ERIA Research Project Report FY2023 No. 05

Financing Infrastructure for Climate-Change Adaptation in Developing East Asia

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Table of Contents

List of Figures

List of Tables

Chapter 1
Overview

Fauziah Zen and Usha Iyer-Raniga

1. Introduction

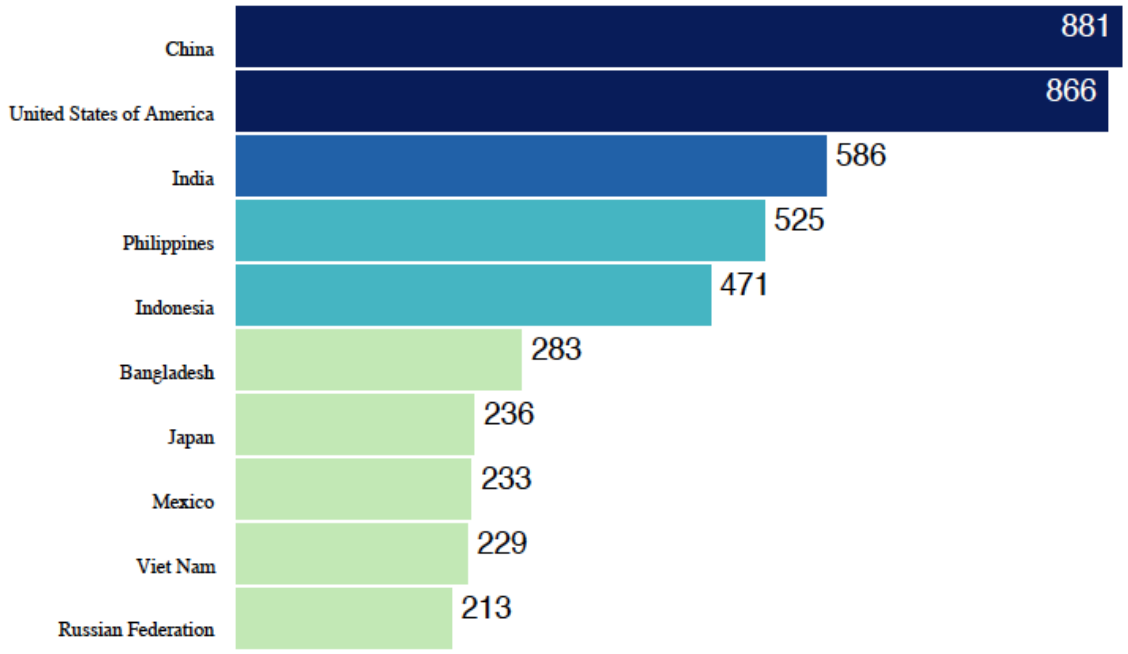
There are various definitions of disasters, depending on the institution defining them. This report uses the definition from the United Nations Office for Disaster Risk Reduction (UNDRR), 'a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts'.[1] Effects of disasters can be immediate and localised, but they are often widespread and can last for long periods. The Centre for Research on the Epidemiology of Disasters (CRED) – one of the leading institutions for disaster data and analysis – further classifies disasters into two groups: natural and technological. [2] Natural disasters consist of several sub-groups, including geophysical, meteorological, hydrological, climatological, biological, and extra-terrestrial. Technological disasters consist of industrial, transport, and miscellaneous accidents.

Due to its geography and associated features – the Pacific Ring of Fire, several major faults, and tropical weather – East Asia experiences a large number of natural disasters. Although China and the United States have the most number, many countries in East Asia rank in the top 10 globally of those having the most natural disasters (Figure 1.1).

[1] UNDRR, Disaster, Sendai Framework Terminology on Disaster Risk Reduction, https://www.undrr.org/terminology/disaster

[2] CRED, General Classification, EM-DAT: The International Disaster Database, http://emdat.be https://www.emdat.be/classification

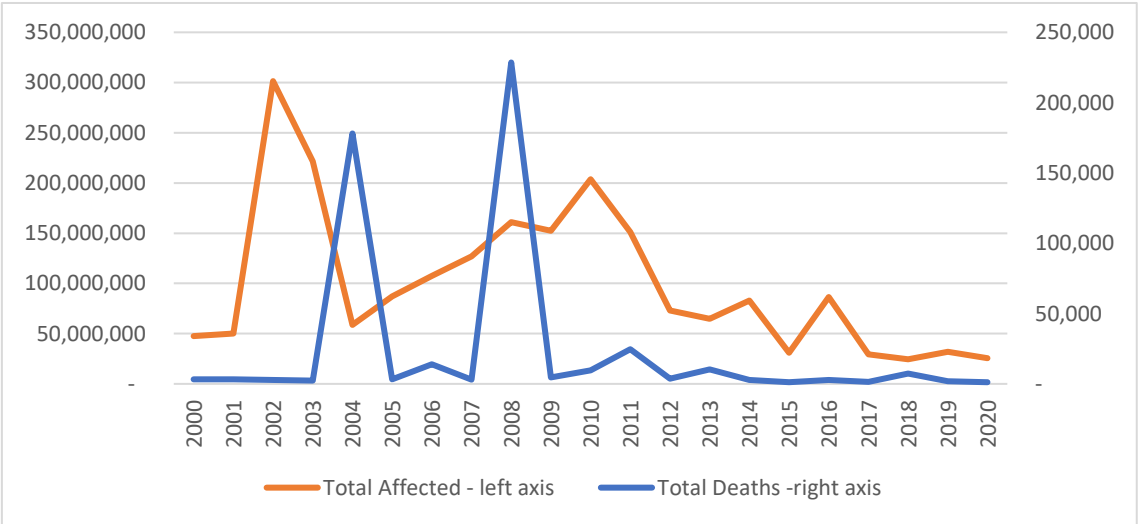
Figure 1.1. Natural Disasters by Country, 1980–2020



Source: CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed February 2021).

Such disasters often lead to death, injuries, and the destruction of property and other assets (Figure 1.2). It also impacts people's sources of livelihood both immediately and into the future; thus, the costs of coping with disasters' long-term effects are typically underestimated, especially in countries with frequent – and sometimes overlapping – disasters.

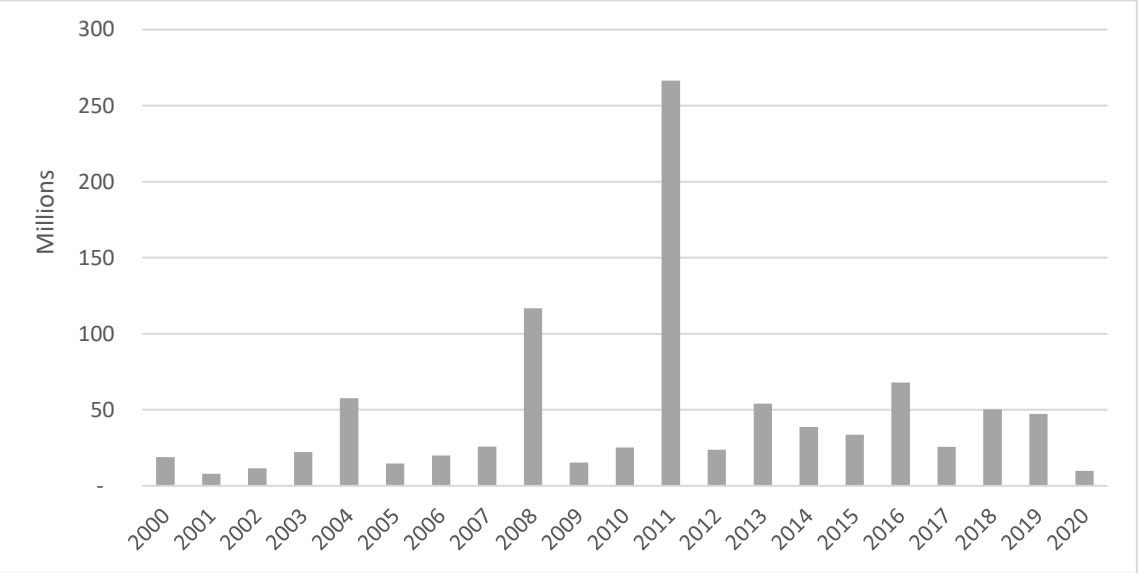
Figure 1.2. Humans Affected by Natural Disasters, East Asia, 2000–2020



Source: CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed February 2021).

Damage costs from natural disasters are frequently enormous, with some years topping hundreds of millions of US dollars (Figure 1.3). In 2011, the Tōhoku earthquake and tsunami devastated Honshu, the main island of Japan. The disaster cost $210 million – 80% of the total 2011 global damage costs from natural disasters. Moreover, the earthquake severely damaged the nuclear facility in Fukushima, leaving the area compromised for years due to radiation.

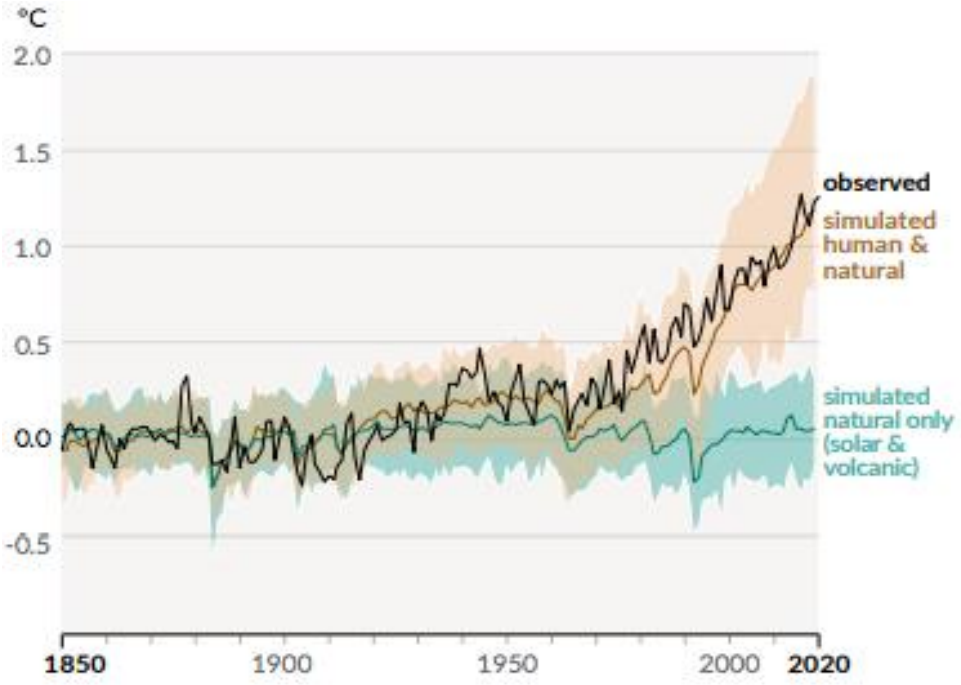
Figure 1.3. Total Damage from Natural Disasters
($ million)



Note: Figures do not include indirect costs, such as rapid corrosion and deterioration of infrastructure, reduced productivity, and land-use changes.
Source: CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed February 2021).

Over the past few decades and years, the number of natural disasters has increased, which is attributed to effects from climate change. The latest report from the Intergovernmental Panel on Climate Change (IPCC) showed that human activities are contributing significantly to alterations in global surface temperature (Figure 1.4).

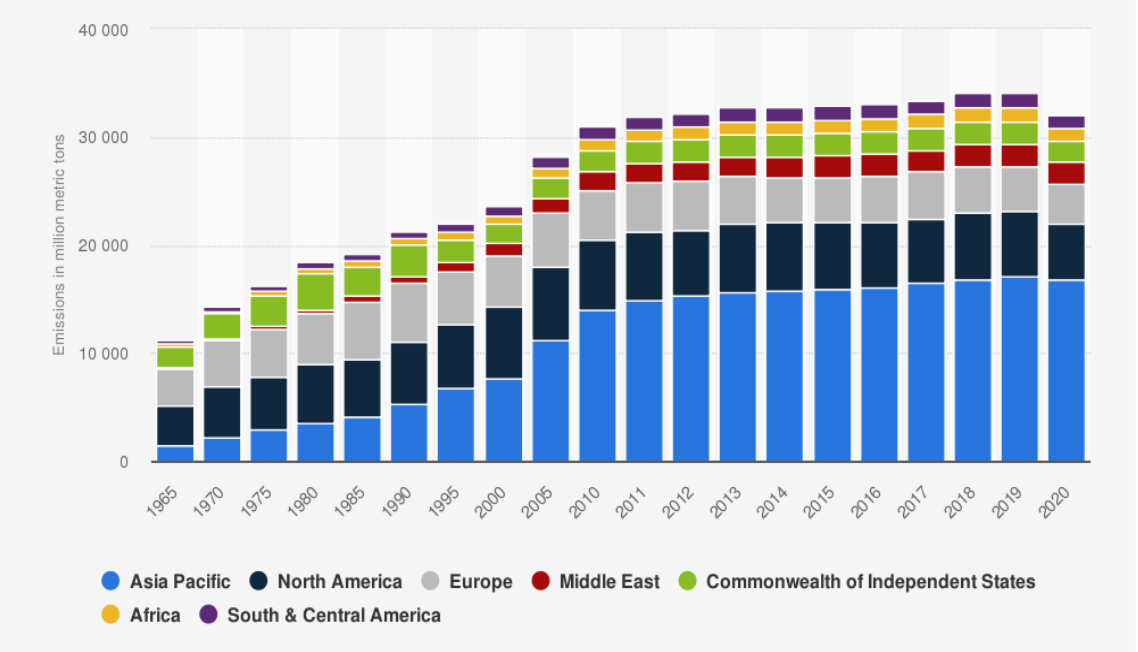
Figure 1.4. Change in Global Surface Temperature, 1850–2020
(annual average, °C)



Note: As observed and simulated using human and natural, and only natural factors.
Source: IPCC (2021).

The Asia-Pacific region emits around half of the world's total carbon dioxide (Figure 1.5). These emissions can be reduced by implementing appropriate climate-change adaptation measures, including in the planning, design, implementation, management, and utilisation of various infrastructure. The following study explores financing climate-change adaptation infrastructure in select developing East Asian economies, with additional chapters on Australia and Japan as advanced economies in the region.

Figure 1.5. Carbon Dioxide Emissions by Region, 1965–2020
(million metric tonnes of carbon dioxide)



Source: BP (2021).

2. Analytical Framework

Infrastructure is both affected by climate change and can help increase human resilience towards climate-change effects. Simultaneously, poor design and management of infrastructure can contribute to climate change.

Climate-resilient infrastructure is needed; that is, infrastructure that is planned, designed, built, and operated in a way that anticipates, prepares for, and adapts to changing climate conditions (OECD, 2018). It is also expected to withstand, respond to, and recover rapidly from disruptions – that is, natural disasters – caused by these changing climate conditions.

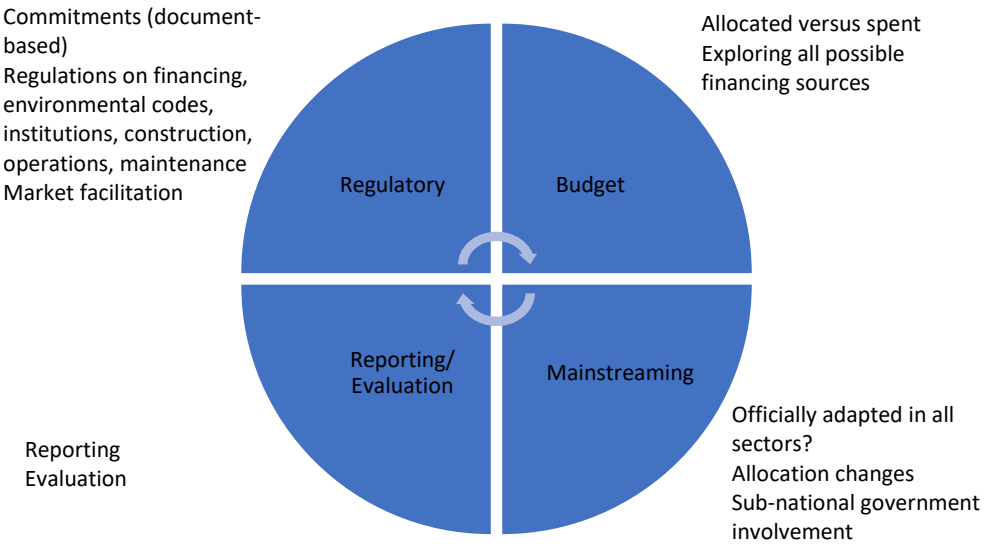
Efforts responding to climate change can be grouped into adaptation and mitigation. Adaptation involves efforts to adjust to actual or expected future climate conditions, to reduce negative impacts, and to make use of potential benefits. Mitigation is concerned with endeavours to lessen the rate of climate change, such as by reducing carbon emissions. Mitigation also aims to minimise the effects of human interference in the climate system.

The European Financing Institutions Working Group on Adaptation to Climate Change (EUFIWACC) (2016) divided infrastructure climate-change adaptation into two main groups. Structural adaptation measures distinguish climate-resilient infrastructure from ordinary infrastructure by changing its actual physical structure (e.g. altering the composition of road surfaces so that they do not warp or crack in high temperatures, or adopting riverbank naturalisation to stabilise a river). Management adaptation measures do not require any structural changes; the difference is in the way the infrastructure is managed (e.g. enhancing monitoring of existing infrastructure to reduce the risk of failure as climate conditions change).

Both the public and private sectors contribute to adaptation efforts based on their interests. Profit motives or social responsibility may drive the private sector, while governments have clearer mandates to showcase and to lead environmental responsibility. However, climate-adaptive infrastructure requires additional efforts, including adopting new technology, incorporating social and environmental considerations, and creating a green-and-transparent governance system. This new approach resulted in higher upfront investment costs and required a modern institutional setup. This is a serious challenge, especially for developing economies.

As illustrated in Figure 1.6, the public sector approach to climate-change adaptation can be evaluated through its policy, such as regulatory setup, budgeting, programmes, and monitoring. Indeed, analysing the relationship between regulations and programmes is important to ensure that the regulations are resulting in correct actions (i.e. programmes). Since climate-change adaptation is a cross-sectoral issue as well, policies must be mainstreamed across all relevant sectors.

Figure 1.6. Analytical Framework of Infrastructure Financing for Climate-Change Adaptation



Source: Author (2020).

One of the most challenging issues in climate-change adaptation is financing. Climate-change adaptation financing should be as important as that for other national priorities, such as education, health care, and security. Financing climate-change adaptation requires prioritisation, innovation, and participation from outside of the public sector as well.

Fiscal policy plays a significant role in directly influencing climate-change adaptation at all stages – mitigation, adaptation, and transition to a greener economy. Fiscal policy can be used to mobilise sources of financing and as an instrument to influence human behaviour by providing incentives or disincentives. Some countries adopt a mainstreaming strategy, initiated by the

view that climate change adaptation is a cross-sector issue; hence, efforts should be embedded in all related sectors. To monitor and track dedicated funds for climate-change adaptation, governments usually mark those budgets – known as 'climate budget tagging'. This is an important monitoring and evaluation tool for governments and helps promote the efforts to public as well as private investors.

This study attempts to provide an analytical report on key aspects of infrastructure financing in selected Asian developing economies. It begins with this overview chapter, including key messages from the countries covered in this study, followed by country chapters (arranged alphabetically, followed by the advanced economies), and a conclusion. The COVID-19 pandemic is also included in the discussion.

3. Key Messages

3.1. China

China implemented the National Climate Change Programme through the *Work Plan for Controlling Greenhouse Gas Emissions* during its *12th Five-Year Plan* period of 2011 to 2015. Since then, it established the China National Committee for Biodiversity Conservation and enacted the *China Biodiversity Conservation Strategy and Action Plan (2011–2030)*. In 2013, the *National Strategy for Climate Change Adaptation* was released, focussing on climate-change challenges such as extreme weather conditions and impacts on livelihoods. The National Development and Reform Commission also published *China's Policies and Actions for Addressing Climate Change* to detail the country's climate-change mitigation and adaptation activities, low-carbon pilots, strategic planning, capability building, broad participation, international negotiation, information exchange, and cooperation on the matter.

Aside from strengthening laws and policies for green development, green finance is also being encouraged to better develop green technological innovations. Multilateral banks, bilateral development agencies, climate funds, Certified Emission Reductions and the Clean Development Mechanism, and the national carbon emission trading scheme are helping leverage multiple sources of financing, therefore enabling the projects covered in the case study. Moreover, for green bonds, there are more varieties of issuance, including financial bonds, corporate bonds, medium-term notes, asset-backed securities, Panda bonds, and non-public targeted debt financing instruments.

