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Pathways to Climate Resilient and Decarbonised Critical Infrastructure in the 21st Century

A discussion paper

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Pathways to Climate Resilient and Decarbonised Critical Infrastructure in the 21st Century

A discussion paper

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Pathways to Climate Resilient and Decarbonised Critical Infrastructure in the 21st Century – A discussion paper

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Contents

Key messages:

1) Investing in climate resilience and decarbonisation of critical infrastructure is fundamental to addressing both economic and environmental goals as critical Infrastructure (e.g. energy, transport, water and sewage, agriculture) constitutes the backbone of a functioning society.

2) Years of chronic under-investment in critical infrastructure has led to declining quality of infrastructure. Significant levels of infrastructure investment are required globally to upgrade existing and build new systems. The additional investment needed to incorporate climate change considerations is estimated to be only a fraction of the financial resources already needed.

3) The scale of the investment in critical infrastructure is well beyond the capacity of the public sector alone. To address this funding deficiency there is a need to mobilise private capital.

4) Transitioning to a low-carbon economy requires "pro-growth" economic and financial reforms of the highest greenhouse gas (GHG) emitting economic sectors and their infrastructure systems (i.e. energy, agriculture, forestry and land use, industry and transport). This should be supported by consistent public policy for climate mitigation and climate adaptation, with aligned regulatory frameworks and infrastructure plans to incentivise long-term investments.

5) There is a need for clear and consistent public policies and regulations for climate adaptation and disaster risk management to make climate risk assessment and climate resilience a prerequisite for infrastructure systems.

6) Complexities and fragmented governance, project life cycle and jurisdiction of the critical infrastructure lead to a number of risks for investors that need to be managed. For institutional investors to invest in critical infrastructure, they require a stable, predictable regulatory and political framework, a pipeline of investable-grade projects and an efficient market. Relevant policy-making, regulatory and standard-setting bodies need to ensure the development of "sustainable/green financing frameworks" to foster long-term investing.

7) The insurance industry is contributing to climate adaptation and mitigation measures. As part of carrying and transferring risk functions, the insurance industry plays a critical role in de-risking the infrastructure project life cycle. Most insurers (particularly life insurers) see infrastructure projects as a potential opportunity for investment for reasons such as: (i) potentially lucrative risk-adjusted return on equity; (ii) long-term exposure as a good match for their long-term liabilities; and (iii) increased diversification across asset classes, structure, geography and exposure. The industry wants to do more, but a number of challenges remain.

8) Solving the global infrastructure challenge and ensuring climate resilience and decarbonisation requires coordinated multi-stakeholder action to address the challenges and put the world on the path towards the 2°C or less climate change scenario.

1. Critical infrastructure – the backbone of a functioning society

The adoption of three international framework agreements in disaster risk reduction, sustainable development and climate change by over 190 countries in 2015 has offered a unique opportunity to reshape the future of global socio-economic development while taking into consideration sustainability, resilience and environmental factors.[1]

Critical infrastructure constitutes the backbone of a functioning society, providing critical basic services that are fundamental to improved quality of life, national security, economic growth and productivity, commerce, trade, and job creation.

"Infrastructure" is generally defined as the systems, assets, facilities and networks that provide essential services and are necessary for the national security, economic security, prosperity, and health and safety of their respective nations (Critical Five, 2014). "Critical" refers to the infrastructure that provides essential support for economic and social well-being, for public safety and the functioning of key government responsibilities (OECD, 2008). Definitions of "critical infrastructure" in OECD countries are provided.

Different countries consider different economic activities under their critical sectors; however, for most energy, information and communication (ICT), transportation, dams and flood defence, water and sewage, health, finance and banking, and the chemical industry fall under top ten critical sectors (OECD, 2017a-b).

Years of chronic under-investment in critical infrastructure has led to declining quality of infrastructure in many high-income economies, reduction of public capital assets and poor quality of life in middle- and low-income countries.

Since the 2008 global financial crisis, government spending on infrastructure has decreased as a percentage of GDP in 11 of the G20 economies (GIH, 2018). Public infrastructure spending has begun to rebound and is expected to grow over the coming decade (McKinsey & Company, 2016).

China spends more on economic infrastructure annually than North America and Western Europe combined. According to McKinsey & Company (2016) the Americas have the most significant investment gap, followed by Africa, Asia, Europe, Middle East and Oceania.

In general, among critical sectors, transportation (airports, ports, railways, roads and bridges) has the largest investment gap, followed by energy, telecommunications, water and sewage.[2]

2. Addressing the critical infrastructure investment gap

Significant levels of infrastructure investment will be required to upgrade existing systems and build new ones. To address this funding deficiency there is a need to mobilise private capital.

Latest OECD estimates suggest that from 2016 to 2030 around USD 95 trillion of investments (USD 6.3 trillion per year) are needed to upgrade existing and build new infrastructure systems, without taking into account climate change concerns (OECD, 2017c). McKinsey & Company (2016) and the Global Infrastructure Hub (GIH, 2018) estimate the annual global investment needs at USD 3.3 to 3.5 trillion up to 2030. According to Global Infrastructure Facility (GIF) of the World Bank Group (WBG) between 60 and 70 % of needed infrastructure investment is in middle- and low-income countries.

1 For more information see:
- Sendai Framework for DRR: http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
- The 2030 Agenda for Sustainable development: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%2 Sustainable%20Development%20web.pdf
- COP21 Paris Agreement: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

2 See McKinsey & Company, 2016. For example, between 1999 and 2008, in the United States, the number of dams with structural or hydraulic deficiencies has tripled. Over a third of the nation's dams are over fifty years old, a number that will increase to 70% in less than ten years (FEMA, SFI 2011). This makes the infrastructure more vulnerable to shocks.

Institutional investors require a stable, predictable regulatory and political framework, a pipeline of investable-grade projects and an efficient market for critical infrastructure.

