance patterns[10] in which corruption has been, and will remain, a way to access and keep political power and to retain loyalty.[11] The Russian model of governance is therefore likely to show signs of continued administrative inefficiency with high levels of corruption, inertia in the model, and loyalty to the system and leaders. This would remain an obstacle to change, even if a reform policy was adopted.

A large-scale, state-controlled project promoting patriotism, nationalism and Russian values is in progress to maintain public support for the current leadership under President Putin. This will also garner public support for revisionist, nationalist foreign policy. New institutions, such as the National Guard, the 'Youth Army' and the All-Russia Front, are also being created to help the state control the population. Younger Russians may therefore be more indoctrinated than the older generation who remember the Soviet era. As a result, demand for reform may be limited, unless social conditions decline significantly, but any protests are likely to be ruthlessly suppressed.

Geopolitics

Russia assesses that international affairs are entering a time of increasing competition over resources, values, influence and access to markets, and uses this to generate a baseline for a Russian geopolitical viewpoint.[12] Power politics will remain important and Russia will be prepared to use military means to secure its national interests and defend the Russian Federation. It is likely to continue to push for a multipolar world order with Russia as one of the leaders. It may seek to regain equilibrium with the United States (US) by reducing US global influence while increasing its own. Russia may also increase its soft power and propaganda efforts, as a disruptive force and an integral part of efforts to achieve foreign policy objectives that undermine other states' security through effects on civil society.[13]

10 Ledeneva, A., (2013), *Can Russia Modernise? Sistema, Power Networks and Informal Governance.*

11 Galeotti, M., European Council on Foreign Relations, (5 April 2016), 'The Panama papers show how corruption really works in Russia'.

12 The Ministry of Foreign Affairs of Russian Federation, (2016), *Foreign Policy Concept of the Russian Federation.*

13 Kuhrt, N. and Feklyunina, V., (Eds), BISA, King's College London and Newcastle University, (2017), *Assessing Russia's Power: A report.*

Core Russian foreign policy priorities will probably remain largely unchanged in the early part of the period and the Eurasian region will retain dominance in Russian strategic thinking. Russia's insecurity about its territorial integrity, and even national survival, will continue to drive expansion and attempts to maintain pressure and influence on countries in Russia's neighbourhood. This will act as both a security buffer zone and a manifestation of Russian status and values.

Russian engagement in the wider international arena may also increase, particularly in the Arctic but also in the Middle East and North Africa. Power projection further afield may prove desirable and to enable it, Russia may seek to establish new relationships and develop bases.

The Asia-Pacific region accounts for 60% of Russia's arms exports, and will therefore continue to be of high importance to the Russian defence industry. As Russia seeks to deepen commercial and defence trade relations with China, it will also engage with other regional powers, shown by expanding projects in Southeast Asia, ongoing military ties with India and a new strategic engagement with Pakistan.

China and Russia will continue to explore potential areas of mutual interest, and promote cooperation and trade, to enhance economic growth and balance US influence. As China's Belt and Road Initiative develops, Russia may seek to deepen its involvement and could gain from cooperation between the Eurasian Economic Union and the Belt and Road Initiative.[14] The initial promise of improved relations with China has, however, not been realised and less than 3% of China's promised investments in Russia have materialised. This suggests that although Russia is a major supplier of gas and especially oil to China, it is not yet seen as a critical economic partner. Nevertheless, China's increasing need for Russian oil and gas, especially in its eastern provinces, may deepen the relationship.[15]

Free Wind 2014 / Shutterstock.com

Russian engagement in the wider international arena is expected to increase, particularly in the Arctic

14 Saalman, L., (Ed.), Stockholm International Peace Research Institute (SIPRI), (2017), *China-Russia relations and regional dynamics – From Pivots to Peripheral Diplomacy.*

15 Maslow A., et al., Chatham House Russia and Eurasia Programme, (2015), 'Russia and China: Entanglements and Points of Tension'.

The resources to support Russia's old and young dependant population will be spread thinly

Russia will remain suspicious about China's intentions in Northeast Asia, Central Asia and the Western Pacific. It may perceive China as a threat in the medium or long term, especially in the Russian Far East. Depopulation, combined with increased Chinese agricultural and industrial activity may give substance to fears that China could dominate the region, either directly via incursions over the border, or indirectly through the expansion of Chinese businesses northwards.[16]

Russia will also continue being an influential actor in the Central Asian region. As Central Asian populations increase, the power dynamic with Russia may begin to shift. Russia may become more engaged in the region in response to an increasingly Muslim population and a growing fear of religiously-motivated extremism and terrorism. Russia will continue to use investment in Central Asian economies and projects, such as gas distribution systems, as a tool of influence, as well as for economic gain.[17]

Since the Soviet era, the Arctic has been of great importance to Russia. It will continue to view the region as both a strategic priority and a resource base, especially once the retreat of the ice cap opens the Northern Sea Route and allows extraction of oil and gas.[18] Russia is claiming 1.2 million square kilometres of the Outer Continental Shelf in the Arctic Sea, and therefore, can be expected to enhance its Arctic military presence. The ongoing military build-up is partly a reacquisition of bases and capabilities that were lost after the Cold War. Russia's Arctic infrastructure has suffered from severe underinvestment over the last 20 years. Russia will continue to uphold the United Nations Convention on the Law of the Sea (UNCLOS) as a means of maintaining status and influence, but without damaging diplomatic relations or upsetting potential Asian investors.

16 Institute for Security & Development Policy (ISDP), (2016), *Northeast Asia to 2050: Key Trends*, a research paper commissioned by DCDC.

17 Central Asia-Caucasus Institute Silk Road Studies Program, (2016), *The Silk Road to 2050: Key Trends*, a research paper commissioned by DCDC.

18 Kefferpütz, R., Centre for European Policy Studies, Number 205, (February 2010), *On thin ice? (Mis)interpreting Russian policy in the High North*.

Russia has also increased its Antarctic presence and ambitions since the early 2000s, and may be preparing for an eventual breakdown of the Antarctic Treaty System. However, Russia has not yet moved to exploit Antarctic resources and may merely be keeping its Antarctic options open.

Security

Traditional fears about internal and external threats will continue to underpin the importance of security to Russia, and lead to continued investment in military and internal security capabilities, even at the expense of economic growth. These fears shape Russian approaches to the use of force, and coercive operations short of actual conflict.

The share of military expenditure in Russia's gross domestic product (GDP) has increased from 3.6% in 2005 to 5.3% in 2016. This is the manifestation of a political will to prioritise military expenditure over other public sector spending.[19] Russian defence and security priorities reflect concerns about international instability. A major programme of reform and re-equipment will continue to modernise Russia's armed forces, and would only be delayed by a significant upsurge in the requirement for welfare spending. This programme will include Russia's strategic deterrence capability, precision weapons, and specific capabilities such as cyber, autonomous systems, directed energy or hypersonic weapons, and robotics. Russia may develop a different ethical and legal framework for using these technologies compared with the West. The mobilisation of the whole state in support of Russia's strategic objectives will remain a feature of Russian operations.

Russian military ambition could be hindered by a lack of recruits. In the next five years, the youth population will fall to less than 25 million and will continue to decline. This could limit traditional Russian aspirations for a one million person armed force, especially when combined with public health factors. Today, a third of recruits to the armed forces are not fit for active service. Russia's decision to recruit foreigners aged 18 to 30 offers some mitigation. There is potential for increased domestic disorder as a result of economic conditions. In addition, an increased terrorist threat may emerge, particularly among diaspora Central Asian Muslim communities, and where fighters have returned from the Middle East.

NaumB / iStock.com

The Russian Armed Forces are embarking on a major programme of reform and modernisation

19 Persson, G., (Ed.), FOI Report, (2016), *Russian Military Capability in a Ten-Year Perspective – 2016*.

1 Bermuda
2 Canada
3 Greenland
4 Saint Pierre and Miquelon
5 United States of America

North America

The United States (US) will retain significant influence in the international system and is likely to remain the pre-eminent global military power, supported by an extensive network of allies and partners. However, its world-leading economic and technological position will be challenged by China and its response will have global ramifications. Nevertheless, North America will remain one of the world's most prosperous, safe and stable regions. With higher birth rates than many other developed parts of the world, North America will have a relatively large and young working-age population by 2050. Rising levels of wealth inequality and uneven access to education between socio-economic groups and regions may, however, cause social (possibly violent) discontent and may influence domestic politics. The effects of climate change will be felt across the region, particularly in the US, which is likely to experience a fourfold to sixfold increase in heat stress. Southern areas are particularly likely to suffer from worsening droughts. More intense storms, combined with sea level rise, will make coastal cities, particularly along the East and Gulf Coast of the US, vulnerable to flooding.

Environment

In the last 70 years, Canada has experienced increasing precipitation and a higher rate of average annual temperature rise than most of the rest of the world. These trends support projections that temperature increases of up to 2° Celsius are likely to be experienced in North America by 2050. The region's vast span from north to south means that the effects of climate change will be felt very differently from the Arctic and tundra of northern Canada and Alaska to the semi-arid and desert areas in the southern interior. The north is likely to experience increases in precipitation, whereas southern areas will probably experience decreases. The southwest, already affected by droughts, is also likely to experience increased moisture loss due to evaporation at higher temperatures. Additional tropical cyclone activity may result in more extreme rainfall on the East and Gulf Coasts and, along with sea level rise, may increase the risk of storm surge damage. New York, Miami and New Orleans are expected to be among the 20 cities with the greatest exposure of population and assets to coastal flooding.[1]

By 2050, a fourfold to sixfold increase in heat stress is likely across the US, with the largest rise expected in the Southwest. The effects on agriculture will vary. Overall yields of major crops, such as maize and wheat, will probably decline by mid-century. In Southeastern US, wheat will be particularly vulnerable to reduced soil moisture. However, northern areas are likely to see a modest increase in agricultural production. Longer and warmer growing seasons should allow higher-value warmer-weather crops to be grown further north and lengthen outdoor feeding seasons for livestock. The lucrative maple syrup industry could expand northward.[2]

1 Davie, J., *et al.*, (2017), *Climate Change report for Global Strategic Trends 2050*, pages 70-72, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

2 Government of Canada, (2015), 'Impacts of Climate Change'.

The US is likely to become a net oil exporter, resulting in an expansion of Alaskan oil infrastructure

Increased water stress and drought are likely in arid and semi-arid areas of Canada and areas of the Western US, such as the Rio Grande basin.[3] Declining flows in southern Canadian rivers are already resulting in problems over sharing and water quality along the Canada-US border, including the Great Lakes.[4] These issues are currently well-managed by a joint Canadian-US organisation, the International Joint Commission, although they may increasingly become a cause of regional tension.

Across Alaska, Canada and Greenland, infrastructure will be affected by changes to permafrost and sea ice that currently provide stable surfaces for buildings and pipelines, contain waste and protect shorelines.[5] Ice routes that use frozen lakes and rivers will need to shift to land routes, potentially increasing the isolation of many northern communities. However, melting sea ice might reduce remoteness, resulting in economic benefits, but also challenging the traditions of indigenous Arctic communities. Greenland is already benefiting economically from climate change due to increases in the variety and amount of fish caught in warmer waters, better agricultural opportunities and improved access to onshore and offshore mineral resources.

Across North America, increased energy efficiency is likely to offset increases in demand. By 2022, the US should become a net energy exporter, driven by flat domestic demand and growing hydrocarbon production of both oil and gas. Due to falling costs, new power plants will increasingly be gas or renewable, while nuclear power use may reduce.[6]

The Canadian government has made enduring policy commitments to reduce greenhouse gas emissions and progress is likely. In 2014, 65% of Canada's electricity came from renewable sources and 80% from non-greenhouse gas-emitting sources. Hydroelectricity accounts for 67% of Canada's power generation (90% in British Columbia), but is

3 Davie, J., *et al.*, (2017), *Climate Change report for Global Strategic Trends 2050*, page 72, a research paper prepared for DCDC.

4 Government of Canada, Natural Resources Canada, (2015), 'From Impacts to Adaptation, Canada in a Changing Climate'.

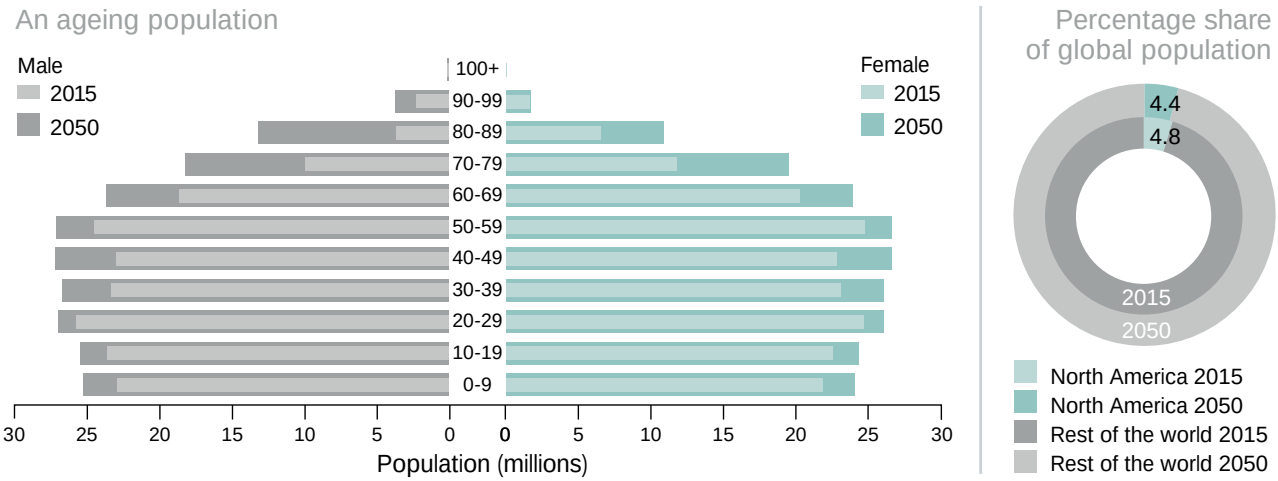
5 *Ibid.*

6 US Energy Information Administration, (6 February 2018), *Annual Energy Outlook 2018 with projections to 2050*.

particularly vulnerable to climate change. As the world's second largest producer of uranium, 88% of which is exported, Canada will continue to make significant investment in nuclear power. Despite the increasing energy independence of the US, Canada will continue to export significant amounts of electricity, oil and gas across its southern border, possibly expanding the current network of 34 cross-border electricity transmission lines and 840,000 kilometres of oil and gas pipelines. Higher demand for water in a more arid Southwestern US may result in the bulk export of Canadian water, possibly via a new network of water pipelines. This would require significant adjustments to trans-border agreements on water and trade.

