

Cities at risk

Building a resilient future for
the world's urban centres

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With expertise earned over centuries, Lloyd's is the foundation of the insurance industry and the future of it. Led by expert underwriters and brokers who cover more than 200 territories, the Lloyd's market develops the essential, complex and critical insurance needed to underwrite human progress.

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Newcastle University's Centre for Urban and Regional Development Studies (CURDs) is based in the School of Geography, Policy and Sociology. The centre specialises in academically rigorous and policy relevant research for the development of sustainable urban and regional areas. Their commitment to producing impactful research that will enact policy changes has been driving CURD's award-winning work for over 40 years.

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Contents

Executive summary	8
1. Introduction.....	12
2. Trends shaping the future of cities.....	15
3. Cities case studies.....	23
Definitions	24
New York.....	26
Miami.....	28
Johannesburg	30
Shanghai	33
Mexico City	35
Riyadh	37
London	40
4. Risks and nexuses	43
Geopolitics and society	44
Natural catastrophe and climate.....	49
Technology and space	54
Finance, economics and trade	57
5. Fostering further collaboration	61
6. Conclusions.....	64
References.....	66

Executive summary

Executive summary

Overview

More than half the world's population now lives in urban areas, up from a third in 1950. This is projected to reach two-thirds by 2050. These urban environments range from connected and sophisticated metropolises to unplanned and informal settlements. Megacities of 10m+ people will increase from 31 to 41 by 2030. These will be the economic powerhouses driving future global GDP (UN, 2018).

However, urbanisation is occurring on an uneven basis. Driven by concentrations of productive human populations and associated economic yields, large cities now account for around 75% of global GDP, forecast to rise to over 85% by 2030 (McKinsey Global Institute, 2016). As cities continue to grow and develop, the amount of assets at risk is increasing. Yet, many cities could do more to strengthen their resilience reduce their risks, and protect their economies and populations. (UN-Habitat, 2016).

COVID-19 has sharpened the world's attention on the capacity of cities to withstand the impacts of systemic risks such as pandemics, highlighting features that contribute to greater resilience as well as greater vulnerability. COVID-19 has also brought into focus the impacts systemic risks can have on our urban areas, with severe economic and social consequences extending across the world.

This report, published in association with Urban Foresight and Newcastle University, and commissioned before COVID-19 swept around the world, analyses the risks cities are facing and will face in the future. It also looks at how these threats will affect urban areas.

This study helps city administrators and risk managers, as well as Lloyd's market insurers and brokers, understand the risks that will influence the design and function of cities in the coming decades. It provides insight into how these threats could be reduced and how local authorities and insurers could be working together to do so.

It helps insurers understand better the factors that can heighten or reduce a city's vulnerability, and work with officials to provide additional risk transfer support.

The report also emphasises the role insurance can play in helping municipalities transfer risk. It looks at how insurers are planning for every class of business in the cities of the future, and what that means for new product and service development.

Key findings

The trends shaping cities

The report uses four global trends to show the type of changes that are affecting cities – and will continue to affect – cities worldwide. These trends are themselves connected and include several sub trends. The four trends are:

Changing planet. Climate change is a global priority, with cities responsible for a large proportion of carbon dioxide emissions. Urban life is being, and will increasingly be, affected by extreme weather events, which are projected to happen more frequently and with greater severity.

Changing systems. As society changes, cities are adapting their infrastructure, becoming more interconnected and using technology to share assets and services.

Changing people. The middle class is growing in developing economies, while the population is becoming older in developed countries. This presents opportunities and challenges for public authorities (e.g. development and construction of infrastructures). Levels of trust in government, media and large businesses are deteriorating, with people demonstrating on the streets to show their disaffection with the political and social climate. The spread of infectious diseases, such as COVID-19, is emerging more frequently and severely in urban areas.

Changing technology. The use of new technologies is growing. Cities are becoming more interconnected and are becoming 'smart' ecosystems. Around the world, the way businesses and people work will change due to technological and cultural developments, some of which has accelerated in response to COVID-19.

Future risks facing cities

Based on the framework used by the Cambridge Centre for Risk Studies, this report identifies four main categories of threats facing cities. These risks interact with one another and have the potential to adversely impact multiple critical elements of a city's operations, affecting inhabitants and the economy. These four categories of threats are:

Geopolitics and society. Global geopolitical tensions have increased recently, and the current political climate is one of significant tension in some areas. This has created uncertainty and drained confidence, and thus deterred long-term investment. The risk of resource scarcity, social unrest, pollution, pandemics and terrorism is more acute.

Natural catastrophe and climate. Cities are dealing with the pressures of climate change. Concentrations of urban populations make cities and their residents more vulnerable to extreme weather events.

Technology and space. Urban areas are becoming more interconnected and rely on smart technologies, which generate a vast amount of critical data. The scale and complexity of cities mean that catastrophic scenarios such as space weather that knock out satellite communications, cause power outage or disrupt information flows could threaten essential infrastructure on which cities rely.

Finance, economics and trade. Cities stand to lose the most GDP to financial risk, including market crash, commodity price shock and sovereign default, according to Lloyd's City Risk Index. Economic development could become an onerous challenge for local authorities.

The role insurance can play in protecting cities

Managing risks can be done using different tools. Risk transfer is one of the possibilities. The report does not focus on other sets of tools but recognises their efficiency. The report emphasises (1) what role insurance as a risk transfer tool should play in cities' broader risk management strategy and (2) how can insurance data and approaches help cities take better risk management decisions overall.

Insurers and reinsurers can play a valuable role in protecting cities from these types of threats and are already doing so in many cases. For example, Lloyd's has developed a range of insurance solutions that enable cities to transfer risks. Insurance products covering threats like political risks, natural catastrophes, cyber risks or finance and economic risks are illustrated in the report.

However, in general, cities are still underinsured. This report finds there are several reasons why this is the case.

Barriers preventing cities from buying insurance

The study found the insurance industry and cities need to develop stronger and more effective working partnerships. Based on the research carried out for this report, the following hurdles need to be overcome before this can happen:

Cultural barriers. Historically, municipalities mainly self-insure the risks they face. The idea of transferring all risks to third parties is not yet the norm in the public sector.

Knowledge gap. Insurance penetration rates are still low in most countries, and in developing economies customers have lower awareness of insurance products or the value of risk transfer.

A lack of communication. Local authorities would like more clarity about insurance products in terms of coverages and pricing methodologies.

Prevention of long-term partnerships. Some processes such as tendering are preventing local authorities and insurers from collaborating over the long-term.

Next steps for insurers and city officials

Cities provide business opportunities for insurers as they tend to be more affluent and have more assets, people and liabilities that need protecting than rural zones. At the same time, there is desire on the part of local authorities to develop relationships with insurers to mitigate and transfer risk off the public balance sheet and into private capital.

To realise this commercial opportunity insurers and city officials should:

- **Share data and analytics.** As data becomes more ubiquitous and cities collect more of it, they need to harness the power of this data to develop the risk retention and risk transfer strategies that are right for them. Using data and analytics could help cities to identify, assess and quantify threats (insurable or not), and the short-term economic impacts, as well as inform longer-term strategic objectives. By sharing data and risk insights, cities could forge deeper, more transparent, more beneficial relationships with insurance markets.
- **Improve cross-sector/industry learning.** The public sector could learn from the private sector, with insurers sharing their expertise and experience.
- **Improve risk preparation and-mitigation measures.** As cities' risk approach matures, their focus could include better risk management and mitigation. Better understanding of losses would also help in this regard.
- **Meet customers' needs.** Insurers and brokers should engage more with customers to understand better what they are looking for. Interacting more with insureds will help them adapt and improve their products.
- **Increase understanding of risk.** Governments, insurers and other stakeholders should work together to ensure there is a greater understanding of the economic and social consequences of poor risk management, and facilitate the development of appropriate risk transfer solutions.

Understanding the insurance industry's role

Insurers can play a major role in helping cities become more resilient in the following ways:

- **Risk managers.** Insurers have data and analytics on catastrophe risk. They could share this data to define the price of insuring specific risks and to guide risk managers' insurance buying (ICLEI, 2017).
- **Risk carriers.** Insurers could pay insurance claims to alleviate the impact of disasters and take recovery costs off the public balance sheet (ICLEI, 2017).
- **Major institutional investors.** Insurers could invest in vehicles such as resilience bonds that could shape the future of urban areas. They have a direct interest in reducing risks and improving resilience in cities to reduce losses (ICLEI, 2017).
- **Risk advisors/brokers.** As risks become ever more complex and more interconnected, the role of the broker is becoming less transactional and more advisory. Through their vast databases and modelling expertise, risk advisors can push insurers to develop new products and services, creating competition and levelling the playing field for cities and municipalities.

Ideas for products development

Interviews and research undertaken for this report indicate these product development ideas could be explored:

- [Public entities' umbrella insurance policies](#) could be extended to other geographic areas. Public entity packages could include a range of products for different classes of risks targeting the public sector's specific risk transfer needs.
- [A claims data repository](#) could be created to help identify trends relating to the losses incurred by cities. Insurers could use this information to advise cities on their risk transfer requirements.
- [A register of recognised issues](#) for various segments (e.g. industry, client, national) could be established to share expertise. The register could develop cross-sector and industry learning.
- [Risks pools for emerging risks](#) could be developed and implemented (e.g. similar to Pool Re for terrorism).

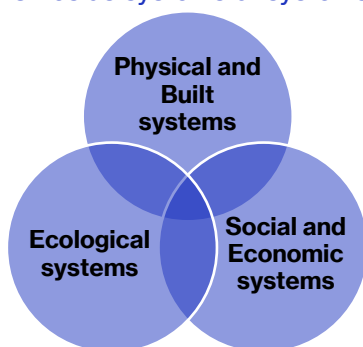
1. Introduction

1. Introduction

While urbanisation has occurred on an uneven basis every region of the world has seen an increase in urban populations over the last decades. The UN population index predicts that the global population will swell to 11 billion by the end of this century (UN, 2018). Today, the most urbanised regions include Northern America (with 82% of its population living in urban areas in 2018), Latin America and the Caribbean (81%), Europe (74%) and Oceania (68%) (UN, 2018). At least half a billion more people will live in cities in 2025 compared to 2019. Africa and Asia will be home to 86% of new urban citizens. Europe is only set to see city populations grow by 10 million people.

Cities, and particularly major global cities, are more than just concentrations of people. They are networks of people and services. They are very complex ecosystems, involving energy, water and sewerage, food, transport, health and biodiversity, as well as economic, social and cultural systems. This network of systems, interconnections and flows can be described as a system of systems.

Figure 2: Cities as systems of systems



These systems fall naturally into three core areas:

- **Physical and built systems** such as infrastructure, commercial and residential buildings, utilities and networked technology;
- **Ecological systems** such as green infrastructure, natural spaces, water catchment systems, natural resources and air quality;
- **Social and economic systems** such as demographic characteristics, governance and legal systems, economic systems, culture and customs, characteristics of labour markets and ethical norms.

“New and persistent challenges will continue to shape the landscape of urban areas for years to come”.

As cities continue to evolve, these systems become more interconnected and perils affecting one system can have knock-on effects on others. It means that assets or types of business which have previously been isolated from a particular threat or peril may in the future be exposed. These disruptions can have a disproportionate effect on the economy due to the concentration of GDP being created in cities. These clustering or agglomeration effects mean that any management of risks should be considered within a systems view, especially as cities are increasingly home to a variety of stakeholders, from the municipalities themselves, businesses, and the individuals that choose to make cities around the world their homes.

The unique physical, social, economic and environmental composition of a city influences the degree of risk and vulnerability of its citizens. While some of the risks are not new, they are persistent and growing across the last two decades and will continue to shape the landscape of urban areas for years to come. However, new threats are also developing, and cities will have to manage them. Enhancing resilience at city and global scale will require action at many levels to move from reacting after a disaster strikes, to creating a world where failure to plan in advance is unacceptable. Local authorities need to continue to prepare for and lessen the effects of threats.

The insurance industry can help mitigate the risks cities are facing. Insurance is a key mechanism by which humans prepare for risk and has played a central role in the development of the global economy. Insurance policies create confidence, encourage innovation and enterprise, and ultimately enable human progress. However, insurers will have to work on and develop adequate products that target policyholders' future needs.

While the physical evolution of cities will take decades given the time it takes to procure, finance and build infrastructure and for society to change, insurers are planning now for the implications of the future of cities for every class of business, and are considering developing new products and services that will meet customers' needs. The insurance industry could start now to help municipalities mitigate the risks they will face in the future.

Lloyd's of London has been looking at cities since 2015, starting with the *Lloyd's City Risk Index* produced in collaboration with the Cambridge Centre for Risk Studies followed by the *Future Cities: Building infrastructure resilience* published in collaboration with Arup in 2017.

For this report Lloyd's has worked in collaboration with Urban Foresight and Newcastle University. This study is designed to enable the Lloyd's market as well as cities' risk managers to better understand what the big trends impacting the development of cities in the coming years are, how these trends are altering the threats faced by cities and how cities are managing them. The report emphasises the role insurers can play to help municipalities transfer risks and the existence of Lloyd's risk transfer solutions opportunities to meet policyholders' needs.

The report presents seven case studies: London, New York City, Miami, Mexico City, Johannesburg, Riyadh and Shanghai. These cities have characteristics of other metropolises around the world and can be used to demonstrate global issues and cross learning. The case studies can also serve as scenarios to understand how specific risks are managed and mitigated at city level (*Section 3: Cities case studies*).

Figure 3: Selected cities for the 7 case studies –City risk index

New York

- A highly technological and stronger resilience city. Located at a temperate latitude, exposed to coastal and river flood risk. A high-density city with no informal settlements.

Miami

- A mid-technological and stronger resilience city. Low-lying and located at a tropical latitude, exposed to sea-level rise. A mid-density city with no informal settlements.

Shanghai

- An urbanising mega-city which is highly technological with moderate resilience. A coastal city exposed to sea level rise and estuary flood risk, located at a temperate-tropical latitude.

Riyadh

- A mid-technological and stronger resilience city. A desert city with water scarcity, located at a tropical latitude. Low density, with a policy to densify as the economy rapidly diversifies.

Mexico City

- A mid-technological and weaker resilience city. Located inland at altitude and at a tropical latitude, in a water scarce area. A sprawling city, with a significant level of population in informal settlements.

London

- A highly technological and very strong resilience city. Located at a temperate latitude, exposed to sea level rise. A densifying city with no informal settlements.

Johannesburg

- A mid-technological and weaker resilience city. Located inland, at a tropical latitude, with high levels of intra-continental inward migration. A rapidly changing city with high inequality and a significant level of population in informal settlements.

To understand changes affecting cities worldwide, four different trends have been considered when looking for common characteristics and risks shared by the seven selected cities. These trends are themselves connected, and a number of sub-trends have also been used to highlight interconnections (*Section 2: Trends shaping the future of cities*).

Figure 4: The four trends examined

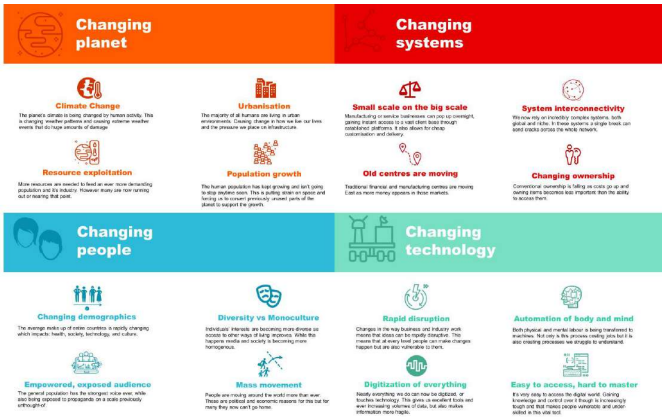
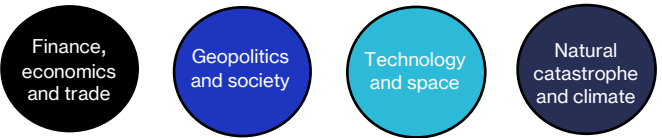


Figure 5: The four risk areas affecting cities

The study then moves onto four risk areas drawn from the Lloyd's City Risk Index. These four risk areas highlight the effects and impacts at city level (*Section 4: Risks and Nexuses*).



2. Trends shaping the future of cities

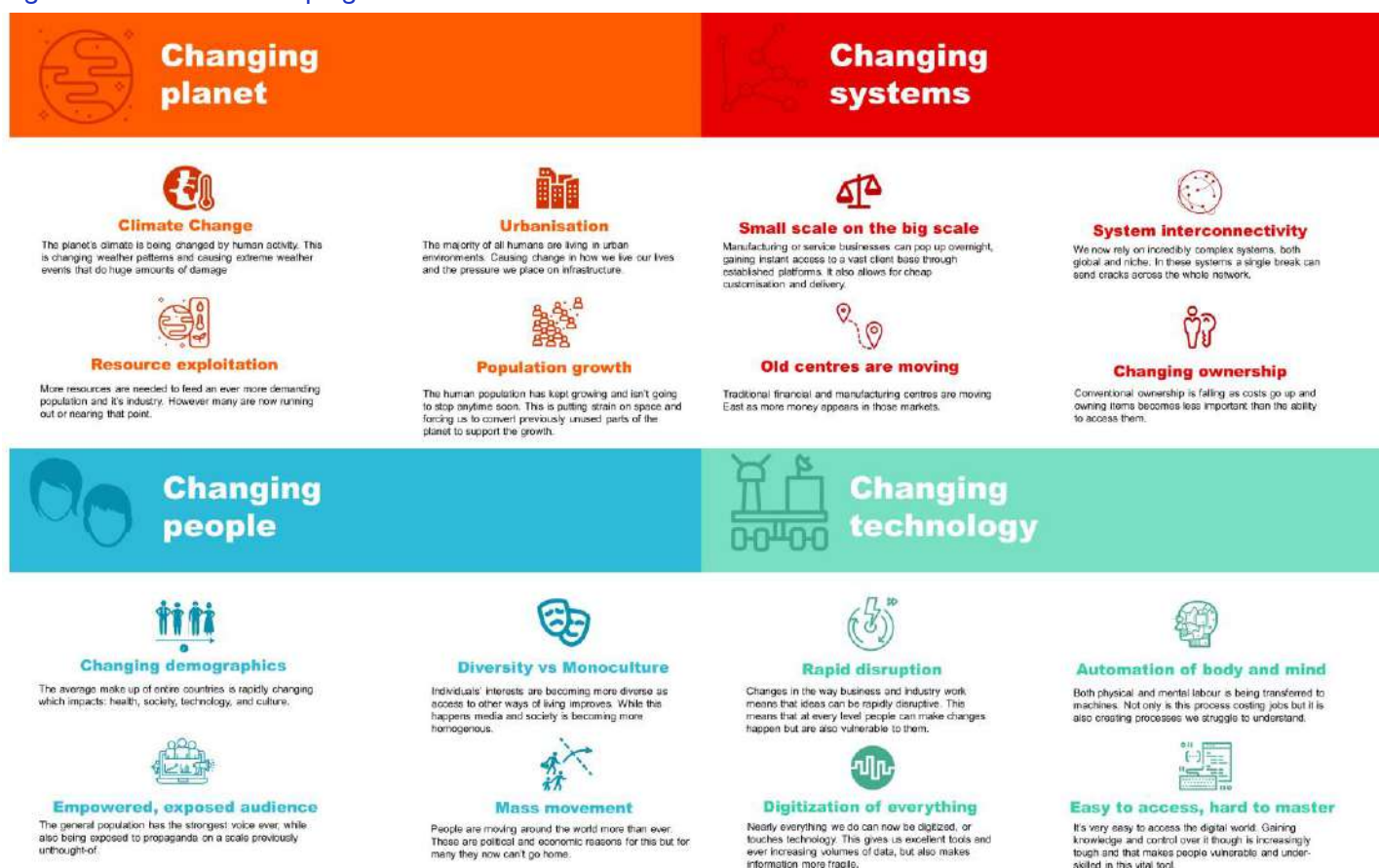


2. Trends shaping the future of cities

The megatrends and sub-trends in Figure 7 were developed by the Lloyd's Innovation Team in 2018 following a 1-year horizon scanning exercise. These trends are shifts and forces that are reshaping the world we live in. The awareness of megatrends and sub-trends offers real insights as they influence risk management and insurance products – from the businesses insurers provide risk transfer for to the risks policyholders will have to mitigate and how insurers should think about finding new opportunities.

Megatrends and their sub-trends are interconnected, meaning that none of them exists in isolation and they often overlap. Their intersection results in 'nexus of risks' resulting in a compounding and interconnection of emergent and changing risk. This section explores what the implications are for cities right now and in the future.

Figure 6: Four trends shaping the future of cities



Changing planet

Concentrations of GDP

Driven by concentrations of productive human populations and associated economic yields, large cities now account for around 75% of global GDP, forecast to rise to over 85% by 2030 (McKinsey Global Institute, 2016). As cities continue to grow and build resilience, assets at risk will also increase.

In Western Europe, North America and Japan urbanisation is slowing or stagnant. With little or no net population increase to drive GDP growth, economic success in cities will revolve around the potential demographic shift to a larger working age population and increased productivity and incomes.

Climate change

Human activities have increased carbon-dioxide emissions, driving up temperatures. While there are natural fluctuations in the climate it seems that temperatures are now rising faster than at any other time in recorded history. Climate policies agreed during the 2015 Paris Agreement are estimated to result in between 2.6°C and 3.4°C of warming, way above the limit of 2°C (Intergovernmental Panel on Climate Change, 2018).

There is uncertainty about how great the impact of a changing climate will be. Nevertheless, climate change is expected to increase the frequency of extreme weather events.

Climate change is a global phenomenon that impacts materially on urban life. Rising global temperatures causes sea levels to rise and increases the number of extreme weather events. It has costly impacts on cities' basic services, infrastructure, housing, and human livelihoods. Cities are a key contributor to climate change, as urban activities are major sources of greenhouse gas emissions. Estimates suggest that cities are responsible for 75% of global CO₂ emissions, with transport and buildings being among the largest contributors (UN Environment Programme, 2019)

Transition and liability risks impact cities and business operating in cities. Lloyd's report *Below 2°C* provides a strategic overview of the potential effects of the low carbon transition on the general insurance market. This work focuses on the impact of transition and liability risks on general insurance, seeking to understand sectoral trends up to 2030.

Population growth

The UN population index shows that the global population will swell to 11 billion by the end of this century. According to this forecast at least half a billion more people will live in cities in 2025 compared to 2019 (UN, 2017).