McKinsey & Company (2016) estimates that USD 120 trillion of total assets under management (AuM) globally are a potential source of capital from institutional investors.[3] They frame institutional investors' requirements in three main areas:

1) ***Availability of investable-grade project pipeline*** - With established and well-justified user fees, public revenue, ancillary funding; alignment with national infrastructure plans; stakeholder management and approval; project preparation facilities; early-stage funding; unsolicited bidding framework; and Public-Private Partnership (PPP) units and capabilities.

2) ***Availability of funding*** - Regulatory adjustments (e.g. Basel III, Solvency II, pension fund allocation rules); credit enhancement, political risk insurance in high-risk countries and improving general and international investment frameworks (e.g. adoption of OECD rules).

3) ***Robust market development*** - For example, development of infrastructure as an asset class and taxonomy, standardisation of terms, appropriate risk-return on the investment, development of indices; project pooling into funds; securitisation of projects; development of securities exchange platforms together with multi-lateral development banks, governments and market makers.

PPPs have assumed an important role in infrastructure financing, although there is continuing controversy over whether PPPs lead to higher efficiency and lower costs (McKinsey & Company, 2016).

Increasingly, countries are creating a variety of frameworks and institutions to attract private infrastructure investment, both foreign and domestic (C.D Howe Institute, 2017; GFIA[4]). For example, Canada has established Canada Infrastructure Bank, which aims to attract institutional investors to new revenue-generating infrastructure projects that are of public interest (Canada Infrastructure Bank, 2017). In Australia in 2016, the government released a 15-year Australian Infrastruture Plan, which set up a priority list and recommendations at all levels of government for reforms to improve public funding and make infrastruture attractive to institutional investors. In Chile, the government changed the law to improve investment in government concessions, and approved the creation of a public infrastruture fund. In Europe in 2014, the infrastructure investment plan was aimed at both fostering the supply of infrastruture assets and addressing regulatory barriers. This led to the creation of the European Fund for Strategic Investment (EFSI), and the European Investment Project Portal (EIPP). On the regulatory side, the Capital Markets Union Project was established by the EU to address Solvency II barriers to infrastruture investments. Furthermore, activities in the EU have been complemented by other initiatives, including the EU High-Level Expert Group on Sustainable Finance (EU-High-Level Expert Group, 2018) and the European Commission's legislative action towards development of sustainable financial framework to enable long-term investments, including investing in sustainable and green infrastrutrue (EC, 2018).

Asset recycling programmes are among other tools used by government to increase the capital available for infrastructure investment—this is when the government sells assets with a proven flow of income to private investors, and the cash generated is used to create another project, and the cycle is repeated (Porado, 2017).

3 The USD 120 trillion potential private funding includes: ***Banks:*** USD 40 trillion; Investment companies: USD 29 trillion; ***Insurance companies and private pensions:*** USD 26 trillion; ***Public Pensions:*** USD 11 trillion; ***Sovereign Wealth Funds:*** USD 6 trillion; ***Infrastructure operators and developers:*** USD 3 trillion; ***Infrastructure and private equity:*** USD 3 trillion; and ***Endowments and foundations:*** USD 1 trillion. (Source McKinsey & Company, 2016)

4 Private discussions with Global Federation of Insurance Associations (GFIA), based on the GFIA Survey on Infrastructure Investments.

In emerging economies, international and regional development banks are critical of addressing this investment gap and related risks to attracting private investors. For example, the World Bank Group established its Global Infrastructure Facility to assist governments with bringing well-structured and bankable infrastructure projects to market.[5]

3. Complexities and risks associated with critical infrastructure governance and project life cycle

Governance of critical infrastructure is complex and highly fragmented involving different stakeholders. It varies significantly by economic sector and country.

Infrastructure governance includes ownership, operation models and delivery across the entire life cycles of the project (or asset). In general, it can be characterised by five different models (OECD 2017a-b, 2018; see Annex 1):

1) Direct provision by the government (federal, provincial and/or local)
2) Traditional public procurement
3) State-owned enterprises (in full or in part)
4) Public-private partnerships and concessions
5) Full privatisation with regulation

An infrastructure project life cycle has several phases, spanning several decades and engaging different stakeholders. There are a variety of risks associated with different phases linked to governance and mode of delivery, jurisdiction and economic sector.

In general, *infrastructure project life cycle* involves several phases with different risks. These include:

1) Planning and acquisition
2) Project financing
3) Project design
4) Construction
5) Operation and maintenance
6) Upkeep and improvement

A number of technical risks arise during different phases of an infrastructure project (see Annex 2). Furthermore, there are a number of other risks such as regulatory (e.g. changes on regulations on investments), political (e.g. nationalisms, expropriation, political disruptions such as civil war, terrorism, riots and coups), economic, supply chain, and financial (e.g. credit, financial, exchange rate) associated with the execution of infrastructure projects. Particularly in emerging economies, economic uncertainty also deters investment in infrastructure, as the rate of return can change drastically through unexpected fluctuations in inflation and exchange rates when payments are in local currency and debt obligations are in a foreign currency (GIF, 2016; The Geneva Association, 2018a). Political and credit risks are a major concern in low-income countries.

5 GIF's project support can cover the spectrum of design, preparation, structuring, and transaction implementation activities, drawing on the combined expertise of the GIF's Technical and Advisory Partners and focusing on structures that can attract a wide range of private investors. More information is available at: https://www.globalinfrafacility.org/

4. Critical infrastructure and climate change: Emerging risks and opportunities

Investments in and building of climate resilient and low carbon infrastructure are seen as crucial to achieving both economic and environmental goals at scale.

The annual global investment needs in critical infrastructure are estimated to be higher, by just a fraction of the already needed investments, if climate resiliency and decarbonisation (consistent with the 2°C climate change scenario)[6] are to be considered: USD 6.9 trillion annually (OECD, 2017c), and USD 4.4 trillion (Global Infrastructure Hub, 2018).

Economic sectors and greenhouse gas emissions (GHGs)

According to the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014), the highest GHG emitting economic sectors (and related infrastructure systems) include: energy 25% of total global GHG emissions); agriculture, forestry and other land use (24%); industry (e.g. chemical, waste management, metallurgical and mineral) (21%); transport (14%); buildings (6%); and other energy (10%) (see Annex 3).