Human development

By 2050, there will be approximately 435 million people in North America. Canada and the US will both experience population growth of just over 20%, to around 45 and 390 million respectively. Net immigration will play a significant part in this population increase, especially in Canada. Greenland and Bermuda could see small reductions in their populations due to decreasing fertility rates and greater emigration.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

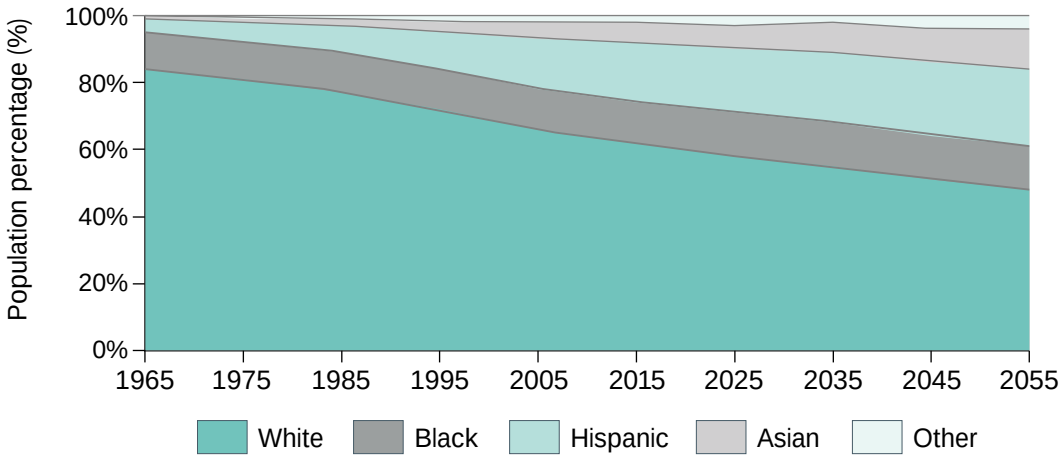
Immigration and differing fertility rates will continue to change the racial composition of the US. Between 2000 and 2015, the US Asian population grew by 72%,[7] whilst in the same period the Hispanic population grew by 60%, accounting for more than half of all population growth. In the next 30 years, projections suggest that there may be no racial or ethnic majority in the US[8] and that there could be more Asian than Latin American immigrants. By 2050, the median age in the US will have increased by nearly five years to 42, but will still be relatively low compared with many other developed economies, such as Canada at 45 and Europe at 47. As a result the US is likely to have a strong working-age population. However, the age of the population will not be evenly distributed among racial and ethnic groups, and should broadly reflect 2014 median ages: Hispanic 28; Black 33; Asian 36; and White 43.[9]

7 Lopez, G., *et al.*, Pew Research Center, (8 September 2017), 'Key facts about Asian Americans, a diverse and growing population'.

8 Cohn, D. and Caumont, A., Pew Research Center, (2016), '10 demographic trends that are shaping the U.S. and the world'.

9 Patten, E., Pew Research Center, (2016), 'The Nation's Latino Population Is Defined by Its Youth'.

United States population by ethnicity



Source: Pew Research Centre

In 2015, more than 81% of the US population lived in urban areas, and this proportion should continue to rise and, by 2050, 89% of Americans, 87% of Canadians and 93% of Greenlanders are likely to inhabit urban areas.[10] Work patterns will also continue to change. In 2017, 31% of the US workforce mainly worked remotely, up from 24% in 2013. Such substantial alterations in the way people work will affect office space requirements and commuter travel, as well as urban economies and culture, but there are currently no indications that this is affecting urbanisation trends. Multigenerational living, with two or more adult generations under the same roof, has gradually increased and is at its highest level since 1950, at 20% of households. This trend is expected to continue.

Higher education institutions in the US and Canada, particularly the best performing ones, should remain strongly competitive academically, helping to prolong the region's global technological and economic lead. Since 2000, there has been a gradual increase in tertiary education enrolments in both countries, a trend which is expected to continue. Canada's workforce currently has the highest levels of tertiary education in the world. The US is currently the most popular destination for people studying abroad and places at North American universities will remain in high demand for international students, especially in graduate school and science and technology programmes.

The US consistently underperforms in science, mathematics and reading at secondary school age.[11] Canada ranks in the top ten globally in all three subjects, despite spending 20% less as a proportion of gross domestic product (GDP). The effects of socio-economic disadvantage on academic performance in the US have been reducing, but significant inequalities in educational outcome remain, depending on family income and ethnicity.[12] Of those currently gaining college degrees, 15% are Hispanic Americans compared with 23% Blacks, 36% Whites and 53% Asians. For high school completion, the current figures are Hispanics 67%, Blacks 88%, Asians 89% and Whites 93%.[13] Without mitigation, the US may not realise the full economic benefits of its relatively young and sizeable population.

10 United Nations (UN) Department of Economic and Social Affairs (DESA), '2018 Revision of World Urbanization Prospects'.

11 Organisation for Economic Co-operation and Development (OECD), (2016), *Country Note: Key findings from PISA 2015 for the United States*, page 18.

12 Alvaredo F., *et al.*, World Inequality Lab, (2018), *World Inequality Report 2018*.

13 Pew Research Center, (27 June 2016), 'On Views of Race and Inequality, Blacks and Whites Are Worlds Apart: 1. Demographic trends and economic well-being'.

Despite a probable increase in the number of people without a religious affiliation, belief is likely to play a relatively important part in North Americans' private, public and political life, particularly in the US. In 2010, 77% of North Americans identified as Christian and 17% were religiously unaffiliated. By 2050, demographic changes, including migration, combined with a continuing gradual trend for secularisation, could reduce the percentage of Christians to 65% and increase the unaffiliated to around 25%. Muslims and Hindus should overtake Buddhists becoming the second and third largest religious groups. Levels of religious engagement among North American Christians and Muslims show fluctuations but no clear trends. However, North Americans are consistently more religiously engaged than Europeans, with almost twice as many likely to attend a religious event each week.

Between 1995 and 2013, life expectancy in the US increased from 74.7 to 78.8 years, and in Canada from 76.3 to 81.7 years. In Canada the upward trend continues, but in the US life expectancy has plateaued, despite world-leading health care research, cancer outcomes and waiting times.[14] Among the contributing factors may be a US obesity rate that has more than doubled since 1978, reaching 38.2% of the population in 2015. Childhood obesity is also trending upwards, meaning that overall obesity may exceed 46% by 2030. If unaddressed, this may lead to an increase in non-communicable diseases, such as diabetes and cardiovascular disease, with associated rises in deaths and disabilities. In addition to increased health care costs, this would also damage the economy due to reduced productivity.

Health care costs in the US will probably continue to outstrip economic growth. In 2016, total national expenditure on health care comprised 17.9% of GDP (double the Organisation for Economic Co-operation and Development (OECD) average), and without policy intervention, this could reach between 24% and 37% of GDP by 2050.[15] High costs, an ageing population and workplace health insurance schemes may result in unfunded liabilities creating fiscal shortfalls for states and cities, and bankruptcies for businesses.

High health care costs and an ageing population may result in unfunded liabilities

sshepard / iStock.com

14 OECD, (2017), *Health at a Glance 2017*.

15 Getzen, T., Altarum, (6 January 2015), 'Medical costs over the long run 1850-2050'.

North America's share of global merchandise trade is expected to decline from 11% in 2015 to 9% in 2050

Economics

The US and Canada have an extremely close trade and investment relationship, with over 75% of Canada's merchandise exports going to the US. Since World War 2, Canada has successfully transitioned through the growth of its manufacturing, mining and service sectors. Despite the abundance of its natural resources, which may be in greater demand due to climate change, this shift is unlikely to be reversed. The future of Canada's economic success will, however, remain closely tied to that of the US. Despite having had the world's largest economy for more than a century, in 2014 the US was overtaken by China in GDP at purchasing power parity,[16] and is expected to be overtaken in GDP at exchange rate by around 2030. By 2050, the US could have just 12% of the world's economy at purchasing power parity compared with China's 20%, and India's 15%.[17] The North American region's share of global merchandise trade is also expected to decline from 11% in 2015 to 9% in 2050. US policy responses to the loss of its economic lead, and in particular the effects on its workforce, may have important global ramifications.

In 2013, the US spent more on research and development than all European Union countries combined, more than a quarter of global research and development expenditure. However, China has gradually been closing the gap, and now spends nearly the same amount as the US.[18] Between 2005 and 2016, research and development spending by the US (as a share of GDP) increased slightly from 2.51% to 2.74%, while China's rose from 1.31% to 2.12%, with the result that China's actual expenditure rose from 25% to 90% compared to the US. If, as trends suggest, China's share of global GDP increases and US GDP declines, the latter may struggle to retain its technological lead.

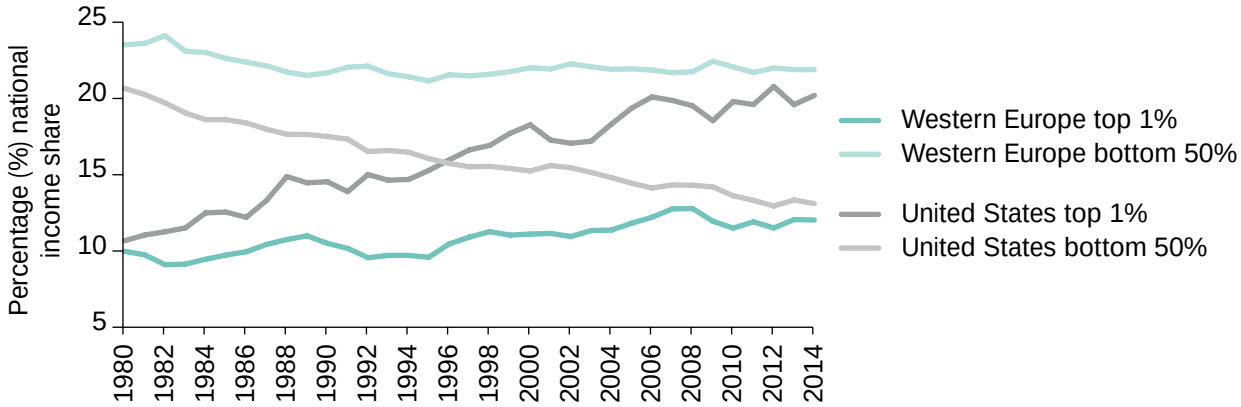
16 International Monetary Fund (IMF), (2018), *World Economic Outlook, April 2018: Cyclical Upswing, Structural Change*.

17 PwC, (February 2017), *The World in 2050*.

18 UN Educational, Scientific and Cultural Organization (UNESCO), (2015), *UNESCO Science Report, Towards 2030*.

Since the start of the century, the US has seen its share of global exports fall from 11.8% to 9.1%, whilst China's has increased from 4.3% to 13.8%, with over two million US manufacturing jobs lost during the same period. It is unclear to what extent these job losses are due to Chinese import competition as opposed to the effects of automation or other factors. These effects will continue to be felt unevenly between more prosperous US regions and those where the economic and industrial base has not adapted. If manufacturing jobs continue to decline, many Americans will probably move to lower-tier industrial or service employment. Given the two-tier US labour market, in which newer employees and those with less professional skills are paid less, receive smaller pay rises and fewer benefits such as health insurance, this may generate social discontent and economic uncertainty.

Diverging income-inequality in the United States



Source: World Inequality Lab, *World inequality report 2018*

Rising international trade competition, technological change, differences in access to education, and US labour market conditions will continue to generate financial inequality in the US. Between 1980 and 2014, the wealth share of the top 1% rose from just over 10% to 39%, while that of the bottom 50% decreased from 20% to 13%.[19] Similar developed economies in western Europe saw much smaller rises and falls. A lack of public capital in the US may also limit both federal and state governments' ability to tackle inadequate ageing infrastructure, particularly where local tax revenues are low.

Socio-economic factors will continue to drive uneven educational outcomes

19 Alvaredo, F., *et al.*, World Inequality Lab, (2018), *World Inequality Report 2018*.

Religion is likely to remain an influence on politics in the US

Ted Odeh / Shutterstock.com

Governance

The traditional model of Canadian party politics was overturned in the 2011 election when the New Democratic Party replaced the Liberal Party as the official opposition and made significant gains from the Bloc Quebecois. It was reinstated with the Liberal victory of 2015. The relatively centrist positions of all major Canadian parties suggest that far-left or far-right politics will not have significant influence in Canada and that secessionist movements in Quebec and other provinces and territories are also unlikely to garner significant political traction. Although plausible, the prospect of a province or territory leaving Canada is low.

The US two-party political system may be more susceptible to polarisation, which could increase as a result of social and economic inequality. In the last 25 years, the number of American voters who expressed consistently conservative or consistently liberal opinions doubled,[20] and there are significantly less senators and representatives adopting cross-cutting positions on partisan political issues.[21] Such polarisation may make bipartisan consensus more difficult to achieve and limit prospects for a modern 'New Deal' to address social inequality. Religion is also likely to remain an influence on politics in the US, for example, 57% of Republican support is based on a combination of evangelical Christians together with Catholics and Mormons of similar views, and in the 2016 presidential election, 81% of evangelical Christians voted for Trump.[22] Nevertheless, the Washington establishment, comprising the career civil service, bureaucracy, Congress and the Senate, should continue to provide long-term continuity and balance in US domestic and foreign policy, even if presidential administrations are shorter term in outlook and influenced by populist and protectionist views of the electorate.

20 Pew Research Center, (12 June 2014), 'Political Polarization in the American Public'.

21 Parker, C., Phys Org, (21 December 2017), 'U.S. political parties more polarized than voters'.

22 Aaltola, M., *et al.*, Finnish Institute of International Affairs, (31 January 2018), *Between change and continuity: Making sense of America's evolving global engagement*, page 17.

Greenland is the most likely candidate for revised status within the region. Having gained self-rule in 2009, it is not fully independent. It is currently sustained by a US $580 million grant from Denmark, equivalent to one quarter of its GDP. Economic opportunities, whether as a direct result of climate change, which will allow access to minerals and hydrocarbons, or because of China's investment in mining and fishing, could lead to a reduction in reliance on Denmark. This, in turn, could lead to an increased demand for full independence.[23]

Geopolitics

Despite the increased economic prominence of China and other Southeast Asian nations, the North American Free Trade Agreement members (the US, Canada and Mexico) should remain one of the world's strongest economic blocs. The US in particular will retain significant influence in the international system due to its extensive network of alliances and partnerships and strong global linkages to interdependent networks of trade, finance and information.