The challenge of population growth demands innovative city development, the deployment of new technologies and strong metropolitan policy making for urban populations to benefit and to be economically productive. Greater access to gainful employment and fit-for-purpose housing connected by integrated transport can improve living standards and grow GDP on the back of a rising population. This version of the future however is not without risks and challenges. Urban populations are growing and as cities progress through their development journey so do their citizens. Three to five billion new consumers who have never purchased or uploaded anything are about to come online and provide a significant impetus to global GDP.

Urbanisation

More than half the world's population now lives in urban areas, up from a third in 1950. This is projected to reach two-thirds by 2050. These urban environments range from connected and sophisticated metropolises to unplanned and informal settlements. Megacities of 10m+ people will increase from 31 currently to 41 by 2030. They will be the economic powerhouses driving future global GDP growth (UN, 2018).

Table 1: Urban agglomerations, 1970, 2018 and 2030

1970		2018		2030	
Rank	City	Rank	City	Rank	City
1	Tokyo	1	Tokyo	1	Delhi
2	New York	2	Delhi	2	Tokyo
3	Osaka	3	Shanghai	3	Shanghai
4	Mexico City	4	Sao Paulo	4	Dhaka
5	Buenos Aires	5	Mexico City	5	Cairo
6	Los Angeles	6	Cairo	6	Bombay
7	Paris	7	Bombay	7	Beijing
8	Sao Paulo	8	Beijing	8	Mexico City
9	London	9	Dhaka	9	Sao Paulo
10	Calcutta	10	Osaka	10	Kinshasa

Source: UN, 2018

Migration, rising birth and declining mortality rates in cities mean urban areas will keep growing faster than rural ones. Factors driving migration are multifaceted and include war, religious and political dissidence, sustained and chronic underinvestment in rural areas, lack of jobs, international migration, and the pull of an urban life. Global populations will continue to shift to the less-developed regions.

Europe has been at the centre of migration issues in recent years. The migration wave into European countries of refugees and asylum seekers is occurring against the backdrop of international fights against terrorism, as well as a relatively weak labour market and poor economic conditions in these migrants' countries of origin. This large migration wave represents a risk for city authorities because in the absence of integration policies, it can lead to the formation of ghettos and marginalised communities (Meeks, 2016).

Growth in city boundaries

In much of the world urbanisation has resulted in sprawling cities wherever more people are crowded on compromised land. Cities are growing and extending their boundaries, building on land that is not prepared or appropriate for new infrastructures (e.g. flooding zones). This is exacerbating risks for cities and their population.

Sprawling cities also can become inefficient. One example is Dar es Salaam, Tanzania. Relatively small by megacity standards, it is set to grow from 6 million inhabitants today to over 10 million by 2026. In response to congestion, the city is creating a new bus system to allow residents to have access to transportation within the space of few years. The average journey time is supposed to decrease, saving time for bus passengers. But this new infrastructure brings new vulnerabilities - the capacity of the bus fleet was halved after the main depot flooded and, smart card readers failed, leading to negative impacts on revenue (Guardian, 2019).

Vision City on the edge of Kigali in Rwanda and King City in Ghana are targeted at the middle classes (Giles, 2018). Other developments, such as Kenya's new tech hub Konza, plan to include space for productive commercial activity. However, such developments create the risk of 'dual cities', with older, informal parts of the city left under-developed and more exposed to risks (Noorloos & Kloosterboer, 2018).

Unplanned and informal settlements

Slums and informal settlements are not a new issue for cities and continue to be a persistent risk for local authorities. Today 1 billion people live in informal urban settlements and this is due to increase to 2 billion by 2030 (Barthel, 2017). Inequality has become a major emerging urban issue, as the gap between the rich and the poor in most countries is at its highest recorded levels (Politico, 2017). As cities in emerging economies have grown, so have their informal settlements: The World Bank estimated that in 2011, 880 million residents lived in informal settlements, which represented 11% growth from 2000. The International Monetary Fund believes 53% of countries have seen a rise in wealth inequality in the past three decades

There are a number of factors exacerbating the threat of civil conflict and social unrest. These factors are fanning the embers of discontent around the world, embers which occasionally and increasingly burst into flames. Indeed, the World Economic Forum's 2018 survey of business leaders identified "rising income and wealth disparity" as the third most important risk facing economies today. Rapid urbanisation in lower income countries will continue to be accompanied by the proliferation of informal, low-rise and low-quality housing - an inefficient urban sprawl disconnected from formal transport and utility infrastructures of the city.

Densification of assets

Planned densification results in more tall buildings being developed in concentrated places, often revolving around residential or mixed-use developments. Highly densified cities will result in a raised exposure infrastructure risk. Whereas countries across Sub-Saharan Africa are experiencing a boom in new developments on the peripheries of existing overpopulated cities, cities like London and New York are densifying by building upwards.

Box 1: The only way is up – New York City

The planning system allocates volumetric height allowances as a function of plot footprint. Buildings which do not use the full vertical allocation of their plot therefore have unused development height according to current Zoning laws. Transferable Development Rights (TDRs), or air rights, allow landowners to sell any unused development rights to adjacent lots. Owners of adjoining plots can buy these rights, enabling them to be aggregated over time and ultimately to increase the height of their own development.

It is estimated that air rights are currently trading for \$225 per square foot which is more than three times as much as the national average building cost, but much less than the average \$1,780/sq. ft cost of a Manhattan condo. One example of this is the 95-storey residential development Central Park Tower, which purchased air rights in 2014 for \$31.8 million and is set to complete in 2020 (Sinclair Colman, 2017).

Without regulatory changes there are huge untapped TDRs which can be utilised with 3.7 billion square feet available across New York, enough air rights to build more than 1,300 Empire State Buildings. Around 1.8 billion square feet of these are in current residential zones. In comparison just 1.6 million square feet of air rights were traded in 2016 (Municipal Art Society of New York, 2017).

Risks can manifest in two ways:

- In cases where a group of shareholders in a cooperative sell air rights, if one of the shareholders challenges the transaction post-closing, the title company would be required to defend and indemnify the air rights purchaser.
- Political risk can threaten the value of collateralised air rights.

This is already happening in New York, but other cities are experiencing the same issue, and this is something to consider now before others take this as best practice and it becomes normality.

Changing people

A growing middle class

A growing middle class could lead to challenges similar to that of a young population. Asia is expected to be home to nearly 9 in 10 of these new middle-class citizens (Naím, 2017). This nascent middle-class will demand improved living standards, education, health and connectivity and, require more intensive forms of agriculture to meet their dietary expectations. Failure to service this socio-economic grouping will likely lead to their disaffection with public services and governments. In Colombia, middle-class protests about education and transport brought disruption to Bogota (Associated Press, 2018).

Africa now has the fastest growing middle class in the world. The current trajectory suggests that the African middle class will grow to 1.1 billion (42% of population) by 2060 (Deloitte, 2014).

Growing urban populations and a larger middle-class will increase demand for urban infrastructure and mobility. Significantly increased grid capacity will be required to support the expected rollout of smart city and smart mobility infrastructure.

Ageing cities

Ageing cities in developed economies present an economic opportunity and a challenge. Relatively high levels of disposable income and asset wealth are accompanied by increased demands around health, social care and accessibility. Opportunities exist for technology companies providing in-home assistance and monitoring, or for the retail and service sector.

In Japan annual GDP growth could be impacted by one percentage point reduction per annum during the next 30 years due to population decline and ageing (Financial Times, 2018). In Vancouver, older people cannot afford to downsize in the urban core either through buying or renting, prompting new policies and zoning changes to broaden the range of housing options (City of Vancouver, 2017). The Lloyd's report – *Taking control: robots and risk* - explores how robots could be a way to assist and help ageing populations, but might also introduce new risks such as damage to property, healthcare and homecare risks associated with working directly on people and risks linked to the use of artificial intelligence in agriculture.

Increased provision of infrastructure such as lifts, elevators and air conditioning are deployed in cities to answer this population's upcoming needs. For example, a 2014 power blackout in Buenos Aires lasting days resulted in several deaths reported of elderly citizens who were left unable to use air conditioning.

Trust, social media and governance

Levels of trust in government, media and large business are deteriorating. Macro issues such as climate change and terrorism, social, economic and political flux have resulted in citizens being more vocal in politics.

Social media giants remain powerful platforms and key opinion formers. It is therefore a matter of ongoing concern and a challenge for policy makers that such platforms continue to wrestle with issues such as targeted disinformation content pushed to different socio-demographic groups.

The public sector is facing a general increase in litigation. States and local authorities across the globe are already faced by lawsuits challenging insufficient climate protection policies and the non-implementation of international climate treaties. Claims are mainly based on human rights and public international law. For example, claimants argue that their governments' climate policies are insufficient and so violate their human rights, including the rights to life, health and property (CMS, 2019).

Institutions of metropolitan governance are constrained almost as never before. Sovereign debt levels across much of the globe have played out into an environment of public fiscal austerity. National and city governments are increasingly constrained in terms of human and financial resource. The new paradigm of the technology informed smart city makes significant demands on the relationship the city has with its citizens in terms of trust, but also requires significant investment in the technology to harvest the relevant data - from infrastructures, the public realm and ourselves – but also to process and interrogate that data once captured. It is within the context of these institutional challenges that global cities are operating.

Social unrest

The current political climate is one of significant uncertainty and tension. In addition to the macro trend of a shift in economic and political power toward the East and to China, there are political and economic tensions between the major trading blocs.

Citizens are being empowered; they are reacting to and engaging in the political dialogue. Citizens are also protesting against social inequalities and their general conditions. Some cities in less developed countries have been unable to marry productive industrialisation and employment opportunities with burgeoning unplanned and uncontrolled urban immigration flows, resulting in lower average incomes for citizens and an elevated risk of social instability.

There will be a growing risk of instability and civil unrest in countries where job creation and economic growth does not keep pace with rising youth populations. 58% of young people in the Middle East and North Africa (MENA) told the International Labour Organisation that they were dissatisfied with the number and nature of job opportunities (Future Agenda, 2019).

For example, Uganda has one of the world's youngest populations with around 70% of the population being under 25 years old (United Nations, 2018). This created a widespread unrest in Kampala in August 2018 (BBC, 2018), said to be the result of youth disillusionment with a lack of employment opportunities and political disengagement (African Institute for Development Policy & University of Southampton, 2018).

Changing technology

Smart cities, big data and systemic risks

In 2018, the total smart cities market reached \$308 billion. It is expected to grow to \$717.2 billion by 2023 (Smart Market, 2018). These will provide an institutional and technological framework to re-think the provision of essential services in the urban realm. Static, dynamic and citizen generated data will inform continued service improvements and increase concentrations of technology assets.

As datacentres grow in importance, capacity and power demand the impact to society and industry of energy network shocks or blackouts increases. Interruptions to energy supply will likely bring more and more city activity, from business to mobility, to a standstill.

Artificial intelligence, automation and robotics, virtual and augmented reality are affecting all sectors in the global economy. Connected by the Internet of Things (IoT) this technological revolution is referred to as Industry 4.0.

To make sense of this new world, Lloyd's report: *Networked world: risks and opportunities in the Internet of things* published in collaboration with the University College London's (UCL) and the PETRAS IoT Research Hub analyses IoT's opportunities, risks and regulatory landscape.

Changing nature of work and disruption

Around the world, the way in which businesses and people work will change due to technological and cultural developments. Workplaces in cities are evolving. Digital disruptors will create new markets and as smart city data and technologies become more prevalent, cities will themselves become platforms to drive innovation and value creation.

Industry 4.0 and the increasing use of technology in the workplace will displace jobs in some geographies and sectors and create new ones in others. The impacts will be unevenly felt across different job and skill levels, sectors and geographies. Technology is changing the way we consume goods and services and ultimately the physical and human resource assets required to generate value and revenue in cities.

In the USA, geographical differences in the impact of AI on jobs is stark. In absolute terms, 8.6 million jobs are at risk in California, 6.5 million in Texas and 4.6 million in New York State (Miller, 2018).

Parts of Latin America that have the highest proportion of low-skilled workers are most at risk from job displacement, demonstrating the importance of ensuring a growing workforce have opportunities to benefit from, and not lose out to, automation (Borgen, 2018).

The development of artificial intelligence in cities is going to change the way these ecosystems are structured and evolved. AI can enable sustainable cities, maintain infrastructure, and improve public services for residents and communities. AI technologies can be deployed at different levels in cities. Driverless cars could bring relief from traffic congestion and human error on the road. AI technologies for security purposes are implemented in cities for surveillance and predictive policing at the street level (Citylab, 2017).

Box 2: Driverless cars – risk and opportunities at cities level

Car manufacturers are currently competing in developing driverless car technology. The Society of Motor Manufacturers and Traders believes that 3,900 road deaths in the United Kingdom could be prevented with driverless car technology (Edbrooke, 2020).

As the arrival of driverless cars get closer, cities are getting ready. City planners are currently reviewing the organisation of urban areas to prepare for the autonomous future. Some see an opportunity to create on-demand public transit or open streets for more green space and greater walkability. However, others see possible issues, warning that such vehicles could encourage greater urban sprawl and cut into funding for public transit (Higgins, 2018).

Oxbotica is an autonomous vehicle software company whose AI-powered software, Selenium, is being used to develop driverless cars. The use of AI helps the vehicles navigate complex routes efficiently and safely. AXA XL and Oxbotica have worked together to deliver a risk management solution for autonomy, as well as supporting the adoption of autonomous vehicle technology. This collaboration has seen the development of a real-time risk model that enables a better understanding of how to improve overall system performance across a range of real-world conditions. The system has displayed the potential to transform how insurance and autonomous vehicles will work together in connected cities (Oxbotica, 2019).

Changing systems

Sharing economy platforms

Cities are becoming hosts of this new economic system based on the use of technology to share assets or services between parties. Participants in the sharing economy use it because it can provide a more flexible and affordable option than some other economic systems. As a result, numerous sharing economy models have emerged including peer-to-peer, business-to-business, business-to-crowd, as well as equipment and service sharing for public agencies. Despite the clear opportunity, respondents representing both consumers and providers cite a number of concerns around risk, which are preventing shared platforms from growing their consumer and provider bases. Lloyd's analysed this new phenomenon in two reports: *Sharing risk, sharing rewards: who should bear the risk in the sharing economy?* and *Squaring risk in the sharing age: How the collaborative economy is reshaping insurance products?*

In the service sector digital technology is also changing the way shops operate. 'Dark kitchens' refers to food prepared at remote takeaway premises rather than in the restaurant itself. These activities are increasing the value of previously marginal urban spaces. This shift of value creation to smaller and lower quality property units has interesting insurance consequences. Property owners may see an increase in the property value due to demand from food delivery businesses, but the clustering of dark kitchens in less regulated, lower quality and densely populated neighbourhoods raises the risk of fire starting and spreading.

Box 3: Housing opportunities and risks

Real estate platforms are creating opportunities and risks for municipalities to understand and regulate. In most touristic cities, landlords have realised they can make more profit out of short lets by using platforms such as Airbnb than from renting to conventional tenants who work and live in the city year-round. This is creating a housing crisis as it becomes more difficult for residents to find accommodations (Hinsliff, 2018).

For example, Amsterdam is heavily restricting short-term lets by residents after street protests the swamping of the city by tourists last year. Other European cities are also restricting day and short term let (Hinsliff, 2018).

Box 4: Milan – Sharing cities

The **Sharing Cities** programme is providing ground for a better approach to making smart cities a reality. The programme aims at fostering international collaboration between industry and cities, the project seeks to develop affordable, commercial-scale smart city solutions.

Milan developed an extensive smart and sharing city strategy in the run up to hosting the World expo in 2015. The city has become one of the leading European cities in the field of social innovation, smart shared mobility and sharing economy. Milan has created an online register which includes a list of over 100 operators and experts of the sharing economy. This list allows the city to map the stakeholders of the sharing economy (Euro Cities, 2017).

New power centres

There is a macro trend of a shift in economic and political power toward the East and to China. Regional programmes are having global impacts and foregrounding global infrastructure investment in the East. For example, China's Belt and Road Initiative (BRI), an ambitious programme to connect Asia with Africa and Europe via land and maritime networks, aims at improving regional integration, increasing trade and stimulating economic growth (EBRD, 2020). The BRI includes 68 countries accounting for one third of global GDP and 60 per cent, or 4.5 billion, of the world's population (London School of Economics LSE IDEAS & CIMB ASEAN Research Institute, 2018). China's investment in smart city technologies, infrastructure and manufacturing across the world will profoundly impact the emerging cities of the BRI, the economic activity they pursue and the insurable assets they house.

Changing cities and state conflict

Social and cultural change is feeding emergent tensions between metropolitan and national governments. The views of these cosmopolitan urban populations often contrast with wider national sentiment. Like all major world cities London's political and cultural outlook is often in contrast to the rest of the country. The most significant example of this was the 2016 referendum on the UK's European Union membership. London was the only region in England where most voters wanted to stay in the EU. With technology and digitalisation comes a new form of connectivity. Access to the internet has changed the way citizens organise, mobilise, share information and educate.

3. Cities case studies

3. Cities case studies

This report focuses on seven cities that can be used to demonstrate issues seen globally and enable cross-learning. The selected cities are London, New York City, Miami, Mexico City, Johannesburg, Riyadh and Shanghai.

“The unique physical, social, economic and environmental composition of a city influences the degree of risk and vulnerability of its residents”.

Cities around the world, including the seven case studies, are at different stages of their development trajectories in terms of urbanisation, economy, population, land use, and technology deployment. This also means they are at one point in their risk profile journey and challenges are emerging from the changing trends. These trajectories can provide lessons for smaller cities which share some of the characteristics of the seven cities investigated. Cities are constantly facing new challenges and dealing with existing persistent ones. These challenges will continue to shape the landscape of urban areas for years to come.

The Lloyd's City Risk Index shows that \$48.52 billion of GDP is at risk in the seven cities selected. GDP@Risk is the average annual loss (also known as the 'expected loss') to a selected location's economic output from each threat or threat category. New York City with \$14.83 billion GDP@Risk is facing more threats than the other cities.

One way of looking at cities is by looking at where they are located. Indeed, specific assessment of urban risks will differ across cities based on different factors such as poverty levels, the pace of urbanisation, exposure to disaster risks and awareness surrounding climate change.

However, the location of a city can have an impact on the risks it is facing. A general typology includes coastal cities, dryland cities, inland and high-altitude cities.

- **Coastal cities** are made vulnerable by the low-lying land they are typically built on. They are susceptible to impacts related to climate change such as sea-level rise, flooding and coastal erosion. They historically have included a high percentage of the world's population because people move to the coast due to the trading and inter-connectivity aspects of these cities, and hence employment opportunity. The 10 coastal cities in terms of most exposed populations are Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Kolkata, Greater New York, Osaka-Kobe, Alexandria and New Orleans (World Bank Group, 2012).
- **Dryland cities** suffer from scarce water resources due to extended droughts and more frequent sandstorms. The effects of droughts are widespread but can be particularly severe on drinking water supplies and food prices. Innovations to access water are being developed by the local authorities in dryland zones. The city of Dubai for example is carrying out cloud seeding operations to maximise and increase the duration of rainfall (Zaatari, 2019).
- **Inland and high-altitude cities** will be affected by climate change predominantly as a result of changing patterns of precipitation. In many of these cities, minor floods that affect people's lives and livelihoods take place more frequently than other major disasters, but these events are seldom reported outside the local area (World Bank Group, 2012). For example, Mexico City is an inland and high-altitude metropolis with, both rainfall driven flooding and yet a shortage of potable water.

Definitions

- **GDP - Gross Domestic Product** - is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. It functions as a comprehensive scorecard of the country's economic health.
- **GDP@Risk** is the average annual loss to a selected location's economic output from each threat.
- **Scenario costs** is the amount of GDP that a city will lose if a specified threat scenario occurs.
 - **Extreme loss** is the loss if an extreme scenario took place.
- **GNI – Gross national income** – is the total amount of money earned by a nation's people and businesses.
 - **GNI per capita** is the gross national income divided by the midyear population.
- **Eight top threats facing the seven case studies** according to the City Risk Index



Flood



Civil conflict



Interstate
conflict



Cyber



Market
crash



Sovereign default



Tropical
windstorm



Human pandemic

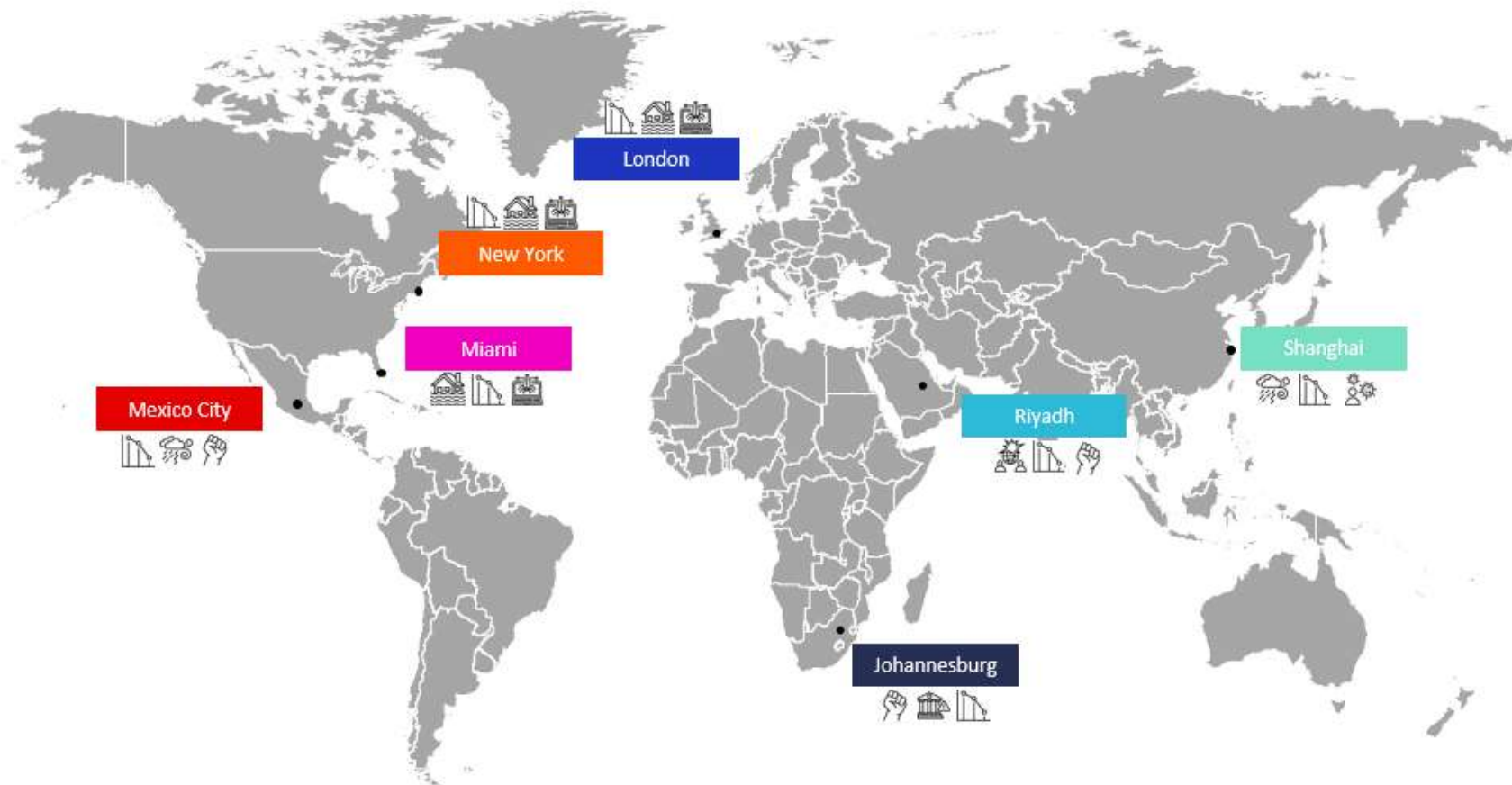
How do we use this data in the case studies?