The world's top ten emitters in 2013 included China (27% of total global GHG emissions); United States (14%); European Union (10%); India (6%); Russia (5%); Japan (3%); and Brazil, Indonesia, Canada and Mexico (2%) (World Resources Institute, 2017).[7]

Development of clear pathways for decarbonisation requires close collaboration between the government and those sectors as to what the transitioning would mean in terms of delivery of related infrastructure systems.

Impacts of physical risk of climate on critical infrastructure

Interruption in critical infrastructure could lead to cascading effects across economic sectors and sometimes across borders, causing significant harm to populations' well-being and hindering socio-economic growth.

Over the past three-and-a-half decades, a significant portion of reported economic losses have been related to physical risk of climate on critical infrastructure and related cascading effects.[8, 9] These include direct and indirect impacts of weather-related extremes such as inland and coastal floods, windstorms, hurricanes, droughts and heat-waves as well as slow-changing climatic trends such as sea level rise and water scarcity.[10] In some cases, these catastrophes are further compounded by technological failures.

Changing frequency and severity of hazards linked to climate change, an increasing concentration of people and assets in high-risk regions (e.g. coastlines and cities), poor development planning and construction practices are further exacerbating these impacts in all countries (OECD, 2017b-c; Forzieria et. al 2018, IISD, 2014; European Commission's Infrastructure Website) (see Annex 4).[11]

6 The Paris Agreement aims to keep a global temperature rise for this century well below 2 degrees Celsius, with the goal to drive efforts to limit the temperature rise to 1.5 degrees Celsius above pre-industrial level.

7 G20 countries are responsible for about 80% of global energy use and GHG emissions. It is expected that low carbon technologies in emerging and developing economies can leapfrog existing high carbon technology and create competitive national advantage in a global economy where carbon is likely to be increasingly more highly priced/taxed.

8 Physical risks include economic risks that could arise from direct (e.g. destruction of property and critical infrastructure) and indirect (e.g. business interruption, affected labour force, interconnectivity of supply chains) impacts due to: (i) increasing severity and frequency of extreme weather events such as cyclones and floods (acute risks); and (ii) long-term shifts in climate patterns such as changes in precipitation patterns linked to reduction of water supplies and sustained high temperatures that may cause rising sea level and chronic heatwaves (chronic risks) (FSB-TCFD, 2016).

9 1998 Eastern Ice Storm in Canada, 2005 Hurricane Katrina in New Orleans, 2007 U.K. flood, 2011 Thailand flood, 2012 Super Storm Sandy in the eastern U.S. and New York City, 2013 Southern Alberta Flood, 2018 Hurricane Maria in Puerto Rico, and 2018 Cyclone Gita are just a few recent examples.

10 According to Munich Re's NatCatSERVICE, between 1980 and 2017, 17,320 disaster loss events were reported. Of those, 91.2% were caused by weather-related extremes (meteorological, hydrological and climatological events), accounting for 49.2% of the total of 1,723,738 lives lost, 79.8% of the total USD 4,615 billion in reported economic losses and 90.1% of total insured losses of USD 1,269 billion. In 2017, weather-related extremes accounted for 97% of total reported economic loses reported and 98.2% of total insured losses.

11 As a consequence of climate change, design thresholds for safe and efficient operation may be breached more frequently, projects may have to function within tighter margins between "normal" operation and critical threshold, resulting in decreased efficiency and more frequent periods of restricted operations, leading to reduced asset lifetimes, higher running costs and capital expenditure, loss of income, increased risk to environmental damage (European Commission, 2013). For example, it has been estimated that damages from climate hazard impacts to critical infrastructure in Europe could increase 10-fold by the end of 21st century if no action is taken (Forzieria al., 2018).

Failure of critical infrastructure compromises emergency response operations, accessibility to markets and communities' ability to return back to normality in a timely manner after a disaster. Furthermore, a significant portion of direct and indirect economic impacts (World Bank Group, 2014 and 2017) are related to:

1) Government's post-disaster spending to fix damages and/or rebuild uninsured or partially insured public infrastructure, government buildings and low-income dwellings

2) Decreased tax revenues associated with business interruption due to infrastructure damages (e.g. electricity, transportation and water)

3) Opportunity cost of diverting public funds from development plans to infrastructure reconstruction and recovery efforts

4) Reduction in economic productivity, economic output and trade

Urban systems and climate change

With increasing urbanisation and a growing concentration of people and assets in high-risk zones (e.g. coastal regions and flood plains), urban systems are particularly vulnerable to climate change.

Climatic conditions such as recurrent coastal and urban flooding, sea level rise, storm surges and urban heat waves impact urban infrastructure systems, access to water, sewage and waste management systems, energy production and distribution, transportation and other services.[12, 13]

Over the next 40 years, more investment in urban infrastructure, including schools, hospitals, road construction, water and sanitation, energy and transport systems, and housing will be required as urbanisation continues to expand (GPDRR, 2017).

5. Technology, critical infrastructure and climate change nexus

A variety of new technologies offer opportunities to improve and even transform the design, delivery, efficiency, resilience and greening of infrastructure projects.

These include: (i) green, efficient and carbon capture technologies, including the use of carbon capture and utilisations and storage (CCUS) (e.g. Shell Sky Scenario and IEA scenarios)[14]; (ii) digitisation and control systems; (iii) real-time design, construction and performance management and cloud collaboration platforms; (iv) advanced risk analytics; (v) supply chain optimisation; and (vi) advanced materials and construction practices for more resilient structures, just to name a few (McKinsey & Company, 2018; Morgan Stanley, 2017 and World Economic Forum, 2017). Currently, in many countries national infrastructure consists of large centralised facilities designed to serve large regions. However, technological trends (e.g. solar and wind energy production, smart grids and grid-scale storage and electric vehicles) are suggesting that future plans are moving towards lighter, decentralised and more locally focused infrastructure systems. There is also increasing R&D related to decentralised water management systems with consideration for droughts and water scarcity (C40 Cities, 2017).