The government is also supporting green financing. In 2012, the China Banking and Insurance Regulatory Commission issued *Green Credit Guidelines*, and at the end of 2015, the People's Bank of China and National Development and Reform Commission issued, respectively, *The Green Bond Endorsed Projects Catalogue* and *Green Bond Guidelines*. In 2016, the Shanghai Stock Exchange and Shenzhen Stock Exchange issued notices to encourage investment in green corporate bonds. Also in 2016, seven ministries and commissions jointly issued *Guidelines for Establishing the Green Finance System* to elevate the development of a green finance system to the national level and to cultivate new economic growth. It also helps guide social capital to participate in green projects, reduce entry barriers for funding and fundraising, and promote healthy development of the economy.

3.2. Indonesia

Indonesia is committed to working on climate action through its nationally determined contributions and the adoption of the Sustainable Development Goals. In 2009, the government formulated the *Indonesia Climate Change Sectoral Roadmap*, followed by *Rencana Aksi National – Perubahan Iklim* (RAN-API) in 2014, the national action plan for climate change adaptation. Moreover, in 2012, Ministry of Public Works and Housing (MOPH) formulated *Rencana Aksi Nasional Mitigasi dan Adaptasi Perubahan Iklim* (RAN-MAPI), a road map focussing on climate change mitigation and adaptation in the infrastructure sector. Indonesia does have several regulations regarding green buildings and sustainable construction, but specific guidelines for climate-resilient technical specifications and risk estimation are needed and should be implemented during the planning of infrastructure.

Indonesia implements climate budget tagging; uses several innovative financing options, especially green bonds; and has access to funding from various international climate funds. However, it still needs to create an enabling environment to improve infrastructure financing for climate-change adaptation by creating standardisation for climate-resilient infrastructure, strengthening the existence of de-risking instruments, and providing incentives for developers. The government could also tap into other funding sources, such as pension funds, *Hajj* savings, and the sovereign wealth fund.

Infrastructure development in Indonesia is tiered at the regional and national levels. Although the government has a plan for creating climate-resilient infrastructure through the RAN-API, not all regions have regional action plans for climate-change adaptation. Moreover, climate budget tagging is still centred at the national level; only a few regions have budget tags for climate action.

The COVID-19 pandemic may be an opportunity to achieve sustainable recovery by integrating current infrastructure plans with climate resiliency. The government has emphasised that the infrastructure sector should spearhead economic recovery, as it has a strong output and labour multipliers that can reinvigorate the country's economy. The 2021 budget aims for infrastructure financing to return to the levels of the original 2020 infrastructure budget (i.e. twice the infrastructure budget of 2020 after COVID-19 revision). It is using PT Sarana Multi Infrastruktur to distribute loans for infrastructure to local governments and has sought international funding to support climate-change adaptation programmes.

The increasing role of MOPH to implement climate-resilient infrastructure guidelines for strategic national projects may improve compliance with climate resiliency in infrastructure. Mainstreaming climate-resilient infrastructure and involving local governments through Bappeda may also further the implementation of climate-resilient infrastructure. In addition, the Ministry of Finance needs to incorporate the *Climate Change Financing Framework* for climate-change adaptation financing, which will sharpen budget tagging and synchronise climate activities and funding.

3.3. Malaysia

Malaysia has increased its budget for climate-change adaptation measures, from RM282 billion in 2018 to RM308 billion in 2021. The increase is also reflected in the share of adaptation-related activities to the overall budget, which grew from 0.24% to 0.44%. The largest allocation is for flood-mitigation plans and urban drainage; the second-largest allocation is for modernising paddy irrigation.

In the longer term, allocations for flood-mitigation projects have substantially increased. Under the *12th Malaysia Plan (2021–2025),* RM16 billion is allocated for flood mitigation projects, which is similar to the RM17 billion allocated from the entire period from 2005 to 2020. A major reason for the increase in flood-mitigation funding is due to the visible impacts and shocks that Malaysia has recently suffered. In particular, in late 2021 to early 2022, Malaysia faced one of the worst flooding incidents in its history, resulting in 54 deaths, about 100,000 displaced persons, and economic losses of $1.46 billion.

External funding for climate change in Malaysia is focussed on mitigation. Adaptation funding is concentrated on policies and information such as developing a national adaptation plan and conducting vulnerability assessments.

3.4. Philippines

The Philippines is the ninth most at-risk country in the world in terms of disasters arising from earthquakes, cyclones, floods, droughts, or sea-level rise. Around 60% of its 110 million people lives in coastal areas vulnerable to climate change-induced disasters. The primary government agency responsible for climate adaptation advocacy is the Climate Change Commission (CCC), which works to coordinate, monitor, and evaluate government programmes on climate change and to ensure the mainstreaming of climate-change concerns in national, sub-national, and sectoral development plans.

Climate-change efforts are based on relevant regulations. The CCC formulated the *National Framework Strategy on Climate Change, 2010–2022,* which is a road map for a national programme on climate change. It details climate-change planning, research and development, extension services, monitoring of activities, and climate financing. The *National Disaster Risk Reduction and Management Plan, 2011–2028* is also being implemented, through the four mutually reinforcing thematic areas of disaster preparedness, disaster response, disaster prevention and mitigation, and disaster rehabilitation and recovery.

Funding for infrastructure for climate-change adaptation occurs through the government budget. The government is practising climate-change expenditure tagging in national agencies' budgets and local government unit budgets. The National Disaster Risk Reduction and Management Fund and local disaster risk reduction and management funds are also sources of financing since some resiliency measures can be considered adaptation responses.

International climate finance sources being tapped include the Climate Investment Funds, Green Climate Fund, and Global Environmental Facility. Potential additional sources include the Adaptation Fund through a regional project proposed by the United Nations Development Programme (UNDP), and the Joint Crediting Mechanism. The private sector also plays a role in

climate-change adaptation, such as through the Sustainable Energy Finance Program by Bank of the Philippine Islands, activities of the Philippine Business for Social Progress, and activities of the Philippines Disaster Resilience Foundation.

3.5. Singapore

Singapore has adopted whole-of-government efforts for climate-change adaptation. At the centre, supporting cross-departmental outcomes, is the National Climate Change Secretariat. Early adaptation efforts are reflected in the *Singapore Green Plan 2012* and *Sustainable Singapore Blueprint 2015.* Climate adaptation is focussed on coastal protection, water resources management, and drainage and flood protection. To protect Singapore's coasts in the long term, Singapore is assessing the possible impacts of coastal inundation under various scenarios of climate change and developing long-term strategies and adaptation measures best applicable to Singapore's coasts. In addition, it is taking a holistic approach to manage its drainage system, considering its water needs and flood risks. Flexibility and adaptability are the two key pillars in the approach to stormwater management.

The Second National Climate Change Study for Singapore provides information on anticipated climate change. The study was carried out in two phases. Phase 1 provided projections of changes in the main climate variables of interest to Singapore, while Phase 2 of which began in 2014, aims to provide the best available scientific information on the spatial and temporal scales most relevant to Singapore.

Singapore has aligned its adaptation efforts with green growth. Green growth has five thematic areas – clean technology, test bedding, clean information and communication technology (ICT), carbon services, and climate finance and climate risk management. Along with these areas, Singapore has developed a low-emissions development strategy for adaptation focussing on coastal protection, water resources and drainage, buildings and infrastructure, network infrastructure, biodiversity and greenery, public health and food security, and the urban heat island effect.

Singapore is focussed on three key adaptation actions in the long term – developing the country's resiliency framework, building climate science capabilities, and establishing adaptation measures. For climate actions in the long term, Singapore is implementing these actions through eight thematic areas – a future electricity grid, Energy Efficiency Fund, transport, buildings, Green Towns Programme, waste and water, Energy Grid 2.0, and sustainable finance.

3.6. Australia

The country's climate-change adaptation measures are guided by the *National Climate Resilience and Adaptation Strategy, 2021–2025*; however, specific goals to support resilience are the responsibility of state and local governments. Industries have also responded to existing pressures, leading to a multipronged approach with no clear strategic direction due to lack of leadership by the national government.

As a large country with a low population density, infrastructure plays a significant role in the economy, accounting for nearly 10% of the gross domestic product (GDP), with transport alone accounting for nearly 20% of Australia's greenhouse gas emissions. The ownership and

management of public infrastructure are either by state or national governments. Again, however, lack of national leadership has not supported effective climate-change adaptation in the infrastructure sector. Increasingly, responding to climate change is falling to local governments as they respond to community pressures.

Some private companies, such as the Brisbane Airport Corporation, have incorporated adaptation measures, such as responding to sea level rise by building a new sea wall and tidal channels. The cost for these were split amongst1 shareholders, loans, and an increase in landing fees and airline fees.

Australia has supported other countries largely through overseas development aid (ODA), derived as a proportion of the country's annual budgeting process. Australia's budget for ODA is well below the international agreed level of 0.7% of its total budget and has not increased in recent years, although the way it is packaged has changed. Determining the level of aid offered relies on a strategic approach and willingness to deal with climate change and related impacts, shifting to low-emissions development in the region and supporting innovation, including private sector investments.

The COVID-19 pandemic has impacted funding, with efforts being directed towards economic recovery activities rather than climate change and adaptation activities. Despite the impact on transport and global travel resulting in lower carbon emission levels, overall temperatures are expected to rise over the continent, leading to changes in weather patterns and to further uncertainties related to climate change, unless concerted actions to deal with emissions are not taken urgently.

3.7. Japan

The country's climate-change adaptation plan was developed in November 2015. However, its enactment was delayed until 2018. The mitigation policy – the Law Concerning the Promotion of the Measures to Cope with Global Warming – was established in 1998. Thus, mitigation and adaptation policies for climate change are dealt with separately in Japan.

The government has decided to enact new laws on adaptation on the grounds that mitigation and adaptation measures differ in their main objectives and measures, and the impacts of climate change are already in place and are likely to increase in the future. The laws centre on promoting adaptation, developing information infrastructure, strengthening adaptation in the region, and expanding adaptation internationally.

The position of adaptation finance remains insufficient, but there are increasing efforts to prepare for potential natural disasters. Japan also links the climate-resilience concept with other relevant sectors such as sustainable development, poverty eradication, and climate-change adaptation. Both the government and private sector have been putting serious efforts into financing climate-change adaptation.

4. Financing: A Collective Effort

Financing climate-adaptive infrastructure requires huge budgets, because many effects are still unknown or uncertain – especially the probability and scale of future disaster events. Consequently, it requires lengthy, resource-rich research efforts, and the transition process to new methods and technology often entails delaying important projects and asking for higher upfront investment costs. This has thus been met with some challenges in the learning process to comply with environmental requirements, along with limited government fiscal capacity and sources of financing.

Another challenge to embracing green infrastructure is that investment typically requires substantial upfront costs, while most benefits from these adjustments are seen only in the long term or in the form of avoiding potential damages. Business models can face difficulties translating these benefits into project business plans. The burden of the high upfront costs is thus often distributed to other stakeholders, especially governments. However, many countries with limited government funding – usually small and/or developing countries – are those most vulnerable to the impacts of climate change. Pacific island countries, for instance, face various economic obstacles including geography; market sizes; remote locations; distances amongst islands; and increasing threats of climate change such as rising sea levels, rising earth and seawater temperatures, hurricanes and typhoons, and floods.

During the COVID-19 pandemic, community vulnerability increased, particularly in poorer areas often most affected by climate change. This double burden is something that is becoming increasingly clear, providing an even stronger argument for all parties – especially governments – to work to prevent rapid climate change. Indeed, the costs incurred to adopt climate-change mitigation efforts are less than those from the damage caused if stakeholders do not adopt them (Hallegatte, Rentschler, Rozenberg, 2019).

Global efforts have been made to facilitate green investments, but the pace has moved slowly. Attempts to include the intangible benefits of green investments have been made in some estimates, but it is challenging to transform them into actual project finance. Economic benefits and saving economic losses may have indifferent impacts on private investors, especially if the figures are high – they cannot directly enter the project's income statement and rate of returns. This is where non-business stakeholders, such as governments and multilateral agencies, should play a prominent role.

The abovementioned challenges make key stakeholders call for 'innovative finance'. Some schemes under public–private partnerships are using climate-change adaptation principles. Another effort is the creation of blended finance schemes, which mix funds from multilateral agencies, development agencies, the private sector, philanthropic foundations, and other donors. Apart from financial sources, the diverse actors in blended finance have various complementary roles. For instance, philanthropic foundations, donors, and development agencies typically have higher risk tolerance than the private sector. The funding from these actors can be used to de-risk the project so it will be more attractive to private investment. They can also provide indirect investment, such as through technical assistance grants, demonstrating the initial initiatives and then taking on subordinate positions.

Blended finance is a relatively new scheme in infrastructure finance; however, it has become more popular, especially for projects adopting environmental, social, and governance (ESG) principles. Complexities in climate adaptive projects are multidimensional; not only do they contain size, technological, and risk-measurement challenges, but the causes and impacts are borderless. For these reasons, this report asks that this issue be considered a collective measure.

Country reports show the need to respond globally when countries face a huge burden in dealing with a grave, immediate situation – such as the COVID-19 pandemic. Climate-change adaptation should thus be a collective effort of the Earth's inhabitants, because the externalities of climate change and environmental damage do not recognise administrative, territorial, or other barriers created by humans. The greenhouse effect, to which industrial and consumptive human actions contribute, will be experienced by all humans and living creatures.

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Chapter 2

China

Hongyuan Yu, Yunjie Zhu, and Yanfei Li

1. Introduction

Climate change has emerged as a top security challenge of the early 21st century. Although China's ability to adapt to climate change is still insufficient, it has been significantly enhanced. Its policies should continue to focus on the ability to respond to extreme weather events, to resist climate risks to agriculture and major infrastructure projects, to adapt to climate change in essential realms, as well as to develop and to use climate resources for climate-change adaptation measures.

As a developing country experiencing rapid urbanisation and industrialisation, China has significant development inequality amongst its regions, which forces the country to focus on both huge and incremental development-oriented climate-change adaptation needs. Even for the developed coastal areas, where the infrastructure is relatively complete, the increasing climate risks have significantly increased its vulnerability. Therefore, it is necessary to rely on government-backed financial investment to promote development-oriented adaptation, including for infrastructure.

In this chapter, China's policies and regulations for financing and investing in climate resilience are reviewed. Five climate-change adaptation engineering projects, which are the most prominent in the country, are discussed. The typical financing sources, mechanisms, and tools are also detailed accordingly.

2. Overall Country Policies and Regulations

In 2019, the Global Commission on Adaptation released *Adapt Now: A Global Call for Leadership on Climate Resilience*, which posited that climate-change adaptation can provide a triple dividend – it avoids economic losses, brings positive gains, and delivers additional social and environmental benefits (China Meteorological Administration, 2019). Following this, China worked to combine climate-change adaptation with the implementation of sustainable development strategies by accelerating the construction of a natural resource-saving and environmentally friendly society; building innovative cities that focus on energy conservation, optimising energy structure, and strengthening ecological protection and construction; supporting scientific and technological progress; and striving to control greenhouse gas emissions. Outlined as follows, a series of climate-change mitigation and adaptation plans and policies have materialised, and many important climate-change adaptation projects have begun.

In 2009, China announced that by 2020, it will lower carbon dioxide emissions per unit of gross domestic product (GDP) by 40% to 45% from the 2005 level, increase the share of non-fossil fuels in primary energy consumption to about 15%, and increase forested area by 40 million

hectares and forest stock volume by 1.3 billion cubic metres compared to 2005 levels (China.org.cn, 2015).

To build an energy-efficient and low-carbon industrial system in China, the industrial sector is being encouraged to embrace low-carbon development through the *Action Plan of Industries Addressing Climate Change (2012–2020),* which details carbon-emission control targets and action plans (China.org.cn, 2015). In the same year, the National Development and Reform Commission (NDRC) launched national demonstration projects of low-carbon technology innovation and industrialisation and approved 20 demonstration projects in three industries – steel, non-ferrous metals, and petrochemicals. During 2011–2012, 59 science and technology projects began in the energy sector, with CNY2.74 billion allocated by the state. These projects focussed on formulating plans for developing energy technologies, clean and efficient coal transformation, and wind-power generation; they also worked to issue the *Fourth Batch of the National Key Energy Savings Technology Promotion Catalogues* (SCIO, 2012). China also implemented the National Climate Change Programme. Specific policy documents include the *Comprehensive Work Plan for Energy Conservation and Emission Reduction for the 12th Five-Year Plan Period*; *12th Five-Year Plan for Energy Conservation and Emission Reduction*, *2014–2015; Action Plan for Energy Conservation, Emission Reduction, and Low-Carbon Development*; and *National Plan on Climate Change (2014–2020)* (SCIO, 2014).

Further, China established the National Committee for Biodiversity Conservation and enacted the *China Biodiversity Conservation Strategy and Action Plan (2011–2030)* to implement the relevant provisions of the Convention on Biological Diversity (Government of China, 2016). In 2009, it approved the *Plan for the Protection and Construction of the Eco-safety Barrier in Tibet (2008–2030)*. By the end of 2017, 10 projects under this plan had been implemented, with a total investment of CNY9.6 billion.

In 2005, the State Council of China approved *The Overall Plan of Qinghai Sanjiangyuan National Nature Reserve's Ecological Protection and Construction*, marking the official opening of the first phase of ecological protection and construction project of the Sanjiangyuan Nature Reserve in Qinghai Province. The first phase of the project covers the headwaters of the Yellow River, Yangtze River, and Lancang River. The administrative scope includes all 21 counties in Qinghai Province and Tanggulashan town in Golmud City, with a total of 22 projects and a total investment of CNY7.5 billion (Government of China, 2006a). The government, in 2011, implemented the *Plan for Regional Ecological Construction and Environmental Protection on the Qinghai-Tibet Plateau (2011–2030).* Under this plan, several eco-projects have been implemented, achieving positive results in ecosystem conservation, helping control the degradation of the local ecosystem, and restoring biodiversity (SCIO, 2018).[1]

In 2013, *China's National Climate Change Adaptation Strategy* was released to cope with climate-change challenges such as extreme weather conditions and impacts on livelihoods (MEE, 2016). It recommended that adapting to climate change should be included in China's economic and social development in a holistic manner. The strategy set the main objectives of adaptation

[1] For example, to date, about 71,300 hectares of degraded wetlands have been restored, 20,000 hectares of farmland have been returned to wetlands, and 112 national wetland parks have been created. Six cities have the title of 'International Wetland City'. At the provincial level, 13 provinces and cities – including Yunnan – have designated 541 important wetlands.

to climate change by 2020, including enhancing adaptability, fully implementing key tasks, and forming a regional pattern of adaptation. Promoting international cooperation is also encouraged by the strategy to help ensure its implementation.[2]

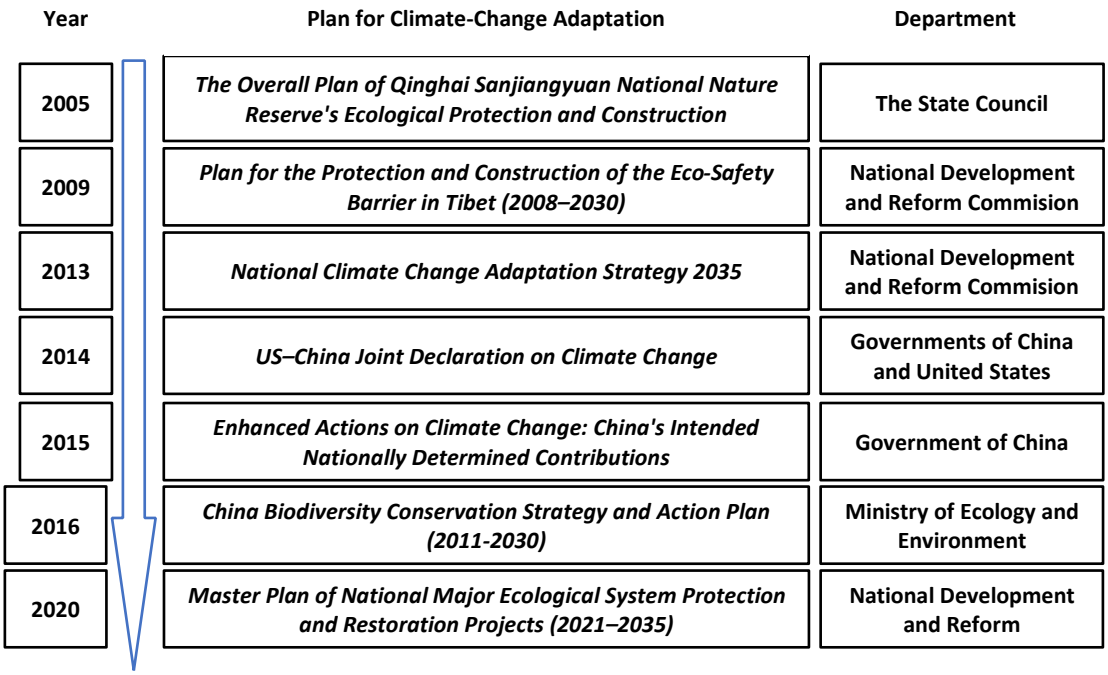
Regarding the goal of limiting global temperature increase to 1.5°C, the *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions, Third National Assessment Report on Climate Change,* and *China's Policies and Actions on Climate Change: 2017 Annual Report* propose related strategic plans and policy advice towards this goal and the reduction of carbon emissions (Government of China, 2015, 2017).