For each of the city case studies we show the annual “GDP@Risk” for the top three hazards on that basis. We also show an estimate of the loss arising from an extreme event of that nature should it arise in the year. It is important to realise the difference between these concepts.

The GDP@Risk is an estimate of the average amount of GDP that would have to be saved each year – in order to pay for the hazard over the long run. It is not the amount of economic damage that would arise if the event occurred. Events come in all sizes – from relatively small which can happen quite frequently to very severe which tend to happen rarely. To illustrate the size of potential loss we also show an “Extreme Loss” figure which shows the amount of economic damage that could arise from an extreme but plausible example of the event.

Making this more concrete, the Cambridge/Lloyd's City Risk Index estimates that an extreme cyber-attack on New York could cost \$330bn. However, the GDP@Risk from Cyber-attack (the amount that should be saved annually to pay for the costs over the long term) is \$2.53bn, less than 1% of the potential economic damage a cyber-attack might cause.

Figure 7: Top threats facing the seven cities case studies






Case study **New York**



New York

A highly technological and stronger resilience city. Located at a temperate latitude, exposed to coastal and river flood risk. A high-density city with no informal settlements.

Table 2: New York - Key data in 2018

Greater metropolitan area population	19.9m		
Total country GNI per capita	\$63,080		
Total country GDP	\$20,544bn		
Total city GDP	\$1,681bn		
Global city GDP@Risk	\$15bn		
City top threats	GDP@Risk	Scenario costs – Extreme loss	
 Market crash	\$3bn	\$308bn	
 Flood	\$2bn	\$1,300bn	
 Cyber	\$2bn	\$333bn	

Sources: City Risk Index, 2018; OECD. Stat, 2018; World Bank, 2018

New York City is a mature global city that plays a central role in the world economy. New York is a long standing financial and trading hub, a leader in emerging sectors and a city becoming more diverse through international migration. As with cities like London, New York's large and diverse labour markets, public transport networks and access to investment finance means it is a leader in deploying new smart city technologies.

New York has the highest GDP@Risk from Finance, Economics and Trade of all cities in the City Risk Index. New York's risk profile is most similar to London's, another global market and smart city - where Finance, Economics and Trade accounts for over 30% of GDP@Risk. As with many cities around the world, New York is exposed to the risks of climate change through sea level rise and increasing temperatures.

However, New York takes a lead in policies to reduce energy consumption and emissions creating new markets for renewable energy and associated technologies.



A vision of New York city in 2050

OneNY 2050 consists of 8 goals and 30 initiatives that comprise a strategy to prepare New York City for the future (OneNY 2050, 2019):

- 1) Create a vibrant democracy that welcomes newcomers and engages all New Yorkers in civic life.
- 2) Build an inclusive economy that attracts and grows good-paying jobs and guarantees fair wages and dignified work conditions.
- 3) Support thriving neighbourhoods with safe, affordable housing and ample community resources.
- 4) Promote healthy lives by guaranteeing access to quality health care and a healthy environment for all, regardless of neighbourhood, income, race or ethnicity, or gender.
- 5) Provide equity and excellence in education with a focus on creating strong schools that reflect the diversity of thought, backgrounds, and experiences of the communities they serve.
- 6) Secure a liveable climate for the next generation with a just transition that ends our reliance on fossil fuels, fully prepares for the impacts of climate change, and achieves climate justice.
- 7) Ensure efficient mobility for all by restoring our subways and buses to world-class status so no New Yorker needs to rely on a car.
- 8) Invest in modern infrastructure that serves the needs of New Yorkers and creates the systems to better deliver that infrastructure.

What is changing?

The Metropolitan Transport Authority is planning to raise up to \$60 billion of capital investment to modernise the subway over the next 10 years (EY, 2019) to provide new subway cars and buses and to improve mobility access to the network (Matousek, 2018). The subway network will remain systemically vulnerable to flooding (Gannon, 2018).

One of the biggest changes facing building developers and owners will be the implications of the Climate Mobilization Act (CMA) passed by New York City authorities in April 2019. The new regulation sets emissions caps and energy efficiency measures.

Congestion road pricing in Manhattan will increase reliance on public transport and shared mobility. Smart infrastructure for bus management is planned, and road pricing along with planned People Priority Zones with restricted vehicle access could increase demand for shared micro-mobility accessed via digital platforms.

Focus on the future

New York will remain a nexus city whose markets are at the core of global trade and the international financial system.

Global markets require extremely time sensitive trading and market-making systems and the ability to process large volumes of data will remain critical to their operation. New York's tech and finance sector have an existing vulnerability to the threat of power outages and cyber-attack. Critical public services and transit systems are also increasingly reliant on the secure movement of data and high-speed connectivity. Additionally, data platforms delivering everything are reliant on the same ageing energy grids.



New York City's Hazard Mitigation Plan

Throughout its history, New York City has been confronted with natural disasters and man-made events. Each time the city is learning how to make its infrastructure, environment and people more resilient. However, New York City changed its approach to disaster planning. New York City has shifted towards mitigation, to reduce losses after a disaster.

The Hazard Mitigation Plan outlines goals, objectives, and specific actions New York City can take to reduce risks. The plan details the city's mitigation strategy for all hazards. It is ensuring that New York City is continuously identifying, assessing and reducing risk from hazards threatening the city. The aim of this strategy is to be cost-effective and sustained action taken to reduce the long-term risk to human life, property, and infrastructure from hazards. In order to be eligible for post-disaster mitigation funding from the Federal Emergency Management Agency (FEMA), the hazard plan has to be updated every five years.

In May 2019, NYC Emergency Management (NYCEM) launched the FEMA approved **Hazard Mitigation Plan** - the first online plan for a local jurisdiction. This on-line plan identifies 11 hazards that pose a risk to the city and actions the City is taking to reduce the impacts of these hazards: coastal erosion, coastal storms, earthquakes, extreme heat, flooding, high winds, winter weather, CBRN, cyber threats, respiratory viruses, and emerging diseases. To understand the city's risk and actions to reduce the risk, the website contains multiple tools that can be a resource for community groups, businesses, government stakeholders, and academia. This includes: Hazard History and Consequence Tool – an online database which contains both historic weather data and localised impacts from hazard events; the Mitigation Project Tracker - an interactive map which displays over 800 mitigation projects citywide; and the NYC Hazard Environment Story Map – which provides an existing conditions analysis of how features in the city's natural, social, built, and future environment may amplify the impacts of hazard events through a series of interactive maps and dashboards. In addition, the NYCEM developed a user-friendly communications guide called NYC's Risk Landscape: A Guide to Hazard Mitigation, which is a hard copy version of the HMP website.

Through this new online format, NYCEM anticipates that the plan will be more useful to its partner agencies and accessible to the general public. In addition, the website provides the foundation to build additional interactive tools for its users that will continually be updated to communicate risk awareness and promote mitigation investments in the city. (NYC Hazard Mitigation, 2019)




Case study Miami



Miami

A mid-technological and stronger resilience city. Low-lying and located at a tropical latitude, exposed to sea-level rise. A mid-density city with no informal settlements.

Table 3: Miami - Key data in 2018

Greater metropolitan area population	6.3m		
Total country GNI per capita	\$63,080		
Total country GDP	\$20,544bn		
Total city GDP	\$339bn		
Global city GDP@Risk	\$3bn		
City top threats	GDP@Risk	Scenario costs – Extreme loss	
 Flood	\$0.6bn	\$263bn	
 Market crash	\$0.6bn	\$62bn	
 Cyber	\$0.4bn	\$67bn	

Sources: City risk index, 2018; OECD.stats, 2018; World Bank, 2018

As a low-lying city, Miami is well known for the risk it faces from coastal flooding and hurricanes. These make property in the city one of the biggest concentrations of real-estate risk in the global reinsurance market. In the long-term, projections estimate between \$15 billion and \$23 billion of existing Florida property will be underwater by 2050 (Risky Business, 2014).

Miami has the 34th highest GDP@Risk to Natural Catastrophe and Climate threats in the City Risk Index. The city has a similar risk profile to San Francisco where Natural Catastrophe and Climate accounts for 35.4% of GDP@Risk and Finance, Economics and Trade 28%.

Miami is forecasted to see a growing resident and business population following a similar pattern of population growth as neighbouring cities like Fort Lauderdale.

This continuing urbanisation and population growth are set to put more strain on infrastructure and housing supply in the city leading to increased vulnerability of business and built assets to flooding and hurricanes.



Resilient 305

Greater Miami & the Beaches (GM&B) is a unique partnership of Miami-Dade County, the City of Miami, and the City of Miami Beach. This partnership came together to lead development of their community's resilience under the 100 Resilient Cities Network.

Resilient305 is a strategy built to enable Greater Miami and the Beaches (GM&B) to more effectively tackle emerging global challenges and trends such as urbanisation, globalization and climate change. The strategy is focusing on 3 key areas:

- 1) *Places action:* aim to address location-based challenges and improve climate resilience through research, design and planning; create, connect, and improve mobility and housing options; and enhance and safeguard the ecosystems.
- 2) *People action:* aim to improve the lives of our citizens every day by supporting job and wealth creation; addressing specific health needs for the most vulnerable; and preparing and empowering neighbourhoods and networks to anticipate and respond to disruptions.
- 3) *Pathways action:* aim to build the connections, collaborations, and committed leadership needed to change the status quo, enabling GM&B to become a global leader in resilience.

(Resilient 305, 2019)

What is changing?

Miami-Dade County is one of the oldest populations in the USA and has the most 60+ residents in Florida, more than half a million. This number expected to rise to over 800,000 by 2040.

The ageing population challenge in Miami is exaggerated by the fact that 20% of the city's elderly residents have incomes below the federal poverty line of 75% (Rothman, 2015) which could have implications for health insurers.

The Miami-Dade Age-Friendly Initiative is an established programme focusing on ensuring public spaces and buildings, transport and housing are adapted to be more accessible (Age Friendly Initiative - Miami-Dade County, 2017). A shortage of affordable and rentable accommodation is a challenge preventing ageing residents from moving into more suitable and accessible homes. This is increasing demand for goods and services to help care for residents and assist them in living independently, creating new market opportunities for private companies.

Focus on the future

Miami is adopting smart city technology, investing in large scale transport infrastructure and climate adaptation measures and seeing the emergence of local energy generation and efficient buildings. For example, Miami has already been declared the leading city in the world for smart streetlights with 500,000 connected streetlights compared to 280,000 in Paris, the next highest (Smart Cities World Forum, 2018).

The Miami-Dade SMART Plan is set to see investment to upgrade and extend the public transport network along rapid transit corridors incorporating smart city technology. The coming three years will see smart city demonstration projects such as last mile solutions using electric vehicles and on-demand mobility services using mobile apps (Miami-Dade Transportation Planning Organization, 2020).



Southeast Florida Regional Climate Change Compact

Southeast Florida is home to the eighth-largest metropolitan population in the U.S. – over 6 million people. The region is particularly vulnerable to climate change. High-density coastal development, which dominates the state's modern landscape, sits atop a very flat, low elevation limestone foundation. This low-lying topography makes people, infrastructures and economy vulnerable to the impacts of rising sea levels. Sea level rise can exacerbate storm surges, decrease capacity of gravity-fed stormwater drainage and increase saltwater intrusion of the region's drinking-water aquifers.

Given these challenges, the Southeast Florida Climate Change compact was created by Broward, Miami-Dade, Monroe and Palm Beach counties in 2009 to coordinate climate mitigation and adaptation activities across county lines (Southeast Florida Regional Compact, 2020).

Broward County Resilient Actions

Broward County has undertaken a series of strategic actions and investments to coordinate resilience planning across the organisation. The County is committed to reducing greenhouse gas (GHG) emissions through energy conservation and clean energy initiatives. The County has comprehensively integrated climate and sea level rise considerations across the broad spectrum of local government planning processes including water supply, emergency management, comprehensive planning, land use planning, and capital budgeting to provide a framework for integrating the economic, environmental, and social factors of climate change.

The County has worked collaboratively to develop regional resilience standards to support coordinated infrastructure investments, engaging municipalities and stakeholders in the process. Fundamental to these efforts has been the use hydrologic models and down-scaled climate data to inform requirements for drainage, flood elevations, design storm events, and tidal flood barriers (Broward.org, 2018).


Case study Johannesburg



Johannesburg

A mid-technological and weaker resilience city. Located inland, at a tropical latitude, with high levels of intra-continental inward migration. A rapidly changing city with high inequality and a significant level of population in informal settlements.

Table 4: Johannesburg - Key data in 2018

Greater metropolitan area population	10.5m	
Total country GNI per capita	\$5,750	
Total country GDP	\$368bn	
Total city GDP	\$77bn	
Global city GDP@Risk	\$1bn	
City top threats	GDP@Risk	Scenario costs – Extreme loss
 Civil conflict	\$0.3bn	\$38bn
 Sovereign default	\$0.2bn	\$28bn
 Market crash	\$0.2bn	\$11bn

Sources: City risk index, 2018; World Population Review, 2020; World Bank, 2020

Johannesburg has plans to be Africa's fastest growing smart city, a growing financial sector and a vibrant business-start up and community culture.

However, it is a city of contrasts. On the one hand Johannesburg can be viewed as a global city with a key role in the southern hemisphere economy and a gateway to the African continent for business and investment. On the other, there is a risk of growing polarisation as efforts to address social problems cannot keep pace with health epidemics, corruption, the social inequalities that are a legacy of apartheid, the growing threat of social unrest and tensions surrounding the volume of migrants from a wide African diaspora. Johannesburg has the 39th highest GDP@Risk to Finance, Economics and Trade threats in the City Risk Index. The city has a similar risk profile to Buenos Aires, where Finance, Economics and Trade risks accounts for 52% of GDP@Risk and Geopolitics and Security 29%.



National Development Plan 2030

The **National Development Plan** or NDP, launched in 2012, offers a long-term perspective. It aims to eliminate poverty and reduce inequality by 2030. South Africa can realise these goals by growing an inclusive economy, building capabilities, enhancing the capacity of the state, and promoting leadership and partnerships throughout society. The NDP highlights 14 priorities that need urgent actions. These are:

- 1) Quality basic education
- 2) A long and healthy life for all South Africans
- 3) All people in South Africa are and feel free
- 4) Decent employment through inclusive economic growth
- 5) A skilled and capable workforce to support an inclusive growth path
- 6) An efficient, competitive and responsive economic infrastructure network
- 7) Vibrant, equitable and sustainable rural communities contributing to food security for all
- 8) Sustainable human settlements and improved quality of household life
- 9) A responsive, accountable, effective and efficient development local government system
- 10) Protecting and enhancing environmental assets and natural resources
- 11) Create a better South Africa, contribute to a better and safer Africa in a better world
- 12) An efficient, effective and development-oriented public service
- 13) An inclusive and responsive social protection system
- 14) A diverse, socially cohesive society with a common national identity (Brand South Africa, 2017)

What is changing?

Johannesburg's Corridors of Freedom (CoF) vision has a goal to overcome the negative effects of urban sprawl and the reliance on private cars or crowded public transport for citizens living in wealthier suburban communities (Du & Lvovna Gelman, 2018). More importantly, the CoF project focusses on social development by providing better access for poorer communities to the urban centre and connecting informal settlements to centres of employment, education, leisure and recreation (Robinson, 2013).

The economic centres along these corridors will continue to undergo further densification with high-rise residential developments, new office buildings and retail and leisure space. By connecting marginalised communities to new districts, the CoF aims to link economic development with improved social health and wellbeing. In addition to changing the shape and appearance of Johannesburg the city government is accelerating its plans to become Africa's leading smart city.

Focus on the future

Looking to the future of climate change adaptation and mitigation and human well-being, Johannesburg has a unique yet almost hidden asset. The city has one of the largest urban forests in the world (Wende, 2010) with 6 million trees, part of a total of an estimated 10 million trees in the city (Buff, 2012) (Ferrini, et al., 2017). The economic value of these forests as green infrastructure or as space for urban food production has the potential to increase. However, in the immediate term the forest appears to be a factor in increasing the risk of the plant epidemic peril, hosting an insect infestation which has spread to agriculture sectors putting food exports at risk

Uncertainty over the security of electricity supplies could undermine Johannesburg's smart city plans with more technology increasing exposure to cyber-attack or disruption. In a broader sense Technology and Space related threats are likely to grow in importance as more of Johannesburg's business activity involves digital platforms and data. Nationwide, analysis indicates a 22% increase in attempted cyber-attacks during the first quarter of 2019 (Zulu, 2019).



JOBURG 2040 GDS

Launched in 2011, the **Johannesburg 2040 Growth and Development Strategy** (JOBURG 2040 GDS) defines the city's vision for the next 30 years – “Johannesburg – a World Class African City of the Future – a vibrant, equitable African city, strengthened through its diversity; a city that provides real quality of life; a city that provides sustainability for all its citizens; a resilient and adaptive society” (Joburg - a world class African city, 2011). The city of Johannesburg has stepped-up strategic effort aimed at rebranding itself as a smart city and competitive city at the centre of innovation toward improved life experiences. JOBURG 2040 GDS aims to ensure that socioeconomic infrastructure will ultimately improve citizens' experience. Four major outcomes define the Joburg 2040 GDS.

- *Outcome 1:* Improved quality of life and development-driven resilience for all
- *Outcome 2:* Provide a resilient, liveable, sustainable urban environment – underpinned by infrastructure supportive of a low-carbon economy
- *Outcome 3:* An inclusive, job-intensive, resilient and competitive economy that harnesses the potential of citizens
- *Outcome 4:* A high performing metropolitan government that pro-actively contributes to and builds a sustainable, socially inclusive, locally integrated and globally competitive Gauteng City Region

City of Johannesburg - Climate Change Adaptation Plan

As a result of projected climatic changes, the city of Johannesburg in 2009 launched the **Climate Change Adaptation Plan**. The plan integrates and prioritises strategic investments and activities to reduce climate risks. A number of risks have been identified and categorised according to an “Action Plan” based upon the potential magnitude of the risk's impact and the likelihood of the risk eventuating. Strategic adaptations have also been developed and focus on the following areas (City of Johannesburg, 2009):

- Integrating climate change adaptation into existing strategic planning mechanisms
- Developing alternative financing options for the funding of adaptations
- Developing an Information Management System to support ongoing climate change risk assessment and cost-benefit analysis
- Maintaining and expanding stakeholder engagement.




Case study Shanghai



Shanghai

An urbanising mega-city which is highly technological with moderate resilience. A coastal city exposed to sea level rise and estuary flood risk, located at a temperate-tropical latitude.

Table 5: Shanghai - key data in 2018

Metropolitan area population	25.6m		
Total country GNI per capita	\$9,460		
Total country GDP	\$13,608bn		
Total city GDP	\$551bn		
Global city GDP@Risk	\$8bn		
City top threats	GDP@Risk	Scenario costs – Extreme loss	
 Tropical winstorm	\$2bn	\$119bn	
 Market crash	\$2bn	\$79bn	
 Human pandemics	\$1bn	\$198bn	

Sources: City risk index, 2018; Macrotrends, 2020; World Bank, 2020

A city with historical ties to trading, and one of China's and the world's most internationally connected cities, Shanghai occupies a critical geopolitical position at the delta of the Yangtze River. With a population of 26 million and rising (World Population Review, 2019), this maritime trading mega-city has the opportunity for continued growth whilst needing to develop a resilient infrastructure proposition in the face of rising sea levels and the challenges of a changing climate (Baca, 2019).

Shanghai has the 8th highest GDP@Risk from Natural Catastrophe and Climate, with Taipei, Manila and Tokyo making up the top three. However, Shanghai's risk profile is different to these three cities having more in common with Los Angeles, where Natural Catastrophe and Climate risks accounts for 47% of GDP@Risk and Finance, Economics and Trade risks 23%. China's Belt and Road Initiative (BRI) is a reconfiguration and re-imagining of the ancient Silk Road.

The BRI also consists of the network of sea routes springing from the megacities running along the country's eastern maritime border, principally centred on Beijing/Tianjin, Shanghai and Hong Kong. The One Belt and the One Road intersect at Shanghai, reinforcing its critical position as an existing and future trading hub.



China 2030

A 2013 [World Bank report](#) prepare a strategic framework for reforms that could assist China's policy making. Vision 2030 for China is to build a modern, harmonious and creative society. The report identifies six new strategic directions that will form the core components of the new strategy for China.

- 1) *The appropriate role of the government, the state, and the private sector:* China's vision of itself in 2030 as an innovative, high-income society will require markets and the private sector to play a bigger role in resource allocation decisions.
- 2) *Encouraging systemwide innovation and adopting an "open" innovation system with links to global R&D networks.* Ensuring free and fair competition for all enterprises would be the single most important policy to encourage innovation.
- 3) *China should "grow green":* green development could potentially become a significant new growth opportunity.
- 4) *Promote equality of opportunity and social protection for all.* China's high inequality in incomes and assets can, in part, be attributed to unequal access to quality public services.
- 5) *Build a sustainable fiscal system* that will meet expected public finance challenges over the next two decades.
- 6) *Develop mutually beneficial relations for the rest of the world.* (World Bank, 2013)

What is changing?