Currently, in many countries national infrastructure consists of large centralised facilities designed to serve large regions. However, technological trends (e.g. solar and wind energy production, smart grids and grid-scale storage and electric vehicles) are suggesting that future plans are moving towards lighter, decentralised and more locally focused infrastructure systems. There is also increasing R&D related to decentralised water management systems with consideration for droughts and water scarcity (C40 Cities, 2017).

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12 According to the OECD, the ten countries with the largest populations in the low-lying coastal zones have some 400 million inhabitants today.

13 According to the OECD and Bloomberg Philanthropies, cities ranked most at risk to flooding today include Guangzhou, Miami, New York, New Orleans, Mumbai, Nagoya, Tampa, St. Petersburg, Boston, Shenzhen, Osaka-Kobe and Vancouver. A number of cities are projected to experience highest socio-economic impacts from flooding by 2050, including New Orleans, Abidjan, Guangzhou, Guayaquil, Ho Chi Minh City, Jakarta, Xiamen, Tianjin, Miami and Kolkata.

14 For more information on Shell Sky scenario please see: https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html. For more information on IEA scenarios, see: https://www.iea.org/topics/climatechange/scenarios/

Fragmentation in infrastructure governance and the project life cycle makes it difficult to collect data at different stages. A number of technologies (e.g. cloud collaboration platforms, digitisation, computational capacities and risk modelling tools) offer opportunities for advanced risk analytics for operations and performance optimisation, assessing vulnerability to various extreme event risks (e.g. weather-related extremes) and monitoring costs and revenues (The Geneva Association, 2018b).

6. Major developments to strengthen climate resilience and enable transitioning to a low carbon economy

Latest trends in climate adaptation and disaster risk management

As rising socio-economic costs become associated with physical risks of climate, there is increasing evidence of a paradigm shift in government approaches, from "inaction" or "post-disaster reaction" towards a more comprehensive and integrated risk management framework spanning the different sectors and layers of government. This involves preventive risk reduction, risk financing and risk transfer measures underpinned by risk identification and quantification. Recognition of financial impacts and a need to integrate these measures into national development planning and budgeting are also increasingly coming into the focus of finance ministers. Traditional post-disaster financial assistance is proving ineffective and insufficient, dis-incentivising people, businesses and local governments from taking proactive action to manage their risks (UNISDR). In addition, recent research shows that climate change is having an impact on the cost of capital in middle- and low income economies and slowing their ability to achieve the SDG's.[15]

Increasingly, governments are recognising the role and benefits of a market-based insurance industry in carrying and transferring risk. There is increasing evidence that countries with widespread market-based insurance coverage recover faster from the financial impacts of extreme events; it is the uninsured part of losses that drives macroeconomic costs and therefore hinders economic development. Yet there is a large and in some places widening protection gap, indicating that the benefits of risk transfer measures are not being harnessed to their full potential. Over the last few years, the insurance industry together with the multi-lateral development banks and other partners have established regional risk transfer pools to address the governments' post-disaster early recovery financing needs (e.g. Caribbean Catastrophe Risk Insurance Facility).[16] Another example is the G7 *InsuResilience* Initiative adopted at the 2015 G7 Summit (Elmau, Germany), which aims to increase access to direct or indirect insurance coverage against the impacts of climate change for up to 400 million of the most vulnerable people in the most vulnerable countries by 2020.[17] The Asia-Pacific Economic Cooperation's Finance Ministers' Process (APEC FMP) identified financial management of disaster risks as a fiscal issue, and recognised it as one of the top priorities under the "Cebu Action Plan," a ten-year roadmap of the region's financial policy agenda agreed by the APEC Finance Ministers in 2015.[18]

In 2017 at the Global Platform for Disaster Risk Reduction (Cancun, Mexico), heads of state and representatives from the private sector and NGOs met and agreed to the Cancun High-Level Communiqué on "Ensuring the Resilience of Infrastructure and Housing", noting that "meeting the needs of a global population that will reach nine billion by 2050, achieving the Sustainable Development Goals (SDGs) by 2030 and responding to the adverse effects of climate change will require considerable investments in resilient infrastructure, including green infrastructure and housing.[19] While the cost of retrofitting infrastructure and building is often high, making new investment resilient is not, and it pays off over the long term."

15 This is based on a recent study commissioned by United Nations Environment Program Finance Initiative (UNEP FI) and delivered by the Centre for Climate Finance & Investmen

16 Examples include: Caribbean Catastrophe Risk Insurance Facility (CCRIF, www.ccrif.org/); Pacific Disaster Risk Financing and Insurance Program (http://documents.worldbank.org/curated/en/818411468289177132/The-Pacific-disaster-risk-financing-and-insurance-program); and, African Risk Capacity (ARC, www.africanriskcapacity.org)

17 https://www.insuresilience.org/about/

18 APEC.org : https://www.apec.org/Meeting-Papers/Sectoral-Ministerial-Meetings/Finance/2015_finance/annexa

19 For list of Sustainable Development Goals, see: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Major developments to enable transitioning to a low carbon economy

Following the adoption of the Paris Agreement,[20] there has been a burst of initiatives and activities across a wide range of stakeholders to support and finance the transitioning to a low carbon economy (mitigation side). Latest developments include:

1) Growing but fragmented and in some cases conflicting climate policy and regulatory frameworks at national to local levels and across regions. A number of countries and regional socio-economic groupings are taking coordinated action with different approaches and processes (e.g. EU, Canada, America's Pledge).[21]

2) Growing number of non-governmental coalitions advocating the urgency for strong and consistent policy action (e.g. New Carbon Economy).[22]

3) Innovation in clean and green technologies, with some starting to gain market share (e.g. solar and wind power, carbon capture systems, EVs, etc.)