Although the US may continue its historic oscillation between isolationism and interventionism, it is difficult to envisage it being anything other than a global power in 2050. The future direction of US foreign policy and global engagement remains unclear over the longer term, but crucial factors are likely to include how the US responds to the potential transition of power to China (and other eastern countries), and the tension between state sovereignty and humanitarian responsibilities. In addition, there is a risk that current economic protectionism could undermine key partner relationships, particularly in Europe, South Asia and Southeast Asia.

There are likely to be changes to how US influence in the international system is achieved. Given the probable reduction in its share of global GDP, the US may find its use of economic levers less viable. While the US will continue to fulfil its international responsibilities, its participation may become increasingly conditional on allies and partners taking on more equitable burden-sharing.

Despite cycles of tension, the relationship between the US and its European allies is likely to remain strong, defined by the North Atlantic Treaty Organization (NATO) security cooperation, economic ties and shared values. Even with political polarisation on both sides, core values and interests should remain sufficiently coherent to maintain a strong transatlantic relationship. The US will remain Europe's major democratic ally and essential partner as no other power can provide similar security guarantees or political, diplomatic, technological and economic resources.[24] However, there may be significant divergence of interest. For example, Europe is unlikely to wish to engage militarily in the Indo-Pacific region, nor will European allies necessarily concur with the methods the US chooses to achieve its strategic ends, especially where the unilateral use of force is involved. The US will also continue to demand that other NATO members commit to spending 2% of their GDP on defence, which may prove problematic for many countries. Greater difficulty in achieving consensus in an enlarged NATO structure could lead to increased multilateral or bilateral arrangements with NATO members.

23 Strategic Comments, 20:2, (16 April 2014), 'China's strategic arctic interests'.

24 Aaltola, M., Finnish Institute of International Affairs, (31 January 2018), *Between change and continuity: Making sense of America's evolving global engagement*, page 107.

Maritime power projection is likely to remain important to the US

michaelbwatkins / iStock.com

European fears of a grand bargain between Russia and the US have receded due to the recent increase in US Armed Forces in Europe, including the deployment of an armoured brigade on a continuous basis and the proposal to add US $1.4 billion to the US $3.4 billion budget allocation.[25] This serves as a direct contribution to deterring Russia in the Baltic States and Eastern Europe, and also signals to NATO allies, other European partners and Russia, that European security remains important to the US.[26]

The Indo-Pacific region is growing in importance to the US (relative to Europe and the Middle East), which has historically been unwilling to accept another power as regional hegemon in Asia.[27] Despite criticism of Japan's participation in burden-sharing, the US is likely to: continue strengthening alliances in Asia; encourage a more interconnected region; and build military capabilities to balance China's prominence. The US may also seek to balance China's influence by supporting India as a regional power and recruiting countries bordering the Pacific and Indian Oceans and the South China Sea to help counter China's maritime ambitions.

When deciding how to act strategically in the region, liberal values and human rights may be less important to the US than interest-based considerations, such as commercial access or security concerns, including the denuclearisation of the Korean Peninsula. This may allow progress to be made on long-term regional issues and limit the likelihood that potential flashpoints, such as the South China Sea, the East China Sea, or Taiwan, spark conflict. Nevertheless, an assertive China seeking a central role in Asia and a larger role in global affairs, does challenge the US' own strategic position and could evolve into a latent strategic rivalry. Over the next 30 years, even if the US loses its economic and technological lead to China and India, it is likely to remain the pre-eminent global military power, supported by an extensive network of allies and partners.

25 Herszenhorn, D., Politico, (24 May 2017), 'NATO cheers Trump's military budget'.

26 Deni, J., Parameters, Volume 46, Issue 1, Spring, (2016), 'Modifying America's Forward Presence in Eastern Europe', page 42.

27 Green, M., (2017), *By more than Providence: Grand Strategy and American power in the Asia Pacific since 1783*, page 3.

Unlike Canada, the US has traditionally been a reluctant Arctic actor, although it has shown greater interest in the region over the last decade. US national security interests in the region will almost certainly endure due to the proximity of Russia to Alaska, and the presence of crucial elements of US strategic deterrence, global missile defence and early warning architecture. The US has also shown greater interest in the maritime area around Greenland, Iceland and the United Kingdom. The US does not recognise Canada's claim that the waters within the Canadian Arctic Archipelago are territorial, which may become an increasing source of tension as climate change renders the Arctic more accessible. If Greenland were to gain greater or even full independence this would alter the North American Arctic's geopolitical balance, especially if it were accompanied by greater economic investment from other actors. Given its strategic interests in Greenland, such as Thule Air Base, the US would probably try to limit Chinese influence there.

Security

North America will remain one of the most stable regions in the world, and there is a very low risk of substantial national instability or conflict within the region. Shared security interests between Canada and the US, derived in part from Canada's up-threat geographic position for the most likely direction of a ballistic missile attack, will continue to drive close defence cooperation. In the US, successive administrations appear to share an enduring consensus regarding threats to US security (such as China, Russia, Iran, North Korea and violent extremist organisations), and this seems unlikely to change.[28]

There will remain a risk of terrorist activity resulting from external issues, particularly when the US and Canada are involved in interventionist military operations or economic coercion. There is a much smaller risk of coordinated internally-motivated terrorism, but it is possible that this could arise, especially if secessionist movements feel underrepresented in the political process. High levels of gun ownership mean that insurgent groups would have little difficulty arming themselves.

Roman Tiraspolsky / Shutterstock.com

Gun ownership levels will remain high

28 The White House, (December 2017), *National Security Strategy of the United States of America*, page 2.

1 Anguilla
2 Antigua and Barbuda
3 Argentina
4 Aruba
5 Bahamas
6 Barbados
7 Belize
8 Bolivia
9 Brazil
10 British Virgin Islands
11 Caribbean Netherlands
12 Cayman Islands
13 Chile
14 Colombia
15 Costa Rica
16 Cuba
17 Curaçao
18 Dominica
19 Dominican Republic
20 Ecuador
21 El Salvador
22 Falkland Islands
23 French Guiana
24 Grenada
25 Guadeloupe
26 Guatemala
27 Guyana
28 Haiti
29 Honduras
30 Jamaica
31 Martinique
32 Mexico
33 Montserrat
34 Nicaragua
35 Panama
36 Paraguay
37 Peru
38 Puerto Rico
39 Saint Kitts and Nevis
40 Saint Lucia
41 Saint Vincent and the Grenadines
42 Sint Maarten (Dutch part)
43 Suriname
44 Trinidad and Tobago
45 Turks and Caicos Islands
46 United States Virgin Islands
47 Uruguay
48 Venezuela

Latin America and the Caribbean

By 2050, Latin America and the Caribbean's (LAC's) increasing share of the global economy (Brazil could be the fifth largest economy and Mexico the seventh) could change the global political and economic order. The United States (US) will remain a key partner for the region, but its dominance is likely to reduce, while China will be an increasingly important trading partner and investor. Trade with other Asian countries, and Africa, is also likely to increase. Whilst levels of poverty had been reducing, since 2014 economic growth has stalled and, in the coming decades, insufficient work may lead to increasing levels of poverty. This, combined with poor governance and inequality, could lead to social unrest, populism and political instability. Levels of violent crime are likely to remain high and organised crime and corruption could reduce economic growth and hamper efforts to improve governance. Armed conflict between states in the region is, however, unlikely and the focus for military activity will continue to be internal security. Rising sea levels, increasingly heavy rains and intense storms combined with urban growth in environmentally exposed areas will make the region vulnerable to natural disasters.

Environment

The vast north to south span of LAC encompasses varied climate types and a high degree of biodiversity. By 2050, the annual mean temperature of the Caribbean, Central America and northern South America is likely to increase by between 1° Celsius and 2° Celsius, with slightly smaller rises projected for western and southeastern South America. A 2° Celsius rise in temperature by 2050 could cost LAC up to US $100 billion, or 2-5% of overall gross domestic product (GDP).[1] LAC experiences high average, but unevenly distributed, rainfall, and this is reflected in uncertain estimates that arid and semi-arid areas may become drier, whilst other areas may experience higher rainfall. In Central America and the Caribbean, extreme rainfall is projected to increase during tropical cyclones, but overall, the frequency of tropical cyclones is projected to decrease.[2] The pattern of coastal urbanisation is likely to continue with densely-populated coastal areas being vulnerable to a combination of sea level rise and extreme weather.

By 2050, there is likely to be water stress in many areas in LAC. This is largely due to economic and demographic growth. Current water shortages in semi-arid areas and the tropical Andes are expected to increase due to the climate change effects of glacier retreat, rainfall reduction and increased evaporation. This would reduce water availability for cities, food production and hydroelectric power generation. Statistics for countries that are relatively water stress-free may mask important differences between

1 Edwards, G., *et al.*, The Brookings Institution, (2015), *A New Global Agreement Can Catalyze Climate Action in Latin America*.

2 Davie, J., Met Office, (2017), *Climate Change Report for Global Strategic Trends 2050*, a research paper prepared for the Development, Concepts and Doctrine Centre (DCDC).

Coastal areas will be vulnerable to a combination of sea level rise and extreme weather

individual states. For example, Brazil, which has nearly the same land area as Europe, and is sustained by the Amazon River, lacks water availability in some states and has recently experienced droughts in Sao Paulo, Brasilia and the north east, worsened by the fragility of supply systems and water allocation regimes.[3] Water stress is likely to be particularly high in the Dominican Republic, Haiti, Peru, Chile and Mexico, closely followed by Cuba, Argentina, Venezuela and Ecuador.[4]

Agriculture will remain the largest consumer of water in the region. Meat and milk production are particularly water-intensive farming industries and may be adversely affected by shortages. However, climate change could create conditions that benefit crops such as soybean, maize and sugar cane, and there could be increased productivity in some parts of the region. Together with an increased demand for biofuel, this could lead to an accelerated expansion of pastures, and associated deforestation, with a potential to influence biodiversity in certain key regions.[5] Careful management will be required to ensure that such land use transitions do not worsen climate change and water shortages.

Energy use in LAC has tripled in the last 30 years and is expected to increase by more than 80% by 2040, with electricity requirements doubling in the same period. The majority of future demand is expected to come from Argentina, Brazil, Chile, Colombia, Mexico and Venezuela.[6] Currently, fossil fuels make up around 74% of total energy use. Natural gas production and use is increasing, but so too are energy efficiency measures and the use of renewable energy sources, such as hydroelectric power. In 2017, almost all of Costa Rica's electricity was generated from renewables. However, reduced water

3 Benton, T., *et al*., (2017), *Food and water systems and security: looking to the future*, a research paper commissioned by DCDC.

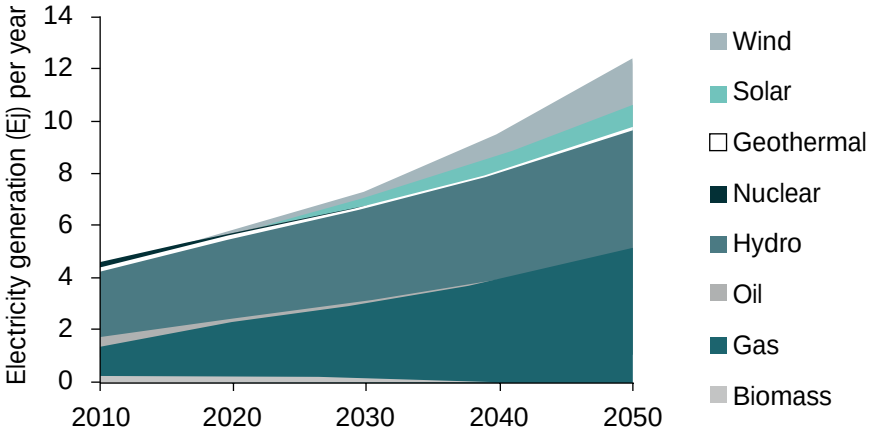
4 World Resources Institute, (2010), 'Aqueduct Projected Water Stress Country Rankings'.

5 Magrin, G. and Marengo, J., Intergovernmental Panel on Climate Change (IPCC), (2014), *Central and South America. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

6 Balza, L., *et al*., Inter-American Development Bank, (2015), *Lights on? Energy needs in Latin America and the Caribbean to 2040.*

availability may in turn reduce the capacity for hydroelectric generation and lead to the diversification of renewable energy sources. Despite LAC generating three times more electricity from renewables than the global average, fossil fuels are likely to remain an important part of the region's energy mix.

Latin American electricity generation

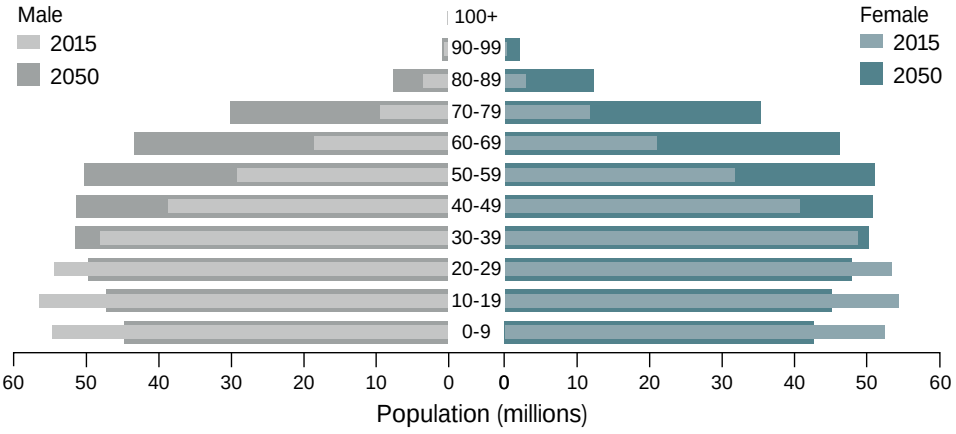


Source: Inter-American Development Bank

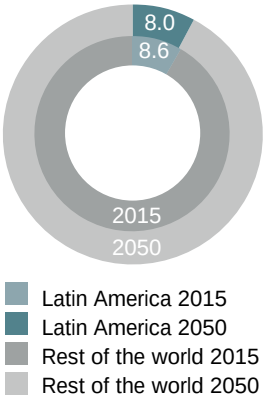
Human development

LAC is experiencing a rapid decline in fertility rates, coupled with a longer life expectancy, creating an ageing population. Life expectancy has increased from 68.4 years in 1995 to 74.6 years in 2015, and, by 2050, is expected to reach 81.3 years, and the region's population is likely to be 779 million. Although Latin America has a very large youth population, the median age rose from 19.7 years in 1980 to 29.5 years in 2018, and it is projected to reach 41.1 by 2050. A consequence of an ageing population is an increase in the dependency ratio (the proportion of children and the elderly compared with those of working age), which is expected to rise from 50% today to 59% in 2050.[7]

An ageing population



Percentage share of global population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

7 United Nations (UN) Economic Commission for Latin America and the Caribbean (ECLAC), Demographic Observatory, (2015), *2014 Population projections*.