The United States (US)–China Joint Announcement on Climate Change*,* issued in November 2014, is a major landmark in the cooperation between China and the US in the field of climate change; it is also proof of China's readiness to undertake international obligations as a major developing country. Both countries reiterated that in the context of meaningful mitigation actions and implementation transparency, developed countries must commit to jointly mobilise $100 billion per year by 2020 to meet the environmental needs of developing countries (Government of China, 2013).

In sum, China's commitment to environmental quality is on a stable and sound trend, and the deterioration of its various ecosystems is being curbed. The quality of key ecological project areas has been improved, and the framework for national ecological security has been established. The *Master Plan of National Major Ecological System Protection and Restoration Projects (2021–2035),* issued in May 2020, states that ecological protection and restoration will be strengthened through the implementation of major ecological protection and restoration projects by 2035. Major projects include the Qinghai-Tibet Plateau Ecological Barrier Area, key ecological areas of the Yangtze River, the Three-North Shelter Forest, the Northern Sand Protection Belt, several southern hilly and mountainous areas, and coastal zones (NDRC, 2020). The following figure summarises the main policies issued in China.

[2] This cooperation does require developed countries to fulfil their obligations under the United Nations Framework Convention on Climate Change, promote the research and development of key adaptation technologies, and carry out South–South cooperation.

Figure 2.1. Main Climate-Change Adaptation Policies Issued in the Past 2 Decades



Source: Authors.

3. Adaptation Projects

Climate-change adaptation projects in China can be divided into two types: (i) passive engineering measures to deal with natural disasters caused by climate change (e.g. Three Gorges Dam, South-to-North Water Diversion Project, and Qinghai-Tibet Railway); and (ii) dedicated climate-change adaptation projects, usually supported by national and local governments (e.g. Sanjiangyuan Ecological Protection Project and Three-North Shelterbelt Project).

3.1. The Three Gorges Dam

The Three Gorges Reservoir is in the upper reaches of the Yangtze River, at the junction of the economically developed eastern region and the resource-rich western region. It is an important ecological barrier, national strategic freshwater resource, and strategic position in China's social and economic development. The Three Gorges Dam is in the Xiling Gorge section of the Three Gorges of the Yangtze River. It controls a drainage area of 1 million square kilometres and an average annual runoff of 451 billion cubic metres (Wertz, 2011). It is not only the world's largest water conservancy project but also a key project for the treatment and development of the Yangtze River. The operation of the Three Gorges Dam is of great significance to guaranteeing national economic security, social security, and ecological security.

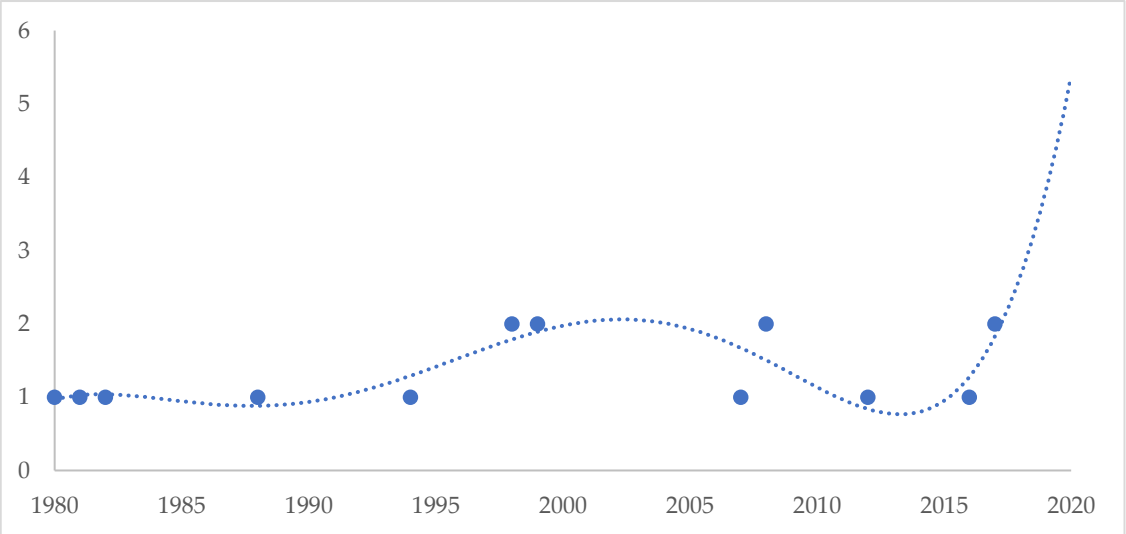
Rainfall and reservoir water trigger landslides around the reservoir; the monitoring and early warning of landslides affect people's lives and property. The reservoir water level also impacts the economic benefits from the Three Gorges Hydropower Station. A rapid drop in water level

is beneficial to power generation, but a too-fast drop may cause landslides along the riverbank. The land mass sliding into the reservoir may generate huge swells, thereby threatening the safety of hydraulic structures and personnel.

In addition, climate change has had an impact on the integrated management and operation of the Three Gorges Reservoir and Dam, especially in terms of the safety of hydraulic structures and staff, water resources management and operation, and vegetation and ecosystem security.

Due to climate change, the hydrological characteristics of the Three Gorges Reservoir's incoming water has been altered. Extreme weather events – such as high temperatures, continuous droughts, strong autumn floods, and floods during the monsoons – have created new challenges. Indeed, from 1980 to 2020, the area in which the Three Gorges Dam is located has witnessed 16 disasters, including 1 drought, 9 floods, and 6 storms. The main form of disasters are riverine floods and convective storms, and the number has increased significantly since 1995. Based on the trend of the number of disasters through a sixth-order polynomial, the period between 1995 and 2010 was the peak period for natural disasters. After a short-term decline after 2010, the number of natural disasters showed an accelerated trend of increases (Figure 2.2).

Figure 2.2. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Three Gorges Project Area



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

The construction funds for the Three Gorges Project include the Three Gorges Project Construction Fund allocated by the state, loans from the China Development Bank, and various monies raised by the China Three Gorges Corporation. The China Three Gorges Corporation is responsible for the fundraising, project construction, and operational management of the Three Gorges Project, as well as the preservation and appreciation of assets.

According to the construction content and price level at the end of May 1993, the Three Gorges Construction Committee's static investment totalled CNY135.266 billion, including the hub

project (CNY50.090 billion), power transmission and transformation project (CNY32.274 billion), and resettlement funds (CNY52.902 billion). Calculated according to factors such as prices and interest rates, the total dynamic investment is CNY248.537 billion, including the hub project (CNY126.385 billion), power transmission and transformation project (CNY36.499 billion), and resettlement funds (CNY85.653 billion).

The Three Gorges Construction Fund, established in 1992, became the most stable source of funds. In January 1997, the State Planning Commission formally approved the Three Gorges Bond issuance plan. In February, the Three Gorges Corporation issued bonds for the Three Gorges Project for the first time in China, with a quota of CNY1 billion.

By the end of 2002, export credits and international commercial loans for the purchase of foreign equipment totalled $1.12 billion (i.e. export credits of $700 million and commercial loans of $420 million involving 26 commercial banks, 21 years of loan terms, 9 years of use, and 12 years of repayment). The annual average interest rate was 7.8%.

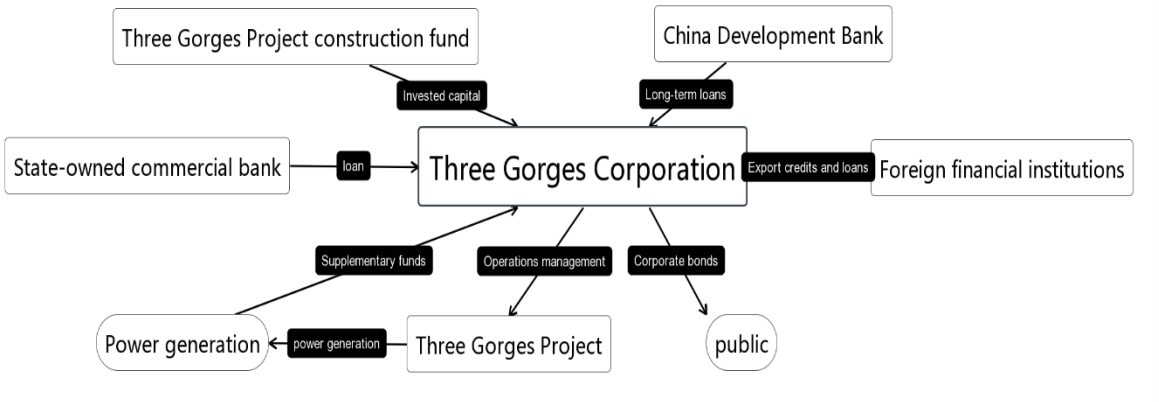
As of the end of December 2011, CNY207.873 billion was invested in the construction of the Three Gorges Project. This included the Three Gorges Project Construction Fund of CNY161.587 billion, revenue from the sale of generator sets to the Yangtze Power Company totalling CNY35.03 billion, power grid income of CNY11.069 billion, and the infrastructure fund and other special funds of CNY186 million. During the construction process, the funds raised through loans from the China Development Bank and the issuance of corporate bonds were fully repaid.

The funds were divided into three stages: (i) investment stage, from 1993 to 2003; (ii) input-output stage, during which the first batch of power generation units began to yield economic returns (2003), and the power generation income of the year plus the profit income of the Three Gorges Project Construction Fund and Gezhouba Power Plant reached a balance with the capital demand of the year (2005); and (iii) output-loan repayment stage, during which a surplus of funds occurred starting in 2006, and the loan principal and interest were repaid. Preliminary estimates show that after 2010, all principal and interest of the loan were paid off.

The government issued three supporting policies in terms of fundraising (Figure 2.3). The first was to assign the Gezhouba Power Plant to the China Three Gorges Corporation, and its power-generation profits were used for the construction of the Three Gorges Project. In addition, the on-grid power price was increased, and the revenue was also used for the construction of the Three Gorges Project. The second was to raise electricity prices for users and to enact levies across the country according to different regions and different standards for the Three Gorges Project Construction Fund. This raised about CNY110 billion, accounting for more than 50% of the total investment in the Three Gorges Project. The third was loans from the China Development Bank, which advanced CNY3 billion to the Three Gorges Project each year from 1994 to 2003, totalling CNY30 billion. The above three policies raised more than CNY140 billion for the Three Gorges Project, accounting for about 70% of the total project investment.

In addition, since 2003, the power-generation units were put into production, adding new sources of funds for the Three Gorges Project from the sale of electricity. A small amount of funds was also raised from domestic and foreign capital markets, through facilities such as export credit and bond issuance.

Figure 2.3. Financing Mechanism of the Three Gorges Project



Source: Authors.

3.2. South-to-North Water Diversion Project

The South-to-North Water Diversion Project involves drawing water from southern rivers and supplying it to the dry north. This massive scheme has already taken 50 years from conception to commencement and is expected to take almost as long to construct. Planned for completion in 2050, it will eventually divert 44.8 billion cubic metres of water annually to the population centres in the north.

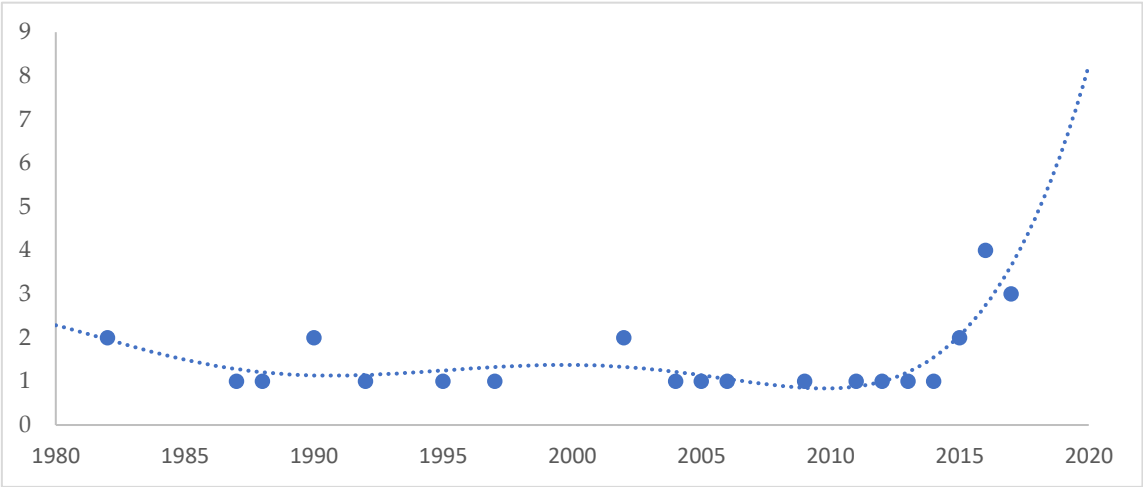
Since the 1950s, based on the analysis and comparison of more than 50 planning schemes, three water transfer areas have been planned in the lower, middle, and upper reaches of the Yangtze River, forming the East, Middle, and West routes of the South-to-North Water Diversion Project. Three water transfer lines are to be connected to the Yangtze River, Huai River, Yellow River, and Hai River. The three water transfer lines complement each other and cannot be replaced. The planned final scale of the South-to-North Water Transfer Project is 14.8 billion cubic metres in the East Line, 13.0 billion cubic metres in the Middle Line, and 17.0 billion cubic metres in the West Line.

The shortage of water resources in the water source area, frequent floods and droughts, and serious soil erosion – combined with the long-term trend of global temperature rise, droughts, and water shortages – make the South-to-North Water Diversion Project face the systemic risk of unsustainable water transfer as well as indirectly lead to the decline of water quality in the water sourcing area.

From 1980 to 2020, there were 27 disasters in the areas covered by the East Line, including 5 droughts, 12 floods, and 10 storms. The main forms of disasters were riverine floods and convective storms. Similarly, there were 25 disasters in the areas covered by the Middle Line, including 3 droughts, 9 floods, 10 storms, and 3 extreme temperature stretches. The main forms of disasters were riverine floods, convective storms, and heat waves.

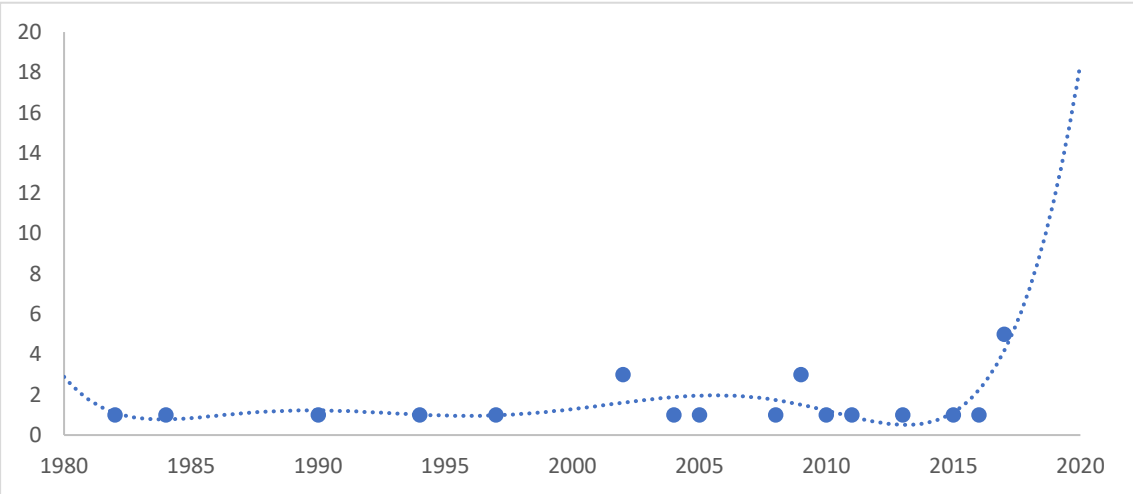
According to data from 1980 to 2020, the frequency of disasters along the East and Middle lines is stable. However, both the number and frequency of disasters show a significant increase in the past 5 years. This will pose a greater threat to both routes of the project (Figures 2.4 and 2.5).

Figure 2.4. Sixth-Order Polynomial Trend Line of Disaster Frequency for South-to-North Water Diversion Project, East Line



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

Figure 2.5. Sixth-Order Polynomial Trend Line of Disaster Frequency for South-to-North Water Diversion Project, Middle Line



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

On 5 September 2008, the South-to-North Water Diversion Project Construction Committee issued fund management measures, which stipulated that project would be funded through the central budget (including special funds from the central budget), South-North Water Diversion Project Fund, and bank loans. Of the CNY194.3 billion in the main project investment, the central government funded CNY31.26 billion; the South-to-North Water Transfer Project Fund, CNY18.02 billion; bank loans, CNY40.72 billion; and major water conservancy project funds, CNY104.3 billion.

On 15 June 2004, the main project financing syndicate for the South-to-North Water Transfer Project was established, led by China Development Bank, China Construction Bank, Agricultural Bank of China, Bank of China, Industrial and Commercial Bank of China, four wholly state-owned

commercial banks, Bank of Communications, Shanghai Pudong Development Bank, and the three joint-stock commercial banks of China CITIC Bank. The syndicate provided loans of the CNY40.72 billion.

The South-to-North Water Diversion Project Fund was raised within Beijing, Tianjin, Hebei, Jiangsu, Shandong, and Henan Provinces, which are the water-receiving areas of the South-to-North Water Diversion Project. The amount of funds raised by the six provinces and cities is as follows: Beijing, CNY5.43 billion; Tianjin, CNY4.38 billion; Hebei Province, CNY7.61 billion; Henan Province, CNY2.60 billion; Shandong Province, CNY7.28 billion; and Jiangsu Province, CNY3.70 billion (SCIO, 2008).

As of May 2016, the Ministry of Water Resources allocated CNY261.92 billion in the first phase of the South-to-North Water Diversion Project, including CNY25.42 billion from the central budget, CNY10.65 billion from special funds (i.e. national bonds) from the central budget, and CNY19.65 billion from the South-to-North Water Diversion Project Fund. CNY158.61 billion was from a national major water conservancy project construction fund, and loans totalled CNY47.59 billion.

On 28 September 2020, the China South-to-North Water Diversion Group was established, with registered capital of CNY150 billion. It is a wholly state-owned enterprise to accelerate the South-to-North Water Transfer Project.

3.3. Qinghai-Tibet Railway Project

The Qinghai-Tibet Railway is a plateau railway at the highest altitude that has the longest line in the world. As the first railway that reaches the heartland of the Qinghai-Tibet Plateau, it will strengthen the connection between the Qinghai-Tibet region and the more economically developed regions of China.

The Qinghai-Tibet Railway is listed as one of four landmark projects in the *10th Five-Year Plan* and ranks first amongst the 12 key projects in the country's development of western areas. It is often referred to as the most difficult railway project in history due to its location and features (Government of China, 2006b).

The Qinghai-Tibet Railway is a national, Grade I railway, connecting Xining to Lhasa. The total length is 1,956 kilometres, including 814 kilometres from Xining to Golmud and 1,142 kilometres from Golmud to Lhasa. There are 85 stations with a designed maximum speed of 160 kilometres per hour (Xining–Golmud section) and 100 kilometres per hour (Golmud–Lhasa section). As of March 2015, the operating speed of the Qinghai-Tibet Railway was 140 kilometres per hour (Xining–Golmud section) and 100 kilometres per hour (Golmud–Lhasa section) (Ma, 2015).

Due to global warming, the permafrost on the Qinghai-Tibet Plateau is currently degrading. Of the total length of the railway, 960 kilometres are at least 4,000 metres above sea level and run about 547 kilometres through permafrost areas. Further, the Qinghai-Tibet Railway is changing the original hydrothermal conditions, influencing the thermal stability of the permafrost along the railway line.