4) Efforts by jurisdictions and standard-setting bodies towards development of sustainable and green financing framework (EU, Canada, etc.) to reduce barriers to green/sustainable investments (EU High-Level Expert Group, 2018; and EU Legislative Proposals, 2018; Canadian Expert Group on Financing Climate, 2018).[23]

5) Growing coalition of investors with interest in investing in sustainable, climate resilient and green economy.[24]

6) Incorporation of climate risk in sovereign, municipal and company credit ratings by the international rating agencies (e.g. Moody's Rating Services, Standard & Poor's, etc.)

7) Innovative win-win environmental and financial and resilience solutions such as "Blue Carbon Resilience Credits".[25]

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20 Paris Agreement: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

21 For more information see:
- EU Climate Change Programme (https://ec.europa.eu/clima/policies/eccp_en)
- Canada's Pan Canadian Framework on Clean Growth and Climate Change (https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170125-en.pdf)
- America's Pledge (https://www.americaspledgeonclimate.com/)—An initiative of the state and local governments with private sector and investors.

22 http://www.centerforcarbonremoval.org/new-carbon-economy/

23 The Legislative Action at the EU involves establishment of: (i) A unified EU classification system ('taxonomy'); (ii) Investors' duties and disclosures; (iii) Low-carbon benchmarks; (iv) Improved advice to clients on sustainability. The European Parliament and Council will next review and agree on the proposals. The enabling legislation is scheduled to be adopted from late 2019, with several elements entering into force six months later. Some measures such as the taxonomy will take until 2022 to resolve, and the investment advice proposals will first go to public consultation. *For more on EU see:*
EU High-Level Expert Group on Sustainable Finance (2018) (https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en);
EU legislative action on sustainable/green finance in June 2018 (https://ec.europa.eu/info/publications/180613-sustainable-finance-teg-members_en);
For Canadian initiatives, see:
Canadian Expert Group on Financing Climate Action and Transitioning to a Low Carbon Economy (https://www.canada.ca/en/environment-climate-change/services/climate-change/expert-panel-sustainable-finance.html).

24 Finally, the private sector is stepping up its efforts in supporting and investing in climate adaptation and mitigation measures. In June 2018, 319 investors with more than USD 28 trillion in assets called on world governments to scale up climate action to achieve the goals of the Paris Agreement (Investor Agenda Statement (2018). In their statement they wrote, "The global shift to clean energy is underway, but much more needs to be done by governments to accelerate the low-carbon transition and to improve the resilience of our economy, society and the financial system to climate risks." The Geneva Association, a platform of Global re/insurance CEOs, issued its 2014 Climate Statement, followed by a major report on the role of the insurance industry as risk managers, underwriters and investors in addressing the climate change goals and targets (The Geneva Association 2014 and 2018a).

25 Announced in 2018 by XL Catlin and The Nature Conservancy, the idea behind this initiative is that, for the first time, insurance firms and other businesses will be able to offset their carbon footprint while simultaneously better understanding the contribution they are making to reducing coastal hazards, unlike other climate mitigation solutions. Coastal natural infrastructure such as wetlands not only sequesters carbon, they also protect coastlines, often at lower costs than man-made infrastructure like sea walls and levees. More information is available at: https://xlgroup.com/press/the-nature-conservancy-and-xl-catlin-collaborate-to-bring-blue-carbon-credits-to-market.

8) Consistent disclosure and reporting for investors, lenders, insurers and other stakeholders, based on accessibility to reliable data on companies' climate risk and how they are managing it in the annual reports (FSB-TCFD, 2016).[26]

9) Emphasis on climate resilience and decarbonisation of critical infrastructure in relation to national economic planning and trade (e.g. G7 Global Investors Initiative).[27]

7. Role of the insurance industry in investing in and building climate resilient and decarbonised critical infrastructure

The global (re)insurance industry believes that investing in climate resilience and decarbonisation of infrastructure is fundamental to scaling up action to meeting the global climate change goals and targets.

The insurance industry is contributing to climate adaptation and mitigation measures, and is interested in doing more (The Geneva Association, 2018a-b). This industry plays a critical role in building socio-economic resilience and enabling economic development and entrepreneurial pathways for achieving climate change goals and targets. Beyond its risk management, underwriting and investment capabilities, it provides expertise in risk assessment and pricing along with significant investment in preventive measures, which can be leveraged (see Annex 5).

As part of carrying and transferring risk functions, the insurance industry is already underwriting critical infrastructure; however, the extent varies from country to country given the different policy and regulatory frameworks. There is a fundamental willingness in the industry to expand coverage; however, a number of challenges remain.

Examples of challenges to expand insurance coverage for infrastructure include the following:

- Much of the publicly delivered critical infrastructure is not insured—with the consequence that a significant portion of the post-disaster aid funding needs to be spent on repairing the uninsured or partially insured structures that have been damaged.

- In many countries, almost no consideration has been given to assessing the impacts of physical climate risks (weather extremes and related cascading effects) on critical infrastructure and incorporating this risk in different stages of project development.[28]

- In general, there are limited incentives and a lack of regulatory requirements for infrastructure operators (public and private) to invest in climate resilience.

- It is also believed that many countries are primarily focusing on decarbonisation of their economy without paying sufficient attention to climate adaptation measures to build climate resilient infrastructure.

As institutional investors, most insurers (particularly life insurers) see infrastructure projects as a potential opportunity for investing.

Investing in infrastructure could (i) potentially lead to lucrative risk-adjusted return on equity; (ii) offer a good match with long-term liabilities; and (iii) offer increased diversification across asset classes, structure, geography and exposure.

In general, for investing in critical infrastructure:

- There are additional constraints (i.e. related to capital charges) under the current regulations on capital regimes for the insurance industry.

26 The G20 Financial Stability Board's Task Force on Climate-Related Financial Disclosure (FSB-TCFD) has framed climate risk under physical, liability and transition risk and has issued voluntary and consistent climate-related financial risk disclosures for use by companies in their annual report to provide information to investors, lenders, insurers, and other stakeholders.