An increasing proportion of the population will be elderly

EvijaF / Shutterstock.com

The middle class (those living on US $10-50 a day) has expanded in LAC in recent years. However, since 2014, this growth has stagnated and the vulnerable class (those living on US $4-10 a day) has increased three times as quickly as the middle class.[8] Insufficient work and suppressed economic growth, particularly from 2030 onwards, could mean that many fall back into poverty.

It is likely that migration will increase. In 2014, 28.5 million people from LAC lived outside their home nation. By 2050, net migration of young low-skilled workers from LAC to the US could slow to zero, as job opportunities decline.[9] Intra-regional migration is likely to increase, mainly as people seek employment opportunities, but also as they try to escape political crises, flee from violence and avoid the effects of climate change.

The general trend of rising urbanisation will continue. In 2016, 80% of the population lived in urban areas, making LAC one of the world's most urbanised regions. Inadequate planning and land shortages will continue to drive the development of informal settlements on hillsides and floodplains, making settlers more vulnerable to natural disasters.

The gender gap in LAC is narrowing faster than much of the rest of the world. An increase in the number of working women has been partially attributed to recent strong economic growth. About 70 million women joined the workforce during a period of record economic growth between 2004 and 2014. Thus, compared with other parts of the world, LAC has a high level of diversity in the workplace, including professional-level employment. However, women are still more likely to work in the informal economy. This is unlikely to change in the next 30 years, despite some initiatives to shift jobs

8 Calvo-Gonzalez, O., World Economic Forum, (2016), 'Why is middle-class growth in Latin America slowing?'.

9 Burke, A., The Brookings Institution, (23 March 2017), 'Why undocumented immigration from Latin America to the US will slow to a crawl – even without a border wall'.

from the informal to the formal economy.[10] LAC has had many female heads of state, although, despite quota laws that increase participation, only 30% of current government representatives are women.

Christians will remain the largest religious group, comprising about 90% of the religiously affiliated population. On current trends, however, the number of people who are religiously unaffiliated could grow from 45 million (7.7%) in 2010 to 65 million (8.7%) in 2050, driven by higher fertility rates among the religiously unaffiliated and by people renouncing their faith.[11]

Health care is improving in LAC, a trend expected to continue over the next 30 years.[12] As economic development increases and the population ages, the prevalence of communicable diseases, such as tuberculosis, is expected to fall, with a corresponding rise in non-communicable diseases, such as diabetes and cancer. Pressure on health services may be most acute when dealing concurrently with both types of disease. As temperatures rise, it is likely there will be an increase in the number of heat-related fatalities, as well as an increase in the spread of vector-borne diseases, such as malaria and dengue fever.

Steady improvements in education levels in LAC will continue, although the region lags behind much of the world. In 2013, Latin America ranked near the bottom of every global test of student achievement. There are skills shortages in the region, with a corresponding impact on productivity, making education a key development priority for all LAC countries. LAC spent less than 4% of its GDP on education in 1990, increasing to 5% by 2013, although there were substantial variations within the region. This level of spending, to which some countries have made a long-term policy commitment, is similar to the Organisation for Economic Co-operation and Development (OECD) average, and is higher than in most other developing countries.[13] Many countries, especially Brazil and Mexico, have invested in Massive Open Online Courses, allowing a greater proportion of the population access to free learning and opportunities for upskilling. Widespread adoption of e-learning may help reduce skills shortages.

Economics

Economic growth is expected to slow, particularly during the next decade. Many countries in the region may find themselves falling behind comparable economies after 2030. However, there will probably be some regional economic success stories, and Mexico and Brazil will remain regional and international economic powers. Brazil is currently the world's ninth largest economy and Mexico the 15th. By 2050, Brazil could be the world's fifth largest economy and Mexico the seventh. Other countries, such as Panama and Peru, are expected to become high-income nations by 2050.[14]

The trend for increased LAC regional economic cooperation and integration should continue.[15] Initiatives, such as the Pacific Alliance formed by Chile, Colombia, Mexico and Peru, are helping to promote open borders and trade agreements with countries all

10 Organisation for Economic Co-operation and Development (OECD)/Development Bank of Latin America (CAF)/UN ECLAC, (2016), *Latin American Economic Outlook 2017: Youth, Skills and Entrepreneurship*.

11 Pew Research Center, (2 April 2015), *The Future of World Religions: Population Growth Projections, 2010-2050*.

12 Bobak, A., School of International Futures, (2017), *The Future of Latin America and the Caribbean out to 2050*, a research paper commissioned by DCDC.

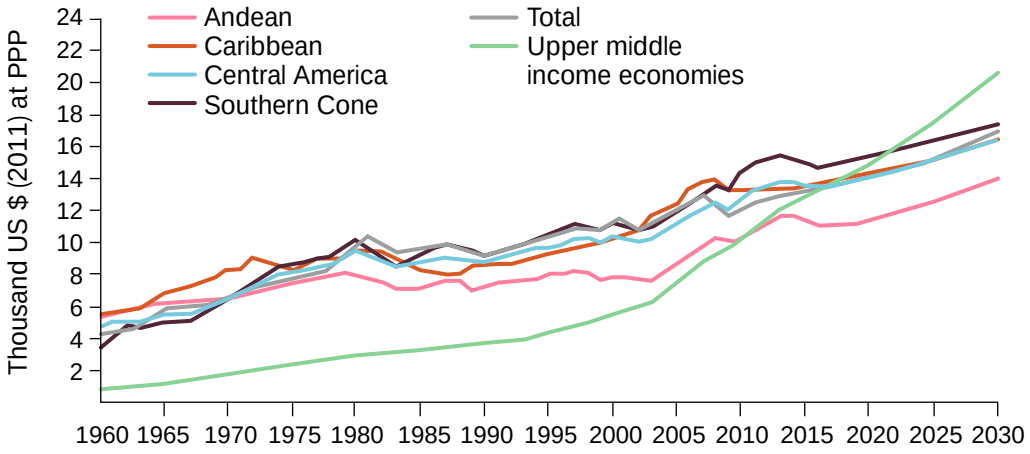
13 Fleischner, N., Americas Society/Council of the Americas (AS/COA), (25 August 2016), 'Weekly Chart: Education in Latin America and the Caribbean'.

14 Marczak, J. and Engelke, P., Atlantic Council, (2016), *Latin America and the Caribbean 2030: Future Scenarios*.

15 Mori, A. and Zanatta, L., (Eds), International Society for Performance Improvement (ISPI), (2017), *Latin America at a Crossroads*.

over the world, as well as intra-regionally. Chile, Colombia, Mexico and Peru currently represent 35% of Latin America's GDP, almost 50% of its trade and attract 45% of foreign investment. Over the next 20 years their annual average growth rate could be 3.3%, rising to 5.2% given further improvements in productivity. In addition, Brazil, historically a 'closed' nation, is opening up, and will continue to explore new trade agreements. For example, despite the absence of a formal agreement, trade between Africa and Brazil rose from US $6 billion in 2003 to US $25.6 billion in 2012.

South American gross domestic product (GDP) per capita at purchasing power parity (PPP)



Note: All figures based on Inter-American Development Bank data except upper middle economies, which is based on World Bank data.

Source: Atlantic Council

The US is currently LAC's largest international investor and should remain a significant trading partner, generating 20% of the region's foreign direct investment flows.[16] However, LAC has substantially increased trade with China as part of its drive to diversify its partners. China has made, or proposed to make, investments in regional projects, such as a car factory in Mexico (US $200 million), and the Nicaragua Canal (a US $50 billion programme). Chinese investment in the region is likely to rise, as a way to protect access to extractive industries. Other large infrastructure projects, such as ports in the Caribbean, could also follow. The region will continue to increase business with Asia in general. Japan is already a significant, and growing, trading partner for many LAC countries, and the Association of Southeast Asian Nations (ASEAN), a group of ten countries, is likely to become more commercially important.

Governance

Most LAC countries have transitioned from dictatorship to democratic governance in the last 20 to 40 years. Some countries have fluctuated between being free, 'partly free' or 'non-free', including Nicaragua, Bolivia and Honduras.[17] In such a recent democratic environment, populist sentiment about the fairness of power transitions and political processes, as seen in Cuba, Venezuela, Brazil and Ecuador, are likely to continue.[18] Economic stagnation, poor governance and high-profile political scandals could be triggers for unrest. Some governments are already responding to this type of pressure by increasing democratic participation and transparency, for example, Chile recently

16 UN ECLAC, (2017), *Foreign Direct Investment in Latin America and the Caribbean*.

17 Freedom House, (2018), *Freedom in the World 2018*.

18 Marczak, J. and Engelke, P., Atlantic Council, (2016), *Latin America and the Caribbean 2030: Future Scenarios*.

involved its citizens in rewriting its constitution. Failure to establish improved democratic processes could cause conflict in the region, for example, political instability and a weak economy in Venezuela caused an estimated 150,000 people to flee to neighbouring countries in 2015 alone. In some countries, very high levels of corruption could result in governance being led, or at least heavily influenced by, drug cartels.

Geopolitics

The balance of power in the region is closely linked to economic success. Argentina, Brazil, Chile, Colombia, Mexico and Peru will continue to be the most influential countries in LAC. Political relationships may, to some extent, follow trade alliances, as the US changes its focus away from the region and as Asian countries, especially China, continue to invest in Latin America. The Caribbean may not undergo the same shift given its physical location away from major trade routes. However, while the influence of the US in LAC may reduce, overall trade will probably not change significantly, given the size of the existing market and the regions' proximity. There are also important social ties between LAC and the US. Hispanics currently make up the largest and fastest-growing minority ethnic group in the US, and may increasingly influence policy towards LAC.[19] Unlike China, the US will also have enduring security interests in the region. These considerations suggest that there may be competing influences from China and the US within LAC. A breakdown in relations between the two powers could trigger tensions in the region.

Lucy Brown - loca4motion / Shutterstock.com

Corruption may continue to fuel unrest

19 Guardiola-Rivera, O., (2010), *What if Latin America Ruled the World? How the South Will Take the North into the 22nd Century*, page 282.

Governments will continue to use military forces for policing and internal security

Antonio Scorza / Shutterstock.com

Many South American countries have a particular strategic interest in the Antarctic. Both Chile and Argentina were original members of the Antarctic Treaty because their southern borders almost enter Antarctic waters. Other LAC countries have subsequently become signatories, including Brazil, Ecuador, Peru and Uruguay. These nations, and others, have invested in research and expeditions in the Antarctic, and are likely to continue to do so, not least to maintain a footing in the region for the review of the Antarctic Treaty System in 2048. The majority of countries in the region believe that resources in the Antarctic will be strategically important by the middle of the century.[20]

Security

There has not been a state-on-state conflict in LAC since the month-long Cenepa War between Ecuador and Peru in 1995. Stability is likely to be maintained, at least in part, by strong bilateral relationships, which are particularly important for countries that have substantial shared borders, such as Brazil. Armed conflicts between countries will therefore remain unlikely.

Military forces are often used for policing and internal security in LAC countries. It is likely that this will persist as long as armed forces are respected by the public. Defence spending in the region, as a percentage of GDP, has remained fairly constant in Central America and the Caribbean since 1988. A slight increase is explained by an increase in military funding to counter drug cartels by the Mexican government. South America's military spending, however, has declined. This recent reduction in spending is probably due to a lack of external threats, the impact of falling oil prices and Brazil's economic problems.[21] Regional militaries could become responsible for protecting natural resources, which would make developing rapid reaction forces a priority.

20 Alejandro Sanchez, W., Center for International Maritime Security, (2017), 'Latin American Navies and Antarctica'.

21 Tian, N., Stockholm International Peace Research Institute (SIPRI), (2017), *Trends in World Military Expenditure 2016*.

Religiously motivated terrorism is an emerging regional threat, particularly in the Caribbean. Radicalisation is increasing due to a lack of education, family breakdown, the spread of violent ideas through social media and the influence of returning fighters from Syria and Iraq. Trinidad had the highest rate of Islamic State recruitment in the Western Hemisphere in 2016.[22]

Crime levels in the region are exceptionally high and criminal activity has a significant effect on wealth and human development. Despite having only 8% of the world's population, the region suffers 38% of global murders. El Salvador, Guatemala and Honduras have some of the highest murder rates in the world, fuelled by drug violence. Jamaica's high level of violent crime over the last 40 years has resulted in significant suppression of economic growth. Drug cartels and organised crime will continue to play a significant role in LAC, wielding significant power and influence in Mexico and Central America, and increasing power in a weakened Venezuela. Weakening governance will exacerbate this dynamic. Corruption is commonplace and not expected to diminish.[23] Diversification of criminal activity is already occurring. Colombia, Bolivia and Peru are the largest cocaine producers in the world, but established smuggling routes are increasingly used for human trafficking. A growing security concern may be cybercrime. Currently, much of the region is unprepared for cyber threats,[24] although some countries are developing national cybersecurity strategies and mapping cyber capacity.

Drug cartels and organised crime will continue to play a significant role in the region

22 Cottee, S., The Atlantic, (8 December 2016), 'ISIS in the Caribbean'.

23 McDermott, J., InSight Crime, (4 December 2014), 'How Organized Crime & Corruption Intersect in LatAm'.

24 World Economic Forum, (2016), 'Global Agenda Council on Cybersecurity'.

Countries adjoining the Antarctic region

1 Argentina
2 Australia
3 Chile
4 Falkland Islands
5 New Zealand

The Antarctic

The Antarctic is the most inhospitable continent on Earth and plays a crucial role in its climate. It holds 90% of the world's freshwater. Since 2014, however, Antarctic ice has started to reduce substantially. If this trend continues, it is likely to have a profound effect on the global climate and sea level rise. The number of people visiting and working in the Antarctic continues to increase, and with it the risk of a major accident that surpasses the capacity of regional actors. As the region becomes more accessible it may become the focus of increased competition, particularly if global demand for resources leads to the end of the prohibition on commercial extraction of minerals, oil and gas. The Antarctic Treaty System is due for renewal in 2048 and, while it is expected to be renewed, it may come under increasing pressure. Should it unravel, a scramble for the Antarctic could follow.

Environment

Antarctica covers 10% of the planet's surface, an area of 14 million square kilometres, (approximately 1.4 times the size of the United States (US)) and holds 90% of the world's fresh water.[1] In the next 30 years, global climate change will be significantly affected by conditions within the Antarctic. For example, the Gulf Stream (a 'conveyor' of heat around the world) is, in part, driven by the cold, dense Antarctic waters. The melting polar ice cap in the Antarctic is therefore likely to influence this process. Antarctic sea ice had been increasing until 2014, but, since then, the amount of sea ice has reduced substantially.[2] If this trend continues it could accelerate changes to the Gulf Stream and contribute to severe climatic events and rising sea levels.