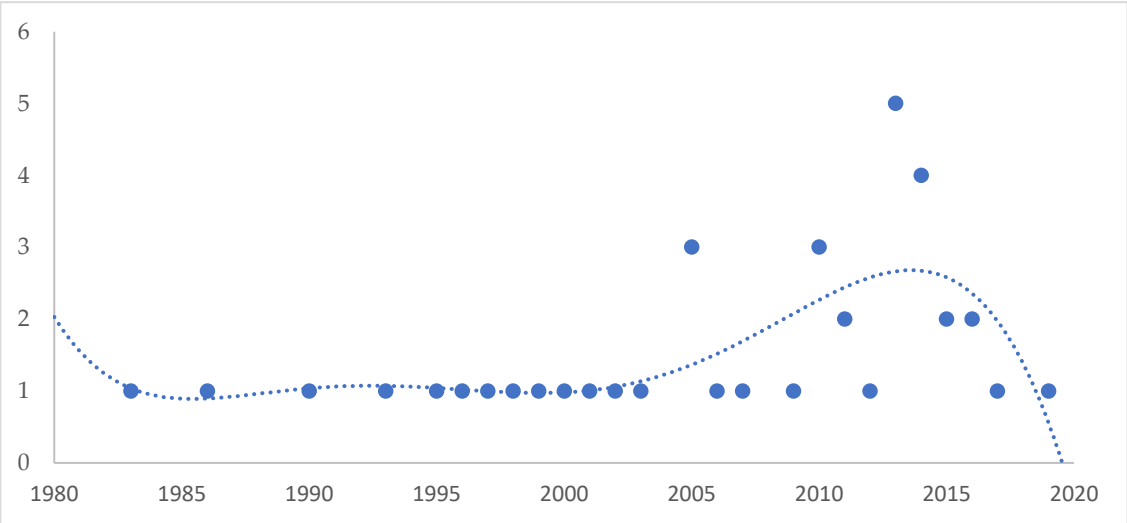
First, the warming and humidifying climate on the plateau may lead to increasing lateral hydrothermal erosion of the roadbed side, resulting in uneven subsidence and deformation of

the roadbed. The roadbed may tilt or even collapse. Second, due to global warming and humidification, glacial meltwater and increased precipitation may lead to glacial lake outbursts, contributing to floods and mudslides. These could destroy the Qinghai-Tibet Railway, highway, and other supporting infrastructure.

From 1980 to 2020, there were 37 disasters in the areas of the Qinghai-Tibet Railway Project, including 2 droughts, 16 floods, 15 storms, 2 extreme temperature stretches, 6 landslides, and 1 wildfire. The main forms were riverine floods, convective storms, cold waves, and severe winter conditions.

According to data from 1980 to 2020, the frequency of disasters along the Qinghai-Tibet Railway was relatively low and stable before 2005. However, since 2005, disasters along the Qinghai-Tibet Railway have seen significant peaks both in terms of number and frequency (Figure 2.6).

Figure 2.6. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Qinghai-Tibet Railway Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

The Tibetan Plateau is the 'starter' and 'amplifier' of global climate change, with its warming occurring earlier than and higher than the global average (Cheng and Wu, 2007). In the past few decades, the permafrost on the Qinghai-Tibet Plateau has been melting. From the 1970s to 1990s, the ground temperature of seasonal frozen soil, thawing area, and island permafrost along the Qinghai-Tibet Highway increased by 0.3℃ to 0.5℃, and the annual average ground temperature in continuous permafrost regions increased by 0.1℃ to 0.3℃ (Wang, Hou, Jia, 2006).

The Qinghai-Tibet Railway passes through the most developed permafrost region. As global warming will affect the permafrost, engineers have taken this effect into consideration when designing the railway. The idea of active cooling, foundation cooling, and frozen soil protection has been established, and the natural cold energy is being used to protect the permafrost. In addition, a complete set of frozen soil engineering and technical facilities, such as rubble air-

cooled subgrade, hot-rod technology, subgrade insulation materials, and bridges passing through extremely unstable permafrost sections, has also been developed.

In the design process, the number of stations was reduced to lessen emissions. After completion and operation, sewage treatment plants and garbage treatment plants will be built at some stations along the line, and clean energy such as solar energy and wind energy will be used as much as possible at these locations (Wang, Hou, Jia, 2006).

According to a press conference of the State Council Information Office on the construction and commissioning of the Qinghai-Tibet Railway, the total investment approved was CNY33.09 billion. More than CNY2.00 billion has been invested in environmental protection, accounting for about 7% of the total investment. In addition, each station along the railway will use clean energy, mainly electric energy and solar energy (CKNI.net, 2006).

In view of the frozen soil problem, 96 ministry-level scientific research projects were listed under the construction of the Qinghai-Tibet Railway, and the scientific research funds have totalled nearly CNY100 million. Under the Ministry of Science and Technology, Chinese Academy of Sciences, and Chinese Academy of Engineering, domestic and international frozen soil engineering has been coordinated. Scientific research and design units carried out frozen soil research, and theoretical research, field tests, survey and design, and scientific construction were actively explored. A breakthrough was made in the combination of frozen soil theory and frozen soil engineering practices, and many scientific and technological innovation achievements with independent intellectual property rights were obtained (Chinese Academy of Sciences, 2009).

For the permafrost area, the entire 32-kilometre subgrade adopted heat-treatment measures, such as the hot-rod technology. More than CNY30 million of investment can be saved per kilometre compared with replacing roads with bridges. The total cost savings of the Qinghai-Tibet Railway has reached more than CNY1 billion. Moreover, the destruction of permafrost ecological environment and resources caused by engineering activities such as surface excavation, vegetation removal, and embankment construction has been largely avoided (Xie, 2009; Wang, Hou, Zhou, 2004; Wu and Mi, 2000).

In the process of building the Qinghai-Tibet Railway, the government has invested CNY1.2 billion in environmental protection. Many kinds of rare wild animals, such as Tibetan antelopes and kiangs, live along the Golmud–Lhasa section. Indeed, about 14 species of rare wild animals live on both sides of the line. To ensure the normal life, free migration, and reproduction of these animals, 33 animal passages – with a total length of 59.8 kilometres – have been set up along the railway through gentle sloping of the subgrade, under bridges, and above tunnels. During the peak construction period in 2004, 1,660 Tibetan antelopes were recorded crossing the wildlife passages. At the beginning of the project in 2006, the number of Tibetan antelopes moving were over 2,000; after 2011, the number exceeded 5,000. The utilisation rate of wildlife passage increased from 56.6% in 2004 to 100% after 2011 (NFGA, 2016).

3.4. Sanjiangyuan Ecological Protection Project

The Sanjiangyuan Nature Reserve was established in 2000 and promoted to a national nature reserve in 2003. The ecological protection and construction project in the Sanjiangyuan Nature Reserve was officially approved in 2005, officially launching the ecological restoration and management of the Sanjiangyuan region. The project includes measures such as returning cropland to forest and cultivated grasslands to natural grass, controlling rodent infestations, conserving soil and water, developing protection and management facilities, and building capacity. The overall goal is to curb the trend of grassland ecological degradation.

The dynamic process of degradation or restoration of grassland ecosystems entails a combination of environment and anthropogenic activities. The Sanjiangyuan Nature Reserve is in the Tibetan Plateau, where climate change has had a vast impact on its grassland ecosystem and is a determining factor on vegetation productivity. The climate of the Sanjiangyuan has been warm and humid overall over the past 50 years, and some scientists have argued that this climate-change trend is favourable for vegetation growth and recovery. However, the climate-change trend has shifted to unfavourable vegetation growth and intensified grassland degradation, posing a threat to ecological security.

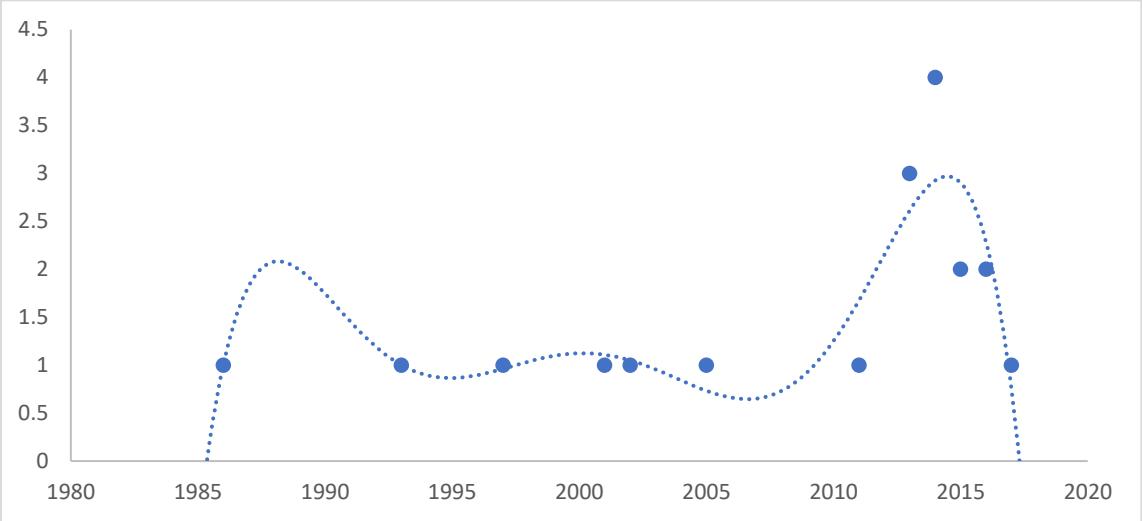
The first phase of the project covers the source areas of the Yellow River, Yangtze River, and Lancang River in Qinghai Province. The administrative scope includes all 21 counties in Qinghai Province and Tanggulashan town in Golmud City. There are 22 projects, with a total investment of CNY7,507.4412 million, including 12 ecological protection and construction projects. The first phase of Sanjiangyuan project was completed in 2011 and achieved good results. The current project, Phase Two, seeks to evaluate the effect of the first phase and to develop the second phase (Zhang and Zhuang, 2014).

As previously discussed, Sanjiangyuan is located on the Tibetan Plateau, one of the most sensitive and vulnerable areas of the natural ecosystem. As an independent climate region with the highest altitude and the most complex terrain in the world, Sanjiangyuan plays an initial role in the water cycle of several major rivers, which has a significant impact on the atmospheric circulation in China, South-East Asia, and even the entire Northern Hemisphere.

From 1980 to 2020, there were 19 disasters in the Sanjiangyuan, including 1 drought, 7 floods, 10 storms, and 1 extreme temperature stretch. The main forms were riverine floods, convective storms, and cold waves.

The frequency of disasters in the Sanjiangyuan was relatively low and stable before 2010. However, since 2010, their number and frequency in the Sanjiangyuan area have seen significant peaks (Figure 2.7).

Figure 2.7. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Sanjiangyuan Ecological Protection Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

Since the 1990s, three national nature reserves – Longbao, Kekexili, and Sanjiangyuan – have been established; policies and regulations, such as ending natural forest cutting and prohibiting the mining of sand and gold, have been issued; and the ecological protection of the Sanjiangyuan has been strengthened through various laws. The province has insisted on putting ecological protection in a prominent position. In 2007, three objectives – scientific development, ecological protection, and improvement of people's livelihoods – and the strategy of ecological province building were established.

As of 2010, the Sanjiangyuan has created 6.687 million hectares of grassland, 6,500 hectares of farmlands for forest, 122,000 hectares of closed hillsides for afforestation, 13,000 hectares of black soil beach treatment, and resettled 40,000 ecological immigrants and 21,000 nomadic herders. The ecological function of some areas of the source of the three rivers has been restored, the productivity of grasslands has been improved, and the Thousand Island Lake that has been dried up for many years has begun to again appear (Luo, 2010).

The Normalized Difference Vegetation Index (NDVI) was used to study the change of vegetation cover in the Sanjiangyuan area (Ma et al., 2022). With the establishment of Sanjiangyuan Nature Reserve in 2000, environmental management in the area achieved good results, and the vegetation shows a trend of recovery. Based on the change intensity of NDVI, combined with the scope of Sanjiangyuan Nature Reserve and the corresponding protection measures, before 2000, the vegetation of Sanjiangyuan was degraded due to human and natural factors, and the NDVI of six counties decreased significantly. In 2006, the declining trend of NDVI in Yushu, Nangqian, and Shengda counties was weakened, and the NDVI of Changdu and Leiwuqi counties improved. This phenomenon shows that the Sanjiangyuan Nature Reserve has achieved its initial results. At this time, the NDVI in most areas shows a stable or slight increased trend, but there are still large areas of Qumalai and Zaduo counties in the middle of the source area showing a strong downward trend, and the specific reasons for the decline need to be further studied (Zhao, Jiang, Li, 2008).

On 26 January 2005, the State Council approved the *Overall Plan of Qinghai Sanjiangyuan National Nature Reserve's Ecological Protection and Construction*, which plans to invest more than CNY7.5 billion. In August 2005, the plan was implemented, and the construction of nature reserves has been steadily promoted. Until the first half of 2012, the state invested CNY5.6 billion, accounting for 74.6% of the total planned investment. A total of 22 projects have been implemented, including returning grazing land to grassland and comprehensive treatment of black soil beaches, with an investment of CNY5.18 billion, accounting for 92.5% of the total investment. About 3.3 million hectares of grassland have been restored; 92,267 hectares of black soil beach were treated; 5.9 million hectares underwent rodent control; 6,540 hectares of forest were restored; 0.19 million hectares of hillsides were closed for afforestation; 44,106 hectares underwent desertification control; 38,667 hectares of wetlands were protected; 75.2 square kilometres of soil and water were conserved; 1,667 hectares of irrigation and forage bases were created; and 28,588 livestock-raising households, 10,733 ecological immigrants, and more than 55,000 people were resettled (NFGA, 2012).

From 2014 to 2018, in the first 4 years of Phase Two, CNY9.711 billion was released, accounting for 60.5% of the total planned investment. The total investment reached CNY9.548 billion, accounting for 98.3% of the released investment.

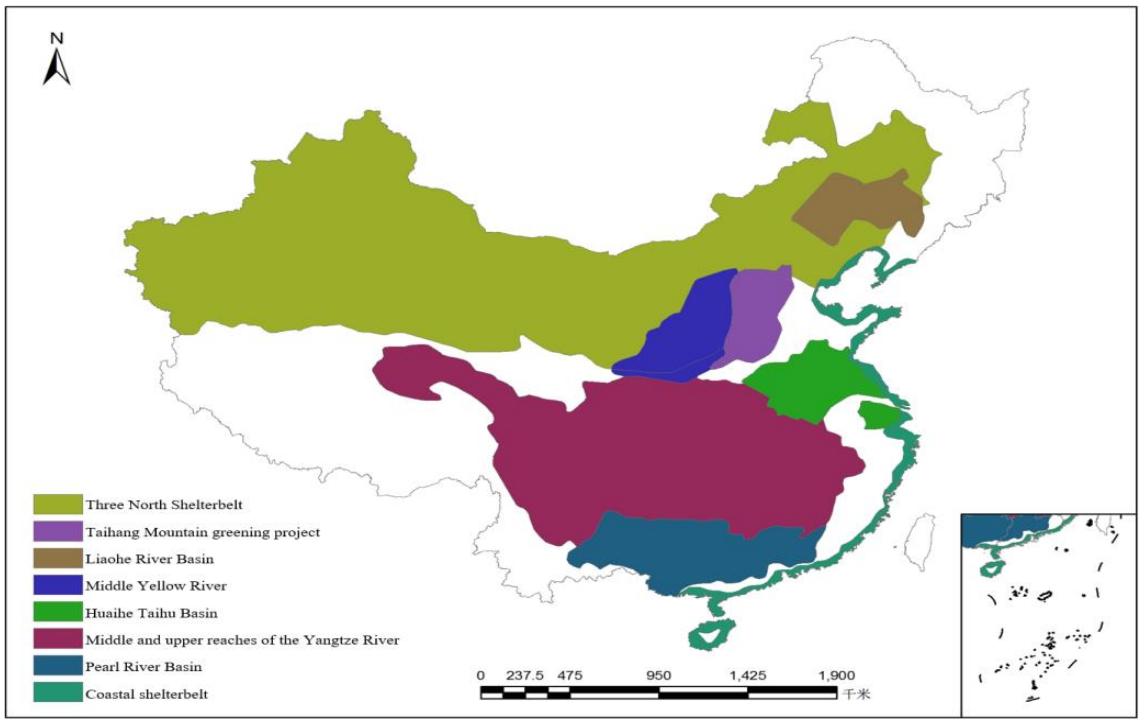
3.5. Three-North Shelterbelt Project

The Three-North Shelterbelt Project refers to a large-scale artificial forestry ecological project in the three northern regions of China. To improve the ecological environment, the government listed it as an important project of national economic construction in 1979. The planning period of the project is 73 years. It is divided into eight phases, and the sixth phase has been started.

The Three-North Shelterbelt Project was launched to improve the ecological environment in Northern China and to prevent sandstorms and soil erosion. The forest protection system starts from Binxian County, Heilongjiang Province in the east; reaches the Uziberi mountain pass in Xinjiang Province to the west; touches the country’s northern border; and continues along the Hai, Yongding, Fen, Wei, and Tao rivers downstream and Kunlun Mountain in the south. The total area is 4.069 million square kilometres, accounting for 42.4% of the land area in China. The planned afforestation area is 35.7 million hectares. By 2050, the forest coverage in the three areas will increase from 5.05% to 14.95%.

There are eight deserts and four sandy lands in the three north areas in the master plan, comprising 1.33 million square kilometres, which is larger than the total cultivated land area of China. Annual sandstorm days in this area number 30 to 100, and the riverbed in the lower reaches is more than 10 metres above ground. The construction of the project not only plays a decisive role in improving the ecological environment of the three north areas, but also plays an important role in improving the national ecological environment.

Figure 2.8. Three-North Shelterbelt Project



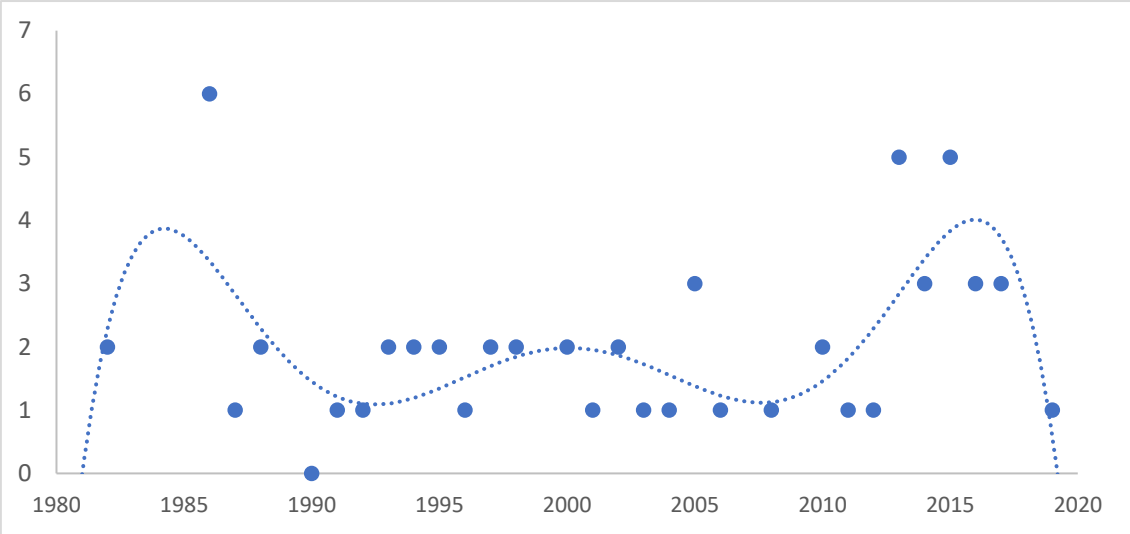
Source: Resources and Environment Science and Data Center, Spatial Distribution of Forestry Engineering in China, http://www.resdc.cn/data.aspx?DATAID=138&WebShieldDRSessionVerify=7pmmBPgaHhIKm2iZPr7U.

Wang et al. (2014) found that over the past 52 years, the temperature in the project area showed a significant increase, while precipitation showed a decreasing trend, which will limit the implementation of the protective forest project. Research has also showed that the climate of Northern China will see a warm and humid trend in the next 30 to 60 years, which will be beneficial to merge and to expand the ecological construction achievements of the protective forest and grassland, shortening the ecological recovery time. However, the warming climate will increase the occurrence and frequency of forest and grassland fires, diseases, and pests. Xie et al. (2020) found that precipitation is a key climatic factor influencing the growth of vegetation in the growing season of the protected forest project area. Warming promotes vegetation growth, but the decrease in precipitation brought about by the increase in temperature in the growing season makes warming inhibit the growth of vegetation. Whether the shelter forest has a strong climate ecological adaptability will directly affect the success or failure of the project.