The Shanghai Metropolitan Plan calls for “One Dragon Head, Four Centres.” This means that Shanghai will be the dragon head of the entire Yangtze River Delta metropolitan region, containing an international economic centre, a financial centre, a trade and logistics centre, and “an international centre of socialist modernisation” (Zang, et al., 2020).

Shanghai continues its expansion towards becoming a 100-mile city (Logan, 2008), an increasing number of local government bodies and development corporations are responsible for urban centres across the wider metropolitan area. In-between land is in places less well planned than new developments, with lower quality and isolated residential areas. These areas could see increasing physical and mental health issues and risks of social unrest.

The city so far is big enough to house old and new districts and the different demographic groups who live in them. However, as development continues and land availability for planned densification becomes constrained the challenge of integrating the old and new raises the risk of social unrest.

Focus on the future

Shanghai will remain a nexus trading city at the heart of global trade and a key nodal point in growing intra-Asian flows of goods and services. As such it will remain exposed to the macro environment around international tariffs and trade agreements. Material adverse movements in such international economic policies could affect marginal commercial businesses and reduce the competitiveness of the worst affected export led sectors. This in turn may result in stranded physical manufacturing assets if activities are re-located to lower cost production areas.

The ageing nature of its existing populace is likely to see a greater degree of diversity of both domestic and international workers in the city. International workers will bring increased expectations of liberalised access to information and consumer goods, whilst domestic migrants may force the weakening of the long-standing hukou system. Added to this the emerging middle-class has higher expectations of public services and increasingly demands access to a western style diet. In aggregate these are material cultural, social and political currents that have risks attached should they be constrained.



“Sponge city” initiative

A growing number of megacities such as Shanghai are sinking at the same time as seawaters are seeping in. This not only because they are heavy, but because of the extraction of vast quantities of groundwater by their residents (World Economic Forum, 2019).

Chinese local authorities are taking action to mitigate and adapt to sea-level rise. In 2014, China launched the “sponge city” initiative. The strategy requires that 80% of all urban land is capable of absorbing or reusing 70% of storm water. The goal is to repurpose and retrofit cities so they can absorb water. Candidate cities are investing in permeable pavement, artificial ponds and wetlands and rain gardens that store excess rainfall in underground storage tanks and tunnels. Some city authorities are entering into public-private partnerships to cover the costs (Zevenbergen, et al., 2018)

Shanghai’s authorities are putting enormous stock in adaptation strategies. Shanghai has constructed 520 kilometres of protective seawalls and has also installed massive mechanical gates to regulate overflowing rivers (World Economic Forum, 2019).




Case study Mexico



Mexico City

A mid-technological and weaker resilience city. Located inland at altitude and at a tropical latitude, in a water scarce area. A sprawling city, with a significant level of population in informal settlements.

Table 6: Mexico City - Key data in 2018

Greater metropolitan area population	20.5m	
Total country GNI per capita	\$9,180	
Total country GDP	\$1,221bn	
Total city GDP	\$284bn	
Global city GDP@Risk	\$8bn	
City top threats	GDP@Risk	Scenario costs – Extreme loss
 Market crash	\$3bn	\$39bn
 Tropical windstorm	\$1bn	\$335bn
 Civil conflict	\$1bn	\$129bn

Sources: City risk index, 2018; OECD.stat, 2018; World Bank, 2020

The second most populous city in Latin America and the largest Spanish speaking city in the world, Mexico City is often considered as one of the most important financial and cultural centres in the region. It occupies a total of 1,485 square kilometres (573 square miles) (World Population Review, 2019).

Mexico City has the 13th highest GDP@Risk from Natural Catastrophe and Climate, behind New York, Seoul, Xiamen and Suzhou. Mexico City's risk profile is most similar to Houston, where natural catastrophe and climate accounts for 39% of GDP@Risk and Finance, Economics and Trade at 26%.

The demographics of Mexico City are similar to other cities with a relatively young and a growing working-age population. Census data from Mexico's National Institute of Statistics and Geography (INEGI) shows that the numbers of foreigners in the country has grown by 95% in the past decade, the majority of which is from the US (World Population Review, 2019).



CDMX Resilience strategy

Mexico City (CDMX) faces multiple risks, both natural and man-made.

In 2013, Mexico City was selected to be part of the 100 Resilient Cities initiative. The **CDMX Resilience Strategy** is being developed as part of this initiative, and to address the challenges facing the city through five pillars. These pillars will drive the implementation of actions to improve the adaptive capacity, disaster response, and infrastructure development of CDMX. The 5 guiding principles are:

- 1) *Foster regional coordination:* maintaining a regional view and coordination at all levels are key to building resilience.
- 2) *Promote water resilience as a new paradigm to manage water in the Mexico basin:* ensure equal access to the water supply and guarantee the water supply for the entire population.
- 3) *Plan for urban and regional resilience:* citizens have equal access to urban amenities, housing, green areas, and public spaces.
- 4) *Improve mobility through an integrated safe and sustainable system:* Investment in public transportation is required in order to improve the quality and safety of the mobility system, as well as to create an integrated system that serves the entire population of the city.
- 5) *Develop innovation and adaptive capacity:* innovative processes and tools must be developed that enable government and various social and economic sectors to be aware of and understand their vulnerabilities and reduce the risks they face.

(CDMX, 2013)

What is changing?

In positioning itself as an 'innovation bridge' between North and Central/South America, as well as a launch pad for European and Asian companies looking to tap into the large markets in the surrounding area, Mexico City has a compelling economic offer for the future (Virgin, 2020). The City's accelerating growth and renewed economic vigour have brought fresh challenges to this megalopolis, including mobility.

Infrastructure and services are being extended into its densely populated informal settlements, commerce and services are growing (City Lab, 2017). This process of the gradual formalisation of mature informal settlements into Mexico City's greater urban fabric can be seen repeated elsewhere in Latin America and will bring buildings, physical infrastructure and businesses, as well as the millions of people that live in these changing urban realms, into the market for insurance products.

Focus on the future

Mexico City is a city with both too much water (particularly during the rainy season of June to September) and not enough (potable water is piped in from remote valleys at huge distance from the metropolis) (Tortajada, 2007) (Watts, 2015). As with transport and energy infrastructure, the city's water infrastructure requires significant investment to service the existing population by conventional means (Rodriguez, 2019).

When the need to meet carbon emissions targets are added into the infrastructure investment picture then it can be seen that the coming decade presents a material economic, logistical and planning challenge.

Water management and energy generation are the two key nexus risks that will impact on economic growth, attractiveness of the region to business and quality of life. A further macro sensitivity arises from Mexico's national trading relationship with its neighbour to the North – the USA.



Mexico – Financial resilience and disaster response

Mexico stands at the forefront of initiatives to develop comprehensive disaster risk management programs.

As part of its disaster risk management efforts, in the late 1990s the Federal Government of Mexico established the Fund for Natural Disasters - *Fondo de Desastres Naturales* (FONDEN). The FONDEN was established as a mechanism to support the rapid rehabilitation of federal and state infrastructure affected by natural events. The Emergency Fund is a financial instrument for immediate disaster response, providing relief, aid and assistance to severely affected populations. FONDEN consists of two complementary budget accounts: the FONDEN Program for Reconstruction and the FOPREDEN Program for Prevention (Natural Disaster Prevention Fund (*Fondo para la Prevención de Desastres Naturales*)).

In the early 2000s, in recognition of the need to strengthen preventive actions for natural catastrophes, funding for preventive activities were allocated (FOPREDEN). FONDEN has evolved since its creation to improve the efficiency of its resources.

To access FONDEN resources, affected federal and state agencies must demonstrate that the magnitude of reconstruction needs exceeds their financial capacity. FONDEN does not provide direct support to municipalities. However, state governments have traditionally applied for FONDEN resources to restore municipal assets and have then provided municipalities with assistance for the execution of these resources (World Bank, 2012).




Case study Riyadh



Riyadh

A mid-technological and stronger resilience city. A desert city with water scarcity, located at a tropical latitude. Low density, with a policy to densify as the economy rapidly diversifies.

Table 7: Riyadh - Key data in 2018

Metropolitan area population	6.9m		
Total country GNI per capita	\$21,600		
Total country GDP	\$644.94bn		
Total city GDP	\$157bn		
Global city GDP@Risk	\$5bn		
City top threats	GDP@Risk	Scenario costs – Extreme loss	
 Interstate conflict	\$3bn	\$171bn	
 Market crash	\$0.5bn	\$26bn	
 Civil conflict	\$0.4bn	\$65bn	

Sources: City risk index, 2018; Macrotrends, 2020; World Bank, 2020

Riyadh is a car dependent, low density city subject to the climate and environmental perils associated with cities in arid and high-temperature regions. The spatial nature of Riyadh is representative of sprawling cities in middle-income economies. Like many cities across Asia, Riyadh is constructing a metro network and rolling out a series of new smart city programs and initiatives.

Riyadh has the 5th highest GDP@Risk from Geopolitics and Security, behind Cairo, Istanbul, Baghdad and Tokyo. Of these, Riyadh's risk profile is most similar to Cairo, where Geopolitics and Security accounts for 75% of GDP@Risk and Economics and Trade 14%.

Riyadh along with the rest of Saudi Arabia is seeing explosive population growth. There has been considerable liberalisation recently. More unique to Riyadh is the planned speed and scale of economic reform and diversification of the economy to create new private sector jobs in a mixed service economy.

The economy has traditionally been unbalanced and dominated by the oil industry, whilst the public sector has been the main source of employment. The mixed economy is being built on sectors such as finance and retail.



Vision 2030

Saudi Arabia's vision for the future expresses the country's long-term goals and expectations and reflects its strengths and capabilities. The blueprint is based on three pillars:

- *A vibrant society* where everyone enjoys a rich, happy and fulfilling life as a strong foundation for economic prosperity. This society is characterised by strong roots and foundations that emphasise moderate Islam, national pride, Saudi heritage and Islamic culture. World class entertainment options, sustainable living, care in the community, and efficient social and health care systems should also be offered.
- *A thriving economy*: a key focus is to create an environment which unlocks business opportunities, broadens the economic base, and creates jobs for all Saudis. The country aims at attracting best talent, increasing global investment, stimulating and diversifying economy and revenues.
- *An ambitious nation*: the vision 2030 aims at creating a high-performing government that is effective, transparent and accountable. It empowers citizens, the private sector and non-profits to take initiative. It also transforms the country's location into a global hub connecting three continents (Asia, Europe and Africa).

The Vision set out 96 strategic objectives that cascade from each of the three pillars (Saudi Vision 2030, 2017).

What is changing?

To date the city has grown in a sprawling manner with unorganised land uses (Al-Mosaind, 1998). In response, the Riyadh Metropolitan Development Strategy set out to densify the city by increasing the proportion of medium density housing in the residential stock, a process which is continuing in the coming years (Future Saudi Cities, 2017).

Government policy is focused on increasing both land and building supply to encourage densification. The Idle Land Tax, or 'white land tax', makes levies on landowners of undeveloped land and uses proceeds to fund 'suburban core' developments around Riyadh where high-density and high-rise mixed-use developments are being built (Construction Week, 2019). A 2.5% White Land Tax was approved in November 2015. Under the law, owners of empty plots of urban land designated for residential or commercial use in towns and cities will have to pay a tax of 2.5% of the value of the land each year (EY, 2016).

Riyadh continues to be a car dependent city; a consequence of the relatively unplanned nature of its low-density urban growth coupled with a lack of public transport. The city will see the growth of new mobility assets in response to these challenges. US\$23 billion is being invested in public transport including the expansion of 176 km of metro lines and 1,200 km of rapid bus routes (Dixon, et al., 2019).

Focus on the future

Riyadh's climate leaves the population at risk to high temperatures, increasing the demand for energy to power cooling infrastructure. Research shows a trend of rising land surface temperatures across all land use types, with urban industrial heat islands suffering the highest temperatures (Aina, et al., 2017).

Whilst the future planned densifications are likely to increase temperatures further, measures are being implemented to counter this. The King Abdullah Financial District is designed in a way to enable natural cooling. The shape and positioning of the buildings are designed to block desert winds and provide shelter from sun resulting in predicted temperatures being up to 10 degrees Celsius (50 Fahrenheit) cooler than other urban areas of the city (Henning Larsen, 2020).

Riyadh is vulnerable to flash-flooding despite being located in a desert climate. Studies on flood vulnerability suggest that the low-lying central and southern half of the city is the most vulnerable. In the absence of mitigating measures, densification will likely increase such flood risk (Rahman, et al., 2016)



Saudi Arabia's smart cities program

Rapid urbanisation is a highlight feature particularly in metropolitan areas such as Riyadh, Dammam, Jeddah and Makkah, that presently do not meet standards of sustainability. Urbanisation in Saudi Arabia was extremely fast and significant during the last five decades; being the third highest in 2000 and expected to continue until 2050 at the same rate. The goal is to build or develop future cities that achieve all the three essential objectives i.e. personal satisfaction, financial competitiveness and environmental protection (Advanced Electronics Company, 2018).

In 2017, the Ministry of Municipal and Rural Affairs (MOMRA) launched the nation's first Smart Cities program. This initiative aims at driving smart transformation in Saudi cities to enter the digital age. 17 cities have been selected - comprising about 72% of the Kingdom's population - to carry out smart urban projects. This effort will be supplemented by US\$ 500bn investment which will be focused on modernising the infrastructure of the existing 285 municipalities across Saudi Arabia (Center for Local Administration, 2019).

Riyadh – the world's next leading smart city

Riyadh aspires to become the world's next leading smart city. The city has been moving rapidly to implement Vision 2030 and the National Transformation Program 2020. According to the Ministry of Municipal and Rural Affairs, Riyadh has reached only 15% of its smart city transformation program (Abdellatif, 2019). Information technology spending in Saudi Arabia is expected to grow 14% each year (Abdellatif, 2019).

Riyadh on track to become a sustainable city

In November 2019, over 60 international experts concluded a 2-day symposium 'Riyadh: The Sustainable City', offering advice and suggestions on the projects that will help transform Riyadh into a world-class sustainable city. Four wellbeing projects: **King Salman Park**, **Green Riyadh**, **Riyadh Art** and **Sports Boulevard** are being developed to cover sustainable urban development, conservation, socio-economic wellbeing, cultural nourishment, and the promotion of a healthier lifestyle for all citizens. They will improve residents' way of life by providing a greener, healthier environment and by encouraging participation in cultural and sporting life, in line with the Kingdom's Vision 2030 (Businesswire, 2019).




Case study London



London

A highly technological and very strong resilience city. Located at a temperate latitude, exposed to sea level rise. A densifying city with no informal settlements.

Table 8: London - Key data in 2018

Greater metropolitan area population	12.4m	
Total country GNI per capita	\$41,770	
Total country GDP	\$2,855bn	
Total city GDP	\$990bn	
Global city GDP@Risk	\$8bn	
City top threats	GDP@Risk	Scenario costs – Extreme loss
 Market crash	\$1.8bn	\$182bn
 Flood	\$1.6bn	\$506bn
 Cyber	\$1.4bn	\$197bn

Sources: City risk index, 2018; OECD.stat, 2018; World Bank, 2020

Representative of global cities around the world, London is a nationally dominant metropolis in terms of population, employment and GDP. London has the 10th highest GDP@Risk from Finance, Economics and Trade, with New York, Sao Paulo and Moscow making up the top three. Of these, London's risk profile is most similar to another global market city - New York - where Finance, Economics and Trade accounts for over 29% of GDP@Risk.

Economic differences between London and the rest of the UK are reflected in higher average incomes and areas of particularly high house prices. London, like New York, faces the challenge of housing shortages and unaffordability. London is a smart city leader, highly connected internationally with well-developed infrastructure and services. This includes extensive digital connectivity generating large volumes of user data and enabling disruptive technologies, and new ways of working and travelling.



London City Resilience Strategy 2020

The **London City Resilience Strategy 2020** takes a broad and long view of what city resilience means, by considering immediate risks and looking at a wider range of shocks and stresses to determine how best to respond to them. The aim of the strategy is to look at the long-term shocks and stresses that are likely to affect the material wellbeing of the city between now and 2050.

- **Shocks:** sudden impact events that can immediately disrupt a city and may have wide-ranging and unexpected impacts (e.g. terror attack, flooding, cyber-attack, infrastructure failure, disease pandemic)
- **Stresses:** chronic issues that weaken the fabric of a city and can eventually lead to a major shock (e.g. inequality, poor air quality, food insecurity).

This strategy identifies three cross-cutting opportunities that will make London a more resilient city. These resilience opportunities should not be viewed in isolation, as they are interconnected.

- **Resilience for People:** Building resilience for London's Communities
- **Resilience for Place:** Developing resilience for London's physical environment and infrastructure
- **Resilience for Process:** Designing resilience into governance

The strategy outlines projects that are aimed at building resilience to one or more risks. Each project description explain why the work should be undertaken, identifies key shocks and stresses, and the resilience value of completing the project (Greater London Authority, 2020).

What is changing?

The growing young working age population in London is driving densification of the urban centre in much the same way as many major metropolises around the world, although the impacts of the post COVID-19 economy may reduce the attractiveness and necessity of inner urban living.

As at end 2019 there were 541 tall buildings in the pipeline across London, 90% of which were predominantly residential (New London Architecture, 2019). A number of these developments are in locations with the greatest flood risk, such as the Greenwich Peninsula and other areas along the River Thames in East London.

Off-site and modular buildings are a growing trend (WPI Economics, 2017) and increasingly seen as making an important contribution to London's future house building (Pinoncelly & Belcher, 2018). In fact, London will be home to the world's tallest modular building completing in South London in early 2020 (Lane, 2019).

Rooftop developments could become more widespread as the London Plan identifies airspace development as an opportunity for building up to 40,000 new homes in zones 1 and 2 (Architects Journal, 2018). 'Permitted Development Rights' (PDR) legislation is being drafted to allow rooftop, or airspace, development to happen without the need for planning permission, with echoes of New York's development approach cited in this report (Building, 2019).

Focus on the future

London's role in the global financial system, as a leading location for debt and equity raising, pension funds, overseas Head Offices, insurance, Venture Capital and Private Equity and its large levels of international inward investment in real estate means London is likely to still be exposed to its main peril Market Crash and other Finance, Economics and Trade related threats.

However, this exposure may soften proportionally as Technology and Space related threats are likely to grow in importance with more of London's economic activity, including Fintech, reliant on digital platforms and data security.

With the scale of building and densification in riverside areas of London and the large-scale regeneration of the Thames Estuary area there is set to be a greater value of assets exposed to flood risk, even if the probability of flooding does not increase.



Infrastructure Resilience

Anytown model

Anytown was elaborated by the London Resilience team to explore cross-sector interdependencies between infrastructure systems through a series of hypothetical visioning exercises. The project raised awareness of the knock-on consequences of infrastructure disruption. It brought together experts and practitioners to discuss the impacts of disruptions beginning in specified infrastructure sectors (e.g. water), and the potential cascading effects these could have across other sectors.

- *Phase 1* of the project looked at the potential implications of disruption to electricity and water supply, and mapped out the knock-on effects
- *Phase 2* focused on the cascading consequences and interdependencies associated with disruption to telecoms networks and gas supply with scenarios considering infrastructure disruption lasting hours, days, or weeks.

London Data Innovation

London's infrastructure networks are interconnected and rely on digital, electrical and physical connections to function properly. While an understanding of these interdependencies is critical for short term emergency response planning, the Greater London Authority is also looking at opportunities for improving how infrastructure providers incorporate this information into their future-looking investment plans. In particular, the GLA is exploring how enhanced digital tools and data sharing practices could be used to supplement the decision-support tools that infrastructure providers already use, so that investments are targeted to maximise cross-sector resilience benefits.

London Climate Change Partnership

The **London Climate Change Partnership (LCCP)** gathers public, private and community sector organisations to exchange expertise on climate change adaptation and resilience to extreme weather in London. LCCP works to increase climate resilience within and between sectors in London. The partnership is driving awareness and action on climate change so that London can remain a great place to live, work, visit. The group is currently working on projects:

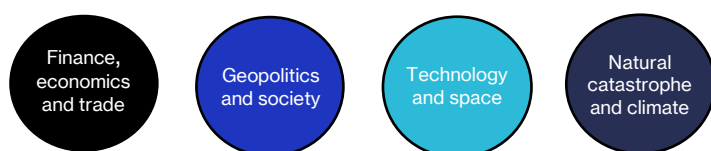
- *Climate Change Adaptation Indicators for London*: London Environment Strategy calls upon LCCP to work with stakeholders across sectors to identify, develop, and monitor a set of climate change adaptation indicators for London. Such indicators would aim to provide a systematic collection of data about observed weather conditions, impacts experienced by different sectors of society, and interventions taken to prepare for, respond to, and recover from climate-related risks.
- *Food Security and Climate Change*: Food security has been identified in 2017 as a top priority for the UK. In partnership with the London Food Board, LCCP organised a roundtable discussion to explore the issue, understand how it can affect London, and work out what needs to happen at different levels of decision-making to ensure the resilience of the city, food-wise.
- *Climate Just*: LCCP helped produce Climate Just, an online resource that helps practitioners in England develop socially just responses to climate change. LCCP is working with partners across London to map social vulnerability to climate change and address it through targeted adaptation interventions.

4. Risks and nexuses

4. Risks and nexuses

Following the four trends presented in section 2 and the seven cities analysed in section 3, this section focuses on four risk areas affecting cities.

Figure 8: Four risk areas affecting cities



As the report takes a system of systems approach to cities, this section is exploring how those systems interact with one another and how the nodal points of those interactions may be compromised by risk events.

Such risk event factors have the potential to adversely impact multiple critical elements of a city's operations, its ability to provide positive outcomes for its inhabitants and ultimately its economic ability to generate GDP.

Finally, this section also looks at insurance products offered by Lloyd's that enable cities to treat and transfer risks.

"Many cities all over the world are grossly unprepared for the multidimensional challenges associated with urbanisation"
(UN-Habitat, 2016)

Cities at risk
Building a resilient future for the world's urban centres

Geopolitics and society



Geopolitics and society

The current political climate is one of significant uncertainty and tension. Global geopolitical tensions have raised due to several factors including competition between the eastern and western economic powers, increased conflict-driven migration and technology platforms, social media and so-called 'fake news' being used to influence national policy debates. With all these concerns, it is not a surprise that cities are facing some repercussions. Metropolises represent the economic, cultural and social heart of a nation and are the symbols of a country's standing in the world. They are often used and targeted by protestors to demonstrate their disaffection or to raise concerns. Against this backdrop the perils of social unrest, political dislocation, trade wars and terrorism are on the rise. These multiple sources of uncertainty increase risks and might deter long-term investment. Such trends place assets at risk and negatively impact trade flows and GDP. *Lloyd's City Risk Index* analysis also found that geopolitical and security risks – interstate conflict, civil conflict and social unrest, terrorism – have an estimated annual impact of \$133 billion globally.