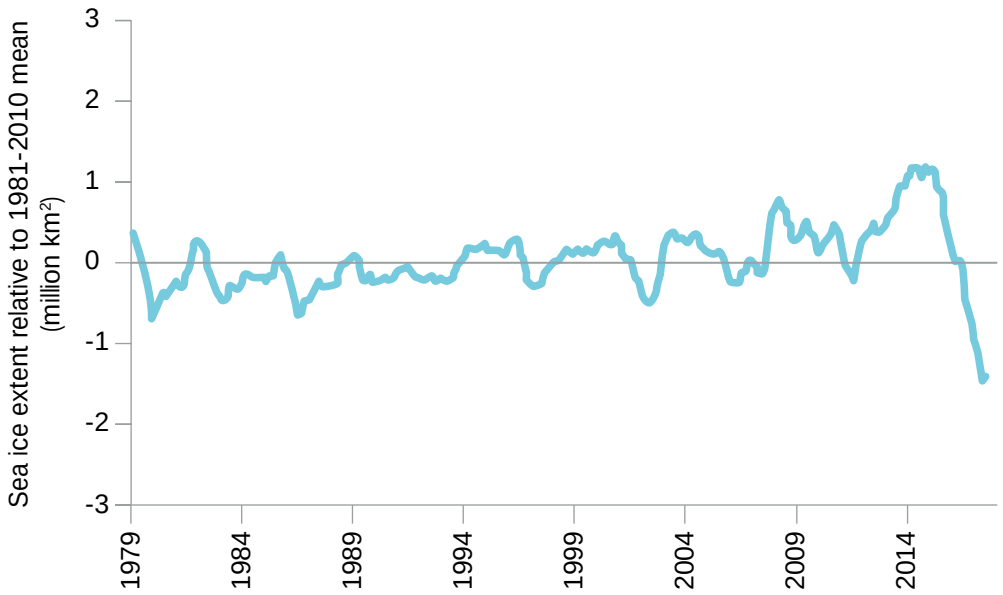
Antarctica has a large and diverse ecosystem, with species unique to its inhospitable environment. The Antarctic Circumpolar Current is one of the most powerful ocean currents on Earth that has physically isolated the Southern Ocean from adjacent oceans for millions of years. The steep drop in climatic temperature across the Antarctic has also acted as a physical barrier to any species unable to adapt to the colder weather. These two phenomena have traditionally acted as a barrier within the Antarctic to counter the effect of significant change in other ocean environments around the globe. One of these changes is increasing ocean acidification, which is particularly harmful to the polar ecosystems. The dramatic decrease in sea ice (from 2014) may be an indicator of future environmental change that would significantly impact the Antarctic ecosystem.[3]

1 British Antarctic Survey, (2015), 'Antarctic Factsheet'.

2 Nature, (19 July 2017), 'Solve Antarctica's sea ice-puzzle'.

3 Aronson, R. B., *et al.*, (2011), Annals of the New York Academy of Sciences, *Anthropogenic impacts on marine ecosystems in Antarctica*.

Changes in Antarctica's sea ice cover



Note: Total area with sea ice concentration of 15% or higher (calculated using satellite pixels).

Source: National Snow and Ice Data Center

As well as oil and gas, Antarctic resources include minerals such as copper, uranium and gold, with many undiscovered deposits likely throughout the continent. The Antarctic's weather, ice and distance from any industrialised areas mean that mineral extraction can be extremely hazardous and is currently not commercially viable. However, automated mining technology has seen significant advances in recent years and is used throughout the world.[4] As this technology develops, climatic conditions change and global demands for resources increase, it may become more feasible to extract the region's minerals. If so, current international agreements protecting the environment and resources in the Antarctic may come under strain.

Scientific research will continue to drive cooperation in the region

4 Atmanand M. A. and Ramadass G. A., *Deep-Sea Mining*, (2017), 'Concepts of Deep-Sea Mining Technologies', pages 305-343.

Human development

The Antarctic has no indigenous population and is inhabited mainly by scientific research staff. In 2017, the number of residents varied from around 1,100 in the winter to 4,400 in the summer. The countries with the most people within Antarctica during the peak summer months include: the US (1,293), Argentina (667), Russia (429), Chile (359), the United Kingdom (UK) (217), Australia (200), France (125), Japan (125) and Italy (102).[5] In the coming decades there could be growing numbers of tourists as the continent becomes increasingly accessible, and infrastructure to support the more casual visitor is developed. Landed Antarctic tourist numbers have risen from 1,055 in 1990 to 36,907 in 2016. Estimates of future growth vary dramatically, from around 6% per year to more extreme scenarios where tourism could double every five years.[6] This potential growth in tourism is likely to drive changes in the way the industry is regulated in the region through the Antarctic Treaty System.[7]

Economics

Fishing, bioprospecting (looking for valuable plants and animals) and scientific activities are currently important industries in and around Antarctica. Traditional fisheries include mackerel, icefish, Antarctic rock cod and seals. Toothfish and krill are the most commonly fished species, and whaling (for scientific purposes) still occurs.[8] The region has traditionally suffered from fishing to near-extinction before stocks are allowed to recover. Although international agreements (for example, the Commission for the Conservation of Antarctic Marine Living Resources) have helped limit overfishing, illegal, unregulated and unreported fishing remains a significant regional problem, which could worsen in the future. Fish stocks may also be affected by ecological changes, such as warming ocean temperatures.

MarcAndreLeTourneux / Shutterstock.com

The number of tourists travelling to Antarctica is likely to increase significantly

5 World Population review, (2017), *Antarctic Population 2018*.

6 Bender, N., *et al*., *Antarctic Science*, Volume 28, Issue 3, (February 2016), 'Patterns of tourism in the Antarctic Peninsula region: a 20-year analysis'.

7 Antarctic and Southern Oceans Coalition, (2005), *Some Legal Issues Posed by Antarctic Tourism*.

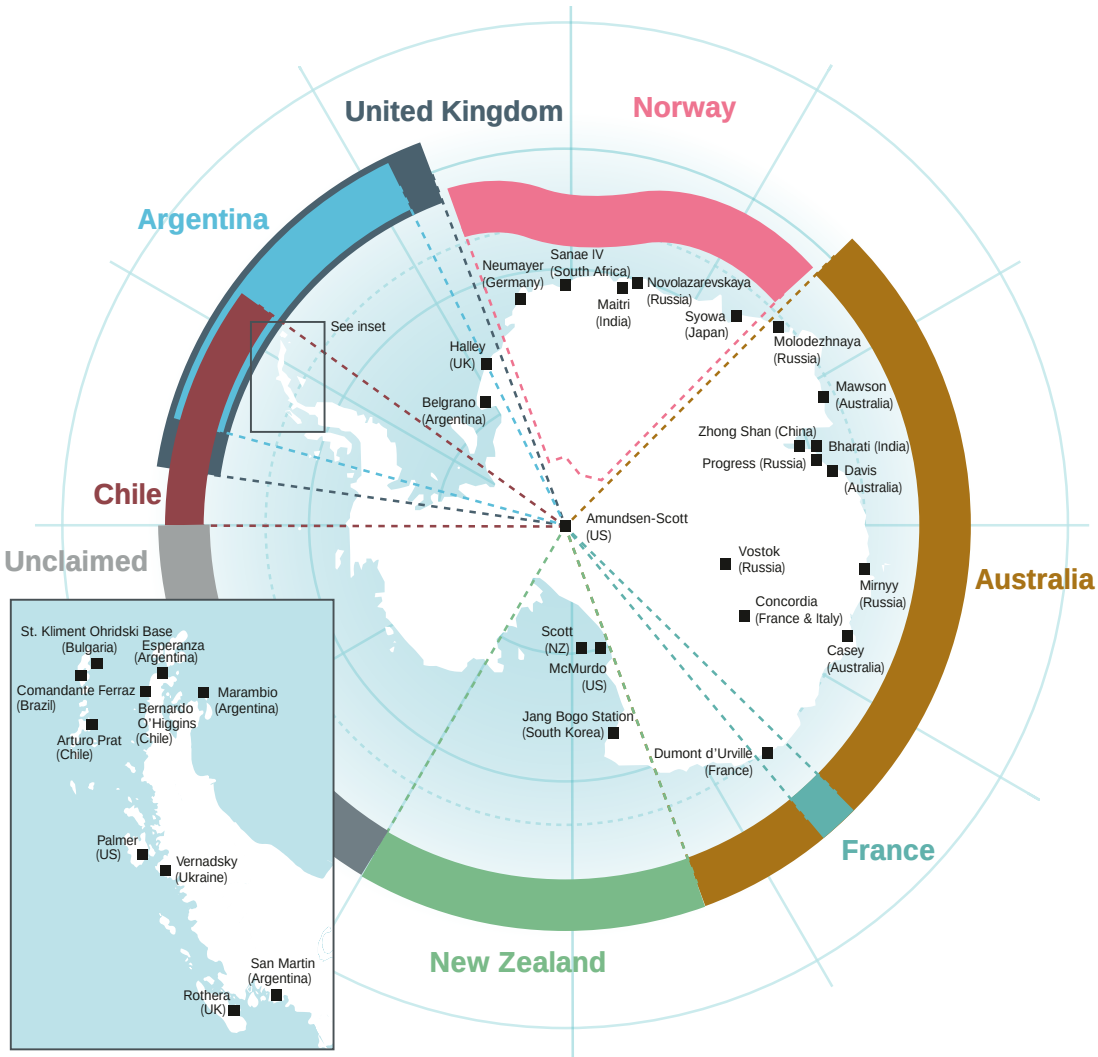
8 British Antarctic Survey, 'Fishing'.

Governance and geopolitics

Seven countries have made territorial claims within the Antarctic: Argentina, Australia, Chile, France, New Zealand, Norway and the UK. The UK, Argentina and Chile have overlapping and competing claims that will continue to be disputed. Additionally, around 30 countries operate an Antarctic research station, including China, the US and Russia.[9] Occupied research stations are often seen as contributing to the legitimacy of territorial claims, and these outposts may develop into hubs for industrial and tourist activity. This could add to geopolitical tensions within the region.

Many governance issues relating to the region are covered by the Antarctic Treaty System, comprising the original treaty of 1959 and a series of subsequent agreements that came into force in 1998. The Antarctic Treaty System is likely to endure (with a review due in 2048), but it will probably come under increasing pressure as perceived tipping points are reached. Access to resources, more tourism and growing geopolitical tensions could all strain international cooperation. Countries who are not full signatories to the Antarctic Treaty System may increasingly feel as if they have been 'shut out' of access to valuable territory, and view the Antarctic Treaty System as invalid.

International territorial claims



Source: Discovering Antarctica

9 Cool Antarctica, 'Antarctic Stations – Bases – Currently Occupied'.

Security

Military activity is banned by the Antarctic Treaty System, but military support to civil activity is permitted. National militaries are currently the primary regional providers of search and rescue, scientific access, resupply, monitoring and policing. In the coming decades, there is likely to be a significant increase in military activity to support growing numbers of civilian operations, raising the possibility of an accidental or deliberate incident involving military vessels, aircraft or personnel. More intense commercial activity within Antarctica (including illegal fishing and illegal mineral extraction) is likely to require military forces to be able to monitor, intervene and rapidly react.

Antarctica does not have its own judicial system or a resident governance capacity: all decisions about the region are made jointly by international committee and implemented by representatives of countries active in the region. For example, fishing patrols are conducted by the armed forces or coastguards of participating countries, while prosecutions occur through international courts or the judicial system of the accused person's home country. As the number of people within the region rises in the coming decades, an increased burden is likely to be felt by resident organisations.

HMS Protector: more intense commercial activity in Antarctica may require military forces to monitor, intervene and react


1 Canada
2 Finland
3 Greenland (Denmark)
4 Iceland
5 Norway
6 Russia
7 Sweden
8 United States
Arctic

The Arctic

As the Arctic region becomes increasingly accessible it will assume ever greater geostrategic significance as competition between global and regional actors increases. Rising temperatures, melting sea ice and thawing permafrost will alter the region's landscape, with significant impact on its population and infrastructure. Although the Arctic will continue to be a challenging environment in which to operate, commercial activity in the region will increase and it could become a global shipping route. By 2050, the Arctic could be a major supplier of oil and gas and, as its waters warm, an increasingly important fishing ground. As competition in the Arctic increases the security paradigm could change and the region may become increasingly militarised. New institutions and frameworks may be required to ensure security and governance of the region and to reduce the risk of military conflict.