From 1980 to 2020, there were 56 disasters in the areas covered by the Three-North Shelterbelt Project, including 9 droughts, 22 floods, 21 storms, 3 extreme temperature stretches, and 1 landslide. The main forms included riverine floods, flash floods, convective storms (including sand/dust storms and winter storms/blizzards), and heat and cold waves.

The frequency of disasters in the project area was stable before 2010. However, since 2010, disasters have seen significant peaks both in terms of number and frequency. In addition, due to the vast area covered, the Three-North Shelterbelt Project area has suffered frequent disaster over the past 40 years, of which 6 occurred in 1986, 5 in 2013, and 5 in 2015 (Figure 2.9).

Figure 2.9. Sixth-Order Polynomial Trend Line of Disaster Frequency for Three-North Shelterbelt Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

To protect the existing forest and grassland vegetation, methods of artificial afforestation, aircraft-seeding afforestation, closing mountains and closing sand for afforestation, and grass cultivation are adopted to build windbreak and sand-fixation forests, soil and water conservation bodies, and forests. It is a shelter forest system with a reasonable allocation of trees and coordinated development of agriculture, forestry, and animal husbandry.

The construction of the ecological forestry project in the Sanbei region has played an important role in the restoration of vegetation in the region, and the overall condition of the vegetation in the project has improved over the past 3 decades (He et al., 2015). The Three-North Shelterbelt Project has contributed to changes in the ecosystem's wind and sand-control services, with contribution rates ranging from 85% to 89% and 11% to 15%, respectively (Lin et al., 2018). The influence of climatic conditions on the project is mainly realised through changes in temperature and precipitation.

On 18 August 2020, according to a State Forestry and Grassland Administration report, the fifth phase of the Three North Shelterbelt Project was about to be completed; 30.14 million hectares of forestation and preservation, increasing the forest coverage rate from 5.05% to 13.57% (*Xinhuanet,* 2020).

The total planned investment of the Three-North Shelterbelt Project is CNY57.68 billion.[3] Furthermore, the total investment of the fifth phase (2012–2020) has reached CNY90.21 billion. The planned project areas include 725 counties of 13 provinces in the Three North region and Xinjiang Production and Construction Corps. A total of 16.473 million hectares have been afforested, and 1.936 million hectares of degraded forests have been restored (*Sohu*, 2016).

[3] State Forestry Bureau, 'Introduction on the Three North Shelterbelt Project', http://www.forestry.gov.cn/portal/main/s/414/content-273078.html

For more than 40 years, the timber reserve of the project area reached 1.83 billion cubic metres, with an economic value of CNY913 billion. A total of 4.63 million hectares of forests have been created, forming several important production bases for walnut, jujube, chestnut, pepper, apple, and other fruits. The annual output of dry and fresh fruits is 48 million tonnes, and 15 million people rely on this forest and fruit industry for their livelihoods. The project area has also formed a new pattern of eco-tourism, with the forest park network as the core and the wetland and desert parks as supplements.

New forestry industries such as *Corylus heterophylla*, oil peony, and *Gleditsia sinensis* have been introduced and developed. A batch of new industrial bases have been built, such as the 666-square kilometre *Haloxylon ammodendron* forest and another 666-square kilometre *Corylus heterophylla* forest. Forest tourism, ecological convalescence, recreation, and other emerging service industries are other developments. At present, the Three-North Shelterbelt Project area receives 380 million tourists annually, and the direct tourism income is CNY48 billion (State Forestry Bureau, 2020).

4. Financing Mechanisms and Policy Tools for Climate-Adaptive Infrastructure Projects

The financing mechanisms and policy tools for climate-adaptive infrastructure projects in China are analysed in this section, based on the previous two sections.

4.1. Typical Financing Mechanisms

To finance climate-change-related projects, besides routine sources such as the central budget, commercial banks, equity financing, and domestic financial markets, the following mechanisms play an important role in leveraging multiple sources of financing and therefore enabling the projects.

(i) **Multilateral banks**. Multilateral banks are leaders of climate-impact management tools and innovation of investment and financing activities. The World Bank, Asian Development Bank, Global Environment Facility, and other institutions have experience in climate risk and benefit management of investment and financing activities, both in terms of policy tools and technical tools (CIFA, 2020).

(ii) **Bilateral development agencies.** The United Nations Framework Convention on Climate Change (UNFCCC) website provides a list of the bilateral development cooperation agencies, such as AusAid, Canadian International Development Agency, Global Climate Alliance under the European Commission, Japan Bank for International Cooperation, Japan International Cooperation Agency, and United States Aid for International Development.

(iii) **Climate funds.** Climate funds help countries adopt low-emission, climate-resilient development trajectories. They have a role in capacity building, research, piloting, and demonstrating new approaches and technologies, and removing barriers to other climate finance flows. Multilateral climate funds also hold critical political significance, reflecting developed countries' acknowledgement of historical greenhouse gas emissions, and are

in line with the commitments made by developed countries under the UNFCCC to support developing countries mitigate and adapt to climate change. There are several types of climate funds currently available, such as the Green Climate Fund, Climate Investment Funds, Global Environment Facility, REDD+ funds,[4] adaptation funds, mitigation funds, and regional climate change funds.

(iv) **Clean Development Mechanism.** The Clean Development Mechanism allows a country with an emission-reduction or -limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction credits, each equivalent to 1 tonne of carbon dioxide, which can be counted towards meeting Kyoto targets. The Sustainable Development Mechanism could become a successor of these credits under the Paris Agreement (Rashmi and Ahuja, 2019).

(v) **National carbon emission trading market mechanism.** On 18 December 2017, NDRC issued the National Carbon Emission Trading Market Construction Plan, announcing the establishment of a national carbon emission trading market in three phases. Several provinces and cities initiated local carbon emission trading markets. *The Guidance on Promoting Investment and Financing in Response to Climate Change*, which was issued by the Ministry of Ecology and Environment along with NDRC and financial market authorities in October 2020, has also emphasised a carbon emission trading system as a key pillar in China's climate-change finance. Subsequently in November 2020, the Ministry of Ecology and Environment stated that national measures for carbon emission trading were about to be officially announced so that a nationwide carbon emissions trading market could be formally established.

4.2. The Role of Policies

Kimura et al. (2016) summarised a comprehensive framework to facilitate the financing of renewable energy. In this regard, energy policies focus on addressing perceived market risks, revenue and profit risks, technological risks, and risks due to policy uncertainty, while financial policies address the availability of funds, provision of financial instruments, lowering financial costs, and improving the capacity of the financial sector, for example, in green finance. Moreover, it is highlighted that the focal points that link these policies are the business models of investment projects, financial mechanisms, as well as the energy market design. Chang, Fang, and Li (2016) counted the frequency of different policies applied in East Asia to promote the financing of renewable energy. Accordingly, policies addressing legislative uncertainty are ranked highest in prevalence, followed by policies that promote profitability, financial resource availability, market creation, and development of technologies. In China, since 2005 when the Renewable Energy Law was enacted, the government has launched a variety of policies to

[4] REDD+ refers to a process moderated by the UNFCCC that supports countries' efforts to reduce emissions from deforestation and forest degradation as well as to foster conservation, sustainable management of forests, and enhancement of forest carbon stocks. See Green Climate Fund, REDD, https://www.greenclimate.fund/redd and Climate Funds Update, https://climatefundsupdate.org

promote investment in renewable energy; China has thus become a leading country in developing renewable energy.

The financing of climate-adaptive infrastructure presents a wider scope of challenges than those in developing renewable energy. The previously mentioned *Guidance on Promoting Investment and Financing in Response to Climate Change* issued in October 2020 represents the first top-level government policy for climate-change financing in China. A total of 15 measures were put forward under five aspects, including speeding up to build investments and a financing policy system, gradually improving the climate financing standards system, encouraging investment by foreign and private investors in climate-change financing, supporting local practices in climate-change investment and financing, and deepening the climate investment and financing of international cooperation. These goals aim to create a favourable policy environment for the development of climate investment and financing by 2022, which includes promoting relevant standards and launching local pilot programmes. The major climate investment and financing targets for 2022 and 2025 and related actions proposed in the guidance are in line with the need to reach the peak ahead of schedule and to achieve carbon neutrality as announced by the government (Xinhuanet, 2020).

Climate-change finance is a component of a larger concept in China's ecology and environment policy framework – green finance. In 2016, a consortium of government bodies, led by the People's Bank of China, issued the *Guidelines on Building a Green Finance System*, the first document to officially define green finance in China and to announce the development plan, incentive mechanisms, and risk monitoring and regulation measures for green finance products.

4.3. The Development of Green Finance System in China

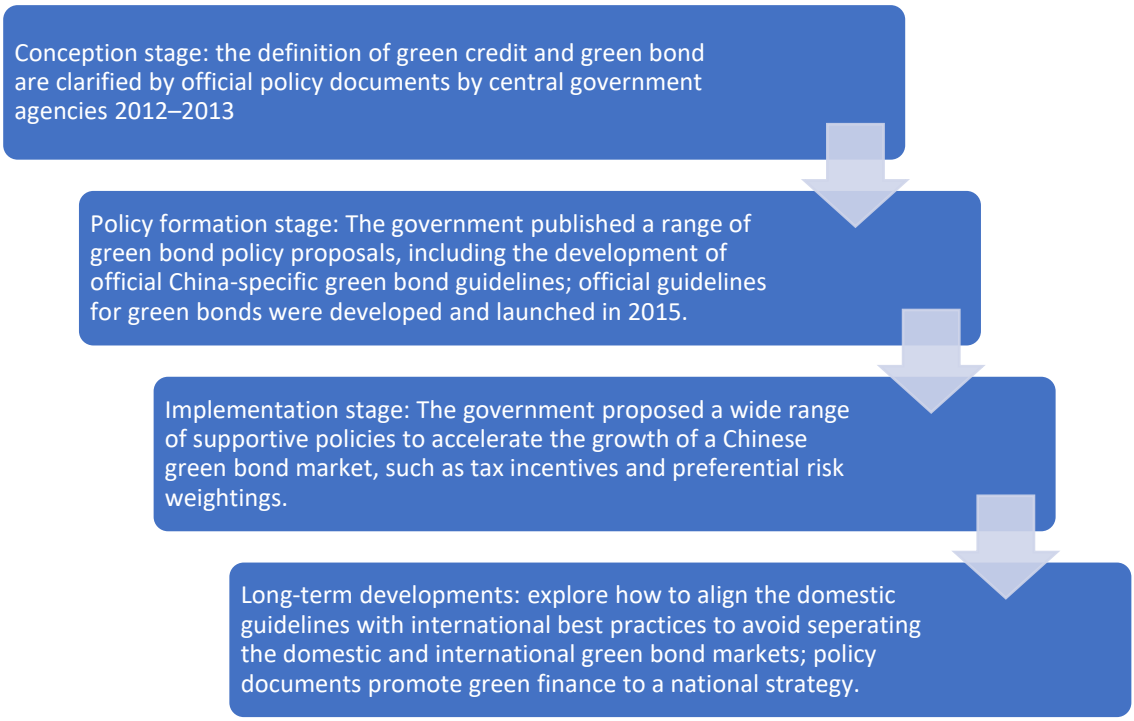
Following the abovementioned policies, China is rapidly developing green finance and green innovation. In 2017, the State Council approved the establishment of pilot zones for green finance reform and innovations in five provinces – Guangdong, Guizhou, Jiangxi, Xinjiang, and Zhejiang. In the same year, China became the second-largest country globally in issuing green bonds, reaching $37.1 billion in value. Since then, there has been an increasing variety of issuance, covering financial bonds, corporate bonds, medium-term notes, asset-backed securities, Panda bonds, and non-public targeted debt financing instruments.

This could not have occurred without strong support from the government. In 2012, the China Banking and Insurance Regulatory Commission issued a green credit guide. The definition of a green bond was then built around the domestic definition of green credit, which was given by the China Banking Regulatory Commission in 2013. In April 2015, the Green Finance Taskforce, co-convened by the People's Bank of China and the United Nations Environment Programme, published a range of green bond policy proposals, including the development of official China-specific green bond guidelines.

At the end of 2015, the People's Bank of China and NDRC issued green bonds. In March and April 2016, the Shanghai Stock Exchange and Shenzhen Stock Exchange issued notices on the pilot implementation of green corporate bonds and green business corporate bonds to encourage institutional investors. In the same year, *Guidance on the Construction of the Green Finance System* further promoted green finance to a national strategy. It encourages social capital to

actively participate in green projects by reducing entry barriers for funding and fundraising while creating a healthy institutional environment for the development of the new sector (CIFA, 2019).

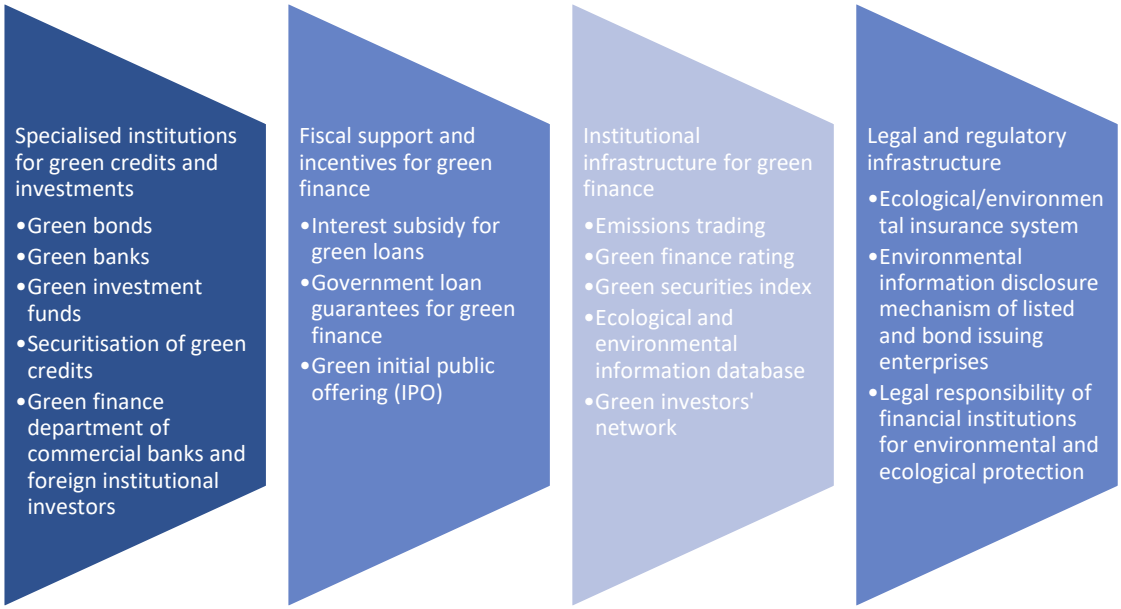
Figure 2.10. Developing a Policy Framework for Green Bonds in China



Source: Authors based on CIFA (2019).

Beyond green bonds, China established a comprehensive green finance system after 2020, supported by the issuance of corresponding legislation and regulations (Guotai Junan Securities, 2021). This system mainly consists of specialised institutions for green credit and investments, fiscal support and incentives for green finance, institutional infrastructure for green finance, and legal and regulatory infrastructure (Figure 2.11).

Figure 2.11. Green Finance System in China



Source: Authors based on People's Bank of China (2015).

In addition, in 2020, the Ministry of Ecology and Environment issued the *Guidelines on Promoting Investment and Financing in Response to Climate Change.* It clarified the definition of climate investment and financing and elaborated the specific work of promoting climate investment and financing from the aspects of a policy system, standards system, social capital, local practice, international cooperation, organisation, and implementation. This policy document also makes clear that climate investment and financing are important parts of green finance in China.

4.4. Lessons Learned

The financing of climate-adaptive infrastructure in China presents a changing landscape as new policy frameworks are being developed. The financial and fiscal sustainability of such projects are also improving accordingly.

Many of China's climate-adaptive infrastructure projects, such as the five mega-projects discussed in this chapter, started before a modern green finance system and the corresponding policy framework were well established. Therefore, the government, both at the central and local levels, played key roles in providing the necessary financing, especially before green credit guidelines were issued in 2012. The private sector was also mobilised to engage in the parts where regular commercial revenues could be generated or externalities internalised, such as in the Three Gorges Dam and the South-to-North Water Diversion projects. The remaining externalities were borne by public funds.

Additionally, state-owned companies and state-owned banks are playing increasingly larger roles in investing in climate-adaptive infrastructure projects in China. They mobilising high-revenue streams in the economically developed regions of the country to subsidise the high costs and externalities of these projects. One example is the ultra-high voltage power

transmission lines built to link the renewable energy-rich western regions and energy-consuming east.

Lastly, climate-adaptive infrastructure projects, along with green energy and environmental protection projects, are moving towards market-based financing mechanisms. On the market end, more companies are aware of green financing mechanisms and facilities, such as the Clean Development Mechanism and carbon emission trading. Especially at local levels, government-backed financing vehicles and public–private partnership models are widely used in environment protection and restoration projects. Local governments typically expect returns from such investments by auctioning lands with higher economic value supported by improved environment, as well as higher tax revenue brought by the sprawl of commercially developed urban areas.

5. Conclusions and Policy Recommendations

Climate change presents China with an array of shared economic, resource, environmental, and security challenges. China is a critical player in both regional and global efforts against global warming, particularly in global climate-change mitigation and adaptation. The five projects reviewed all have created better capacity for climate-change adaptation within the country. However, new projects need to address global warming, land deterioration, and biodiversity loss, and developing countries need to scale up support for such projects in financing, technology, and capacity building.

Aside from strengthening law and policy support for green development, China is encouraging green finance for better developing climate-adaptive infrastructure, along with green technological innovations. Multilateral banks, bilateral development agencies, climate funds, Certified Emission Reduction credits and the Clean Development Mechanism, and the national carbon emission trading market mechanism play an important role in leveraging multiple sources of financing and therefore enabling associated projects.

While China aims to have carbon emissions peak before 2030 and to achieve carbon neutrality before 2060, the risks of future climate change should not be underestimated. Climate-adaptive infrastructure and its corresponding technologies should thus receive sufficient investment and financing as clean and green technologies do.

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Chapter 3

Indonesia

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1. Introduction

Indonesia is the world's fourth most-populous nation, home to around 260 million people. Fifty-six percent of the country's population lives in urban areas, and a majority lives in Java. One-half of employed persons works in the services sector, one-third works in agriculture, and the rest works in the industrial sector. Moreover, Indonesia is the world's 10th largest economy, with a gross domestic product (GDP) of $1.1 trillion in 2019. This economic level has recently prompted Indonesia to reach upper-middle income status. Geographically, the country is an archipelago situated in South-East Asia. As a country made up of multiple islands, Indonesia is more prone to climate-change effects, including rises in sea level and shifts in temperature and rainfall (Veron et al., 2019).

Climate change has affected every nation in the world. Activities in the past to improve economies – including the use of fossil fuels and deforestation – have impacted the environment. This has caused natural phenomena such as rising surface temperatures, rainfall, ocean temperatures, and sea levels, as well as extreme climate and weather events. These are also becoming increasingly erratic and extreme, which negatively impacts several sectors.