Insurance solutions

Political risk insurance covers losses arising from physical damage – for example, following a war, terrorist incident or riot – and business interruption. Political risk insurance also covers financial lines – the loss of earnings due to credit restrictions being imposed, and the expropriation of assets by a public body, for example.

Political risk often prevents international businesses from investing in a new market and can also lead to businesses reducing or withdrawing their investment. In part, this is because political risk has a high (and hard to quantify) cost and is unpredictable.

Political risk will always have a detrimental effect on foreign direct investment and the wider economy. However, improved data and access to insurance solutions may allow for investments to occur which benefit both the business and the local economy. (Lloyd's City Risk Index, 2018)

Resource availability

Increased populations, energy use and irrigation for food production are the most significant factors for emerging water shortages. In the US, up to 96 out of the 204 freshwater basins are projected to face shortages (Brown, et al., 2019). These shortages are concentrated in the middle and southern Great Plains, the Southwest, and much of California where cities' reliance on groundwater pumping at levels beyond natural replenishment is already becoming more frequent (Brown, et al., 2019). Water shortages in the US are reported to be increasing conflicts between different industries (Brown, et al., 2019). Research has found that as shortages become more common and severe, users in high-value areas in cities, such as industrial and energy sectors, have been securing additional supply at the expense of lower-value sectors such as agriculture. This in turn raises concerns about food security, with the agriculture sector coming to rely on fast improvements to irrigation efficiency beyond the current pace of technological advances as well as moving away from low-value crops (Brown, et al., 2019). As economic activity must change in response to water scarcity, or cities no longer become viable places to live and work, the risk of stranded assets will rise. This is a global threat as well as a US one.

Indeed, droughts affect cities' economies. A study looking at 78 cities in Latin America highlighted how droughts can significantly harm the economic activities of large metropolitan areas. It suggested that the magnitude of the impact of droughts is significantly larger than the impact of wet shocks, such as floods. Large sustained dry events decrease the probability of being employed, hourly wages, hours worked and labour incomes. Informal workers are the most impacted by droughts (Desbureaux & Rodella, 2018).

Example: London

Water supply is set to become a more important issue as water demand in London is forecast to exceed supply during the next ten years with severe water shortages possible by 2040 (Buckle, 2016). As London experiences less rainfall than in the past, water supplies are therefore under pressure, and this is before considering population growth (Ritter, 2018). The water utility companies in London are likely to come under increasing pressure to prevent leaks and stop sewerage overflows as well as potentially having to buy land to develop more storage reservoirs to service London.

Riot & civil unrest

Insecurity and risk undermine the long-term sustainability of cities worldwide. With civil unrest, riots, crime and violence, insecurity in cities is rising. They are the consequences of recent social, political and geopolitical phenomenon. Protests against actual political context, climate inaction, social and economic inequalities, lack of democracy and resources scarcities are becoming more common in cities around the world.

“Cities are being targeted as sites for the confrontation of opposing powers, regimes and ideologies”.

Lloyd's report *Political Violence* found that a combination of autocratic governments, high proportions of young people in populations and growing internet use should be monitored to identify where and when civil unrest might take place. Other factors, such as economic slowdown, financial crises and commodity price fluctuations should also be monitored (Lloyd's, 2016).

War itself is now being urbanised, with cities being targeted as sites for confrontation between opposing powers, regimes and ideologies. Militarisation is seen as being necessary to thwart civil disobedience and consequently greater limits have been placed on protests and violent measures are more often used to sanction demonstrators. Urban crime and violence can be detrimental to economic development by impeding foreign investment and negatively impacting international tourism.

Example: Johannesburg

On the streets of Johannesburg, social unrest is taking the form of demonstrations and violence targeted towards immigrants from elsewhere in Sub-Saharan Africa. Growing resentment of recently arrived migrants and perceptions of them taking jobs from the indigenous population poses risks to economic activity with foreign owned businesses and shops being attacked. This risk is likely to increase as more GDP creation is concentrated in Johannesburg meaning it will continue to be a magnet for migrants from around the African continent (Powel & Cassim, 2018).

Nexus – Climate change and migration

Climate change and economic situations can impact migration flows. Factors driving migration are multifaceted and as much a product of sustained and chronic underinvestment in rural areas as jobs, international migration, or the pull of an urban life.

Climate change has an impact on human migration, with millions of people displaced by shoreline erosion, coastal flooding and agricultural disruption. Climate refugees are likely to be 200 million by 2050 (International Organization for Migration, 2008).

The meteorological impact of climate change can be divided into two distinct drivers of migration; climate processes such as sea-level rise, salinisation of agricultural land, desertification and growing water scarcity, and climate events such as flooding, storms and glacial lake outburst floods. But non-climate drivers, such as government policy, population growth and community-level resilience to natural disaster, are also important. All contribute to the degree of vulnerability people experience (International Organization for Migration, 2008).



Implications for risk managers

A prudent risk manager might want to compare what they spend on insurance for political risks to what they spend on covering geophysical threats in these highly exposed cities. It is usually possible to expand terrorism and political violence coverage to include, for example, organised crime coverage.

Risk managers should also consider the impact of civil disturbance on sales and operations. In some cases, their operations may be a target; goods and services could also be boycotted through a social media campaign and steps should be taken to demonstrate the social value of their investment. Even if specific investments are not targeted, businesses should consider possible routes or focus points for demonstrations. Can employees get to work, can goods be shipped? Is insurance cover in place for interruption to operations? (Lloyd's City Risk Index, 2018)

Terrorism

Cities are on the frontline of 21st century terrorism. They are increasingly becoming targets as they provide high levels of visibility and impact as a result of their social, political, and economic centrality. High concentrations of people and complex infrastructure leave cities vulnerable to potentially devastating attacks. Social and political trends influence terrorism and current political climate tension has seen terrorism on the rise. The rise of extremist ideologies, nationalism and protectionism have raised global geopolitical tensions and increased the number of terrorist attacks against a more liberal world (and neoliberal). Social change and a more liberal outlook in maturing cities make them more of a target for terrorists, who may be better able to coordinate activity through technology and to exploit social unrest. Traditionalism is exposed to liberalism in cities; innovation and development make cities more of a fertile environment for terrorists.

As the threat of terrorism has increased over the past two decades, cities have risen to the challenge. They have invested in smart infrastructure, unobtrusive adaptations and have reinforced the existing building structures to minimise risk. Terrorism prevention and suppression will likely rely on more complex technology, meaning cities are more vulnerable if this technology is disabled through cyber-attack or energy blackout.

“Social change and a more liberal outlook in maturing cities make them more of a target for terrorists”.

The City Risk Index identifies the largest and frequent losses cities face. Businesses in cities with concentrations of high value assets, such as New York, London and Paris, will lose more than emerging cities in terms of direct and indirect losses on an annual basis. One-off costs can be very high. Although New York does not feature in the top 10 cities that stand to lose the most from terrorism annually, a single extreme terrorist event in the city could lead to losses of up to \$102.69 billion (Lloyd's City Risk Index, 2018).

Example: Riyadh

Geopolitics and Security is the major area of threat that Riyadh is facing and is unlikely to become any less relevant. Potential increases in citizen-led pressure for social reform comes at a time when social protests and demonstrations are still banned.

According to the Ministry of Economy and Planning, Riyadh's and Saudi Arabia's economy aim at diversifying and moving away from fossil fuel dependency to develop a more externally focused and sustainable growth. Rather than face internal pressure to reform, there is the risk of domestic pressure against doing so.

For example, liberalisation of alcohol sales was greeted by protests in 2019 by those opposed to the reforms (Toumi, 2019). New infrastructure and urban developments could become a higher profile target for terrorism. The increasingly fraught regional political environment is part of this risk with conflict between Shia majority and Sunni majority states a potential cause of terrorism or interstate conflict.



Counter Terrorism Preparedness Network

In June 2018, the cities of Barcelona, Greater Manchester, London, Paris, Rotterdam and Stockholm came together to discuss the challenges and priorities associated with terrorism in their cities. They recognised that the stresses and challenges caused by attacks were shared across cities in a way that doesn't always affect nations, and so that much could be learned from each other.

The network was established to promote dialogue, the sharing of practices and experiences, and as a means of developing new approaches to counter terrorism, as well as, as the strategic preparedness and response arrangements of cities in this context.

The mission of the **Counter Terrorism Preparedness network** is to bring together strategic leaders, practitioners and academics to inform city-level policies and practices that build resilience to keep cities and communities safe from terrorism (Counter Terrorism Preparedness Network, 2019).

Opportunities and challenges for insurers

The loss of property, infrastructure, communication connectivity and trade has resulted in the rise of terrorism insurance. However, as threats evolve and take different forms buyers are seeking to expand terrorism definitions in insurance coverage. Terrorism attacks are changing in scope, goal and format. With cyber-attacks and social disruption having the potential to cause major disruption they must also be considered significant threats in addition to established forms of terrorism.

The Lloyd's market provides support to face the impacts of political unrest. However, as the form of disruption is changing, insurers should look at the cover they offer and tailor them to this new world.



How is terrorism coverage evolving?

In the UK, Pool Re provides terrorism insurance to insurers to enable them to mitigate risk. Essentially, reinsurance can limit the amount of loss an insurer can potentially suffer.

The gap in insurance coverage was highlighted in the 2017 attacks in Manchester and London Bridge, where small and medium-sized businesses were shown to be particularly vulnerable, with several caught behind police cordons or experiencing a reduction in footfall following the events. In the case of Borough Market, over 150 small business owners together lost at least £1.54 million over 11 days of disruption (Pool Re, 2019).

In February 2019, Pool Re's founding legislation has changed, allowing them to reinsure business interruption losses arising from a terror attack which are not contingent on damage to property. The amendment made Pool Re the first terrorism pool worldwide to extend its cover to include Non-Damage Business Interruption – Denial of Access or Loss of Attraction losses.



Insurance solutions

The Lloyd's market has been a pioneer in the development of political risk cover. Following the rise of expropriation, nationalisation and confiscation in the 1960s and 70s, Lloyd's syndicates took the lead in establishing political risk cover which, until then, had been limited to the public sector. Lloyd's paid billions in claims following the 9/11 terror attacks (Lloyd's City Risk Index, 2018).

Most recently, there has been a trend towards 'lone wolf' terrorist attacks where a single or small group of terrorists, often armed with knives, have been able to cause considerable loss of life and disruption to a city's economy.

Traditionally, insurance has covered businesses that have been directly damaged by terrorism, for both physical damage and business interruption. However, recent terrorist events in Australia, France and the UK have demonstrated that it is not only businesses that suffer direct losses that are impacted. If a business finds itself in the vicinity of an event, or even behind crime-scene cordons, they can suffer substantial losses even if they are not directly harmed.

Insurers in the Lloyd's market are taking the lead in finding insurance solutions to this issue. Beazley, Hiscox and Talbot are among those that have developed terrorism cover as a standalone policy, or as an add-on to property insurance cover, for denial of access to compensate businesses that end up behind a police cordon, and loss of attraction cover to insure against lost earnings.

Business interruption cover is particularly attractive to companies in the hospitality industry, as, typically, room rates fall after a terrorist incident (Lloyd's City Risk Index, 2018).

Lloyd's Product Innovation Facility has developed a parametric solution targeting the hotel industry. The solution is led by Tokio Marine Kiln, with Facility members Chaucer, Munich Re Syndicate, Beazley, Faraday, and AXIS offering additional support. The product leverages a parametric trigger structure to ensure rapid payout post-event against lost profits which could occur as a result of unexpected events. This includes terrorist attacks which can result in less tourism and a loss of revenue for hotels (Gallin, 2019).

Pollution risks

In May 2016, the World Health Organization (WHO) reported that more than 80% of urban areas have levels of air pollution higher than the limits it recommends for health reasons (Notman, 2017).

The transport sector is responsible for a large proportion of urban air pollution. Higher urban air pollution concentrations increase the risk for cardiovascular and respiratory disease, cancer and adverse birth outcomes, and also are associated with higher death rates (World Health Organization, 2020).

Example: New York

To reduce air pollution, local authorities have implemented a new policy in New York. One of the biggest changes facing building developers and owners will be the implications of the Climate Mobilization Act (CMA) passed by New York City authorities in April 2019. The new regulation sets emissions caps and energy efficiency measures for the more than 50,000 buildings over 25,000 sq. ft. The target to reduce emissions from buildings by 10% compared to 2005 and to ban new all-glass fronted buildings could affect the value of collateralised Air Rights if the costs of pencil towers increases (St. John, 2019).

Example: Shanghai

Despite recent significant investment in renewable energy and the remediation of natural infrastructure, driven mainly by central state government, Shanghai, like much of China suffers from significant levels of pollution. A recent study estimated that the country's greenhouse gas emissions will not peak until 2025, though this is five years earlier than originally targeted (SEEC Group, 2015). The World Health Organisation claims that by 2025, air pollution will result in more than one million lung cancer patients across the country. A report in 2013 identified that the number of cases was rising 26.9% year on year (SEEC Group, 2015). According to the China Academy of Environmental Planning, it will be 2030 before water, soil and air pollution levels can be regarded as consistently safe (SEEC Group, 2015).

Example: Fly-tipping in cities

Illegal dumping of waste is on the rise in cities. From fridges on street corners to furniture in car parks and mountains of rubbish bags dotted across town, this phenomenon is increasing in the world (Perry, 2016). Between 2014-2015, England had more than 40% of incidents taking place in London (Perry, 2016). These incidents cost British taxpayers £58 million to clean up (Green Journal, 2018).

Pandemic risks

Based on the interviews in February, several cities raised pandemics as a major risk. Cities gather people together which has serious implications for pandemic risks as denser populations are more at risk of spreading illness due to proximity. In addition, public transport, public spaces and multiple occupancy buildings all increase the likelihood of diseases spreading. Rapid growth and the globalised, highly interconnected nature of cities have added new levels of urban health risks. The spread of disease in cities often occurs as a result of inadequate infrastructure and services. High incidence of traffic fatalities, air pollution related respiratory infections and premature deaths can be related to inadequate urban infrastructure.

The growth of informal settlements has a demonstrably adverse impact on human health. The structural and socio-economic features of such informal settlements suggest the threat of infectious disease will increase as these populations grow. Rapid urbanisation will continue to increase the risk of infectious diseases emerging more frequently and severely in metropolitan areas.

The spectre of similar negative health externalities is also present in developed economies. The homelessness crisis experienced in London is reflected and growing in many other global cities, raising the risk of a return of perils once considered a thing of the past. Infectious diseases such as typhus and measles have occurred in California, first among the growing homeless population and then to the wider urban community. Such instances impact on public service delivery and on the urban economy and suggest a threat which could impact on workplaces and high-value economic clusters.

One possible consequence of the current pandemic is its impact on urban planning in the future. One key consideration is now striking the right balance on population density between economic growth and maintaining public health.

Example: Johannesburg

The Johannesburg metropolitan area population is growing but the prevalence of HIV amongst the young population is a major risk to this population increase. With around 600,000 people in the city living with HIV, the scale of the epidemic is larger than any other city in the world (World Bank, 2016).

Cities at risk
Building a resilient future for the world's urban centres

Natural catastrophe and climate



Natural catastrophe and climate

Cities are dealing with the pressures of climate change, facing the top five hazards due to global warming (surface flooding, heat waves, rainstorms, extreme hot days and droughts) (CDP, 2019). As cities continue to spread, concentrations of urban populations will expose more people, their homes and places of work to the established and growing threats related to climate change. With the densification of people and property continuing in areas of potential vulnerability and on newly urbanised compromised land, it is these most recently urbanised communities that will be at most risk.

Cities are also playing a crucial role in trying to lower the impact of climate change. Indeed, the most ambitious decarbonisation initiatives are at the city level and generally speaking cities have lower energy use per capita than less densely populated areas. Recognising that urban environments play a role is helping to reduce emissions and the need to have greener cities is important.



Insurance solutions

Special catastrophe insurance is available for specific natural disasters, such as flood insurance, storm insurance for hurricanes and tornadoes, earthquake insurance, and volcano insurance.

In 2015, Lloyd's created the Disaster Risk Facility group gathering seven Lloyd's syndicates to help developing economies build resilience against natural catastrophes. Lloyd's syndicates are joining forces to help developing economies tackle underinsurance and improve their resilience against the economic impact of natural catastrophes.

Flooding risks

Coastal cities face a high risk from increasingly costly flooding as sea levels rise due to climate change. A new study looking at cities around the world found out that the cost of damage to large coastal cities globally could rise to \$1 trillion a year if cities don't take steps to adapt. It also encouraged early action and warned that some of the cities where flooding will increase the most in the coming years are not the cities where the risk is particularly high today (World Bank, 2013).

Example: Shanghai

Tropical winds and floods are dominant perils facing Shanghai. The foundations of central Shanghai are being compromised by continued exploitation of underground water as well as the construction of skyscrapers in its densifying core. The physical densification of Shanghai's urban core is likely to place geological pressures on the ability of the land to support the city's weight. This trend will present a greater insurance risk to build assets in the future as melting polar ice caps are projected to increase the level of Shanghai's coastal waters by between 9 and 27 inches by 2050 (SEEC Group, 2015).

The city needs to develop a resilient infrastructure proposition in the face of rising sea levels and the challenges of a changing climate.

Example: New York

New York is exposed to the risks of climate change through sea level rise and increasing temperatures. The city is at risk of flooding.

The Metropolitan Transportation Authority is planning to raise up to \$60 billion of capital investment to modernise the subway over the next 10 years (EY, 2019) potentially resulting in over 3,500 new subway cars, elevators at 180 stations and nearly 5,000 new buses (Matousek, 2018). Currently an average of 13 million gallons of water has to be pumped out of the subway system multiple times a week (Gannon, 2018) rendering the system vulnerable to flooding as seen in 2018. Whilst improved stations and flood defences are intended to mitigate against flooding the effects of climate change could still potentially increase the risk to new subway infrastructure (Meyer, 2017).

Hurricane risks

As the world's population becomes increasingly concentrated in cities, they are witnessing the urbanisation of disasters. Hurricanes Florence, Maria and Irma all underscore urban risk. Cities are reacting and are trying to prepare to face these upcoming challenges.

“Disaster response, experts have begun utilising non-traditional data sources to assist with planning” (Green, 2020).

Example: Miami

Miami is well known for the risk it faces from coastal flooding and hurricanes. The city is becoming increasingly vulnerable to extreme weather disasters, such as Hurricane Irma, and climate threats, such as sea level rise (Garfield, 2017). Continuing urbanisation and population growth are set to put more strain on infrastructure and housing supply in the city and to further render business and built assets in areas vulnerable to flooding and hurricanes.

In recent years, the city has been preparing by elevating its roads, re-building its seawall, installing more pump stations, and improving its drainage systems. To raise the roads the city is implementing traffic detours, removing existing pavements, replacing old water lines, drainage and sewer lines, and adding more asphalt to make the streets higher. Miami is mandating the construction of new buildings to be constructed 1.5 meters above current sea levels (Garfield, 2017).

The probability of future substantial insurance loss to asset values and business disruption of hurricanes and flooding depends on the success of flood protection measures in existing neighbourhoods and new buildings as well as on the scale of the impacts of climate change.



Waterfront Alliance

In 2012, Hurricane Sandy ravaged the New York City metropolitan region along with the entire East Coast of the United States. It was a wake-up call for the potential of not only future storms, but the impact that sea level rise poses to the region's people, economy, environment, and overall long-term viability in which one million people are at risk of flooding today and rising.

Catalysed by the need to act on reducing regional risks to climate, the non-profit organization **Waterfront Alliance** developed a LEED®-like rating system for waterfront projects that builds resilience at the site scale (WEDG®), and has worked with stakeholders to build consensus and a campaign (**Rise to Resilience**) for the changes needed to adapt the region. Diverse stakeholders ranging from grassroots advocates to government officials, to business experts including Lloyd's have identified a suite of policies, investments, and programmatic changes that will better prepare the region for the risks it faces. Key proposals, among others, are to:

- Reform FEMA and the National Flood Insurance Program to better incorporate future risks, reduce vulnerability, and prioritise low- and moderate-income communities.
- Develop long term funding sources for building resilience to sea level rise and coastal storms
- Develop flood-risk disclosure regulations and public awareness campaigns to better inform buyers and renters of property risk.
- Support an equitable and just transition through investments in affordable and public housing options in safe, transit-connected communities on higher ground and workforce development opportunities.
- Invest in habitat restoration and green infrastructure, prioritising environmental justice communities for multiple benefits.

The Rising to Resilience campaign will advocate for these proposals, among others, building public awareness and seeking policy action at federal, state, and local levels and better prepare the region for climate change.

Earthquake risks

Earthquakes affect every continent and certain areas are especially prone. They can cause devastating damage and large numbers of casualties very quickly. According to the Centre for Research on the Epidemiology of Disasters (CRED), more people worldwide are moving into urban areas in highly seismic zones, contributing to the number and size of informal settlements that are extremely vulnerable in the event of an earthquake (Giles, 2017).

Example: Mexico City

In 1985, Mexico City region was shaken by a serious earthquake. More than 360 people died, 150 to 200 buildings were destroyed, and more than 3,000 other structures were damaged. Mexicans endured the violent earthquake and its damage and decided to act rather than retreat (100 Resilient Cities, 2017).

Mexico's recovery and resilience-building efforts remain a central challenge for years to come. Mexico City's Resilience Agency oversees disaster preparedness and integrating community planning to ensure the city's future (100 Resilient Cities, 2017).

In 1991, Mexico City's created an early warning messaging and information system. The system is following a specific procedure: special radio receivers in schools, government offices, and TV and radio stations receive radio broadcast alerts that provide warning of imminent shaking. From its inception through to September 2017, the system issued a total of 33 alerts. Public opinion regarding this procedure is generally positive. People appeared to see value in having an alert system (Allen, et al., 2018).



Instant claims for earthquake damage

In earthquake-prone California, 87% of homeowners don't have insurance because it is considered unaffordable.

Underwriters at Lloyd's are addressing this by underwriting parametric insurance in partnership with retail broker Jumpstart, based in Oakland, California, and coverholder AmWINS. Jumpstart offers a new, more affordable and more accessible alternative to traditional earthquake insurance.

There are several benefits for customers: the buying process is fully automated, claims payments are automatic and since there is no need for a loss adjuster's assessment, funds can be released in a matter of days. Jumpstart's policy does not pay for all the damage to customers' property caused by an earthquake but pays \$10,000 to each policyholder quickly to cover their immediate costs post disaster (Lloyd's, 2019).