27 https://www.iglobalinitiatives.com/en

28 Weather-related extremes (e.g. severe storms, tropical cyclones and storm surges, ice storm, heat-waves, floods and droughts) or slow changing climatic conditions (sea level rise, water scarcity).

- There is a need to develop a sufficient pipeline of investable infrastructure projects that can provide insurers and other institutional investors with appropriate risk-adjusted returns over the project's lifetime. At present, there is limited transparency regarding the volume, funding requirements, and associated risks-returns of these projects, making it difficult for institutional investors to commit to funding, even in the short-term.

- Capital markets for infrastructure assets remain relatively complex, non-standardised and illiquid.

- Low or non-existing risk management requirements (including climate resilience) for infrastructure projects contribute to poor performance of projects today and in the future.

- Addressing regulatory and political impediments could increase investments in critical infrastructure. However, in low- and middle-income countries, political, credit and currency risks remain barriers to investment.

- Across countries, and even within the same countries, infrastructure projects often have different contractual terms; this increases the due diligence insurance companies need to undertake, and at the same time it limits their ability to assess projects efficiently. Therefore, there is a need for greater standardisation in terms of documentation, disclosure and transparency.

- Pooling projects, including the development of respective funds, indexes and securitisation vehicles could reduce transaction costs and make investment tangible.

For insurers to invest in “green” and “resilient” infrastructure there are also additional requirements:

- Financing and market-related factors, such as “green infrastructure” asset classification and taxonomy; standards and methodologies by which institutional investors can assess the relative merits of a green investment or project; issuance of green bonds coupled with a broader variety of issuers; and emergence of new instruments (e.g. green loans).

- National climate change-related policy, climate adaptation and mitigation strategies for critical sectors and related infrastructure systems remain unclear and fragmented.

- Green and clean technology markets cannot yet accommodate the scaling up of the risk-adjusted returns that insurers require.

The insurance industry believes that solving the global infrastructure challenge and ensuring climate resilience and decarbonisation requires a multi-stakeholder engagement to address the challenges and enable the opportunities.

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Annexes

Annex 1: Governance, phases and risks associated with the infrastructure project life cycle

Source: OECD (2017 a-b)

Table 1: Governance of critical infrastructure and the role of government and the private sector (OECD, 2014)

Governance	Functions
Direct provision	- Government takes responsibility for all aspects of infrastructure delivery (financing, construction and service delivery). - Government has the maximum level of control
Traditional public procurement	- Government contracts with private partners to provide infrastructure-based goods services. - Government finances the project and has separate contracts for design, construction, operation and maintenance.
State-owned enterprises (in full or part)	- Government relinquishes infrastructure investment to a state-owned enterprise (SOE). - Financial investment decision may still be subject to government controls if they have fiscal implications.
Public-private partnerships and concessions:	- Involved private investors financing and managing the construction of an infrastructure asset, which they can operate for the time established in the contract. - The private party receives a stream of payments to cover the capital expenses as well as the operating and maintenance costs. - These payment streams may be derived from the national budget, user fees (e.g. tolls) or a combination of these.
Privatisation with regulation	- Private firms are responsible for the financing and delivery of infrastructure, as well as for making investment decisions relating what assets to build. - Usually, governments have reinforced regulatory oversight in the sectors in which the project will be developed.

Annex 2: Critical infrastructure life cycles, risks and governance

Source: OECD (2017 a-b), The Geneva Association

Table 1: Six phases of infrastructure project life cycle and related technical risks (Adapted from McKinsey & Company, 2013)

Infrastructure project life cycle	Characteristics	Technical risks
Planning and acquisition	- Governments are usually in charge of this phase of the project. - A series of forecasts and assumptions (e.g. demographics, demand, prices, revenues, capital expenditures or operating expenses) must be made considering the risk appetite of developers, contractors and private investors to guarantee their engagement in the future phases of the project.	- Incorrect forecasts and assumptions (demographics, demand, prices, revenues, capital and operating expenditures) - Limited understanding of market dynamics and lack of ability/willingness to plan for market volatility and adverse scenarios - Poor conceptual design - Poor procurement model selection - Poor planning of contracting model, or poor project management model - Poor planning and management of future interface risks (project structures and design)
Finance	- The financing of a project requires investors to have solid knowledge of the dynamics of the market where the project is going to be executed, and the ability to plan volatility and adverse scenarios. - Overestimating revenue and growth potential while underestimating risk results in poorly designed projects that deliver lower-than-expected returns. - Funding and financing sources should be aligned so that future means of funding (e.g. tolls, taxes, fares) are matched by the proposed financing (e.g. bank loans, bond proceeds, equity investments.)	
Design	- All required technical designs for the infrastructure project (i.e. environmental study, geotechnical study, structural design, electrical design, signalling, hydraulic design, etc.). - A final design cannot be developed without the approved funding.	- Failure to consider, model and price all the risks as part of the design (e.g. weather-related extremes) - Failure to select the optimal risk-return ownership structure, making it difficult to adjust or reassign risk or responsibility once the project has started - Failure to allocate risk to the right parties and to anticipate potential problems - Poor original planning and performance management of resources and costs (leading to project overrun, delays, and defects or profitability caused by a variety of factors)
Construction	- All parties that participated in the previous stages are involved since at this stage all the forecasting, assumptions and designs are materialised. - Engineering construction contractors are responsible for on-time, on-budget and quality delivery and financing.	
Operation & Maintenance	- The project's owners and funders are the most interested parties since they must monitor the operation and maintenance (O&M) contractor so that the income projected in the initial stage is met. - The O&M contractor is responsible for operating the asset ensuring on-time, on-budget and quality service delivery and financing, as well as maintaining the asset in the proper conditions within the fixed budget and quality.	- Overestimating revenue and growth potential - Failure to meet contractually agreed KPIs - Poor forecasting around service load, maintenance cycles and operating costs - Cost of having to retrofit the infrastructure for unanticipated risks - Costs associated with damaged and failing infrastructure from weather-related extremes
Upkeep & Improvement	- When an asset requires improvements that are not considered within the operation and maintenance phase; in many cases the government is in charge of managing these improvements	