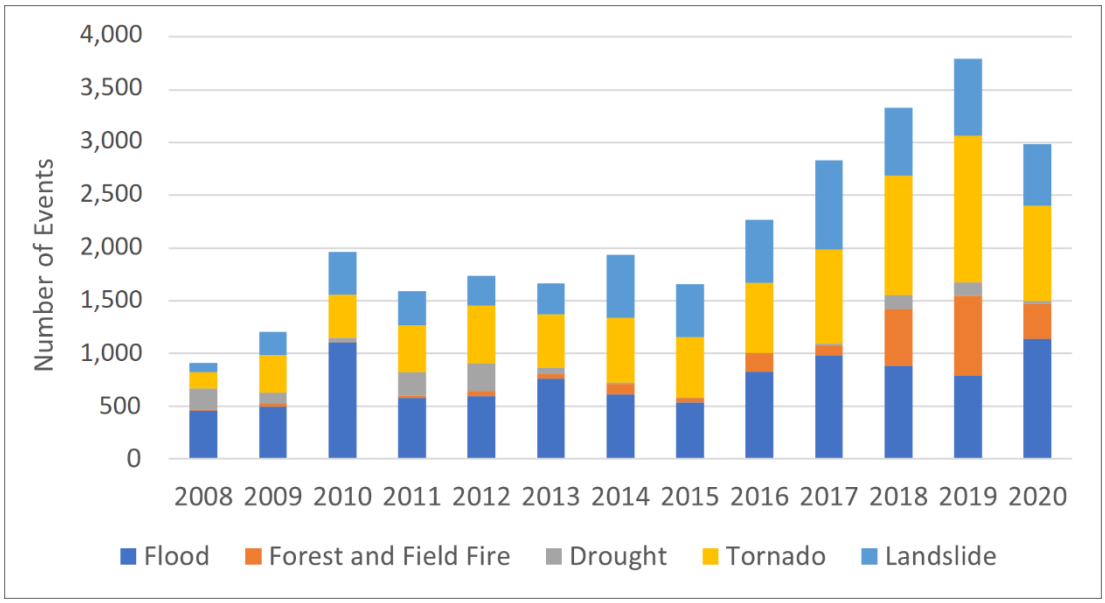
Figure 3.1. Climate-Change Risks in Certain Sectors in Indonesia

	Food Security	Energy	Health	Infrastructure	Housing	Ecosystem	Forestry	Urban Development	Coastal	Telecommunications	Transport
Surface Temperature											
Rainfall											
Ocean Temperature											
Sea Level											
Extreme Climate Events											
Extreme Weather Events											

Notes: Red = High Risk, Orange = Moderate Risk, Light Orange = Low Risk, White = No Risk.
Source: Bappendas (2014).

Figure 3.1 shows how each sector in Indonesia is affected by climate risks. For example, coastal areas are highly affected, as ocean temperature and sea-level changes disturb the livelihoods and settlements of coastal areas. Various transport modes are affected – water by sea level, air by weather, and land by road damage and floods. Buildings are also affected due to damage caused by increased heat, heavy rainfall, and extreme climate or weather events. Hecht (2016) calculated that climate change impacts – including those on crop production, health, and coastal areas – up to 2050 in Indonesia will cost Rp132 trillion.

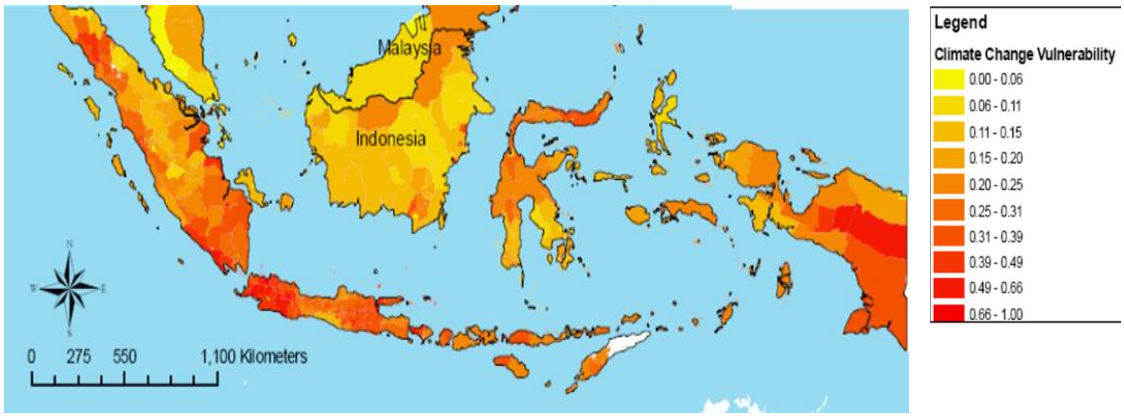
Figure 3.2. Climate-Related Natural Disasters in Indonesia, 2008–2020



Source: BNPB (2020).

Climate change also causes erratic and uncertain changes to climate-related phenomena, which may lead to natural disasters. Since 2015, there has been a continuous increase in climate-related disasters in Indonesia, which reached a peak in 2019. On average, these disasters have led to the deaths of 374 people and the destruction of 44,519 houses and 2,177 public facilities every year. Moreover, such disasters cost $16.8 billion in damage and affected 8 million lives (Gunawan et al., 2016). The El Niño phenomenon in 2015 caused numerous major land and forest fires, which were estimated to have cost at least Rp221 trillion in damages, twice that of the reconstruction after the 2004 Indian Ocean earthquake and tsunami.

Figure 3.3. Climate-Change Vulnerability Map

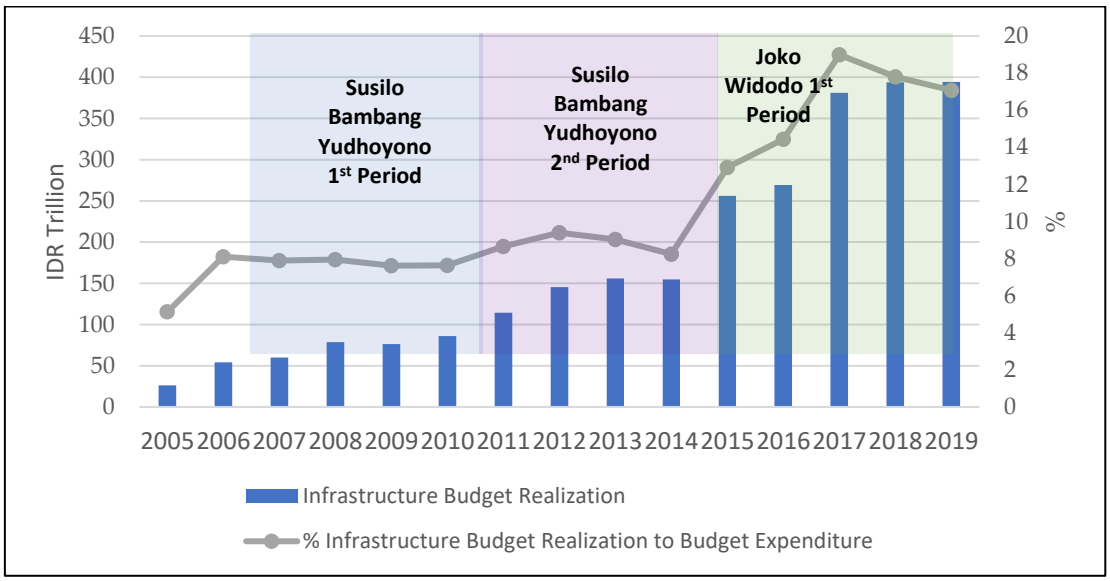


Source: Yusuf and Francisco (2009).

Regionally, Indonesia's vulnerability varies amongst islands (Government of the Netherlands, Ministry of Foreign Affairs, 2018). Figure 3.3 shows the vulnerability of regions in Indonesia. Kalimantan has the least climate-change vulnerability, while Java, Papua, and Sumatra have the most areas that are vulnerable to climate change. Indeed, 77% of climate-related disasters from 2008 to 2020 occurred in Java, Papua, and Sumatra. Note that 82.02% of Indonesia's 2019 GDP was from these three islands. Thus, if climate change goes unmitigated, damage to these areas will be catastrophic for Indonesia's economy.

Figure 3.4. Indonesia's Infrastructure Budget, 2005–2019

(Rp trillion)



Source: MOF (2020b).

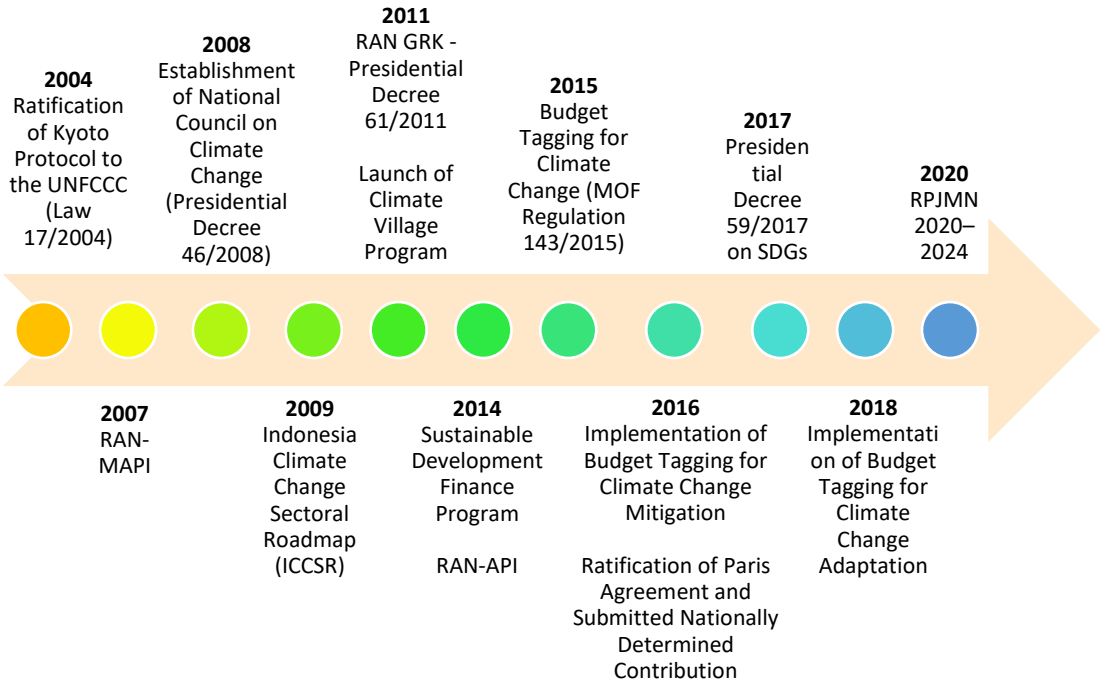
Indonesia's climate-change vulnerability poses risks to infrastructure development, which has become the focus of the current government. During President Susilo Bambang Yudhoyono's tenure (i.e. 2004–2014), infrastructure budget realisation was always less than 10% (Figure 3.4). This level was inadequate to achieve *National Medium-Term Development Plan* (*Rencana Pembangunan Jangka Menengah Nasional*, RPJMN) targets at a time that necessitated infrastructure investment of 7% of the GDP (Bappendas, 2020). By contrast, during President Joko Widodo's term (i.e. 2014–now), many reforms have increased infrastructure investment, which now exceeds 12% of the total state budget every year. Most of Indonesia's current infrastructure development is in Java and Sumatra, with more than 50% of national strategic projects built in these two regions.

The objective of developing climate-resilient infrastructure is to reduce vulnerability to climatic change and variability, thus reducing their negative impacts. The net benefit of adaptation is the damage avoided less the cost of climate resilience (Appendix 1). The cost of adaptation does become complicated, as additional upfront costs are needed for more resilient assets. However, the extra costs for building resilience are estimated only to be 3% of overall investment needs (Hallegatte et al., 2019). Moreover, such costs could be offset by lower maintenance and repair costs. Strengthening infrastructure assets exposed to natural hazards is beneficial, as 96% of cases have a cost–benefit ratio higher than 1, 77% have a cost–benefit ratio higher than 2, and 25% have a cost–benefit ratio higher than 6 (Hallegatte et al., 2019).

Indonesia is committed to contributing to climate-change mitigation and adaptation (Figure 3.5). In 2004, Indonesia ratified the Kyoto Protocol, which began Indonesia's international commitment to lowering greenhouse gas emissions. In 2007, the *National Action Plan for Climate Change Mitigation and Adaptation* (*Rencana Aksi Nasional Mitigasi dan Adaptasi Perubahan Iklim*, RAN-MAPI) was published (Government of Indonesia, 2014). This directs the Ministry of Public Works and Housing (MOPH) to develop infrastructure, including roads, bridges, and water and sewerage systems.

In 2009, Indonesia published its first climate change road map, *Indonesia Climate Change Sectoral Roadmap* (ICCSR) (Bappendas, 2010). It contains adaptation and mitigation efforts in certain sectors, including forestry, industry, and energy. In 2014, the government established its second climate-change road map, the *National Action Plan for Climate Change Adaptation* (*Rencana Aksi Nasional Adaptasi Perubahan Iklim*, RAN-API), as the continuation of the ICCSR (Bappendas, 2014). In 2016, it ratified the Paris Agreement and submitted its nationally determined contribution (NDC), which targets a 29%–41% emissions reduction by 2030. In 2017, the government committed to implementing the Sustainable Development Goals (SDGs) through Presidential Decree No. 59/2017. Currently, the RPJMN aims to develop the environment and to improve disaster resilience and climate change (Bappendas, 2020).

Figure 3.5. Indonesia's Milestones Regarding Climate Change



MOF = Ministry of Finance, RAN-API = *National Action Plan for Climate Change Adaptation,* RAN-MAPI = *National Action Plan for Climate Change Mitigation and Adaptation,* RPJMN = *National Medium-Term Development Plan,* SDG = Sustainable Development Goal, UNFCC = United Nations Framework Convention on Climate Change.
Source: Author.

Overall, climate-change risks are costly and affect many vital sectors in Indonesia, including infrastructure. Currently, the infrastructure gap in Indonesia is still high, and investing in infrastructure is the government's current focus to enhance the economy. Hence, the need for climate-resilient infrastructure to mitigate and to adapt to climate-change risks – while continuing to fill the infrastructure gap – will lead to sustainable development. However, climate resilience in infrastructure development is a relatively new concept in Indonesia and may face certain challenges. This chapter focusses on current climate-resilient infrastructure development in Indonesia, including financing and mainstreaming, and how the COVID-19 pandemic has impacted climate-resilient infrastructure development.

The chapter is presented as follows. Section 2 explains climate-resilient infrastructure, its financing gap, and alternative sources for its funding; Section 3 describes the challenges and opportunities for implementing infrastructure financing for climate-change adaptation in terms of mainstreaming, financing, and evaluation and monitoring, while Section 4 outlines policy considerations due to the COVID-19 pandemic. Section 5 synthesises findings from previous chapters and analyses financing gaps in Indonesia, and Section 6 concludes.

2. Climate-Change Adaptation and Climate-Resilient Infrastructure

2.1. Understanding Climate-Change Adaptation

Before discussing infrastructure for climate-change adaptation, it is necessary to understand the definition of climate-change adaptation. One of the most used definitions was created by the United Nations Framework Convention on Climate Change (UNFCCC). It defines climate-change adaptation as actions taken to help communities and ecosystems cope with changing climate conditions.[1]

In Indonesia, climate-change adaptation is defined in Law No. 32 (2009) on Environmental Protection and Management, Article 57, Paragraph 4. Climate-change adaptation is an effort to increase the ability to adapt to climate change, including climate diversity and extreme climatic events, so that the potential for damage due to climate change is reduced, the opportunities caused by climate change can be exploited, and the consequences of climate change can be overcome.

2.2. Understanding Climate-Resilient Infrastructure

For infrastructure to adapt to climate change, climate-resilient infrastructure must be built. Climate-resilient infrastructure is infrastructure that is planned, designed, built, and operated in a way that anticipates, prepares for, and adapts to changing climate conditions (OECD, 2018). It is also expected to withstand, respond to, and recover rapidly from disruptions caused by these changing climate conditions. The definition of climate-resilient infrastructure is not only limited to new infrastructure development, however. Climate-resilient bridges may be identical objects to ordinary bridges, but they are managed with due regard to the impacts of climate change. EUFIWACC (2016) divided the types of infrastructure adaptation into two groups:

(i) **Structural adaptation measure.** This first type distinguishes climate-resilient infrastructure from ordinary infrastructure by changing its structure (e.g. changing the composition of road surfaces so that they do not deform in high temperatures),

(ii) **Management adaptation measure.** This type of adaptation does not require any structural changes to the infrastructure being built. The difference with ordinary infrastructure is in the way it is managed (e.g. enhancing the monitoring of existing infrastructure to reduce the risk of failure as climate conditions change).

As climate change is inevitable – and Indonesia has a propensity towards associated disasters – ensuring the development of infrastructure that is resilient is mandatory. In Indonesia, the framework for developing climate-change adaptation is arranged in the RAN-API; its main goal is to manage sectors and aspects of development affected by climate change, which is then divided into five main objectives – economic resilience, livelihood resilience, environmental services resilience, special areas resilience, and adequate support systems. Infrastructure is one of the areas discussed under the livelihood resilience objective. The main target of infrastructure is the enhanced coverage of services and strengthening of infrastructure to be reliable and of

[1] UNFCCC, http://unfccc.int/

standard quality in facing the impacts of climate change. To achieve that target, the government has created an action plan for 2013–2025 (Table 3.1).

Table 3.1. Summary of the *National Action Plan for Infrastructure, 2013–2025*

No.	Action Plan	Scope	Priority Location	Institution Involved
1	Cluster 1: Analysing the concept of infrastructure resilience	Research and development of enhancing the resilience of climate-change adaptive infrastructure	National, coastline cities that are high risks	Ministry of Marine Affairs and Fisheries, Ministry of Public Works and Housing
2	Cluster 2: Improving access to roads and bridges	Reducing risks of disrupting access to roads and bridges due to climate-change impacts	National, coastline cities; pilot studies in high-risk areas	Ministry of Public Works and Housing, Bappenas, BNPB, regional governments
3	Cluster 3: Strengthening institutions	Submitting information on infrastructure that is climate-change-resilient Providing infrastructure for climate-change resilient sanitation and waste processing	National, pilot studies in high-risk areas	Ministry of Public Works and Housing, regional governments
4	Cluster 4: Integrating sustainable development	Applying city and area concepts and structures based on studies of community vulnerabilities and application of green cities	National high-risk cities	Ministry of Public Works and Housing, regional governments, Bappenas, LIPI

BNPB = National Agency for Disaster Countermeasures (*Badan Nasional Penanggulangan Bencana*), LIPI = Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia*).
Source: Government of Indonesia (2014).

2.3. Financing Gap

International reports have estimated the financing needs for climate adaptation worldwide, which range from $28.7 billion to $90.0 billion up to 2020 and $247.2 billion to $385.2 billion to 2030 (Fiscal Policy Agency, 2019). However, there is no formal document that estimates

Indonesia's financing needs for climate efforts. Indonesia uses the targets outlined in the NDC, but achieving the NDC requires significant funds. Indeed, Indonesia conveyed that the estimated funding needed to achieve its emissions reduction target is about $247.2 billion (Government of Indonesia, 2018) (Appendix 2).

The energy and transport sectors, which are dominated by infrastructure development, lead the financing needs, with Rp3.307 trillion or 95.5% of the total funds. If calculated on an average basis from 2016, Indonesia needs financing of about Rp220 trillion per year to reach the 2030 target (Government of Indonesia, 2018). However, since Indonesia implemented climate budget tagging, the budget allocated for all sectors has only reached Rp89.6 trillion on average per year. Even if it is assumed that all funds are allocated for the energy and transport sectors, these funds only make up about 40.64% of the total annual funding required.

Another approximation that could be used is the financing needed to fulfil the MOPH strategic plan. This does not show the financing needs specifically for climate-resilient infrastructure nor the financing gap, but it could illustrate that Indonesia needs enormous funds to fulfil its targets in infrastructure development (Table 3.2). From these estimates, it can be concluded that there is still a huge gap in meeting both targets. This gap must be filled not only from the state budget but also from other sources.

Table 3.2. Ministry of Public Works and Housing Vision for 2030

Focus	**Target**	**Financing Needs** (Rp trillion)
Water Resources	Multi-function dam with a capacity of 120 cubic metres/capita/year	1,423
Roads and Bridges	99% steady road Toll road 2,000 kilometres New road 3,000 kilometres New bridge/flyover of 70,000 metres	838
Human Settlements	100% drinking water availability 100% sanitation services Reducing the area of urban slum settlements by 4.4% (to 0 hectares)	170
Housing	The housing backlog for low-income people at 3 million units, achieved through the construction of 4.88 million housing units	1,220
Total		3,651

Source: MOPH (2020b).

3. Financing Options for Climate-Resilient Infrastructure

This section explores the sources used to finance climate-resilient infrastructure projects and the types of projects that are suitable for each funding source. Broadly speaking, they are divided into public, private and blended, and international funds.

3.1. Public Source Financing

Funding from the public sector should be used to finance basic public infrastructure such as water, sanitation, pioneer ports, and roads in border areas, and/or projects that are not financially viable. The government should also invest in projects that are strategic and can improve local and national economies. Some sources of public sector funding are as follows.

(i) **State budget.** Budget tagging for climate change was first carried out by the central government in the 2016 budget. Up to 2020, the government budgeted Rp448.3 trillion for climate change or Rp89.66 trillion per year. In 2018, the budget allocated for climate change reached Rp109.7 trillion (4.9% of the total state budget), whereas most of the budget (i.e. Rp85.9 trillion) was used by MOPH for infrastructure construction. Mitigation efforts included train infrastructure and road reconstruction and construction, whereas adaptation efforts included the construction of dams, flats, and river normalisation (Appendix 3).