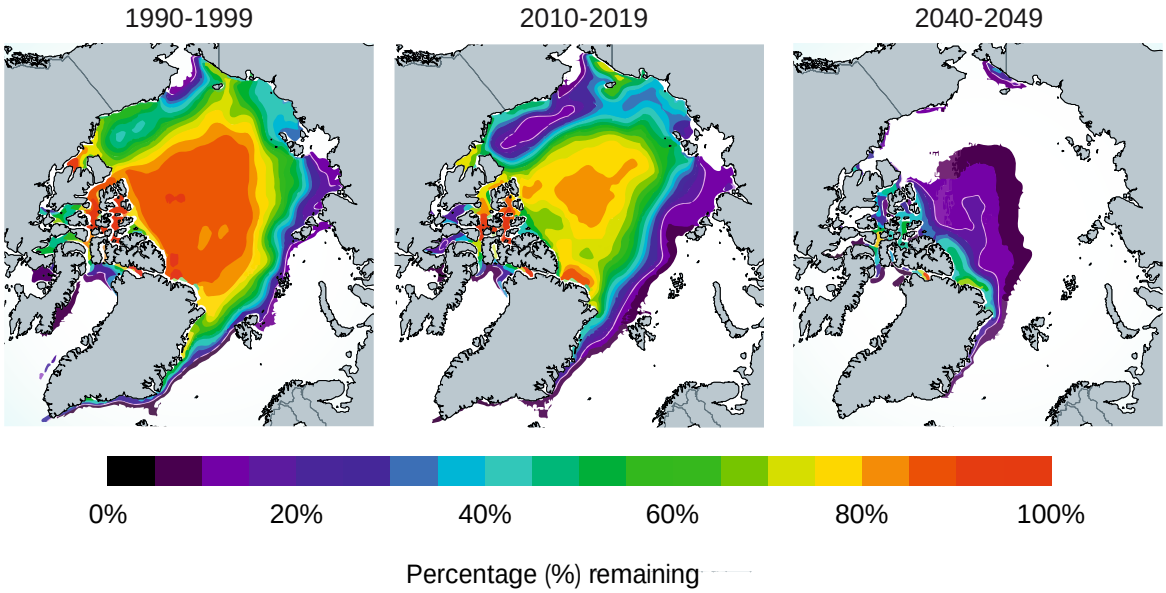
Environment

The Arctic is expected to warm more rapidly than other parts of the world, with average surface temperatures forecast to rise by between 1° Celsius and 3° Celsius.[1] The surface area of sea ice will, on current trends, reduce significantly from an average area of 12.24 million square kilometres (as measured from 1979 to 1999) to just 8.9 million square kilometres by 2050. In summer months, the Arctic Ocean could be virtually ice free. Sea ice is melting most rapidly in the eastern Arctic Ocean and adjacent seas, whilst the thicker, older ice within the central Arctic Ocean and waters north of Greenland and the Canadian Archipelago is likely to persist longer. The Greenland ice sheet is losing an average of 269 billion tonnes of ice per year (against a total mass of around 2.9 million, billion tonnes). The majority of meltwater from Greenland ends up in the North Atlantic, disrupting ocean currents and affecting global weather patterns. Although extremely unlikely, if the whole of the Greenland ice sheet melted, it is expected that the global sea level would rise by over seven metres. These changes will have consequences for the global climate, for example, as the area of sea ice and snow cover reduces, it will lessen the Arctic's ability to reflect solar radiation (the 'albedo effect'), causing further global temperature rises.[2]

1 Overland, J. E., *et al*., (2013), *Future Arctic Climate Changes: Adaptation and Mitigation Time Scales.*

2 Riihelä, A., (2013), nature.com, 'Observed changes in the albedo of the Arctic sea-ice zone for the period 1982-2009'.

Forecast of average yearly Arctic sea ice surface area out to 2050



Source: National Snow and Ice Data Center

Permafrost near the surface is thawing and is forecast to reduce by around 25% by 2050,[3] causing damage to buildings, roads, railways and pipelines. Melting permafrost is already shortening the season in which ice roads can be used. Coastal erosion (occurring at an average of half a metre per year, with high local and regional variations) will almost certainly be exacerbated by the loss of sea ice, which protects coasts from storms. In addition, the thawing of some types of permafrost may release large amounts of carbon dioxide and methane into the atmosphere, potentially accelerating global warming. Some models predict that the release of such methane could cause global temperatures to increase by an additional 0.6° Celsius on top of current forecasts, by 2050.[4] Melting permafrost is also likely to result in the spread of disease. For example, in 2016, reindeer herds in the Russian High North were culled after being exposed to anthrax released from the melting permafrost. There are over 500 anthrax burial points registered in Siberia and the Far East, and the melting of permafrost is likely to expose more infected corpses, potentially including those carrying other diseases, such as bubonic plague and smallpox.[5]

Climatic changes will also lead to alterations in the redistribution of Arctic species. While this may lead to an increase in the number of species present, the survival of native species will be threatened. As oceans further south become warmer, fish will continue to migrate northward, causing catches to increase in higher latitudes by up to 20% by 2050.[6]

3 Kong, Y. and Wang, C., ScienceDirect, (2017), 'Responses and changes in the permafrost and snow water equivalent in the Northern Hemisphere under a scenario of 1.5°C warming'.

4 Oskin, B., LiveScience, (24 November 2013), 'Twice as Much Methane Escaping Arctic Seafloor'.

5 Parkinson, A. J., *et al.*, (2014), *Climate Change and Infectious Diseases in the Arctic: Establishment of a Circumpolar Working Group.*

6 Weatherdon, L., *et al.*, PLOS ONE, (13 January 2016), *Projected Scenarios for Coastal First Nations' Fisheries Catch Potential Under Climate Change: Management Challenges and Opportunities.*

Arctic states are expected to increase the resources they commit to protecting the sovereignty of their Arctic territories

Human development

The population inside the Arctic Circle is currently around four million, a figure which has been broadly stable since 2000 and, on current trends, is likely to remain so. The region, however, has considerable demographic diversity. The population is likely to rise in Alaska, Canada and Iceland, whilst in parts of northern Scandinavia and the Russian Arctic population is likely to decline.[7] This could pose a challenge to respective governments' ability to manage these increasingly empty spaces. Some areas may become ungoverned spaces or become vulnerable to annexation (or proxy annexation) by other states.

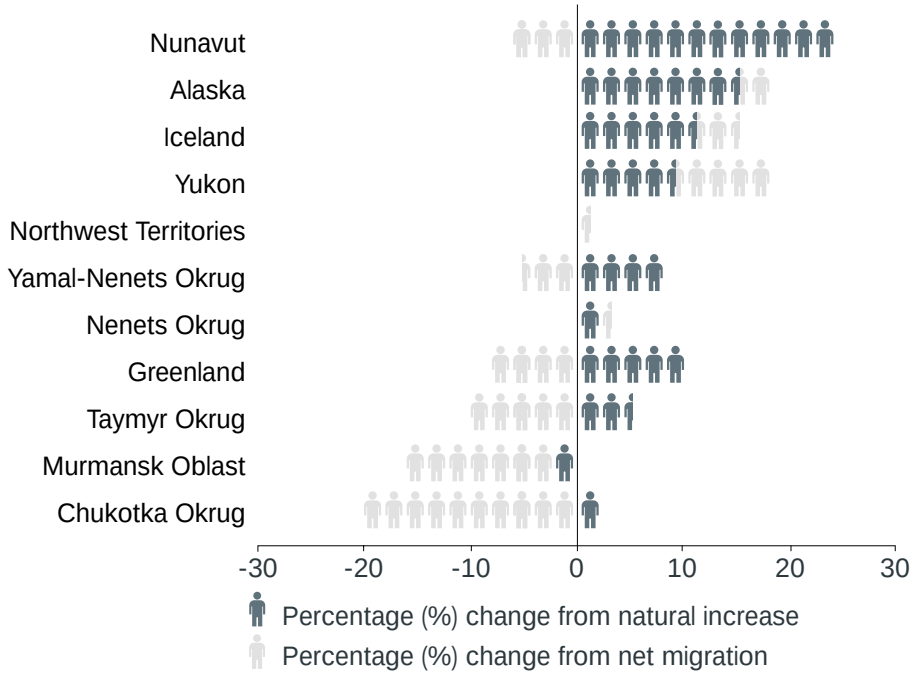
By 2050, the Arctic population is likely to be increasingly male and include a greater proportion of immigrants. For example, in Alaska between 2010 and 2014, the foreign-born population increased by 19.4% (compared to a 5.8% increase in the United States (US) over the same period). Whilst immigration is likely to boost local economies, and be vital to stabilising the decline of the Russian north east in particular, a rapid inflow of immigrants could change the social and religious balance of societies, potentially leading to friction.

The Arctic population will become increasingly urbanised. As well as providing better job opportunities, cities offer superior access to health care, social services and education. Arctic societies tend to have lower levels of educational attainment compared to their more southerly counterparts, a situation which is unlikely to change (although remote

7 Nymand Larsen, J. and Fondahl, G., (Eds.), (2014), *Arctic Human Development Report*.

access to education could help to improve it). For example, only 6.1% of the indigenous population of the Canadian Northwest Territory have graduated from university, compared with an average rate of 25.9% in Canada as a whole. Women have recently been outperforming men and, on current trends, this growth in women's educational performance may widen the gap between men and women.[8] This could improve women's access to better jobs and leadership roles. Rising levels of urbanisation are expected to improve living standards, but may also heighten existing inequalities, creating a new or changing set of 'class' relations. Those with nomadic and traditional lifestyles are already finding their way of life threatened by climate change. Increasing urban centralisation could further isolate and marginalise these communities, possibly resulting in a sense of grievance and hostility.

Population change in selected Arctic regions (2000-2018)



Source: Nordic Co-operation

Economics

On current trends, melting sea ice will open up shipping routes between Asia, Europe and North America, potentially reducing travel times and fuel costs by more than 40% when the Arctic is fully open.[9] Currently, journeys from Dalian in China to Rotterdam in the Netherlands take 48 days via the Suez Canal, but only 38 days via the Northern Sea Route. Though the amount of shipping will increase, the numbers of transits are likely to remain small. Current trends show around 50 transits per year (assuming little or no sea ice reduction), although this could be a significant underestimate, especially when compared to other shipping routes such as the Suez Canal or the Malacca Straits.[10]

8 Emelyanova, A., International Institute for Applied Systems Analysis, (2017), *Population projections of the Arctic by levels of education*, page 12.

9 Kingdom of Denmark, (2011), *Denmark, Greenland and the Faroe Islands: Kingdom of Denmark Strategy for the Arctic 2011-2020*.

10 Government North West Territories, (29 May 2015), '7.3 Trends in shipping in the Northwest Passage and the Beaufort Sea'.

The Arctic will continue to be a difficult area in which to operate, and costs (including insurance premiums) are likely to remain high. Most Arctic shipping is expected to be from vessels travelling to and from the region, and is likely to be heavily tied to the oil and gas mining, tourism and fishing industries. The Arctic will also remain an important air route, with more than 5,000 aircraft currently crossing over the North Pole each year, and this number is likely to increase.

It is estimated that the Arctic seabed contains 13% of the world's undiscovered oil, 30% of undiscovered natural gas and 20% of undiscovered natural gas liquids.[11] The majority of oil and gas extraction is expected to occur in the Barents Sea area, north of Norway and Russia, and in northern Alaska. For there to be a major increase in Arctic oil and gas production, however, there would need to be significant investment in infrastructure and technology. Whether this is forthcoming will depend on increased energy prices. Should renewable energy lead to lower prices for oil and gas, the Arctic may not become a commercially viable option. To date, mining has attracted much less publicity than oil and gas extraction, but it could become the major economic activity in the Arctic. For example, mining already accounts for half the income of the Canadian Northwest Territory. Improving technology, including automation, is likely to improve efficiency, precision and speed of extraction, as well as reducing the number of people needed, which will improve the prospects for extractive industries operating in the Arctic.

Arctic waters are expected to become increasingly important fishing grounds, some of which are unlikely to be covered by a regional fishery's management arrangement.[12] An increase in unregulated and unsustainable fishing in international Arctic waters may lead to tensions between states, possibly of the sort seen during the Iceland/United Kingdom (UK) 'Cod Wars' of the 1970s. Tourism will become an increasingly important element of the commercial sector. For example, between 2013 and 2016, the numbers of Chinese visitors to Finnish Lapland almost tripled (to 10,446).[13]

Permafrost near the surface is thawing and is forecast to reduce by around 25% by 2050

11 Williams, A., *et al.*, (2011), *The Future of Arctic Enterprise: Long-term Outlook and Implications.*

12 Blomeyer, R., *et al.*, European Parliament, (2015), *Fisheries Management and the Arctic in the Context of Climate Change.*

13 Williams, A., *et al.*, (2011), *The Future of Arctic Enterprise: Long-term Outlook and Implications.*

Investment in communications infrastructure is also likely to increase. In 2012, at least three companies had outlined their plans to lay undersea cables in Arctic waters;[14] in 2010 Canada established the Inuvik Satellite Station; and between 2017 and 2025 Russia plans to establish the Arktika satellite network. In the coming years, at least two satellites are expected to be in constant operation over the Arctic, improving weather forecasting, environmental monitoring and communications.

Governance

The eight 'Arctic states' (Canada, Denmark (Greenland), Finland, Iceland, Norway, Russia, Sweden and the US) all have territory extending outside, as well as within, the Arctic Circle (the physical geographical zone above 66° north of the Equator). The United Nations Convention on the Law of the Sea (UNCLOS) is expected to remain the basis upon which Arctic states claim their rights over the seabed and polar waters. Norway has already established its sovereignty over the Outer Continental Shelf in and around Svalbard and northern Norway, and it is widely expected that Canada, Denmark (Greenland) and Russia will continue to present evidence to support their claims.[15] All parties appear committed to this process, and rulings are expected before 2050. Whilst the process is expected to be peaceful, if Russia's sovereign rights over the central Arctic Ocean are not recognised, there is a danger that Russia might reject any further negotiations with Canada and Denmark.[16]

The Arctic Council. The Arctic Council is expected to continue to play an important role in promoting cooperation, coordination and interaction among its member states, including on border issues and the rights of indigenous people. However, such issues are not (and are unlikely to become) the sole preserve of the eight Arctic states. The Council is likely to increasingly involve non-Arctic observer nations and organisations (of which there are currently 39 in total) in its activities. The continued acceptance of observer nations into the Arctic Council is likely to strengthen the position of the Council globally.

By 2050, Arctic states are expected to increase the resources they commit to protecting the sovereignty of their Arctic territories. However, increasing activity, particularly commercial, is likely to require new institutions and frameworks to keep the region secure and effectively governed. For example, negotiations between the five Arctic coastal states (Canada, Denmark (Greenland), Norway, Russia and the US) plus Japan, Korea, China, Iceland and the European Union (EU) (known as the 'five plus five') are exploring the establishment of a fisheries management organisation to protect fish stocks.

Within Arctic states, local (particularly indigenous) communities may seek greater autonomy from their distant, non-Arctic capitals.[17] In particular, further demands for the independence of Greenland from Denmark can be expected. By 2050, the rural population of the Arctic is expected to decrease, potentially weakening states' claims to sovereignty over these areas. Most Arctic states highlight the occupancy of northern peoples in their Arctic policy strategies, a form of political power that has been significant in the background to international negotiations about the conditions of access for

14 Weisburger, A., The Arctic Institute, (4 May 2012), 'Planned Undersea Fiber-Optic Cable Projects in Arctic as Allegory for Changing Region'.

15 Maritime Executive, (2016), 'Rival Claims to a Changing Arctic'.

16 Klimenko, E., Stockholm International Peace Research Institute, (2016), *Russia's Arctic Security Policy: Still Quiet in the High North?*

17 Pelaudeix, C., (2012), *Devolution and globalization in the Arctic: Differentiated Approaches of Arctic states*.

observer states. A trend of weakening occupancy could undermine Arctic states' claims of sovereignty over remote areas. This may present a particular challenge for Russia, where the declining population in its eastern Arctic may undermine its legitimacy and ability to govern.

Geopolitics

The Arctic's relative geographic isolation will reduce in the coming decades, with an increasing number of actors, both state and non-state, having Arctic interests. The last decade has witnessed a growth in formal declarations of Arctic strategies and policy frameworks from both Arctic and non-Arctic states, including the EU, Germany, Japan and the UK. While others, such as China, have not issued any such formal statements, they too appear to regard themselves as Arctic players, and can be expected to seek to play a more significant role in the region.