Annex 2 (continued)

Table 2: Contractual structures and risk allocation in an infrastructure project. Adapted from OECD (2014) "Private Financing and Government Support to Promote Long-Term Investment in Infrastructure" and OECD (2015) "Towards a Framework for the Governance of Infrastructure

Dominant counterparty: Public sector ⟷ **Dominant counterparty: Private sector**

TYPES OF CONTRACTUAL STRUCTURES

Direct provision	Traditional procurement	State-owned enterprises (in full or in part)	Public-private partnership and concessions	Privatisation with regulation
- Government takes responsibility for all phases of the project	- Management of public facilities by private parties - Separate contracts for design, construction and O&M - Tender processes are used to select the most suitable proposal	- Often used in projects related with water, public transport and electricity - The government relinquishes infrastructure investment to a third party but the government has the final investment decision - Design, building, management and transfer (service agreements with the public administration)	- Private investors finance and manage the construction of the asset - Design, build, own and transfer - The private party operates the asset for a period agreed in the contract - Government retains control over project selection	- Assets sale - Private firms make investment decisions - Private firms are resposible for financing and delivering the infrastructure asset
MAIN RISKS AND RELATIVE ALLOCATION AMONG THE INVOLVED PARTIES				
- Pre-planning & Acquisition: Public - Finance: Public - Design: Public - Construction: Public - D&M: Public - Upkeep & Improvement: Public	- Pre-planning & Acquisition: Public - Finance: Public - Design: Public - Construction: Public - D&M: Public - Upkeep & Improvement: Public	- Pre-planning & Acquisition: Public - Finance: Public/Private - Design: Public - Construction: Private - D&M: Private - Upkeep & Improvement: Public/ Private	- Pre-planning & Acquisition: Public/ Private - Finance: Public/Private - Design: Private - Construction: Private - D&M: Private - Upkeep & Improvement: Public	- Pre-planning & Acquisition: Private - Finance: Private - Design: Private - Construction: Private - D&M: Private - Upkeep & Improvement: Public/ Private

Low or relatively low Predominantly public Public	RISK INCURRED BY THE PRIVATE PARTNERS RESPONSIBILITY FOR FINANCING PROJECT GOVERNANCE	High or very high Private Private

Annex 3: Greenhouse gas (GHG) emission by economic sectors

Source: U.S. Environmental Protection Agency.
Available at https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Sector

Table 1: Greenhouse gas emissions by economic sectors and principal sources of generation. Adapted from Global Greenhouse Gas Emissions Data

Industry	Global GHG (%)	Comments
Electricity and heat production	25%	The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emissions.
Industry	21%	GHG from industry involve fossil fuels burned on-site at facilities for energy. This sector also includes emissions from chemical, metallurgical and mineral transformation processes not associated with energy consumption, and emissions from waste management activities. (GHG generated by the electricity used in this sector is covered in Electricity and Heating Production, where industry generates 11% of the GHG).
Agriculture, forestry and other land use	24%	Agriculture and deforestation are the main contributors of GHG to this sector.
Transportation	14%	This sector primarily involves fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.
Buildings	6%	GHG from buildings comes from on-site energy generation and burning fuels for heat in buildings or cooking in homes. (GHG generated by the electricity used in this sector is covered in Electricity and Heating Production, where the buildings category generates 12% of the GHG).
Other energy	10%	This source of greenhouse gas emissions refers to all emissions from the energy sector which are not directly associated with electricity or heat production, such as fuel extraction, refining, processing and transportation.

Annex 4: Impacts of climate on physical infrastructure

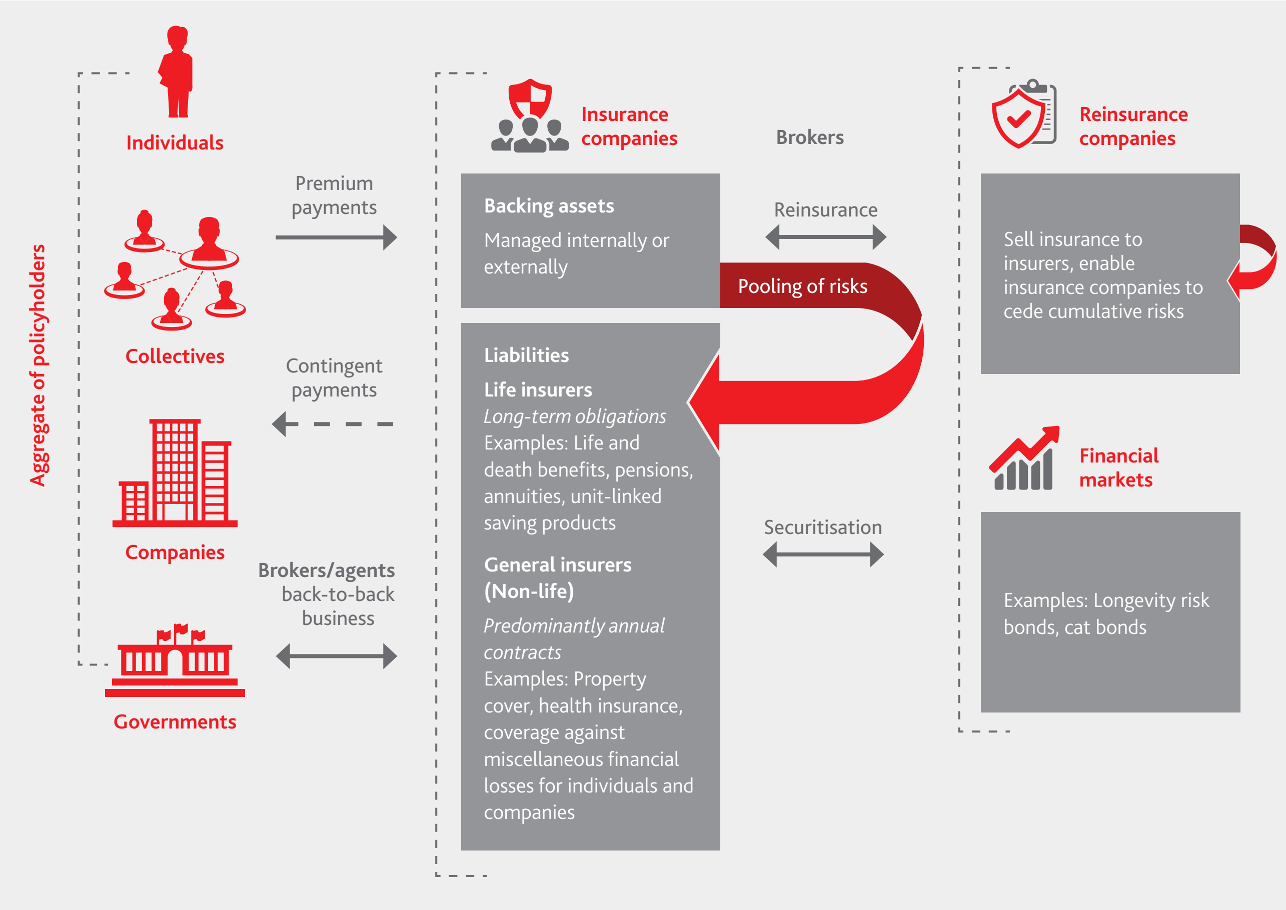
Source: OECD (2017a)