(ii) **Government green bonds and green sukuk.** To support commitments to low-carbon policies and climate resilience, the government developed a green bond and green sukuk framework. In March 2018, Indonesia issued a global green sukuk worth $1.25 billion, which was the first in the world. About 49% of the sukuk's value was backed by ongoing or future infrastructure projects. Projects financed by green sukuk include the double-track railway project on the North Java line and a solar power plant project in Sumbawa.

3.2. Private and Blended Source Financing

The investment made by the private sector – or a combination of the public and private sectors – could be offered for financially and economically viable infrastructure with full cost-recovery and favourable rates of return. These infrastructure projects can take the form of toll roads, transport infrastructure, or housing. Some sources are as follows.

(i) **PT Sarana Multi Infrastruktur green bonds.** PT Sarana Multi Infrastruktur (SMI) is an infrastructure finance company owned by the government that participates in non-public funding for climate change. In the first phase of 2018, PT SMI issued and offered sustainable green bonds with a principal amount of up to Rp1 trillion (PT SMI, 2018). The funds collected will be used to finance infrastructure development in several sectors.

(ii) **OCBC NISP green bonds.** At the initial issuance, the International Finance Corporation collaborated with OCBC NISP and committed to finance bonds of $150 million. It was followed by the issuance of Sustainable Bonds III Phase 1 with a value of Rp1 trillion. The fund is intended to increase the distribution of environmentally sound financing, a part of which is targeted at the development of green buildings, renewable energy, and infrastructure.

(iii) **Bank Rakyat Indonesia green bonds.** In 2019, Bank Rakyat Indonesia issued a global sustainability bond of $500 million as an alternative source of funding. The funds raised were partly used to finance housing, transport, and construction.

(iv) **PT Sarana Multi Infrastruktur SDG Indonesia One**. SDG Indonesia One is an integrated platform that combines public and private funds to be channelled into infrastructure projects related to the achievement of the SDGs. Until October 2020, it collected commitments of $3.03 billion from 32 financial institution partners and philanthropists.[2]

3.3. International Climate Funds

In contrast to public and private sources that target funding based on costs and returns generated by the projects, international climate funds are channelled to projects that match the investment criteria of the institution. The sources of funding are as follows.

(i) **Global Environment Facility.** The Global Environment Facility is an incremental multilateral funding mechanism in which one of the activities is financing climate-change programmes. So far, the facility has financed 60 national projects in Indonesia, with total financing of $281.6 million, and 77 regional or global projects that involve Indonesia, with total financing of $1.02 billion. Several infrastructure projects that have been undertaken include the development of geothermal power plants, bus rapid transit, and pedestrian improvements in Jakarta.

(ii) **Green Climate Fund.** As of 2020, the Green Climate Fund has channelled $213.3 million to climate projects in Indonesia. An example of an infrastructure project is Climate Investor One, a multilateral project involving an investment fund of $821.5 million to support the development of renewable energy projects for 18 countries, including Indonesia.

The availability of funding options is important, as each source has its advantages and disadvantages. Therefore, Indonesia needs to add more financing options so that it can finance a wider variety of projects and capture investors from various circles.

[2] PT SMI, SDG Indonesia One, https://ptsmi.co.id/sdg-indonesia-one/

Table 3.3. Advantages and Disadvantages of Financing Options

Financing Option	Advantage	Disadvantage
State Budget	Open to economically unviable projects Could be directed to national strategic projects	Limited fiscal space
Green Bonds	Big pool of funds High transparency Suitable for big and small players	Shallow market Inefficient financial market in Indonesia
SDG Indonesia One	Enormous funding Comprehensive benefits other than financial support	Projects tailored to the standards of donors and investors
International Climate Funds	Enormous funding	Have their own investment criteria More complicated requirements and procedures

SDG = Sustainable Development Goal.
Source: Author.

4. Challenges in Climate-Resilient Infrastructure Financing

4.1. Classification

Although climate-change adaptation is already defined in legislation, no document specifically classifies and standardises climate-resilient infrastructure in Indonesia. The development of such infrastructure will also face financing constraints. Without a clear classification, climate-resilient infrastructure projects will find it difficult to obtain funding specifically intended for climate-change efforts.

An example is when determining the allocation budget tagging. According to the Government of Indonesia (2018), five sectors need to be managed to achieve the NDC target. These five sectors have their own infrastructure needs and are managed by different ministries and agencies. Without rigid standards, selecting infrastructure projects that will receive funding from the government budget cannot be undertaken systematically. The determination of the participating projects can only be made at the discretion of the respective ministries and agencies.

4.2. Mainstreaming Efforts to Local Governments

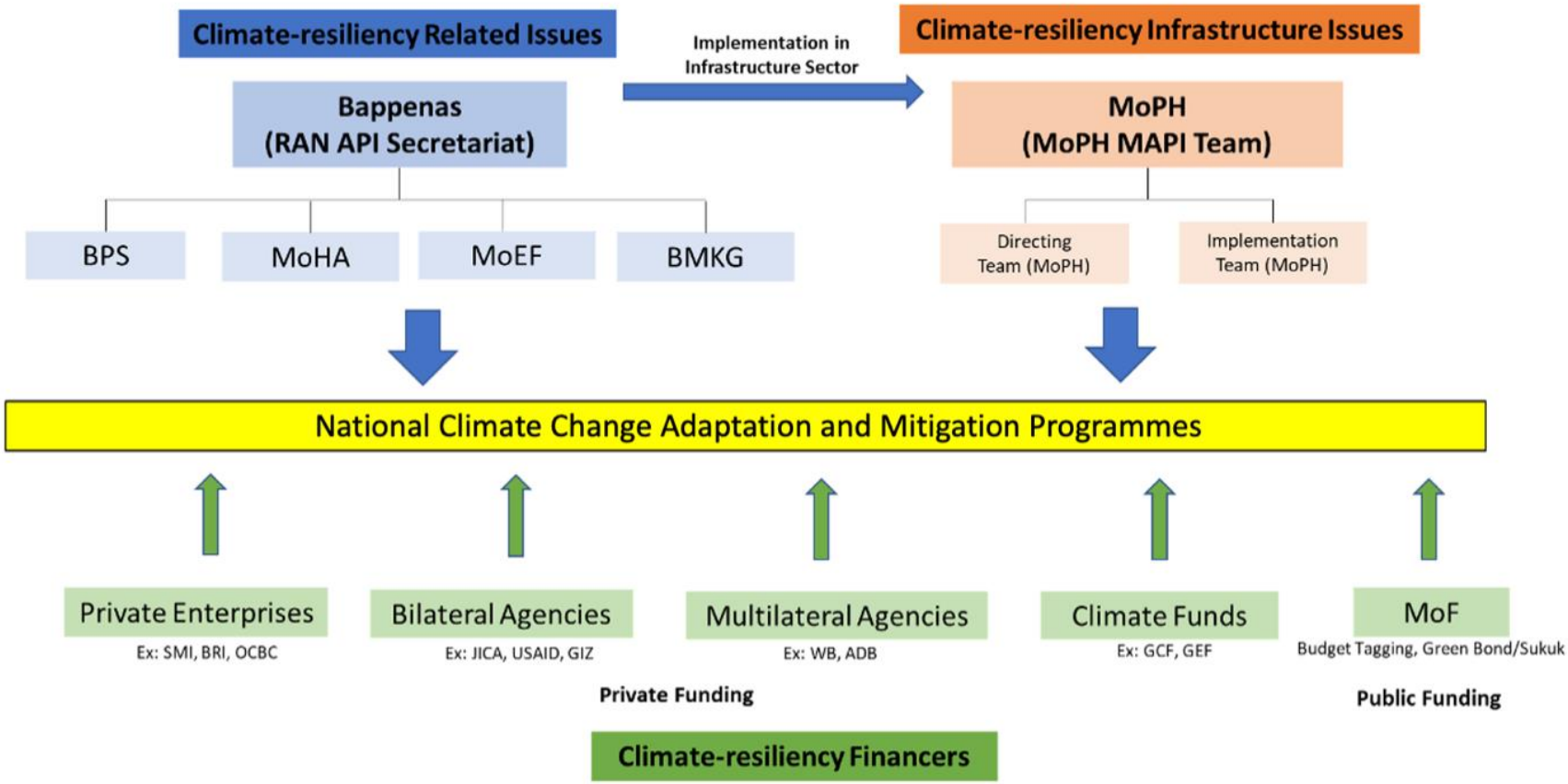
In Indonesia, infrastructure development is tiered at the regional and national levels. Governments at the city and provincial levels usually have their own infrastructure development plans, separate from the central government plans. This system has challenges. First, the differences in planning can lead to a priority mismatch in infrastructure development. Second, in terms of standards, infrastructure development at the regional level usually has lower standards than development at the national level. Third, only a few regions have carried out budget tagging for climate, which mostly focussed on mitigation activities. In terms of climate-change adaptation, although the national government already has a plan for the infrastructure

sector in the RAN-API, not all regions in Indonesia have regional action plans. This is due to differences in issues and challenges faced in the planning of mitigation and adaptation activities amongst regions. The institutional capacity of each region also determines its readiness to create planning and budget tagging for climate action. Given the key role of regions, these barriers can hinder the development of climate-resilient infrastructure.

4.3. Tracking Instruments

Monitoring and evaluation are crucial to ensure that climate resilience is implemented properly. Figure 3.6 shows the institutional arrangements involved in the climate-resilient process at the national level. In terms of planning, monitoring, and evaluation of the RAN-API, local governments and line ministries are responsible and report to Bappenas. The monitoring data at the regional level are gathered by the Ministry of Home Affairs. Based on these reports, Bappenas can revise the RAN-API accordingly. Budget tagging for climate change is also conducted by Bappenas to grasp the status of mainstreaming practices of adaptation in other plans. Bappenas also conducts the scoring process to evaluate and to prioritise adaptation policies and actions.

Figure 3.6. Institutional Arrangements for Climate Resilience in Indonesia

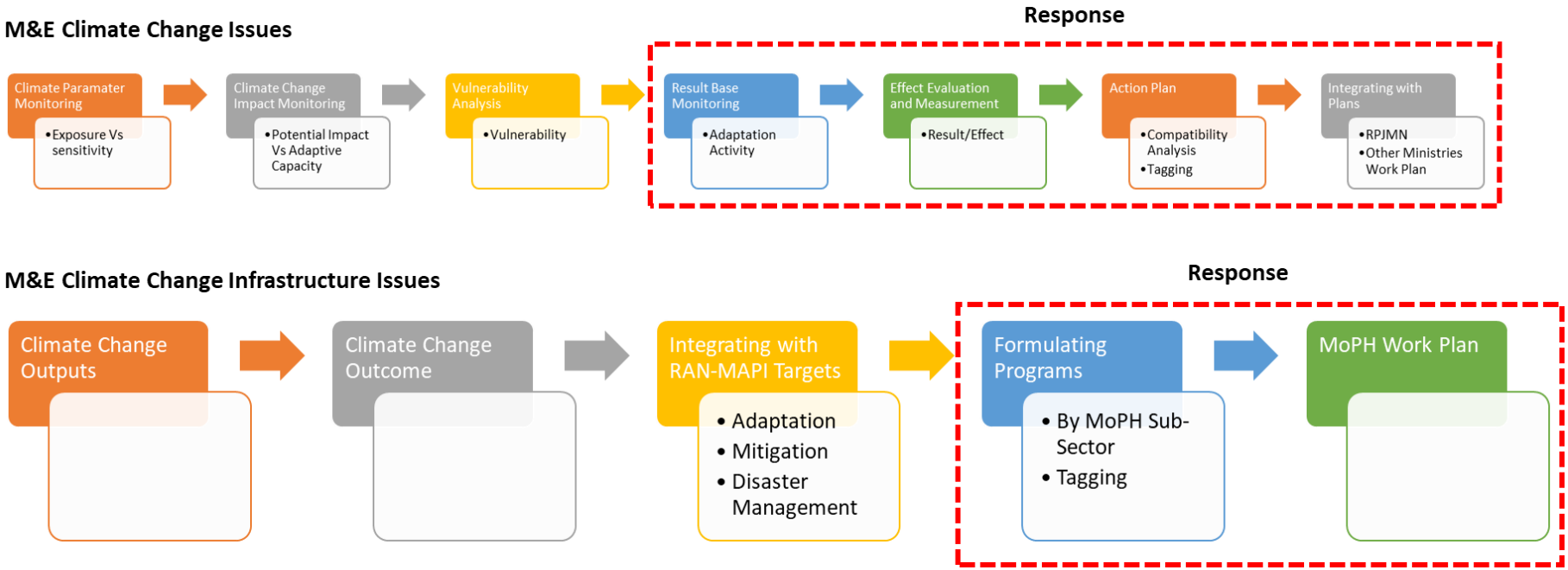


BMKG = Meteorology, Climatology, and Geophysical Agency; BPS = Statistics Indonesia; MOF = Ministry of Finance; MOEF = Ministry of Environment and Forestry; MOHA = Ministry of Home Affairs; MOPH = Ministry of Public Works and Housing; RAN-API = *National Action Plan for Climate Change Adaptation*.
Source: Adapted from Government of Japan, Ministry of the Environment (2015) and MOPH (2018).

The monitoring and evaluation of climate resilience require the collection of data relating to associated measures (Figure 3.7). Bappenas relies on databases that already exist, such as climate data from the Indonesian Agency for Meteorology, Climatology, and Geophysics (*Badan Meteorologi Klimatologi Geofisik*a, BMKG) and vulnerability assessment data from the Ministry of Environment and Forestry. These databases are used to monitor climate-resilient activities such as PEP (*Pemantauan, Evaluasi dan Pelaporan*), which monitors programmes and estimates each contribution to lowering greenhouse gases; SRN (*Sistem Registri Nasional*), which monitors the programme, budget, and estimation of greenhouse gas reduction; and KRISNA (*Kolaborasi Perencanaan dan Informasi Kinerja Anggaran*), which monitors the programme and budget.

MOPH is responsible for the implementation of the RAN-MAPI. To carry out monitoring and evaluation activities, it created a RAN-MAPI team, which consists of a directing team and an implementation team. The team is composed of several directorate-generals in MOPH. In general, the planning process begins by calculating the outputs and outcomes of climate change, which is integrated with one of three RAN-MAPI goals (i.e. climate-change mitigation, adaptation, and disaster management) (Figure 3.7). Through this process, MOPH may form programmes by sub-sector, which are then melded into the MOPH work plan.

Figure 3.7. Indonesia's Climate Resilience Monitoring, Evaluation, and Planning



M&E = monitoring and evaluation, MOPH = Ministry of Public Works and Housing, RAN-API = National Action Plan for Climate Change Adaptation, RPJMN = National Medium-Term Development Plan.
Source: Adapted from Bappenas (2014) and MOPH (2020a).

The Ministry of Finance (MOF) has implemented budget tagging of climate-change mitigation and adaptation, which is monitored using performance-based budgeting under MOF Regulation 214/2017. For climate resilience, outcomes regarding climate-change mitigation targets (i.e. reduction of greenhouse gases) and adaptation targets (i.e. increasing resilience to climate change impacts) are noted. The monitoring of the budget uses the KRISNA system. These evaluations are also used as references for green bond and green sukuk financing (Fiscal Policy Agency, 2019).

There are limited official documents explaining the methods and outcomes used for the monitoring and evaluation of the RAN-API or RAN-MAPI. Moreover, the database for monitoring climate resilience is not integrated, causing some climate-resilient programmes to be recorded on one database and not on others. Each ministry also has its own methods for calculating mitigation impacts, which should be integrated amongst ministries. There have also been issues regarding the difficulties of calculating the indirect impacts of climate-change adaptation programmes on greenhouse gas reduction (Fiscal Policy Agency, 2019). With these issues in mind, the database for monitoring and evaluation of mitigation efforts is still considered more established compared to adaptation efforts, which are still in development.[3]

4.4. Challenges in Accessing International Climate Funds

Several international funds have provided financial support for climate efforts in Indonesia. However, Indonesia is still having trouble accessing funding from these institutions.

There are at least three main challenges. The first is the strict requirements and high standards for obtaining funds. Since international funds need to filter thousands of different project proposals from different countries, they need to set standards to promote high-quality projects that can impact climate change. These standards are difficult and time-consuming for project developers in Indonesia to implement, as they are accustomed to working on projects with less stringent standards and requirements.

The second obstacle is the need to match infrastructure projects with the criteria set by the funds and/or by the state. A project may have a large positive impact or have a high economic contribution, but when the project does not meet the investment criteria of a funding institution or national development priority, the project will have difficulty obtaining funds.

The last challenge is the lack of knowledge about the opportunity of accessing international climate funds. Many infrastructure developers in Indonesia have promising proposals but are not always aware of opportunities to access funding from international climate funds. If they are aware, they often do not know the criteria, requirements, and methods needed to access those funds.

[3] While the SIDIK (*Sistem Informasi Data Indeks Kerentanan*) was created for adaptation monitoring and evaluation, no established method nor standard can be used by all ministries to estimate impacts on planned or ongoing adaptation programmes.

5. Financing Mitigation Infrastructure

This section discusses the climate-resilient infrastructure that was built specifically to mitigate climate change or climate-related disasters. As of 2020, Indonesia has several strategic national priority projects related to mitigation-specific efforts, including 48 dam projects, 1 flood embankment project, and 1 seawall project. Most of these projects are financed through state or local budgets.

In contrast to ordinary infrastructure that is designed with mitigation or adaptation capabilities, infrastructure built specifically for mitigation purposes tends not to be financially viable (Andersen et al., 2017). It lacks a clear revenue stream and tends to generate indirect economic benefits in the long run. This situation makes investors less likely to finance such projects.

While mobilising private funds for mitigation-specific infrastructure poses challenges, there have been some success stories. For example, Korea built a 33.9-kilometre dike for the Saemangeum Dam, of which 97% of the cost was financed by the private sector (Van Dijk, 2016). The Government of Indonesia may try to promote public–private partnerships through viability gap funds and availability payment schemes to encourage the private sector to contribute to mitigation-related infrastructure.

6. Potential Opportunities for Climate-Resilient Infrastructure Development

6.1. Initial Efforts to Identify Climate-Resilient Infrastructure

Although Indonesia does not yet have specific standards for climate-resilient infrastructure, several initial efforts have been made. In addition to action plans in the RAN-API that specifically discuss infrastructure, MOPH also has an infrastructure development plan for climate-change efforts within the RAN-MAPI (Table 3.4).

Table 3.4. Climate-Change Adaptation Efforts in the National Action Plan for Climate Change Mitigation and Adaptation

Sub-Sector	Focus	Strategies
Water Resources	Implementation of network system rehabilitation of water-efficient irrigation, and implementation of the National Partnership Movement Program Water Rescue (GNKPA)	Increase the feasibility and performance of water resources infrastructure in supporting water supply and food security Develop disaster risk management for disaster impacts of climate change
Roads and Bridges	Reduced risk of road damage due to impacts of climate change	Reduce the risk of disruption of road functions that can result from the impact of flooding, sea-level rise, and other climate-change disasters
Engineering	Activation of the Water Saving Movement, and handling of a drainage system that anticipates the impact of extreme rainfall	Create an urban settlement and infrastructure development strategy following the direction of urban development, including adaptation to climate change Encourage the application of environmentally sound drainage technology to anticipate the impact of extreme rainfall Develop clean water supply technology that is environmentally friendly and anticipates the impacts of climate change
Spatial Planning	Identification of districts/cities that are vulnerable to the impact of climate change through assistance in the preparation of detailed spatial plans	Provide access to data related to climate change on spatial planning Identify districts/cities that experience the impacts of climate change

Source: MOPH (2012).

To complement this effort, MOPH procured Regulations No. 02/PRT/M/2015 on green buildings and No. 02/PRT/M/2015 on guidelines for sustainable construction. These two regulations can be the basis for determining climate-resilient infrastructure standards. Moreover, MOPH has 811 standards related to infrastructure development, which are contained in Indonesian

National Standards. These contain procedures, methods, and specification standards for infrastructure development, some of which could be a basis for creating standards for climate-resilient infrastructure.

6.2. Financing Opportunities

Financing opportunities for projects related to climate change continue to increase, in line with increasing global awareness of the issue. The following are several financing opportunities that can be used in Indonesia.