The eight Arctic states will remain the principal Arctic stakeholders for geographical reasons.[18] A stable and orderly Arctic region is likely to remain a priority for them, although that is not to say the relationships between the Arctic states will, necessarily, remain the same. For example, whilst Iceland has traditionally looked to the US and the North Atlantic Treaty Organization (NATO) for security, its small, yet independently-minded population might, if the circumstances were right, decide that its interests were best served by forming alliances with partners outside NATO. For Russia, the Arctic will retain a special significance, since it represents a potential source of riches and a security buffer against encroachment and encirclement. In particular, the Northern Sea Route is expected to become a strategic artery for trade, as well as allowing Russia to reposition its naval forces between the Atlantic and the Pacific Oceans.

Increasing activity, particularly commercial, may require new frameworks to keep the Arctic secure and well-governed

18 Koivurova, T., (2010), *Limits and possibilities of the Arctic Council in a rapidly changing scene of Arctic governance*.

Russia plans to build between 11 and 16 more diesel and nuclear-powered icebreakers by 2050

Maksimilian / Shutterstock.com

China's long-term interest in the region is likely to become increasingly noticeable. In May 2013, China was granted permanent observer status on the Arctic Council, formalising its intent to participate in discussions about Arctic issues. Analysts today refer to China as a 'near-Arctic state' and an 'Arctic stakeholder'. Recently, China has strengthened its diplomatic ties to Nordic countries, and in 2013 Beijing hosted the fifth World Reindeer Herders Congress. This event was widely reported as evidence of its respect for indigenous people.[19] China is also looking to invest in Greenland and should Greenland become independent from Denmark, China might become its primary partner.[20] China may view Arctic shipping routes as an alternative to those in the South China Sea and may, therefore, champion UNCLOS in the Arctic to uphold international access to shipping routes.

The EU is likely to remain a major extraterritorial regional actor, not least because of member states with their own interests. However, the EU has not been granted permanent observer status to the Arctic Council. Opposition to EU admittance may endure, depending on relations with Russia. In the coming decades, India may also become an actor in the Arctic. Cooperation in the Arctic constitutes an important component in recent deals struck between Indian Prime Minister Modi and Russian President Putin, which have boosted Indian involvement in northern Russian energy projects.

Security

The increase in shipping in Arctic waters arising from the melting sea ice will likely lead to a growth in maritime crime, including smuggling. In particular, malicious actors, including terrorists, may take advantage of the empty spaces across the Arctic to enter Europe, Russia and North America. The opening of a counterterrorism centre in Murmansk signals that Russia is already concerned. Despite the melting sea ice, Arctic waters will remain a challenging environment that will require specialist, and therefore expensive, shipping. It will become a more challenging environment in which to operate submarines, as the cover provided by sea ice reduces. In addition to hard

19 Wang, K. and Yang, F. G., ChinaDaily Europe, (2013), 'Last of the Reindeer Hunters'.

20 Lulu, J., Asia Dialogue, (2017), 'China, Greenland and Competition for the Arctic'.

security concerns, it is expected that there will be an increased demand for soft security measures relating to search and rescue and emergency response capabilities, which could drive cooperation between Arctic states and actors. International cooperation in this area will be crucial, not only to provide effective cover across the region but also as a factor in improving regional security over the next 30 years.

Russia is displaying an increased military interest in the Arctic. It has recently established and re-opened bases across the Russian Arctic; set up the Russian Joint Strategic Command North; resumed regular military flights over the region; created two extra brigades to add to existing naval infantry; and formed a brigade on the Kola Peninsula. Russia's current total of 41 icebreakers far exceeds the US' five and NATO's combined total of 20. By 2050, if all current plans for icebreaker expansion follow through to completion, Russia will have an additional 11-16 diesel and nuclear-powered icebreakers, with more capable icebreakers by 2050.[21] This large fleet of icebreakers will allow Russia to move ships between the North Atlantic and North Pacific throughout the year.

The increase in Russian military activity in the Arctic, however, masks long-term economic and social problems.[22] Budgetary constraints may hamper further expansion of Russia's military footprint in the Arctic, at least in the short term.[23] Russia's strategy will therefore most likely focus on controlling access to the Russian Arctic and maintaining its nuclear deterrent capabilities in the region. Russia will almost certainly remain a concern for neighbouring countries, and the possibility of state-on-state conflict over disputed territory, although unlikely, cannot be ruled out.

It is not clear what military presence the US will have in the Arctic in the coming decades. The US has long had airpower superiority in the Arctic, and this advantage is likely to be maintained by the Pentagon's investment in the F-35 series of aircraft. Tested in the Arctic conditions, these aircraft should ensure American power can be projected northward. A new icebreaker is being planned, and there has been discussion of establishing new bases in the region. Much will depend on how the US relationship with Russia develops. Thule Air Base is, however, likely to take on renewed significance within US defence as the only deep water port in that part of the Arctic, particularly as the Northern Sea Route becomes an increasingly important route for shipping. Whilst the prospects for Greenland's independence remain a matter for speculation, an independent Greenland that wanted to leave NATO would throw into question the future of the US military base at Thule.

Partnerships and alliances. Over the past decade, increased military activity in the Arctic has produced new forums such as the Northern Chiefs of Defence conference and the Arctic Security Forces Roundtable. Such forums are still nascent and have been negatively affected by the deterioration of relations with Russia in recent years. However, they do indicate a growing realisation among the Arctic States, including Russia, of the need for some form of Arctic security architecture where joint interests can be discussed in a way that does not pit Russia against the rest.

21 O'Rourke, R., (9 July 2018), *Coast Guard Polar Icebreaker Program: Background and Issues for Congress*.

22 Hille, K., *Financial Times*, 'Russia's economy: challenges facing Vladimir Putin'.

23 Gorenburg, D., Russian Military Reform, (2017), 'Russia's Military Modernization Plans: 2018-2027'.

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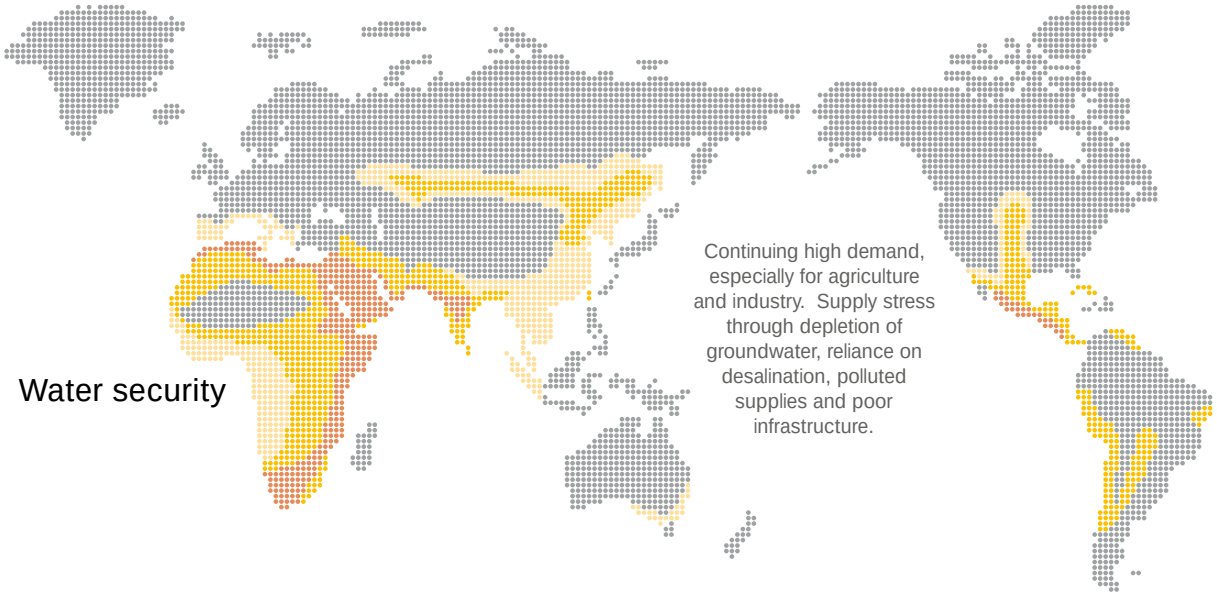
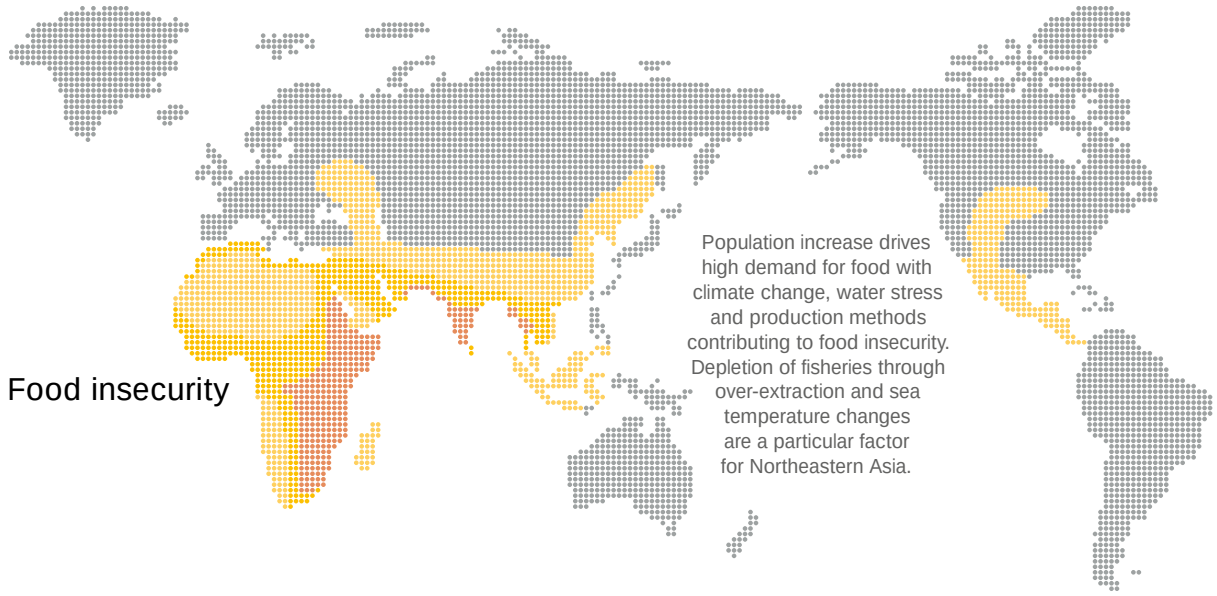


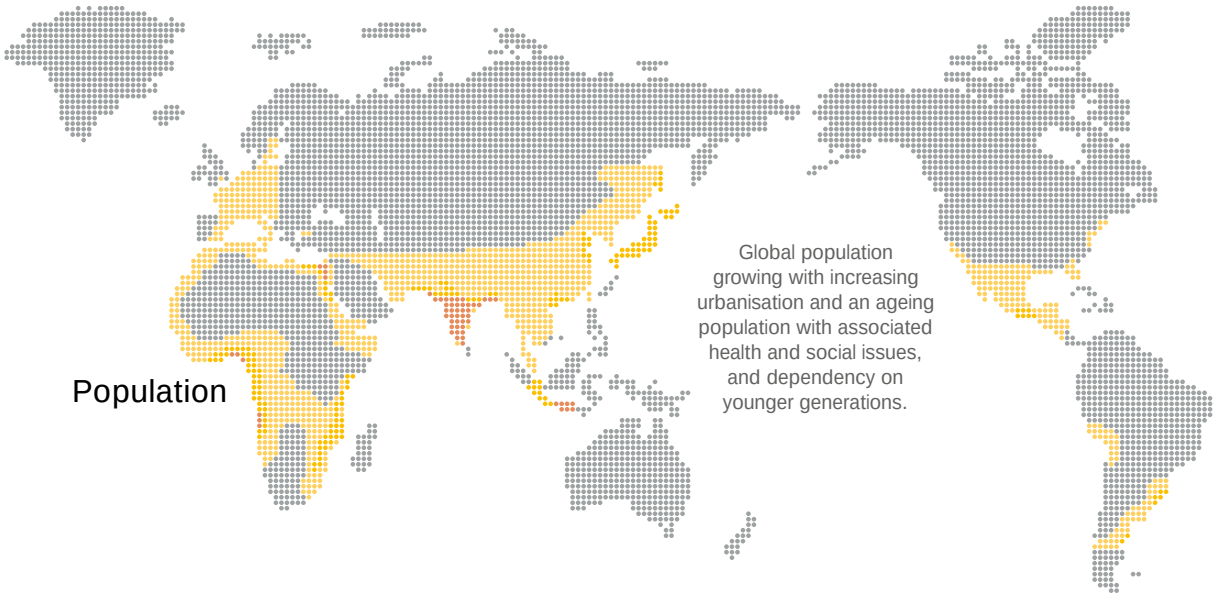
Water security

Continuing high demand, especially for agriculture and industry. Supply stress through depletion of groundwater, reliance on desalination, polluted supplies and poor infrastructure.



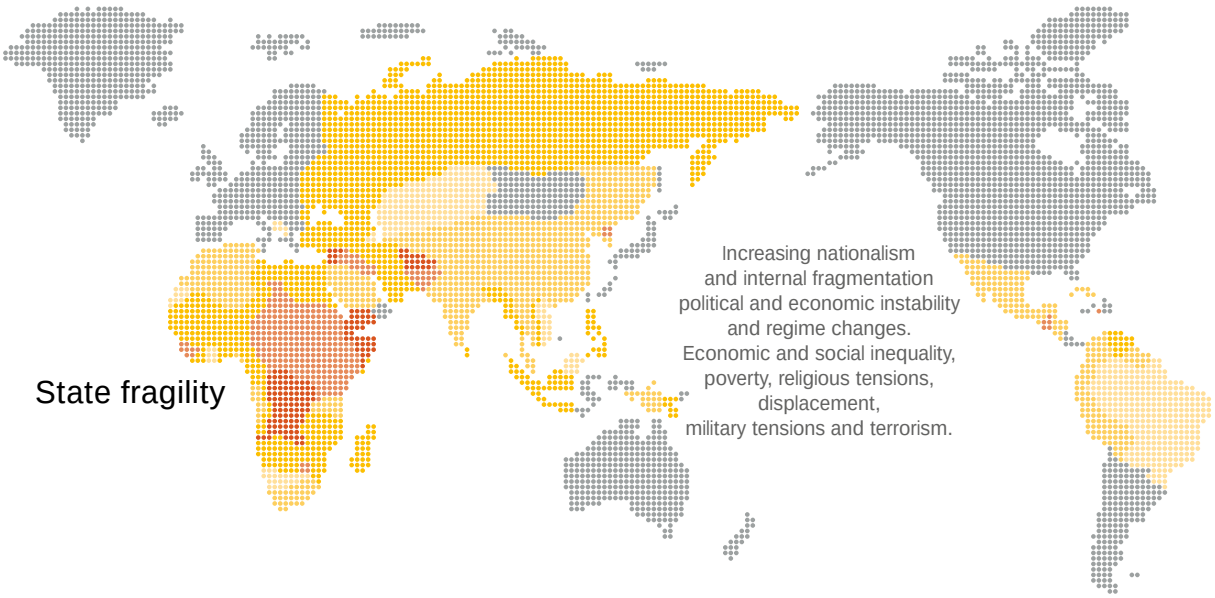
Food insecurity

Population increase drives high demand for food with climate change, water stress and production methods contributing to food insecurity. Depletion of fisheries through over-extraction and sea temperature changes are a particular factor for Northeastern Asia.