Insurance solutions

Property Damage policies indemnify the insured in the event of damage to the physical or material assets of the business. The main items insured are buildings, machinery and plant, stock and other contents. A range of policies are available including fire and special perils, commercial all risks, theft, glass, money, goods in transit.

Business Interruption insurance (BI) is also known as time loss, consequential loss and loss of profits insurance. It provides cover for the financial losses due to an interruption to a business caused by material damage to property.

Heat waves risks

Across the globe, hot days are getting hotter and more frequent. National Climate Assessment estimates 20-30 more days over 90 degrees F annually in most areas by the middle of the century (Centre for climate and energy solutions, 2019). In June – July 2019 Europe experienced unprecedented temperatures in the UK, Netherlands, Belgium and Germany. According to the World Weather Attribution network these extreme temperatures would be the fingerprint of climate change (Dunne, 2019).

Extreme temperatures are the cause of excess morbidity and mortality in our societies. Extreme heat can increase the risk of other type of disasters such as drought and, wildfire conditions (Centre for climate and energy solutions, 2019).

Example: Extrema.Space

An emergency notification system for extreme temperatures has been developed for cities. The Extrema mobile app spots in real time the city areas that are likely to suffer most during the ongoing event, indicating where the victims are to be expected. Extrema uses real-time satellite data, city-specific data to estimate the temperature, humidity, and discomfort index for every square kilometre in the city. The app localises cooling spots, access to water points and shares good practice. Athens, Rotterdam, Paris, Mallorca and Milan are already using the mobile app (Extrema, 2018).

Nexus – Infrastructure and climate change

Urban areas cannot function effectively without layers of infrastructure. This infrastructure ranges from what may have once been viewed as basic utilities such as water, power and connectivity through to multi-faceted, multi-modal areas such as effective integrated public transport. Due to changing technological, social and spatial factors many cities' infrastructure systems are struggling to cope as they are used in ways that were never imagined during their design. With global warming, the energy demand is globally increasing as new systems like cooling infrastructure are implemented massively to face high temperatures

The clustering of assets, services, people and opportunity ensures that cities are efficient and can produce more effectively. The risk is the fact that in cities with highly clustered assets single events can now cause far more damage.

Building effective infrastructure requires a compelling use case. Insurance can help provide a great deal of certainty by offering cover against various risks that threaten projects. In fact, many government projects around the world demand such coverage before projects can move forward.

With climate change, and the increase of extreme weather events, it is going to be increasingly important to create building codes that are robust to both current and future risks. Engineering studies will be necessary to achieve this since past data will not always be a good guide to the future. New tools to face flooding or earthquake-resistant construction for example could be developed.

Failing infrastructure exposes citizens to fresh threats, ranging from health concerns from water supplies to catastrophic harm and disruption when physical infrastructure collapses.

How are cities reacting to natural catastrophes risks?

Cities are developing risk management strategies to assess risks and try to reduce their impacts. The Urban Risk assessment (URA) is a framework created by the World Bank that seeks to strengthen coherence and consensus in how cities can plan for natural disasters and climate change. Local authorities can plan and respond better if the location and nature of risk is known, and also if risk assessment and management is mainstreamed in urban development and management programs. Risk assessment needs to be undertaken at regular intervals so that the city governments can evaluate progress toward reducing risk and vulnerability (Dickson, et al., 2012).



ICLEI - Local Government for Sustainability

ICLEI - Local Government for Sustainability is a global network of more than 1,750 local and regional governments committed to sustainable urban development. ICLEI looks at sustainability and makes it an integral part of urban development to create change in urban areas through practical solutions. The aim of the organisation is to help cities of all sizes to anticipate and respond to complex challenges like rapid urbanisation and climate change (ICLEI, 2019).

The ICLEI Urban Resilience Methodology supports cities and communities to understand the major challenges, shocks and stresses which may impede secure, sustainable development and to develop strategies to build resilience to these challenges. The Cycle is aligned with ICLEI's Green Climate Cities and Nature Pathway planning cycles and is offered as a systematic and achievable way for cities and communities to plan and act. It is a 9-step process in 3 phases: 1) *Analyze* - assess urban risks and vulnerabilities; 2) *Act* - develop and implement options to build resilience to these risks to ensure a city can achieve its sustainable development goals; and 3) *Accelerate* - scale up this activity and to link with national and international networks, campaigns and initiatives (Resilient Cities 2019, 2019) .

Insurance Industry Development Goals for Cities

In 2018, the Insurance Industry Development Goals for Cities, launched at the ICLEI World Congress in 2018, released 10 goals designed to help the insurance industry to respond to the growing threat of extreme weather events, air pollution, and the need to promote clean energy, healthy living, and climate resilience. The Goals provide a global framework to guide collaboration between insurers and local governments to accelerate climate action. The Insurance Industry Development Goals for Cities serve as a global action framework for the insurance industry to make cities inclusive, safe, resilient and environmentally sustainable (Wentworth, 2018).

Cities at risk
Building a resilient future for the world's urban centres

Technology and space



Technology and space

Cities generate a vast amount of data. From measuring power demand to the use of public spaces, urban areas offer insight into the way their citizens think and act. With the scope of data expanding year on year its value is increasing both to the city and private entities who want to use it to drive enterprises, provide services or to support new business models. However, the scale and complexity of city-sized systems mean that catastrophic scenarios are a possibility. As cities are becoming interconnected, they rely more on smart technologies which raise new risks.

Cyber-attacks

A smart city relies on a rich and diverse set of data flows and a growing volume of sensors, devices and nodes to capture and transmit that data. The challenge is that every component, device and node is a possible point of attack. According to Lloyd's City Risk Index, cyber risks represents \$36.54 billion of GDP@Risk.

Example: New York

5G will see more data flowing through New York than ever before and will enable faster communications. The opportunities and impact of 5G are likely to be realised soon with the first 5G network rolled-out in New York in 2019. New and growing data and communications networks will be critical to the deployment of smart city technology. The 2019 New York City plan intends to deploy thousands of smart sensors and a low power wide area network using blockchain to store and secure data collected from city infrastructure assets (SmartCitiesWorld, 2018).

Data security has become a more important issue, not just for businesses and infrastructure owners but also for people and service providers. For example, in April 2019 30 out of the 2,000 open access datasets were made publicly available by New York City authorities on a new platform to enable developers to create apps using household data such as income and health to identify household eligibility for different social benefits (Plautz, 2019). As more data and the economic activity, it drives is exposed to cyber-attack, continued efforts will be needed to combat and prevent these threats. Therefore, cyber security itself is likely to be a growth sector in New York with more investment, innovation and job creation. The \$100 million public-private investment in the CyberNYC initiative is one example of how New York City is seeking to be a global leader in cyber security (NYC EDC, 2019).



Insurance solutions

Lloyd's offers a range of insurance products for cyber risks.

Breach response: A Data Breach Response Policy goes beyond a traditional liability insurance policy. It also provides a service which helps organisations manage the aftermath of a breach as well as providing coverage for the costs of notifying clients, forensic investigations, credit monitoring for customers, legal costs and public relations services to help manage any reputational harm.

Liability: Liability claims from a data breach can be costly to organisations. This policy provides coverage for third party claims and associated defence costs arising out of a data breach.

Regulatory: A data breach can also lead to significant regulatory fines and penalties. This policy provides organisations with coverage for the defence costs associated with regulatory investigations, to the extent insurable by law.

Extortion: Ransom demands and malicious threats are on the rise. This policy provides coverage for the costs in relation to restoring the organisation's affected systems.

Business Interruption: Cyber incidents can lead to significant loss in revenue and bring business operations to a halt. This policy provides coverage for the income loss resulting out of interruption to, or downtime of, an organisation's IT system. It also provides assistance in restoring the data, network and IT system.

Reputational Harm: Cyber incidents can have detrimental effects on an organisation's reputation leading to loss of revenue. This policy provides coverage for financial losses incurred from loss of contracts due to a cyber incident.

PCI DSS Assessments and Fines: Organisations affected by breaches involving payment card data are exposed to PCI related fines and PCI DSS assessments. This coverage deals with costs relating to stolen card data, reimbursements of card reissuing costs and forensic investigations into the extent of the misuse of the card data. (Lloyd's, 2020)

Ransomware attacks

Cities are finding their infrastructure and networks now rely on complex online systems. The incentives to launch ransomware attacks on these networks is growing. Ransomware is a form of malware that threatens to destroy or block access to files unless a ransom is paid. Ransomware can hide in carefully tailored emails that appear to be from a genuine source. Once a single employee has opened the attachment, a hidden executable code may be able to run on the computer, downloading and spreading the ransomware worm.

“The scale and complexity of city-sized systems mean that catastrophic scenarios are a possibility”.

Cities are already regularly facing small scale ransomware attacks that impact on their networks, attacking everything from power supplies to hospitals. These can be handled effectively but with the development of more networked service provision there is an increased chance that any attack will spread.

Nexus – Energy and technology

Cities need energy to function and in a growing city this demand may expand far quicker than its population. Energy is needed by every stakeholder of a modern city and an interruption or lack of supply is rarely a minor issue.

Innovations in city design are also increasing the demand for energy. As these systems become ever more inter-connected to urban infrastructures they are exposed to certain weaknesses. These have been shown to open cities up to lawsuits when systems fail. Insurance can help provide reassurance providing public liability and cover against class action lawsuits.

However, with major data centres becoming more and more attractive targets for malicious actors any new coverage should be contingent on an effective security strategy.

Automation through robotics and AI also both place demands on the energy systems and data security of cities. Companies are looking to ensure that they can avoid costly periods of down time.

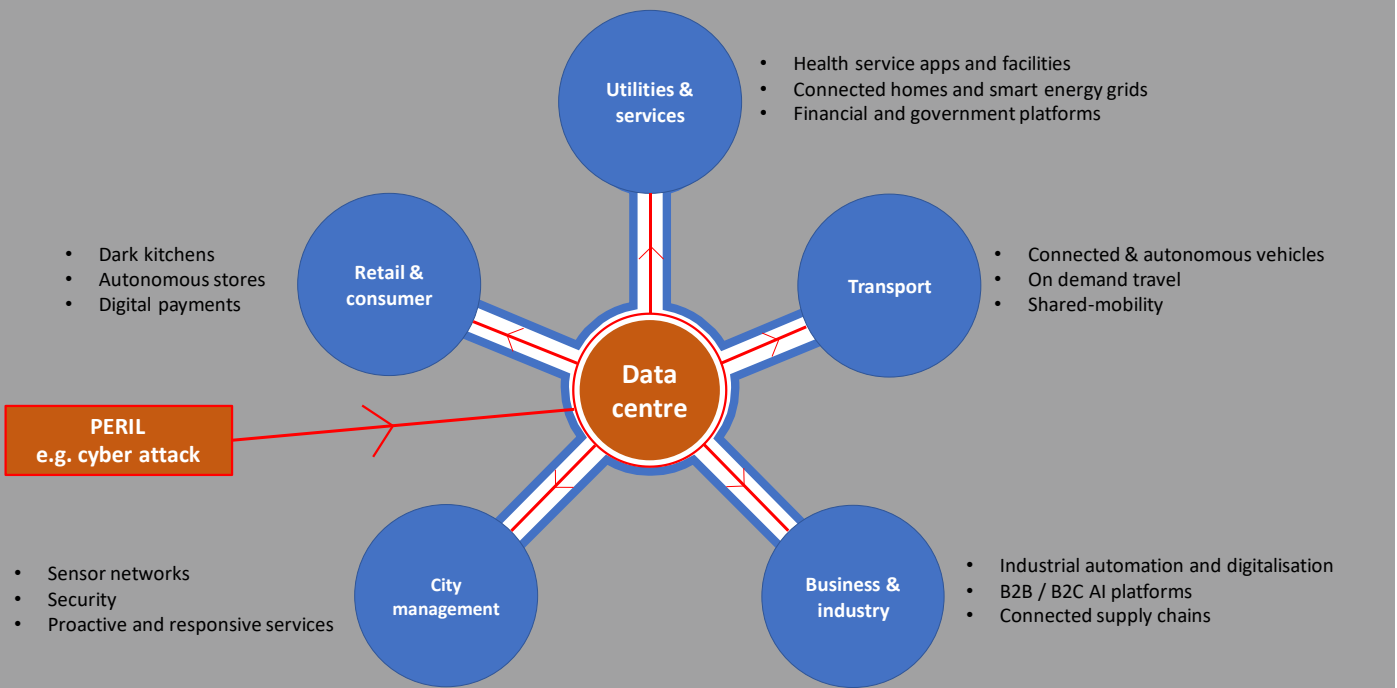
Issues had been known to arise in past blackout periods. There remains a significant threat if a large blackout occurs. The 2015 ‘Business Blackout’ report by Lloyd’s looked at a hypothetical cyber-attack that caused vast and lasting damage to the US power grid. This scenario highlighted risks in a wide range of areas that could be affected, and could be used as a framework to explore the impacts of power outages in cities.

Box 6: Scenario - Data centre shut-down

In such a scenario the resilience of critical nexus infrastructures such as data centres underpin the ability of the city - as an urban system of systems to – to perform effectively. Risks to such underpinning infrastructure pose an existential threat a growing number of different city systems.

Traditionally, the risk of cyber-attack was predominantly faced by the city systems targeted, whether specific organisations, businesses or service providers. The trends investigated in this report show how data and connectivity are becoming critical across all city systems. As a result, cyber-attack on a city’s datacentre or telecoms network no longer impacts just a targeted organisation, it can bring an entire city to a halt. Lack of connectivity and lack of access to data can prevent people from ordering their ride home or food, disrupting automated businesses, and leaving city officials without the data and connectivity needed to manage the city infrastructure, transport and environment.

Figure 9: Data centre shut-down and impacts on city’s ecosystem



To describe the image specifically, it shows the different systems and functions in the city which the data centre supports. The data centre acts as a nexus risk, as any threat which impacts on the data centre is then radiated out with secondary impacts on the people and businesses who directly or indirectly rely on the data centre for everyday activity. In this example the peril shown is an incoming cyber-attack, however energy disruption or flooding are other potential threats which would have the same effect if they cause the data centre to shut down.

Data breach

Cities are becoming a major focal point in the personal data economy. Cities are collecting data from their citizens and there is a clamour for data-informed approaches to everything. This is seen as a triumph for advocates of the better use of data in how we run cities. However, even if there is a general acceptance that social, economic and environmental pressures can be better responded to by harnessing data, the question regarding how and who can use this data is central to local authorities. Cities are looking to develop innovative practices and policies around the responsible use of data about people (Nesta, 2018).

Data breaches are a key concern. Some of the data can be used to directly identify individuals and if this is compromised it can have serious consequences. This leads to reputational damage, fines from regulators and the need to improve and alter digital infrastructure to avoid the event recurring. Insurers can help through using established forms of cyber coverage. Unfortunately, as these targets become more valuable there is a chance that breaches may occur more frequently and could be perpetrated by state actors. There are currently cases being tested in court where insurers have argued they are not liable for this cover as it falls under exclusions set out in the coverage, specifically excluding hostile actions by other countries. While this may save costs and help set a precedent for future claims it does have the potential to highlight the limits of the cover to customers.

“The question regarding how and who can use data is central to local authorities”.

Example: New York

On July 2019, New York amended its data security breach notification law. Governor Andrew Cuomo signed into law the Stop Hacks and Improve Electronic Data Security Act (“SHIELD Act”) (Asner, et al., 2019).

The SHIELD Act represents the latest measure adopted by New York State officials to broaden the cybersecurity-related obligations of New York businesses. It adds new substantive cybersecurity requirements for breach prevention purposes (Asner, et al., 2019).



IoT & Dynamic Pricing

The IoT has the potential to significantly change the underwriting and pricing models of insurance companies. By knowing more about their customers and assets, insurers can react to risks in a dynamic way. Thus, the sector is expected by some, to move away from a reactive passivity to a proactive approach that mitigates and even prevents claims.

Methods of calculating losses based on years of historic data may thereby also transform and shift towards the increasing reliance on sophisticated data science and predictive techniques.

Advances in technology mean the sector will reach a point where proxies currently used may no longer be useful or even necessary to understand an individual's behaviour and product usage. This means that insurers will be in a better position to assess risk, understand complex exposure (and manage it), as well as estimate the necessary capital reserves, making capital calibration more fluid (Lloyd's, 2018).

By using new sources of data such as Internet of Things (IoT) devices, insurers may be able to alert clients to potential losses before they occur, assess damage in real time, speed up the claims process and prevent false claims, reduce administration through automation, and allow more personalised products and services to be developed (Gasc, 2016), aiding overall response.

Cities at risk
Building a resilient future for the world's urban centres

Finance, economics and trade



Finance, economics and trade

Economic development is often the most discussed challenge in local authorities. Mayors cite the many gains in business and job growth in their cities. More and more cities are making it easier for entrepreneurs to start or grow a business. A growing number of cities are working to unleash the creative potential of small-scale manufacturing and the maker movement (Rainwater, 2016).

Almost \$150 billion a year is at risk in 279 cities around the world from market crash, commodity price shock and sovereign default – according to the Lloyd's report: *Global analysis of finance, economic and trade risks*. The cities which stand to lose most GDP to financial risk are primarily established financial centres. This does not mean they are more likely to experience a market crash, rather that the impact will be greater, given their importance as economic hubs (Lloyd's City Risk Index, 2018).



Insurance solutions

The Lloyd's market offers a range of insurance products for finance, economic and trade risks.

Financial guarantee, which insures the policyholder against a number of trade risks including bankruptcy, lack of sales and receipts and changes in currency rates, interest rates, land or securities.

Contract frustration which insures against loss under a specified contract for the sale, purchase, lease or delivery of assets, goods or services as a result of a political event or the action of government.

Trade credit, which covers a business for losses from the failure of debtors to pay debts.

Currency inconvertibility, which protects against a government enacting new currency restrictions.

Business interruption, which covers lost income from an event which impedes business operations and event insurance, which covers financial loss as a result of an event being cancelled.

Market crash

Market crash is the costliest risk in Europe, North America and Latin America, and the second largest threat in Asia Pacific. More than two-thirds of US cities have market crash as their costliest risk, with a combined cost of \$19.9 billion, because of their reliance on private capital. Although established centres stand to lose the most, every city is exposed to this threat, which can lead to reduced investment and increased unemployment (Lloyd's City Risk Index, 2018).

The drivers of market crash are manifold and difficult to monitor. Currently, the IMF is predicting that the global economy will continue to grow, albeit at a slower pace, but economists have indicated a number of concerns. The Chinese economy, which has fuelled global expansion, is growing at a slower pace than previously, which could impact cities with economies that import to China (Lloyd's City Risk Index, 2018).



Implications for risk managers

Market crash has multiple implications. Careful management of slow payments can alert risk managers to a market downturn and allow businesses to adjust credit lines. Risk managers should also have a clear understanding of the legal implication of a bankruptcy - in particular, where would a dispute be resolved?

Market crash can trigger political risks. Demonstrating clear value to a local community can help to prevent a business being targeted by a populist government or local pressure groups who, in the event of market downturn, may organise demonstrations to disrupt operations.

Risk managers should consider the value of insurance in terms of protecting balance sheets, securing investment and credit management (Lloyd's City Risk Index, 2018).

Commodity price shock

One impact of higher commodity prices, particularly oil, is to raise manufacturing and household costs, which can lead to inflationary pressures on an economy. In regional terms, the Lloyd's City Risk Index shows Western European cities to be most vulnerable to this threat. The European Union imports almost 90% of its crude oil. China and US, respectively the largest importers of oil, are also vulnerable to price rises (Lloyd's City Risk Index, 2018).

“The cities most at risk of commodity price shock are manufacturing economies with a high reliance on energy imports”.

Example: Riyadh

Riyadh's economic change could have contrasting implications for the peril of market crash. On the one hand, diversifying away from an oil dominated economy reduces the exposure to commodity market fluctuations. Meanwhile on the other, expansion of the financial and service sectors exposes more economic activity to fluctuations in those markets.

There is a small but relevant linkage between oil prices and financial market performance which results in shortfalls in the national budget in times of depressed oil prices. In these instances, investments from the country's sovereign wealth fund, the Public Investment Fund, are liquidated to meet the shortfall. Such short-term sales will not always realise best value and could, over the longer term, mitigate abilities to invest in key public infrastructure projects.

Sovereign default

Sovereign default can have several consequences. Clearly, it can affect any businesses supplying goods and services - in the energy, construction or telecommunications sectors, for example, - as well as national governments. The rise in state-owned enterprises (SOEs) means that more than a quarter of the world's largest businesses are now state-owned, adding to the risk of sovereign debt crises. The City index shows sovereign default will lead to highest losses in emerging economies (Lloyd's City Risk Index, 2018).

Sovereign debt can also raise the likelihood of expropriation of assets or forced nationalisation of industries. Some indicators - if a government has signed an agreement with the Multilateral Investment Guarantee Agency (MIGA), for example - can reduce the likelihood of expropriation.

The rise in populist policies may also lead to a rise in economic nationalism which could increase the threat of expropriation.



Implications for risk managers

Risk managers, particularly those in the manufacturing sector with high energy use, should run scenarios to establish the impact of commodity price rises.

Understanding the impact of oil price rises on inflation is critical for companies with high borrowing levels. It is also important to establish the impact of inflationary pressures on critical trade partners. Will key customers and suppliers survive a rise in interest rates? How might they impact on supply chains?

Inflation and high prices can also trigger civil unrest, and businesses should review their plans to ensure the security of employees, assets and operations in the face of riots and demonstrations (Lloyd's City Risk Index, 2018).

Furthermore, the period leading up to a sovereign debt default can be characterised by governments reducing social spending. This can increase the likelihood of riots, civil conflict or social unrest, which can disrupt operations and the supply of goods (Lloyd's City Risk Index, 2018).

Example: Johannesburg

Johannesburg's economic growth and ambitious development plans are likely to keep the city exposed to its most significant threat categories in the City Risk Index; Finance, Economics and Trade and Geopolitics and Security. A more important financial and real estate sector with increased foreign investment could leave more economic activity vulnerable to market crashes.

The conflicting interests of government and international investors can be important when thinking about market threats. Zendai, a Chinese developer planned to develop Modderfontein New City on a 1,600-hectare site north-east of Johannesburg. The developers could not agree to affordable home targets or the integration of the development with public transport corridors. The site has since been sold and plans scaled back with some analysts suggesting unexpectedly low demand meant the original level of investment was unfeasible given the city's real estate market (Reboredo & Brill, 2019).