		Sea-level rise					Rainfall					Temperature						Other factors				
		Damaged or disruption from coastal flooding	Tide locking	Saline intrusion	Coastal erosion	Damage or disruption from river flooding	Damage or disruption from pluvial flooding	Droughts and low precipitation	Altered capability or efficiency	Biological processes	Stability of earthworks	Severe heat	Severe cold, snow, ice	Altered capacity or efficiency	Subsidence and/or desiccation	Biological processes	Demand for service	Lightning strike	Humidity	Solar radiation	Fog	Storminess
Transportation	Rail	✓			✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓				✓
	Road	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓		✓				✓	✓
	Ports and marine transport	✓			✓		✓					✓	✓	✓							✓	✓
Water	Potable water	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓
	Waste water and sanitation	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓					
	Flood and coastal erosion management	✓	✓		✓	✓	✓				✓	✓			✓	✓						✓
Energy	Nuclear and fossil-fuel energy generation	✓			✓	✓	✓	✓			✓	✓	✓	✓								✓
	Renewable energy generation	✓				✓	✓	✓	✓					✓						✓		✓
	Power systems, transmission and distribution	✓				✓	✓					✓		✓				✓				✓
	Energy demand	✓				✓	✓	✓				✓	✓							✓		

Annex 5: Insurance industry value chain
Source: The Geneva Association (2018a)

Understanding the insurance business model is key to leveraging the industry's contributions to achieving global climate change goals and targets. To help put our findings into perspective, we first highlight a few critical fundamentals about the insurance business model.

Insurance industry value chain



Transfer of risk

Transferring and carrying risk is at the heart of the insurance business. Insurers assess, price, assume and transfer risk on behalf of their policyholders.

As risk underwriters, insurance companies offer protection to people, businesses and governments in return for a premium. The insurance industry's value chain includes policyholders, (primary) insurers, reinsurers, brokers and the financial market. Traditionally, from an underwriting point of view, there are three basic ways of classifying insurance, including social versus private, life versus non-life, and commercial versus personal. The insurance policy is a mutual agreement whereby the insured transfers the risks of an uncertain loss to the insurer by paying upfront a certain fixed amount. Subsequently, on the occurrence of a covered event, the insurance company indemnifies the policyholder. It needs to be noted that the actual insurance product is not the payment in the event of a covered loss; it is rather the guarantee that losses will be indemnified if the policyholder suffers a loss. The guarantees of the insurance mechanism rely on three methods: pooling of risks, retrocession and securitisation.

Annex 5 (continued)

Liability-driven investment strategy

The investment (asset management) strategy of insurance companies is liability-driven, constrained by regulations and driven by a number of internal and external factors (Asset-Liability Management, ALM).

Insurers invest conservatively. Insurance companies need to ensure that they remain solvent and can make their payouts to the policyholders with the highest probability at any time. Insurers have a fiduciary duty to enhance the value of their "policyholder" assets. These fiduciary duties pose constraints on the industry's investment strategies. On the other hand, insurance regulators impose risk-based capital charges on investments to ensure adequate capital levels to cover insurers' liabilities; the riskier the investment, the higher the capital charge. These vary by country and region. It is important to note that different lines of business are exposed to different risks. This dictates how financial risks associated with assets and liabilities are managed differently by life and non-life insurers (Asset Liability Management, referred to as ALM). Specifically,

(i) Life insurers are typically "buy-and-hold" investors. They aim to generate predictable and stable income to match cash flows of long-dated and generally predictable liabilities. Life insurance contract duration can range from ten years to several decades, involving payout patterns of 20 to 30 years.[1] Life insurers are deeply concerned about the asset–liability mismatch, with interest rate risk being a key issue.

(ii) Non-life insurers are geared towards more liquid investments with shorter time horizons, typically one to three years in duration.[2] However, in some instances (e.g. asbestos-related), claims are paid out many years later, exposing them to interest rate risk.

1 Duration is a term that qualifies the sensitivity of cash flows to interest rate. That is why it is usually shorter than the payout patterns.
2 Liability business is usually longer than one year; typical P&C portfolios have a duration of two to three years. One year is typical for NatCat risks.

Investing in climate resilience and decarbonisation of critical infrastructure is fundamental to addressing both economic and environmental goals as critical infrastructure constitutes the backbone of a functioning society. Solving the global infrastructure challenge and ensuring climate resilience and decarbonisation requires coordinated multi-stakeholder action to address the challenges and put the world on the path towards the 2°C or less climate change scenario. The insurance industry has a key role to play.

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