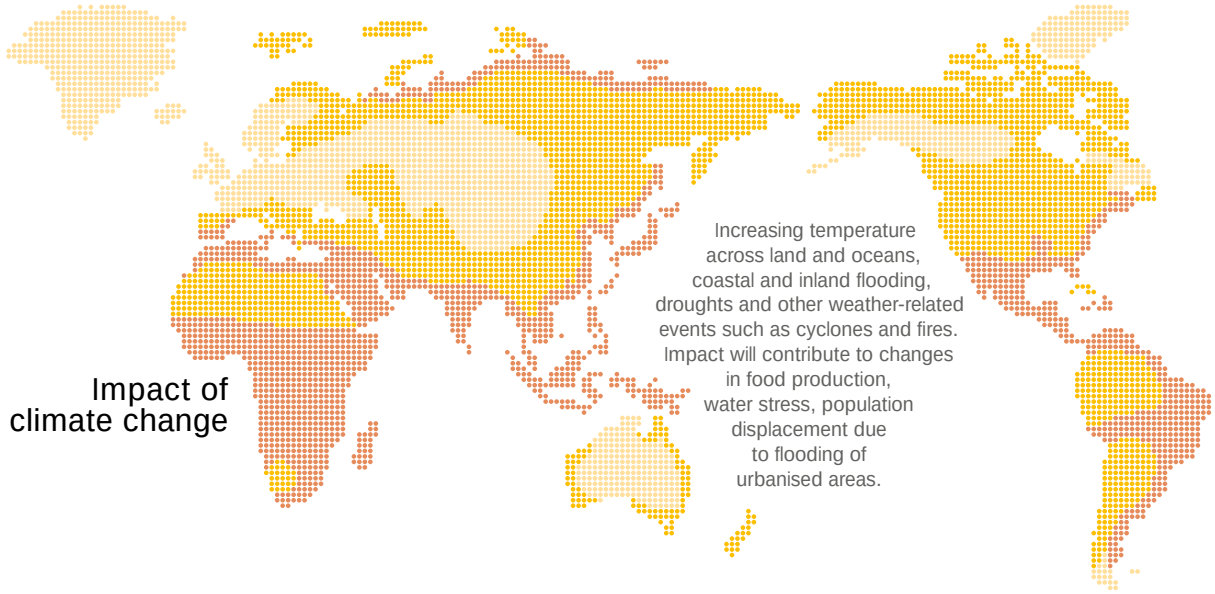
Population

Global population growing with increasing urbanisation and an ageing population with associated health and social issues, and dependency on younger generations.



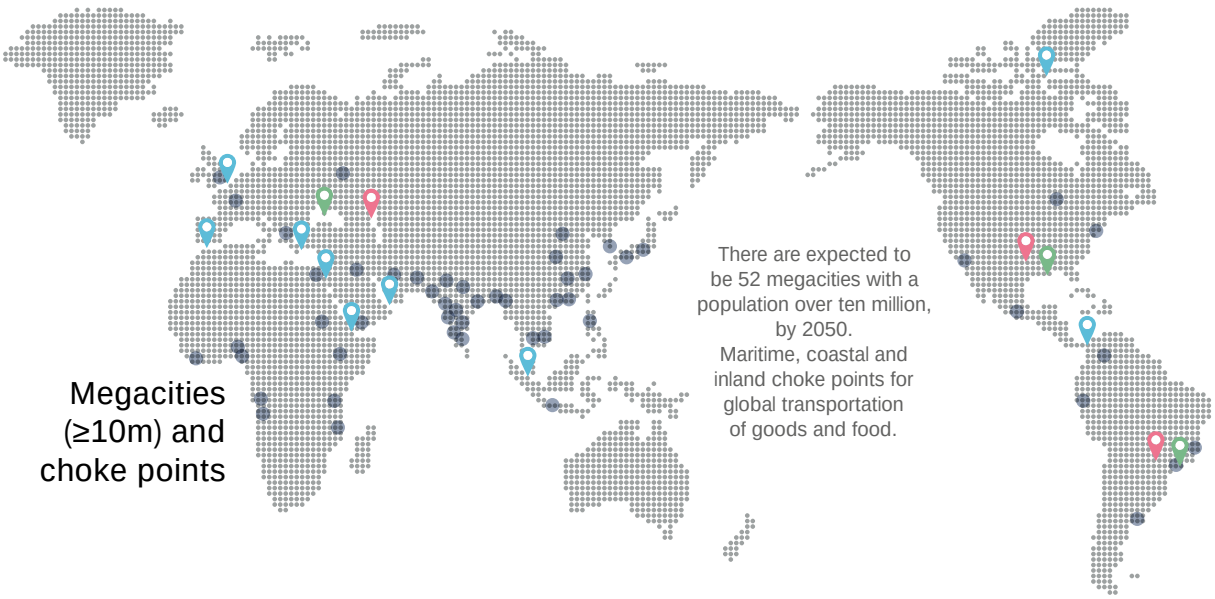
State fragility

Increasing nationalism and internal fragmentation political and economic instability and regime changes. Economic and social inequality, poverty, religious tensions, displacement, military tensions and terrorism.



Impact of climate change

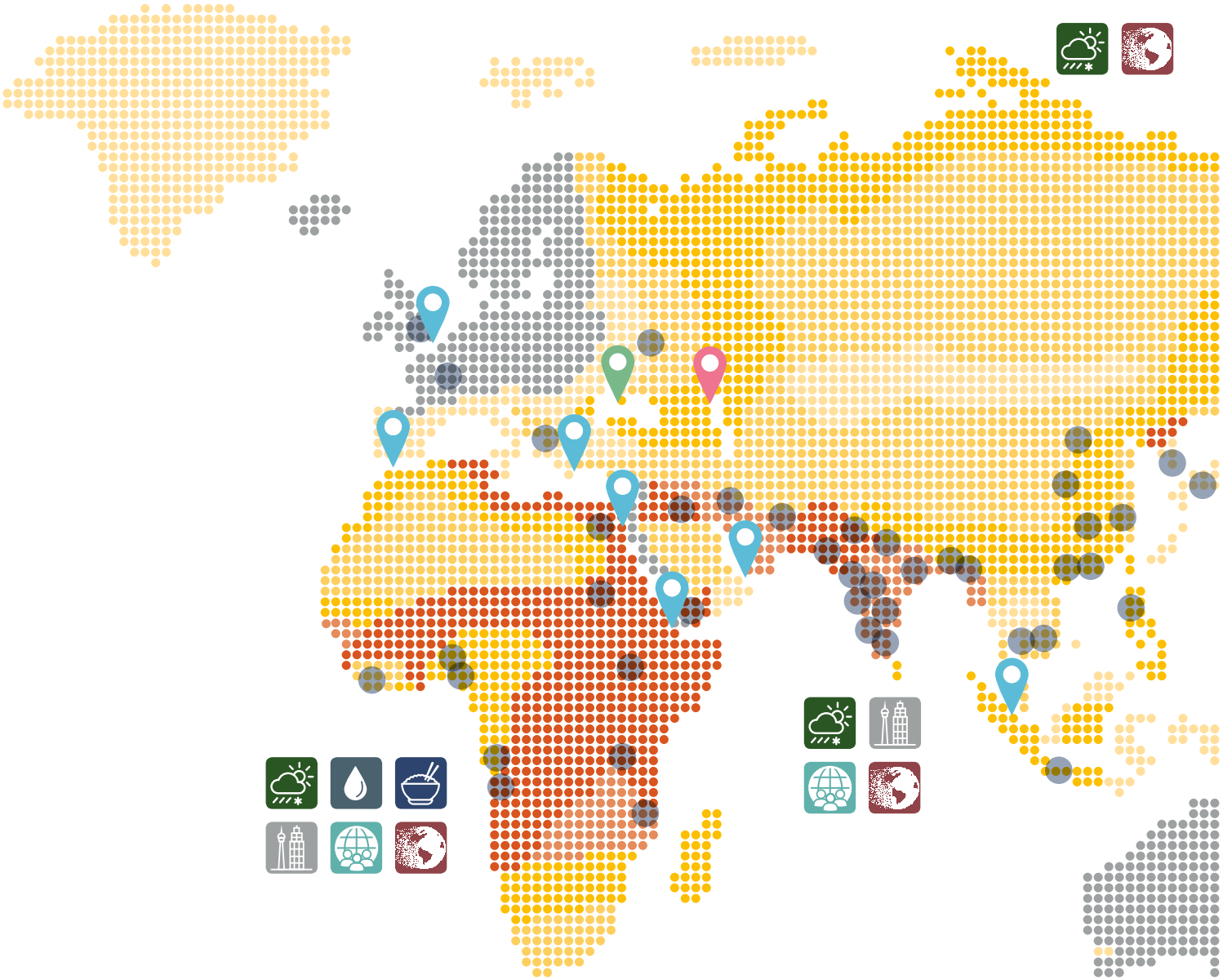
Increasing temperature across land and oceans, coastal and inland flooding, droughts and other weather-related events such as cyclones and fires. Impact will contribute to changes in food production, water stress, population displacement due to flooding of urbanised areas.



Megacities (≥10m) and choke points

There are expected to be 52 megacities with a population over ten million, by 2050. Maritime, coastal and inland choke points for global transportation of goods and food.

Global stress map

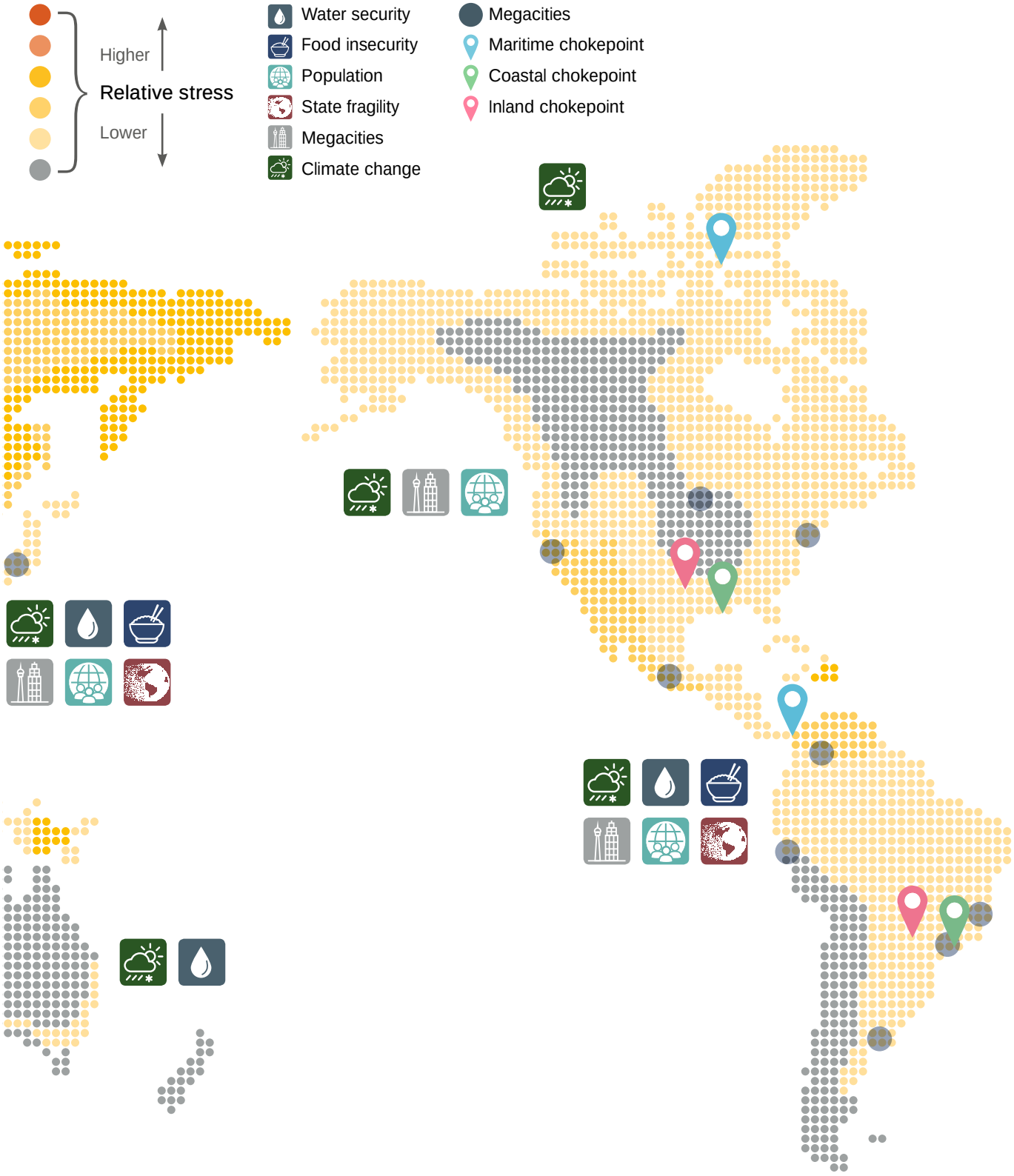


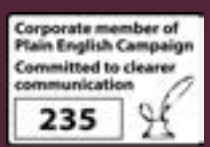
These stress maps are an illustrative visualisation of the potential impact of seven stress influences: water security, food insecurity, population, state fragility, impact of climate change, megacities and choke points.

The maps illustrate expected impacts on people and their activities rather than physical attributes in 2050.

These maps are based on analysis completed as part of this edition of Global Strategic Trends, and made particular use of:

- Human Dynamics of Climate Change, Met Office;
- Global City Populations, UNDP;
- City Population 2050, University of Ontario;
- 2018 Fragile States Index, Fund for Peace; and
- Chokepoints and Vulnerabilities in Global Food Trade, Chatham House, 2017.


Higher
Relative stress
Lower
Water security
Food insecurity
Population
State fragility
Megacities
Climate change
Megacities
Maritime chokepoint
Coastal chokepoint
Inland chokepoint



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