Such market forces could threaten financial returns on public transport investments, which alongside the government debt arising from the state energy company is unlikely to reduce the peril of sovereign default.



Implications for risk managers

Risk managers should develop strategies to manage debts of state-owned enterprises and renew these when governments change.

They should also consider how to manage the risk of earnings being trapped in a market or expropriation of assets. Are guarantees in place? Are they sufficiently robust to withstand a sovereign debt crisis in a state with a populist government?

Insurance to mitigate the risk of expropriation is widely available and should be explored in cities that are vulnerable to sovereign debt (Lloyd's City Risk Index, 2018).

Nexus – Finance and political risks

Some financial lines insurance are classified as political risk - this is usually as a result of civil unrest or protectionism, which can lead to a host government putting trade barriers in place, such as making it hard for a foreign-based business to move assets, or even expropriation and nationalisation of assets.

At present, economic and political conditions are exacerbating these threats. The International Monetary Fund (IMF) predicts a gradual slowdown over the next few years, primarily due to a reduction in Chinese growth. In October 2018, the IMF revised down its global growth projections for 2018 and 2019 by 0.2 percentage points. The IMF expects growth to slow in the US from 2.9% last year to 2.4% in 2019, and in China from 6.6% to 6.2%. Rises in interest rates could also depress growth. Businesses that financed expansion on low interest rates may find themselves under pressure.

The rise of populism is changing the way trade is viewed. The belief that global trade is creating benefits for all, and should therefore be protected by national governments, is changing. Some governments are increasingly taking a more nationalist approach. This was seen most acutely in 2018, with threats (and some tariff measures) in the US-China trade relationship, which is ongoing at the time of going to press. Governments in other countries, including in Europe, have blocked foreign acquisitions of domestic businesses.

This is resulting in an erosion of the rules-based intergovernmental systems. For example, the World Trade Organisation (WTO)'s appointment of arbitration judges is currently blocked by the US and, if this continues, will render the WTO unable to mediate disputes by the end of 2019 (Lloyd's City Risk Index, 2018). In 2020, Brussels created an alliance with 16 countries including China, South Korea and Brazil to bypass the US block on WTO judges (Brunsden, 2020)

5. Fostering further collaboration

5. Fostering further collaboration

Potential barriers are preventing further collaboration between local authorities and insurers. Cities are not always buying and covering their risks using third party insurance services. Municipalities are mostly self-insuring threats they face. Urbanisation provides opportunities for insurers in part because of cities' scale and the demand for rapid change as they develop. Urban areas are a broad market, they tend to be more affluent and have more assets, people and liabilities to insure than rural zones. Nevertheless, there is still a long way to go to develop further interactions between cities and insurers. The Lloyd's Innovation team interviewed and met with four managing agents, seven brokers, several local authorities and global network to understand various opinions and develop a broader picture of the current situation. Lloyd's would recommend the following to ensure better collaboration:

- 1) **Work together for better understanding of risk.** Governments, insurers and other stakeholders should work together to ensure there is a greater understanding of the role of all parties in the economic and social consequences of poor risk management, and to allow the development of appropriate solutions (Lloyd's, 2017). The insurance penetration rate is still very low in most countries. The level of understanding regarding insurance – especially - in developing countries is mostly non-existent and customers are not aware of the existing offers. The knowledge gap about the benefits of using insurance policies is preventing the adoption of insurance coverages. The insurance industry should work to close the knowledge gap in order to increase the insurance penetration rate.
- 2) **Clarify coverages offered.** Insurers noted that customers are increasingly raising claims that are not included in the initial cover they were sold.

Prior to events, insurers should help customers understand what is covered in the policy purchased and what is not included. Insurers and brokers should also communicate better with risk managers and make sure to extend clarity to customers.

- 3) **Clarify how premiums are calculated.** Municipalities are governmental agencies with budgetary constraints and must plan their budgets years in advance. As they face economic constraints, they are also usually planning for emergency responses at the same time. Local authorities are asking for help to better understand how pricing works and how they could mitigate risk by transferring them. It could create greater trust and transparency between cities and the insurance industry. A risk-based pricing approach could be implemented. Indeed, where possible prices should be based on the level of risk, free from regulatory interventions.
- 4) **Work on cultural barriers.** Historically, municipalities have mainly self-insured the risks they face. They only transfer to insurers large losses that occur infrequently. The idea of transferring risks to third parties is not yet culturally implanted for the public sector. Municipalities tend to buy traditional coverages (e.g. property, liability) and they do not invest in policies they will probably need for the future (e.g. cyber). Moreover, public servants are mostly working in isolation. Insurers see this phenomenon as an issue when they try to interact with municipalities. These cultural barriers are preventing the development of further partnership between both parties. It seems that these challenges will inevitably change with time. However, in order to develop further collaboration with insurers, local authorities should work on these actual barriers.

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- 5) **Improve data collection.** Insurers, brokers and cities should emphasise the importance of improving data collection, hazard mapping and other tools to manage and quantify increasing catastrophe risks in underwriting processes (Lloyd's, 2017). Insurers should help communities understand, prevent and reduce risk through risk research and analytics, catastrophe risk models, and loss prevention (ICLEI, 2017).
 - 6) **Share data and analytics.** As data becomes more ubiquitous and cities collect more of it, cities need to harness the power of this data to develop the risk retention and risk transfer strategies that are right for them. When done right, leveraging data and analytics should help to identify, assess and quantify threats (insurable or not) and their impact to the short-term financials as well as the longer-term strategic objectives of cities. By sharing data and risk insights, cities could take the relationship with insurance markets to a new level of transparency that can only be beneficial for everyone involved. Indeed, as these insights are vital for cities to understand and prevent losses, public servants could internally lobby on why and how insurance policies could be beneficial for municipalities when facing severe and unexpected events. As an example, collaboration between insurers and cities have been implemented in Nordics countries. Access to statistics and information from the insurance companies has been proved to be a great value for municipalities and their work on climate damage (Danish Insurance Association, Finance Norway, Federation of Finnish Financial Services, Insurance Sweden, 2013). Indeed, in 2011 during the Copenhagen cloudburst event, the insurance industry played a critical role in providing data on economic losses which informed post-disaster resilience planning (CICERO - Climate Finance, 2018). Claims data containing city's performance following a catastrophe could be used to create a register available to the public. This information could allow to identify trends relating to the losses incurred by cities and be used to inform cities on the insurance requirements needed. Learning from the experiences of cities in loss scenarios could be beneficial for them.
 - 7) **Provide extra services with insurance covers.** Other services such as public relations and crisis management could be included in the insurance covers. This will add value and allow the insurance industry to differentiate from other carriers.
 - 8) **Interact more with customers and meet their needs.** It is important for the insurance industry to engage more with local authorities, to understand the risks they face and to invest in research. Insurers should engage more with clients and understand exactly what they are looking for. Indeed, interacting more with customers will help insurers to adapt the offers they propose to better align with customers' needs. By improving and adapting supply to demand, insurers could extend their collaboration with local authorities. Interactions and dialogue should be developed between insurers and local authorities. Regular policy reviews with carriers on an annual basis could be organised to understand the coverage afforded. These meetings will allow municipalities to express their concerns in a more intimate setting and will challenge the convention that buying insurance is mechanical and does not foster the long-term relationships municipalities value.
 - 9) **Develop long-term relationships.** Governments are employing tendering processes when working with third parties. These processes also apply to insurers. Tender processes are transparent, provide essential information to potential suppliers and ensure a fair chance for businesses. However, some interviewees mentioned that these processes are sometimes preventing the development of long-term relationships as they are frequently renewed. In order to maintain long term relationships, some municipalities are adapting their tendering processes. Working on these processes could allow public entities and insurers to save time and efforts.

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- 10) **Implement risk-mitigation measures.** Insurers should work with governments to administer policies aimed, for example, at improving construction standards or discouraging building in inappropriate areas. Better risk management could lead to lower pricing, reducing the overall cost to economic growth. It is in the interest of policyholders and governments to implement risk-mitigation measures, thereby potentially reducing both the damage from natural catastrophes and the cost of insurance. One way the insurance industry incentivises policyholders to introduce risk-mitigation measures where local regulation prevails, is through risk-based premiums for implementing appropriate mitigating actions. Another method is for insurers to give policyholders the option to share a greater proportion of the risk through offering policies with higher deductibles. It reduces the cost of insurance but leaves the policyholder exposed to more risk, and as such they may need to take additional action to reduce their residual risks (Lloyd's, 2017).
- 11) **Work on cross-sector and industry learning experience.** As the public sector is trying to learn from the private sector, insurers could share expertise and communicate better on the learning experience of other sectors. This will allow the public sector to take learning from one industry, to adapt and to apply it to another. This cross-sector learning would be a way for customers to understand how other industries are dealing with the same threats and how they could learn from their experience. Insurers could play a key role in sharing expertise and providing lessons learned. A register of recognised issues looking at different levels – industry, clients, country – could be established to share expertise.
- 12) **Create and develop umbrella policies.** Public entity packages include a range of products for different classes of risks targeting the public sector specific needs. These programs are designed to suit public entities that want to transfer a comfortable amount of risks. Umbrella policies could be developed and proposed to municipalities. This is already the case in the United States and these programs could be extended to other geographic areas such as Europe.

6. Conclusions

6. Conclusions

This report focused on cities as urbanisation is occurring in every region of the world, making urban populations larger than ever. Cities are large networks of people and assets, made up of complex, interconnected ecosystems. Metropolises are often illustrating and reflecting global trends. As the world is evolving, so cities are also facing new and persistent risks.

The seven city case studies discussed in the report are at different stages of their development strategies and have varying risk profiles, illustrating how cities with a range of trajectories and characteristics are facing and adapting to upcoming threats.

Urbanisation provides opportunities for insurers in part because of cities' scale and the demand for rapid change as they develop. Urban areas are a broad market, they tend to be more affluent and have more assets, people and liabilities to insure than rural zones.

As "many cities all over the world are grossly unprepared for the multidimensional challenges associated with urbanisation" (UN-Habitat, 2016), this report looked at how the insurance industry could be part of cities risk management plans. From interviews with stakeholders, it emerged that cities are mostly self-insured, and insurance is still unknown or culturally not considered in some countries. Insurers are facing cultural barriers as cities are not aware of the offers available and the benefits from purchasing insurance covers. Cities risk managers and insurers should continue to work together in order to increase collaboration and understanding.

Next steps for city risk managers

The Lloyd's market already has a lot of products meeting the needs of the municipalities community and it stands ready to respond to policyholders' demands.

- Lloyd's market can work with cities on the process of understanding their risks and exposures and looking at what kind of risks can be managed or should be covered. Lloyd's market is also developing other tools like crisis management, scenarios and public relations to provide extra services to their clients.
- Lloyd's market is also working on a long-term basis. Insurance is there to provide certainty in the face of disasters and to help customers. Developing long-term relationships will help cities working with insurers from the earliest phases of their projects to understand what the high-risks items are and to allocate funds appropriately for their insurance needs.
- Lloyd's market provides public entities with umbrella policies in some countries. These policies are designed to suit public entities that want to transfer a comfortable amount of risks. Public entity packages include a range of products for different classes of risks.

Next steps for insurers

Based on the interviews conducted, urbanisation provides opportunities for insurers. To take advantage they should:

- Work and interact more often with risk managers at a local level, in order to close the knowledge gap, meet every day municipalities' needs and implement risk-mitigation measures.
- Work with insurance clients to help them understand how pricing for premiums are calculated.
- Communicate and share expertise on the learning experience of other sectors. Cross-sector learning would be a way for customers to understand how other industries are dealing with same threats.

References

References

- 100 Resilient Cities, 2017. *Communities Stepping up in the Face of Disaster: Lessons from the Mexico City Earthquake*. [Online]
Available at: <https://www.100resilientcities.org/lessons-mexico-city-earthquake/>
- 100 Resilient Cities, 2019. *Racial equity - resilient cities forefront*. [Online]
Available at: <https://www.100resilientcities.org/racial-equity-resilient-cities-forefront/>
- Abdellatif, R., 2019. *Riyadh aspires to be world's next leading smart city, but still faces challenges*. [Online]
Available at: <https://www.argaam.com/en/article/articledetail/id/597811>
- Advanced Electronics Company , 2018. *Smart cities - the next stage of urbanisation in KSA*. [Online]
Available at: <https://www.aecl.com/media/2371/urbane.pdf>
- African Institute for Development Policy & University of Southampton, 2018. *East African Regional Analysis of Youth Demographic*. [Online]
Available at:
https://assets.publishing.service.gov.uk/media/5af581a9ed915d0de537b9f6/East_African_Regional_Analysis_of_Youth_Demographics.pdf
- Age Friendly Initiative - Miami-Dade County, 2017. *Miami-Dade County Accepted Into Global Network of Age-Friendly Communities Becoming 5th Largest Community in the United States Committing to Becoming an Age-Friendly Place to Grow Up and Grow Old*. [Online]
Available at: <https://agefriendlymiami.org/miami-dade-county-accepted-into-global-network-of-age-friendly-communities/>
- Alexa, A., 2019. *The city's first marina in 50 years is coming to Brooklyn Bridge Park*. [Online]
Available at: <https://www.6sqft.com/the-citys-first-marina-in-50-years-is-coming-to-brooklyn-bridge-park/>
- Allen, R. M. et al., 2018. *Lessons from Mexico's Earthquake Early Warning System*. [Online]
Available at: <https://eos.org/features/lessons-from-mexicos-earthquake-early-warning-system>
- Architects Journal , 2018. *Budget 2018: Hammond set to further loosen permitted development rules*. [Online]
Available at: <https://www.architectsjournal.co.uk/news/budget-2018-hammond-set-to-further-loosen-permitted-development-rules/10036676.article>
- Asner, M. A. et al., 2019. *New York Amends Its Data Security Breach Notification Law, Enhancing the State's Cybersecurity Framework*. [Online].
- Associated Press, 2018. *Students fill streets of Colombia capital in education march*. [Online]
Available at: <https://www.washingtontimes.com/news/2018/nov/15/students-fill-streets-of-colombia-capital-in-educa/>
- Baca, 2019. *Shanghai Future City*. [Online]
Available at: <https://www.baca.uk.com/shanghai-city.html>
- Barthel, P.-A., 2017. *Slum is beautiful? Rethinking slums* [Interview] 2017.
- BBC, 2018. *Uganda social media tax to be reviewed*. [Online]
Available at: <https://www.bbc.co.uk/news/world-africa-44798627>
- BBC, 2020. *Coronavirus: Outbreak spreads in Europe from Italy*. [Online]
Available at: <https://www.bbc.co.uk/news/world-europe-51638095>

- Borgen, 2018. *Automation in Latin America: A Threat or an Opportunity?*. [Online]
Available at: <https://www.borgenmagazine.com/automation-in-latin-america/>
- Brand South Africa, 2017. *The National Development Plan: A vision for 2030*. [Online]
Available at: <https://www.brandsouthafrica.com/governance/ndp/the-national-development-plan-a-vision-for-2030>
- Broward.org, 2018. *Climate, Energy & Sustainability Program*. [Online]
Available at: <https://www.broward.org/Climate/Pages/ClimateResilienceNewsletterOct2018.aspx>
- Brown, T. C., Mahat, V. & Ramirez, J. A., 2019. Adaptation to Future Water Shortages in the United States Caused by Population Growth and Climate Change. *Earth's Future*, Volume 7, p. 219–234.
- Brugmann, J., 2013. *Building Resilient cities - From risk assessment to redevelopment*. [Online]
Available at: <https://www.cisl.cam.ac.uk/resources/publication-pdfs/building-resilient-cities-from-risk-assessment-to.pdf>
- Brunsdon, J., 2020. *Brussels builds alliance to bypass US block on WTO judges*. [Online]
Available at: <https://www.ft.com/content/e644ffea-3e97-11ea-b232-000f4477fbca>
- Buckle, E., 2016. *Growing London Faces Water Shortages and Overflowing Sewage*. [Online]
Available at: <https://www.bloomberg.com/news/articles/2016-03-09/growing-london-faces-water-shortages-and-overflowing-sewage>
- Building, 2019. *Getting rooftop development right*. [Online]
Available at: <https://www.building.co.uk/communities/getting-rooftop-development-right/5098571.article>
- Burke, A., 2018. *Prototype flood map app captures what satellites can't*. [Online]
Available at: <https://www.nrcan.gc.ca/simply-science/21094>
- Businesswire, 2019. *Riyadh on Track to Become Sustainable City – International Experts*. [Online]
Available at: <https://www.businesswire.com/news/home/20191118005985/en/Riyadh-Track-Sustainable-City-%E2%80%93-International-Experts>
- CDMX, 2013. *CDMX Resilience Strategy*. [Online]
Available at: https://mce2.org/wmogurme/images/reports/CDMX_Resilience_Strategy.pdf
- CDP, 2019. *Cities at risk: dealing with the pressures of climate change*. [Online]
Available at: <https://www.cdp.net/en/research/global-reports/cities-at-risk>
- Center for Local Administration, 2019. *Saudi Arabia's smart cities program: why local government is imperative to digital transformation in Saudi cities*. [Online]
Available at: <http://www.ksclg.org/en/publication-project/saudi-arabias-smart-cities-program-why-local-government-is-imperative-to-digital-transformation-in-saudi-cities/>
- Centre for climate and energy solutions, 2019. *Heat Waves and Climate Change*. [Online]
Available at: <https://www.c2es.org/content/heat-waves-and-climate-change/>
- CICERO - Climate Finance, 2018. *Flood risk for investors - Are you prepared?*. [Online]
Available at: <https://pub.cicero.oslo.no/cicero-xmlui/bitstream/handle/11250/2497350/Flood%20risk%20for%20investors-final-rev-080518.pdf?sequence=1&isAllowed=y>
- City Lab , 2017. *How a Slum Became a City*. [Online]
Available at: <https://www.citylab.com/equity/2017/06/how-a-slum-became-a-city/529488/>
- City of Johannesburg, 2009. *Climate Change Adaptation Plan*. [Online]
Available at:
https://www.joburg.org.za/Campaigns/Documents/2014%20Documents/climate%20change%20adaptation%20plan_city%20of%20joburg.pdf
- City of Vancouver, 2017. *Housing Vancouver Strategy (2018-2027) and 3-Year Action Plan*. [Online]
Available at: <https://council.vancouver.ca/20171128/documents/rr1.pdf>

-
- Citylab, 2017. *When Artificial Intelligence Rules the City*. [Online]
Available at: <https://www.citylab.com/life/2017/05/when-artificial-intelligence-rules-the-city/509999/>
- CMS, 2019. *Climate change liability – New litigation risks*. [Online]
Available at: <https://cms.law/en/pol/publication/climate-change-liability-new-litigation-risks>
- CNN, 2020. *Cities deserted, families separated and social life on hold in Italy's first day of lockdown*. [Online]
Available at: <https://edition.cnn.com/2020/03/10/europe/italy-coronavirus-quarantine-europe-intl/index.html>
- Construction Week, 2019. *Saudi ministry uses \$7m White Land Tax for Riyadh airport homes*. [Online]
Available at: <https://www.constructionweekonline.com/projects-tenders/257917-saudi-ministry-uses-7m-white-land-tax-for-riyadh-airport-homes>
- Counter Terrorism Preparedness Network, 2019. *An overview*. [Online]
Available at: https://www.london.gov.uk/sites/default/files/ctpn_overview.pdf
- Cuccuru, P., 2017. Beyond bitcoin: an early overview on smart contracts. *International Journal of Law and Information Technology*, 1 9, 25(3), pp. 179-195.
- Danish Insurance Association, Finance Norway, Federation of Finnish Financial Services, Insurance Sweden, 2013. *Weather related damage in the Nordic countries - from an insurance perspective*. [Online]
Available at: <https://www.svenskforsakring.se/globalassets/rapporter/klimat/weather-related-damage-in-the-nordic-countries.pdf>
- Deloitte, 2014. *The Deloitte Consumer Review - Africa: A 21st century view*. [Online]
Available at: <https://www2.deloitte.com/content/dam/Deloitte/ng/Documents/consumer-business/the-deloitte-consumer-review-africa-a-21st-century-view.pdf>
- Desbureaux, S. & Rodella, A.-S., 2018. *Drought in city: The economic impact of water scarcity in Latin American metropolitan areas*. [Online]
Available at: <https://ideas.repec.org/a/eee/wdevel/v114y2019icp13-27.html>
- Dickson, et al., 2012. *Urban risk assessments - Understanding disaster and climate risk in cities*. [Online]
Available at:
<http://documents.worldbank.org/curated/en/659161468182066104/pdf/709820PUB0EPI0067926B09780821389621.pdf>
- Duggan, K., 2019. *Soft opening: Singaporean developer unveils new marina at Brooklyn Bridge Park*. [Online]
Available at: <https://www.brooklynpaper.com/soft-opening-singaporean-developer-unveils-new-marina-at-brooklyn-bridge-park/>
- Dunne, D., 2019. *Climate change made Europe's 2019 record heatwave up to '100 times more likely'*. [Online]
Available at: <https://www.carbonbrief.org/climate-change-made-europes-2019-record-heatwave-up-to-hundred-times-more-likely>
- EBRD, 2020. *Belt and Road Initiative*. [Online]
Available at: <https://www.ebrd.com/what-we-do/belt-and-road/overview.html>
- Edbrooke, D., 2020. *A transport revolution*. [Online]
Available at: https://www.comparethemarket.com/car-insurance/content/driverless-cars/?SRC=DE92&&SRC=DE92&qclid=EAlaIqobChMI0LP59Y2r5wIVAbTtCh24mAkIEAAYASAAEgJGMvD_BwE&gclid=c=aw.ds
- Euro Cities, 2017. *Sharing cities: a sharing economy that delivers benefits for citizens*. [Online]
Available at: <https://www.greencycle.si/wp-content/uploads/2018/01/EUROCITIESsharingeconomy policypaper March2017final.pdf>
- Extrema, 2018. *Emergency notification system*. [Online]
Available at: <https://extrema.space/>
- EY, 2016. *Kingdom of Saudi Arabia White Land Tax*. [Online]
Available at: [https://www.ey.com/Publication/vwLUAssets/ey-ksa-white-land-tax/\\$FILE/ey-ksa-white-land-tax.pdf](https://www.ey.com/Publication/vwLUAssets/ey-ksa-white-land-tax/$FILE/ey-ksa-white-land-tax.pdf)

- EY, 2019. *Metropolitan Transportation Authority's 2020-2024 Capital Investment Strategy*. [Online]
Available at: <https://pfny.org/wp-content/uploads/2019/03/MTA-Capital-Plan-2020-24-Econ-Impacts.pdf>
- EY, 2019. *Metropolitan Transportation Authority's 2020-2024 Capital Investment Strategy*. [Online].
- Financial Times, 2018. *How Japan's ageing population is shrinking GDP*. [Online]
Available at: <https://www.ft.com/content/7ce47bd0-545f-11e8-b3ee-41e0209208ec>
- Financial Times, 2019. *Chaos across South Africa as blackouts roll into third day*. [Online]
Available at: <https://www.ft.com/content/8a730f06-4990-11e9-8b7f-d49067e0f50d>
- Future Agenda, 2019. *Rising youth unemployment*. [Online]
Available at: <https://www.futureagenda.org/insight/rising-youth-unemployment>
- Future Saudi Cities, 2017. *Riyadh City Review Report*. [Online]
Available at: <https://www.futuresaudicities.org/wp-content/uploads/2017/07/Riyadh-Review.pdf>
- Gallin, L., 2019. *Lloyd's announces new parametric solution targeting hotel profit protection*. [Online]
Available at: <https://www.reinsurancene.ws/lloyds-announces-new-parametric-solution-targeting-hotel-profit-protection/>
- Gannon, D., 2018. *New York City's subway system has a water problem- a 13 million gallon one*. [Online]
Available at: <https://www.6sqft.com/new-york-citys-subway-system-has-a-water-problem-a-13-million-gallon-one/>
- Gannon, D., 2018. *New York City's subway system has a water problem- a 13 million gallon one*. [Online]
Available at: <https://www.6sqft.com/new-york-citys-subway-system-has-a-water-problem-a-13-million-gallon-one/>
- Garfield, L., 2017. *How Miami has prepared for sea level rise and monstrous hurricanes like Irma*. [Online]
Available at: <https://www.businessinsider.com/miami-hurricane-irma-sea-level-rise-preparation-2017-9?r=US&IR=T>
- Giles, C., 2017. *What would an earthquake-proff city look like?*. [Online]
Available at: <https://www.theguardian.com/cities/2017/dec/11/earthquake-proof-city-christchurch-japan-colombia-ecuador>
- Giles, C., 2018. *CNN, African 'smart cities': A high-tech solution to overpopulated megacities?*. [Online]
Available at: <https://edition.cnn.com/2017/12/12/africa/africa-new-smart-cities/index.html>
- Giuffrida, A. & Tondo, L., 2020. *Italians struggle with 'surreal' lockdown as coronavirus cases rise*. [Online]
Available at: <https://www.theguardian.com/world/2020/feb/24/italians-struggle-with-surreal-lockdown-as-coronavirus-cases-rise>
- Greater London Authority, 2020. *London City Resilience Strategy*. [Online]
Available at: https://www.london.gov.uk/sites/default/files/london_city_resilience_strategy_2020_digital.pdf
- Green Journal, 2018. *How Much Does Fly-tipping Cost Taxpayers?*. [Online]
Available at: <https://www.greenjournal.co.uk/2018/08/how-much-does-fly-tipping-cost-taxpayers/>
- Green, A., 2020. *Deep data helps cities prepare for disaster*. [Online]
Available at: [Collaborating to Close the Protection Gap](#)
- Guardian, 2019. *How an emerging African megacity cut commutes by two hours a day*. [Online]
Available at: <https://www.theguardian.com/cities/2019/jan/08/how-an-emerging-african-megacity-cut-commutes-by-two-hours-a-day-dar-es-salaam>
- Higgins, T., 2018. *How driverless cars are going to change cities*. [Online]
Available at: <https://www.wsj.com/articles/how-driverless-cars-are-going-to-change-cities-1530065340>
- Hinsliff, G., 2018. *Airbnb and the so-called sharing economy is hollowing out our cities*. [Online]
Available at: <https://www.theguardian.com/commentisfree/2018/aug/31/airbnb-sharing-economy-cities-barcelona-inequality-locals>

-
- Hogan, M., 2013. *Understanding the Ripple Effect – Anytown*. [Online]
Available at: <http://climatelondon.org/projects/understanding-the-ripple-effect-anytown/>
- ICLEI, 2017. *Resilient Cities Report 2017*. [Online]
Available at: https://resilientcities2018.iclei.org/wp-content/uploads/2017/11/RC2017_Report_Online_26102017_Final-compressed.pdf
- ICLEI, 2019. *Local Governments for Sustainability - About us*. [Online]
Available at: https://iclei.org/en/About_ICLEI_2.html
- ICLEI, 2020. *Daring cities 2020*. [Online]
Available at: <https://daringcities.org/>
- ICLEI, L. G. f. S., 2017. *How cities can better manage risks and save money, lives and carbon emissions*. [Online]
Available at: <https://talkofthecities.iclei.org/how-cities-can-better-manage-risks-and-save-money-lives-and-carbon-emissions/>
- Indian Express, 2018. *Unplanned urbanisation pose serious development challenges: India to UN*. [Online]
Available at: <https://indianexpress.com/article/india/unplanned-urbanisation-pose-serious-development-challenges-india-to-un-5132574/>
- Inter America Development Bank, 2016. *Latin American and the Caribbean 2030: Future Scenarios*. [Online]
Available at: <https://www.atlanticcouncil.org/in-depth-research-reports/report/latin-america-and-the-caribbean-2030-future-scenarios/>
- Inter American Dialogue, 2013. *The World of 2030: Risks and opportunities for Latin America*. [Online]
Available at:
https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/The%20World%20of%202030_risks%20and%20opportunities%20for%20Latin%20America.pdf
- Intergovernmental Panel on Climate Change, 2018. *Global warming of 1.5°C*. [Online]
Available at: <https://www.ipcc.ch/sr15/>
- International Organization for Migration, 2008. *Migration and Climate change*. [Online]
Available at: <https://publications.iom.int/books/mrs-ndeg31-migration-and-climate-change>
- Joburg - a world class African city, 2011. *Joburg 2040 Growth and Development Strategy*. [Online]
Available at:
https://www.joburg.org.za/documents_/Documents/Joburg%20GDS%202040/Joburg%202040%20GDS%20Low%20Res.pdf
- Lloyd's , 2020. *Cyber products at Lloyd's*. [Online]
Available at: <https://www.lloyds.com/about-lloyds/what-lloyds-insures/cyber/cyber-products>
- Lloyd's City Risk Index, 2018. *Global analysis of finance, economic and trade risks*. [Online]
Available at: https://cityriskindex.lloyds.com/wp-content/uploads/2019/12/Lloyds_city-risk-index_finance-economic-and-trade-risks_v3.pdf
- Lloyd's City Risk Index, 2018. *Global analysis of political risk*. [Online]
Available at: https://cityriskindex.lloyds.com/wp-content/uploads/2019/12/Lloyds_city-risk-index_political-risk_v3.pdf
- Lloyd's, 2016. *Political violence*. [Online]
Available at: <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/society-and-security/political-violence>
- Lloyd's, 2017. *Future cities: Building infrastructure resilience*. [Online]
Available at: <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/society-and-security/arup>
- Lloyd's, 2018. *Networked world - Risks and opportunities in the Internet of Things*. [Online]
Available at: <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/technology/networked-world>

- Lloyd's, 2018. *Sharing risks, sharing rewards: who should bear the risk in the sharing economy?*. [Online]
Available at: <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/technology/sharing-risks-sharing-rewards>
- Lloyd's, 2018. *Volume Claims*. [Online]
Available at: <https://www.lloyds.com/market-resources/claims/volume-claims>
- Lloyd's, 2019. *Instant claims for earthquake damage*. [Online]
Available at: https://www.lloyds.com/~media/files/news-and-insight/risk-insight/2019/lloydsparametric_case_studiesv3part1.pdf
- London School of Economics LSE IDEAS & CIMB ASEAN Research Institute, 2018. *China's Belt and Road Initiative (BRI) and Southeast Asia*. [Online]
Available at: <http://www.lse.ac.uk/ideas/Assets/Documents/reports/LSE-IDEAS-China-SEA-BRI.pdf>
- Long Finance, 2017. *From Slips To Smart Contracts: Intelligent Technology In The London Wholesale Insurance Market*, London: Z/Yen Group.
- Macrotrends, 2020. *Riyadh population*. [Online]
Available at: <https://www.macrotrends.net/cities/22432/riyadh/population>
- Matousek, M., 2018. *The MTA revealed its \$37 billion plan to save NYC's crumbling subway system —but there's one big problem*. [Online]
Available at: <https://www.businessinsider.com/nyc-subway-37-billion-plan-for-repair-unveiled-2018-5?r=US&IR=T>
- Matousek, M., 2018. *The MTA revealed its \$37 billion plan to save NYC's crumbling subway system —but there's one big problem*. [Online]
Available at: <https://www.businessinsider.com/nyc-subway-37-billion-plan-for-repair-unveiled-2018-5>
- McKinsey Global Institute, 2016. *Urban world: Meeting the demographic challenge in cities*. [Online]
Available at: https://www.mckinsey.com/~media/McKinsey/Featured%20Insights/Urbanization/Urban%20world%20Meeting%20the%20demographic%20challenge%20in%20cities/Urban-World-Demographic-Challenge_Full-report.ashx
- Meeks, B. N., 2016. *These 7 major risks threaten urban sustainability*. [Online]
Available at: <https://www.greenbiz.com/article/7-risks-cities-facing-globalization>
- Melgar, D. & Perez-Campos, X., 2018. *Mexico City's potent 2017 earthquake was a rare 'bending' quake – and it could happen again*. [Online]
Available at: <https://theconversation.com/mexico-citys-potent-2017-earthquake-was-a-rare-bending-quake-and-it-could-happen-again-92994>
- Meyer, R., 2017. *Climate Change Will Bring Major Flooding to New York Every 5 Years*. [Online]
Available at: <https://www.theatlantic.com/science/archive/2017/10/climate-change-nyc-floods/543708/>
- Miami-Dade Services, 2019. *Smart Plan demonstration projects*. [Online]
Available at: <http://www.miamidadetpo.org/smartplan-demonstration-projects.asp>
- Miami-Dade Transportation Planning Organization, 2020. *Smart Plan Demonstration Projects*. [Online]
Available at: <http://www.miamidadetpo.org/smartplan-demonstration-projects.asp>
- Miller, D., 2018. *States Where Jobs Are most Vulnerable to Automation*. [Online]
Available at: <https://smartasset.com/checking-account/states-where-jobs-are-most-vulnerable-to-automation>
- Municipal Art Society of New York, 2017. *Accidental Skyline, 2017 update*. [Online]
Available at: <https://www.mas.org/initiatives/accidental-skyline/>
- Naím, M., 2017. *The Uprising of the Global Middle Class*. [Online]
Available at: <https://www.theatlantic.com/international/archive/2017/08/global-middle-class-discontent/535581/>
- Nesta, 2018. *Reclaiming the Smart City: Personal Data, Trust and the New Commons*. [Online]
Available at: <https://www.nesta.org.uk/report/reclaiming-smart-city-personal-data-trust-and-new-commons/>

-
- New London Architecture, 2019. *NLA London Tall Buildings Survey 2019*. [Online]
Available at: <https://newlondonarchitecture.org/whats-on/insight-studies/insight-study-pages/tall-buildings-2019/nla-london-tall-buildings-survey-2019>
- New York State, 2007. *Q&A about Flood Insurance in NYS*. [Online]
Available at: <https://www.dec.ny.gov/lands/40564.html>
- Noorloos, F. v. & Kloosterboer, M., 2018. *Africa's new cities: The contested future of urbanisation*. [Online]
Available at: <https://journals.sagepub.com/doi/pdf/10.1177/0042098017700574>
- Notman, N., 2017. *City air*. [Online]
Available at: <https://www.chemistryworld.com/features/urban-air-pollution/2500224.article>
- NYC EDC, 2019. *Cybersecurity*. [Online]
Available at: <https://edc.nyc/industry/cybersecurity>
- NYC Hazard Mitigation, 2019. *2019 NYC Hazard Mitigation*. [Online]
Available at: <https://nychazardmitigation.com/>
- NYC Mayor's Office of Resiliency, 2020. *New York City Panel on Climate Change*. [Online]
Available at: <https://www1.nyc.gov/site/orr/challenges/nyc-panel-on-climate-change.page>
- OECD.stat, 2016. *Metropolitan areas*. [Online]
Available at: <https://stats.oecd.org/Index.aspx?Datasetcode=CITIES#>
- OneNY 2050, 2019. *The Strategy*. [Online]
Available at: <https://onenyc.cityofnewyork.us/initiatives/the-strategy/>
- Oxbotica, 2019. *AXA XL reviews ongoing autonomy projects*. [Online]
Available at: <https://www.oxbotica.com/insight/axa-xl-reviews-ongoing-autonomy-projects/>
- Pak, J., 2019. *Going cashless in Shanghai*. [Online]
Available at: <https://www.marketplace.org/2019/01/15/going-cashless-shanghai/>
- Perry, F., 2016. *Fly-tipping in your city: share your photos and stories*. [Online]
Available at: <https://www.theguardian.com/cities/2016/oct/25/fly-tipping-illegal-waste-dumping-share-photos-stories>
- Plautz, J., 2019. *New York City releases API to clear up social service eligibility*. [Online]
Available at: <https://www.smartcitiesdive.com/news/new-york-city-releases-api-to-clear-up-social-service-eligibility/552892/>
- Politico, 2017. *What's the greatest risk cities face?*. [Online]
Available at: <https://www.politico.com/magazine/story/2017/06/30/biggest-challenge-american-cities-policy-experts-215308>
- Pool Re, 2019. *Non Damage Business Interruption*. [Online]
Available at: <https://www.poolre.co.uk/cover/non-damage-business-interruption/>
- Powel, A. & Cassim, Z., 2018. *Xenophobic Group Marches in Johannesburg After Violent Killings of Foreigners*. [Online]
Available at: <https://www.voanews.com/africa/xenophobic-group-marches-johannesburg-after-violent-killings-foreigners>
- Rainwater, B., 2016. *The 10 most important issues facing cities, according to their mayors*. [Online]
Available at: <https://www.fastcompany.com/3061619/the-10-most-important-issues-facing-cities-according-to-their-mayors>
- Reboredo, R. & Brill, F., 2019. *What a failed Johannesburg project tells us about mega cities in Africa*. [Online]
Available at: <https://theconversation.com/what-a-failed-johannesburg-project-tells-us-about-mega-cities-in-africa-112420>
- Resilient 305, 2019. *Miami's strategy to effectively tackle emerging global challenges and trends*. [Online]
Available at: <https://resilient305.com/>

-
- Resilient Cities 2019, 2019. *ICLEI's resilience work*. [Online]
Available at: https://resilientcities2019.iclei.org/about/iclei_work/
- Risky Business, 2014. *A Climate risk assesment for the United States*. [Online]
Available at: https://riskybusiness.org/site/assets/uploads/2015/09/RiskyBusiness_Report_WEB_09_08_14.pdf
- Ritter, K., 2018. *Water Scarcity Looms in London's Future*. [Online]
Available at: <https://www.circleofblue.org/2018/world/water-scarcity-looms-in-londons-future/>
- Rothman, M. B., 2015. *Let's focus on our aging population*. [Online]
Available at: <https://www.miamiherald.com/opinion/op-ed/article32488794.html>
- Saudi Vision 2030, 2017. *Vision 2030*. [Online]
Available at: <https://vision2030.gov.sa/en>
- SEEC Group, 2015. *What will Shanghai look like in 2025?*. [Online]
Available at: http://www.timeoutshanghai.com/features/Around_Town-Around_Town/29124/What-will-Shanghai-look-like-in-2025.html
- Setzer, J. & Byrnes, R., 2019. *Global trends in climate change litigation: 2019 snapshot*. [Online]
Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/07/GRI_Global-trends-in-climate-change-litigation-2019-snapshot-2.pdf
- Sinclair Colman, M., 2017. *City Reality, Understanding the Power of Air Rights*. [Online]
Available at: <https://www.cityrealty.com/nyc/market-insight/features/future-nyc/understanding-power-air-rights/2923>
- Smart Cities Africa, 2019. *Smart Cities African Summit*. [Online]
Available at: <http://www.smartcitiesafrica.co.za/>
- Smart Cities World Forum , 2018. *Miami is the world's No.1 city for smart connected streetlights*. [Online]
Available at: <http://www.smartcitiesworldforums.com/news/smart-cities-north-america/smart-infrastructure-na/1005-miami-is-the-world-s-no-1-city-for-smart-connected-streetlights>
- Smart Market, 2018. *Smart Cities Market Future Growth | Trends | Analysis - 2023*. [Online]
Available at: <https://www.marketsandmarkets.com/Market-Reports/smart-cities-market-542.html>
- SmartCitiesWorld, 2018. *NYC adopts blockchain-based smart city standard*. [Online]
Available at: <https://www.smartcitiesworld.net/news/nyc-adopts-blockchain-based-smart-city-standard-3686>
- Smartcity, 2019. *Johannesburg – The Only African City With Lowest Carbon Emissions*. [Online]
Available at: <https://www.smartcity.press/climate-change-in-johannesburg/>
- Southeast Florida Regional Compact, 2020. *Southeast Florida Regional Climate Change Compact*. [Online]
Available at: <https://southeastfloridaclimatecompact.org/>
- St. John, J., 2019. *New York City Set to Pass Ambitious Energy Efficiency Mandate*. [Online]
Available at: <https://www.greentechmedia.com/articles/read/new-york-city-set-to-pass-ambitious-building-energy-efficiency-bill>
- Toumi, H., 2019. *Saudi Arabia denies it will allow sale of alcohol*. [Online]
Available at: <https://gulfnews.com/world/gulf/saudi/saudi-arabia-denies-it-will-allow-sale-of-alcohol-1.61845926>
- UN Environment Programme, 2019. *Cities and climate change*. [Online]
Available at: <https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/cities-and-climate-change>
- UN, 2017. *World Population Prospects: The 2017 Revision*. [Online]
Available at: https://population.un.org/wpp/Publications/Files/WPP2017_DataBooklet.pdf
- UN, 2018. *2018 Revision of World Urbanization Prospects*. [Online]
Available at: <https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html>

-
- UN-Habitat, 2016. *Urbanization and Development - Emerging Futures*. [Online]
Available at: <http://wcr.unhabitat.org/wp-content/uploads/sites/16/2016/05/WCR-%20Full-Report-2016.pdf>
- United Nations, 2018. *The World's Cities in 2018*. [Online]
Available at:
https://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2018_data_booklet.pdf
- United Nations, 2018. *World Urbanization Prospects 2018*. [Online]
Available at: <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf>
- Virgin, 2020. *What does the future hold for entrepreneurship in Mexico?*. [Online]
Available at: <https://www.virgin.com/entrepreneur/what-does-the-future-hold-for-entrepreneurship-in-mexico>
- Weiss, B., 2018. *New York is quietly working to prevent a major cyber attack that could bring down the financial system*. [Online]
Available at: <https://www.businessinsider.com/new-york-cybersecurity-regulations-protect-wall-street-2018-2?r=US&IR=T>
- Wentworth, A., 2018. *How can the insurance industry make cities more sustainable?*. [Online]
Available at: <http://www.climateaction.org/news/how-can-the-insurance-industry-make-cities-more-sustainable>
- Westcott, T., 2018. *New Brunswick Flood Forecast Data Goes Mobile with New App*. [Online]
Available at: <https://www.watercanada.net/new-brunswick-flood-forecast-data-goes-mobile-with-new-app/>
- World Bank Group, 2012. *Urban risk assessments: understanding disaster and climate risks in cities*. [Online]
Available at:
<http://documents.worldbank.org/curated/en/659161468182066104/pdf/709820PUB0EPI0067926B09780821389621.pdf>
- World Bank, 2012. *FONDEN: Mexico's Natural Disaster Fund - A review*. [Online]
Available at: https://www.gfdrr.org/sites/gfdrr/files/publication/FONDEN_paper_M4.pdf
- World Bank, 2013. *China 2030*. [Online]
Available at: <https://www.worldbank.org/content/dam/Worldbank/document/China-2030-complete.pdf>
- World Bank, 2013. *Which Coastal Cities Are at Highest Risk of Damaging Floods? New Study Crunches the Numbers*. [Online]
Available at: <https://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods>
- World Bank, 2016. *Ending AIDS in Johannesburg : An Analysis of the Status and Scale-Up Towards HIV Treatment and Prevention Targets*. [Online]
Available at: <https://openknowledge.worldbank.org/handle/10986/25685?locale-attribute=en>
- World Bank, 2018. *Water Security and Resilience for the Valley of Mexico*. [Online]
Available at: <http://documents.worldbank.org/curated/en/795531576791290777/pdf/Project-Information-Document-Integrated-Safeguards-Data-Sheet-Water-Security-and-Resilience-for-the-Valley-of-Mexico-PROSEGHIR-P164389.pdf>
- World Bank, 2020. *Saudi Arabia Data*. [Online]
Available at: <https://data.worldbank.org/country/saudi-arabia>
- World Economic Forum, 2019. *How China's sponge cities are preparing for sea-level rise*. [Online]
Available at: <https://europeansting.com/2019/07/09/how-chinas-sponge-cities-are-preparing-for-sea-level-rise/>
- World Health Organization, 2020. *Air pollution*. [Online]
Available at: <https://www.who.int/sustainable-development/transport/health-risks/air-pollution/en/>
- World Population Review, 2019. *Mexico City Population 2020*. [Online]
Available at: <http://worldpopulationreview.com/world-cities/mexico-city-population/>
- World Population Review, 2019. *Shanghai Population 2020*. [Online]
Available at: <http://worldpopulationreview.com/world-cities/shanghai-population/>

World Population Review, 2020. *Johannesburg*. [Online]

Available at: <https://worldpopulationreview.com/world-cities/johannesburg-population/>

World Population Review, 2020. *Shanghai*. [Online]

Available at: <https://worldpopulationreview.com/world-cities/shanghai-population/>

Zaatari, S., 2019. *10-15% of UAE's rain in 2018 caused by cloud seeding*. [Online]

Available at: <https://gulfnews.com/uae/environment/10-15-of-uaes-rain-in-2018-caused-by-cloud-seeding-1.61188081>

Zevenbergen, C., Fu, D. & Assela, P., 2018. *Transitioning to Sponge Cities: Challenges and Opportunities to Address Urban Water Problems in China*. [Online]

Available at: <https://www.mdpi.com/2073-4441/10/9/1230>

Zulu, S., 2019. *SA records 22% increase in cyber-attacks in first quarter of 2019*. [Online]

Available at: <https://ewn.co.za/2019/04/29/sa-records-22-percent-increase-in-cyber-attacks-in-first-quarter-of-2019>