(i) **Green bonds**. The government already has green bonds and a green sukuk framework. When Indonesia first issued its green sukuks, both were oversubscribed by 3.8 times the issuance value. When the government issued a green sukuk again in June 2020, it was oversubscribed 6.7 times (CNBC Indonesia, 2020). Funding opportunities from bond issuance are also still wide open from the private sector. To date, only three private entities have issued green bonds for climate change funding: PT SMI, OCBC NISP, and Bank Rakyat Indonesia. These companies also recorded oversubscriptions on each of their offerings. This could be because the green bond market is rising at a fast pace and is perceived to have a significant potential for growth in various countries relative to other financing alternatives. Indeed, compared to 2014, the number of green bonds issued in 2019 increased almost seven times, reaching around $247 billion (Climate Bond Initiative and UniCredit, 2020). Seeing the high market appetite for funding green projects, there is still an opportunity to enliven the green bond market, especially for climate-resilient infrastructure financing.

(ii) **Hajj savings.** The Ministry of Religious Affairs provides a savings account facility for prospective Hajj pilgrims. As a country with the largest Muslim population in the world, Indonesia has a huge amount of Hajj savings. As of 2020, the total Hajj savings managed by the Hajj Financial Management Agency (*Badan Pengelola Keuangan Haji*, BPKH) reached Rp143.1 trillion (BPKH, 2020). Usually, BPKH only invests its funds in conventional bonds, sukuks, and state securities. However, with its nature of long-term construction and income streams, climate-resilient infrastructure could serve as an ideal investment alternative in the Hajj savings portfolio.

(iii) **Sovereign wealth fund.** The government, in January 2021, authorised the establishment of a sovereign wealth fund under the name Indonesia Investment Authority (INA). INA will manage investment funds from outside and inside of the country as an alternative financing source. The emergence of INA is a significant opportunity, as infrastructure development is at the core of its mandate. For this reason, the government should seize the opportunity to allocate part of the financing for climate-resilient infrastructure projects. As of January 2021, INA received initial capital of Rp75 trillion and has also received interest from various investors around the world (Oleh, 2021).

(iv) **Pension funds**. Infrastructure projects are long-term investments that require time to be constructed and to generate economic value. The criterion could match the long duration of pension liabilities. Indonesia also has a large potential for pension funds. As of 2019, the total pension funds managed by Indonesia reached Rp279 trillion (OJK, 2019).

Table 3.5. Indonesia Pension Fund Investments

Type of Investment	Amount (Rp billion)
Savings	615
Deposits on call	1,273
Time deposits	73,621
Certificates of deposit	747
Surat Berharga Bank Indonesia (Bank Indonesia securities)	684
Surat Berharga Negara (Government securities)	63,807
Stocks	31,828
Corporate bonds and sukuk	61,645
Regional bonds and sukuk	1
Mutual funds	15,664
Medium-term notes	175
Asset-Backed Securities Collective Investment Contract (KIK-EBA)	852
Real Estate Investment Fund (DIRE)-KIK	45
Infrastructure Investment Fund (DINFRA)-KIK	50
Direct investment	9,584
Total land and buildings	13,552
Total investment	**273,962**

Source: OJK (2019).

However, as can be seen from the data above, 95% of the funds are spent on financial instruments, where most are invested in time deposits, government securities, corporate bonds, stocks, and mutual funds. It can be assumed that the proportion used from these investment funds for infrastructure development – especially for climate-resilient infrastructure – is not large. If pension funds are to be used as an alternative source, the investment allocation from financial instruments can be shifted to direct investments in climate-resilient infrastructure (Kusuma, 2019).

7. Reprioritisation of Infrastructure Projects due to COVID-19

As the COVID-19 pandemic hit the nation, infrastructure projects were reprioritised, as nearly half of the infrastructure budget was reallocated. While this has caused certain infrastructure projects to be delayed, none have been cancelled. MOF considered previous crisis experiences in which jump-start costs for cancelled projects were costly (Minggu, 2020). Although the reallocation was necessary to mitigate the impacts of COVID-19, the infrastructure sector is still deemed vital for the ongoing economic recovery as it is labour-intensive. Evidently, Indonesia's 2021 financial note stated that one of the focusses for 2021 would be labour-intensive infrastructure, supporting industry and tourism and finishing delayed priority infrastructure from 2020 (MOF, 2020).

In May 2020, amidst the pandemic, the number of strategic national projects approved for 2020–2024 totalled 89 new projects, with 156 other projects rejected. This included 15 road projects, 13 dam and irrigation projects, 12 energy-related projects, 7 clean water projects, 1 seawall project, and 1 waste management project. For every Rp1 trillion spent, it must directly or indirectly utilise 14,000 workers (Kompas, 2020). The emphasis on labour absorption is important to reinvigorate Indonesia's economy. Other criteria for strategic national projects are that investment limits of infrastructure are up to Rp500 billion per project, which is likely due to budget constraints.

While the government has shown a commitment to prioritise infrastructure projects for the post-COVID-19 recovery, it is important for these projects to accommodate climate-resilient aspects. Currently, there are only a few strategic national projects relating to climate-resilient infrastructure, which include a seawall and a flood embankment project. Integrating climate resilience in the infrastructure sector will allow Indonesia to tackle both economic recovery and climate-change adaptation and mitigation. Thus, climate-resilient infrastructure will ensure a sustainable recovery for Indonesia.

The COVID-19 pandemic reallocated the infrastructure budget to other sectors, such as health and social protection. The initial 2020 infrastructure budget was Rp489.2 trillion, which was revised down to Rp281.1 trillion after the issuance of Presidential Decree No. 72/2020. MOF will encourage public–private partnerships, blending finance, direct appointment to state-owned enterprises, and limited concessions schemes to fill the gap caused by the pandemic (Kontan, 2020). Local governments are also incentivised to use funds from the Country Economy Recovery (*Pemulihan Ekonomi Negara*, PEN) programme loan provided by PT SMI, which can be combined with a direct appointment to regional-owned enterprises as blended financing. At the same time, the state budget will still support infrastructure as a catalyst for increasing private sector participation, as the 2021 infrastructure budget is planned to be Rp414.0 trillion, nearly twice the infrastructure revised budget.

Indonesia's state budget can only fulfil 34% of its climate-resilient funding needs. The climate-change mitigation and adaptation budget also decreased from Rp91.0 trillion in 2019 to Rp79.6 trillion in 2020. The government must thus tap into alternative methods or resources to continue investments in climate-resilient infrastructure. Domestically, MOF plans to create tax holidays or tax allowances for the renewable energy sector, including excises and VAT (Setyorini, 2020). MOF also raised $718 million in green bonds. Internationally, MOF issued green bonds while actively seeking out partnerships in infrastructure financing from others, such as Association of Southeast Asian Nations (ASEAN) Members and the United States.

Potential funding includes the ASEAN Catalytic Green Finance Facility. This financing facility provides loans for sustainable transport, clean energy, green cities, and resilient water systems for eight ASEAN Members, including Indonesia. Also, other funding sources, such as the Forest Carbon Partnership Facility and BioCarbon Fund, are being assessed.

8. Analysis of Climate-Resilient Infrastructure Financing in Indonesia

Table 3.6. Current Assessment and Gap Analysis

Type	Aspects	Current Assessment	Gaps Identified
Regulatory	Commitments, regulations on financing, environmental codes, institutions, construction operation and maintenance, market facilitation	Indonesia has ratified climate-change commitments and formulated its national climate-change road maps. Indonesia has created standards for green buildings and sustainable infrastructure. The government has allowed financing mechanisms, such as budget tagging and green bonds, for climate-change projects.	The general and infrastructure climate-change road maps must be updated. Lack of urban climate-change road map Assessment of current and planned infrastructure for climate change and greenhouse gas emissions Detail guidelines and standards for resilient infrastructure
State budget and other financing options	State budget allocation, alternative financing utilisation	Indonesia already has budget tagging for climate efforts. Indonesia has successfully issued state and private green bonds. Indonesia has successfully secured funding from international climate funds.	Climate budget realisation is not optimal. Not all regions have budget tagging for climate efforts. There is no fiscal framework available for climate efforts. The number of private green bonds issued is still minimal. Other alternative funding, such as pension funds and Hajj savings, are still unused.
Main-streaming	Adaptation in all sectors, allocation changes, sub-national government involvement	Indonesia has made initial plans to map the infrastructure needs for mitigation and adaptation action in the RAN-MAPI. Indonesia has infrastructure development planning at the central and regional levels.	There is no clear taxonomy and standards for climate-resilient infrastructure. The current RAN-MAPI only targets limited sectors. Central and local government development planning has not been synchronised.
Reporting and evaluation	Reporting and evaluation	MOPH has a team to report on and to evaluate the progress of infrastructure climate-change adaptation.	There is no public document explaining the specific monitoring and evaluation process.

Type	Aspects	Current Assessment	Gaps Identified
		Databases for climate change monitoring have been created.	Databases for climate change monitoring must be integrated amongst ministries and improve calculations. Periodical publicly available evaluation of climate-change adaptation progress

MOPH = Ministry of Public Works and Housing, RAN-MAPI = National Action Plan for Climate Change Mitigation and Adaptation.
Source: Author.

9. Assessment of Current Regulatory Framework

The regulatory framework for climate change in Indonesia is sufficient. Since 2007, the government has established institutions and regulations regarding climate-change actions due to the commitments made by Indonesia, including the Kyoto Protocol, Paris Agreement, and SDGs. The road maps of Indonesia's climate-change adaptation and mitigation efforts have been established and integrated into the RPJMN. Regarding climate-resilient infrastructure, road maps have considered infrastructure as a sector at risk due to climate change, which has demonstrated the need for mitigation and adaptation efforts for infrastructure. In 2015, MOPH issued regulations regarding sustainable infrastructure, green buildings, and Indonesia National Standards (*Standar Nasional Indonesia*, SNI), which regulated the construction, operation and maintenance, and specification of the infrastructure. The government opened mechanisms for external funding of climate change and raised funds through new instruments such as green bonds and sukuks. However, the MOPH road map for climate-change adaptation and mitigation has not been updated since 2012. As infrastructure has become a focus of the government, it must continue to integrate adaptation and mitigation aspects in infrastructure development, as the sustainability and benefits of climate-resilient infrastructure are vital for the economy.

Indonesia's climate-resilient infrastructure regulatory aspects may still improve. Firstly, while Indonesia already has a rural climate-change road map (i.e. *Program Kampung Iklim*, ProKlim), Indonesia still lacks an urban climate-change road map (UN-Habitat, 2015). This is essential, as most economic activities and infrastructure are in urban areas. Secondly, as examples, the United Kingdom and Australia identify current crucial infrastructure in need of resilience, which in the United Kingdom has been accommodated in a national risk assessment (World Bank, 2016). Moreover, in the United Kingdom, nationally significant infrastructure projects are required to apply projections regarding greenhouse gas emissions, potential vulnerability due to climate-change projections, and climate-change risks. Projects there have detailed flood risk assessments, while in Australia, public–private partnership regulations allow flexibility to facilitate adaptation in the procurement process (e.g. technical specifications and risk assessments). The European Union also published a guide that contains a methodology and step-by-step guidance to assess the climate-change resilience of infrastructure projects to improve their sustainability and liability in uncertain climate conditions (European Commission, Directorate-General for Climate Action, 2011; European Commission, 2013). The planning of infrastructure financing for climate-change adaptation in urban areas and climate-change

assessments for current and planned strategic infrastructure are crucial for Indonesia's climate-change resilience.

10. Paving the Way

Currently, Indonesia has several funding options to finance climate-resilient infrastructure projects, including the state budget, other public funding sources, private and blended funding sources, and international climate funds. Indonesia must take advantage of all of these options. It cannot rely upon the development of climate-resilient infrastructure solely from state funding due to limited fiscal space.

However, not all funding sources have been fully utilised, even from the state budget itself. Based on data from the Fiscal Policy Agency (2019), the realisation of the climate-change budget only reached 69% in 2017 and 86% of targets in 2018. To solve this, contributions from various stakeholders are needed. For the government, it is necessary to develop a public funding framework to sharpen budget tagging for climate efforts. MOF has made initial efforts by planning the creation of the Climate Change Fiscal Framework, which can be developed from several previously published documents such as the *Indonesia Mitigation Fiscal Framework* (MOF, 2012) and *Climate Public Expenditure Review* (World Bank, 2020). Besides being able to improve budget tagging, the framework can also encourage the harmonisation of climate-change control activities and funding amongst the central and local governments, the private sector, and other non-public parties. Several countries have prepared similar documents, such as Bangladesh, Cambodia, and Nepal. Apart from maximising existing funding sources, the Government of Indonesia also needs to take advantage of other funding options, such as pension funds and Hajj savings. These two options are still untapped despite their large financing potential and suitable long-term liabilities for infrastructure projects.

So far, only three entities have issued green bonds for financing climate-change projects amidst a high investor appetite for climate-action financing. Sweden, however, issued 61 green bonds in 2020 only (Bhadare, 2020). Private institutions should be integrating climate change-related risks and opportunities into their analyses, but this is still not done by most companies in Indonesia. Given how big the threat of climate change is and how high investors' appetites for climate-change action are, this kind of analysis is crucial.

This lack of utilisation also occurs in funding from international climate funds. Of the overall plans and potential for infrastructure projects in Indonesia, very few have received funding from international climate funds, as discussed previously. High project standards, strict investment criteria, the need to conform to national priorities, and lack of knowledge from project developers about those funds are some obstacles to using international climate funds. To maximise funding from international climate funds, the government, through related institutions, needs to intensify the socialisation of international climate funds to related ministries and institutions as well as project developers. Socialisation includes defining the institutions that offer funding, standards that need to be met, and investment criteria. Through this socialisation, the government can help create good concept notes or project proposals so that they can be accepted by international climate funds.

10.1. Mainstreaming Efforts

The mainstreaming efforts of climate-change adaptation and climate-resilient infrastructure in Indonesia face several obstacles. Although climate-change adaptation is already defined clearly in legislation, no document specifically classifies and standardises climate-resilient infrastructure. The planning for the development of mitigation and adaptation infrastructure contained in the RAN-MAPI also has a limited scope by only incorporating water resources, roads and bridges, engineering, and spatial planning. In this case, Indonesia can use the United Kingdom as a benchmark. Since 2011, it has had a government policy on infrastructure that specifically discusses climate-resilient infrastructure (Government of the United Kingdom, 2011). In this policy, the Government of the United Kingdom also discussed climate issues for infrastructure broadly, covering transport, energy, water, and information and communications technology.

Another obstacle is a lack of integrated planning between the central government and local governments. Often, the central government's development planning is not in accordance with regional development priorities. In fact, local governments have important tasks in climate-resilient infrastructure development, especially in a country as big as Indonesia. There are at least three items that make mainstreaming and synchronising at the sub-national level crucial (OECD, 2010). First, climate-change impacts are manifested locally, affecting local livelihood activities. Second, vulnerability and adaptive capacity are determined by local conditions. Third, adaptation activities are often best observed at the local level. Indonesia should model the Government of Australia in its *National Adaptation Framework* (Government of Australia, 2007). This framework provides guidance on actions by jurisdictions to generate the information and tools needed by decision-makers to adapt to climate-change impacts. In practice, all jurisdictions need to evaluate and to share information about the extent to which planning and development systems promote decisions that increase resilience to the impacts of climate change and discourage decisions that increase vulnerability and consider changes where appropriate. The Local Government and Planning Ministers' Council then can coordinate a national report based on these assessments.

10.2. Strengthening and Synchronising Reporting and Evaluation

Based on the RAN-API, Bappenas has a key role in the evaluation of climate-change policies with other ministries, with local governments reporting the conditions at local levels. Bappenas has the authority to evaluate the RAN-API and its direction based on these reports. However, discussions are ongoing to revise the RAN-API. The government has also established many databases needed for reporting and evaluation of climate change-related policies. These databases are vital to trace the impact and efficiency of climate-change programmes. While climate-change monitoring and evaluation databases have been well established, adaptation monitoring and evaluation are still lacking. This is worrisome, as adaptation is an important aspect of infrastructure finance for climate-change adaptation, as many economic benefits are based on adaptation ability. However, there are still a few issues regarding the database, including a lack of integration amongst databases, a lack of integration in the calculation method amongst ministries, and difficulties in calculating indirect impacts.

Periodic monitoring and evaluation reports regarding adaptation efforts will influence planning in the following period. For example, the United Kingdom requires lead government departments to produce annual sector resilience plans that assess current situations and critical plans for the following year. The European Union also conducted a local assessment of climate impacts that are important for location-specific guidance regarding climate-change actions. Improving databases for regional analysis is important for Indonesia, as climate risk vulnerability varies amongst regions. Moreover, the European Union attributes indirect impacts of climate change, which have not been calculated in Indonesia's database.

11. Conclusions

The new, recent focus on infrastructure has propelled the process of infrastructure construction in Indonesia, reducing Indonesia's prolonged infrastructure gap. While the influx of infrastructure in Indonesia has been positive, it is prone to climate change. In addition to being an archipelago that is more disposed to climate change, Indonesia has been hit by more costly climate-related natural disasters due to the destruction of infrastructure. To strengthen its resilience to climate change and its impacts, infrastructure – which is the capital of Indonesia's economy – must integrate climate resilience. Moreover, due to the COVID-19 pandemic, its infrastructure sector has been deemed vital to achieving economic recovery. The timing of this situation may become an opportunity for the government to adjust the infrastructure development to accommodate climate resilience to ensure that Indonesia achieves sustainable recovery and growth in the future.

Indonesia has shown its commitment to climate-change actions through its NDC, SDG implementation, and national climate-change road maps. In 2009, Indonesia formulated the ICCSR, followed by RAN-API in 2014, which identified the infrastructure sector at risk of climate change. In 2012, MOPH also formulated its climate change road map, RAN-MAPI, which mainly focusses on roads and bridges, water, waste, and spatial planning. All of these road maps have not been updated, however. There are still issues regarding mainstreaming these aspects to local governments as well. Local governments do not have to integrate climate-change adaptation aspects in their regional development plans. This may become a challenge in implementing a specific infrastructure climate-change adaptation work plan at the local level. However, local governments play an important role in infrastructure provisions such as roads and schools.

In addition to the policy framework for climate action, climate-resilient infrastructure development also needs to be supported by funding. Currently, public financing has provided alternatives such as climate budget tagging and issuance of green bonds and sukuks to support financing climate-change programmes, which are mostly utilised for climate-resilient infrastructure projects. However, financing for the infrastructure sector is still not optimal. Financing at the regional level also faces obstacles since only a few regions have implemented climate budget tagging.

Apart from the public sector, financing from the private sector is also considered sub-optimal. Higher financing needs, investment plans that still tend to be conventional and have not adopted sustainability aspects, and the existence of a maturity mismatch are several reasons that hinder

the private sector from financing climate-resilient infrastructure. Meanwhile, funding from international climate funds is also difficult to access due to certain investment criteria, high project standards, and a time-consuming tapping process.

To tackle these issues, there must be an enabling environment for better climate-resilient infrastructure financing. First, there must be clear taxonomy and standards for climate-resilient infrastructure. This will help better allocate budget tagging and expand the adoption or upscaling of innovative financing. Second, the existence of de-risking instruments – such as loan guarantees and public equity co-investments – must be strengthened to attract the private sector to invest. Third, an incentive – such as a certificate or rating – must exist that indicates the resilience of infrastructure. Projects labelled 'climate-resilient infrastructure' will find it easier to access sustainable or green financing. Lastly, socialisation on how to access international climate funds and utilisation of other financing options such as pension funds, Hajj savings, and sovereign wealth funds also needs to be done.

To further integrate climate resilience in the infrastructure sector, the roles of key actors may need to be enhanced. Bappenas should integrate its climate-change road maps to enhance synchrony. As the road maps have not been updated, this is an opportunity to integrate them and to expand the sectors for climate-resilient infrastructure. MOPH should be involved and implement guidelines for climate-resilient infrastructure when selecting strategic national projects relating to infrastructure, as mostly the decisions for these projects are under the Coordinating Ministry for Economic Affairs.

It is also important to increase local government participation in climate-resilient infrastructure provision, which includes mainstreaming climate-resilient infrastructure in local government planning. Enhancing Bappenas to enforce climate-resilient aspects may strengthen the implementation of climate-resilient infrastructure at local levels.

In terms of monitoring and evaluation, databases have been well established. However, adaptation monitoring and evaluation, integration of databases and methodologies amongst ministries, and incorporation of indirect impacts must be improved to strengthen the climate-resilient infrastructure policies. Meanwhile, MOF needs to incorporate the Climate Change Fiscal Framework in planning for climate action financing. This framework is expected to not only sharpen budget tagging but also synchronise climate activities and funding at the central and regional levels, the private sector, and other non-public parties.

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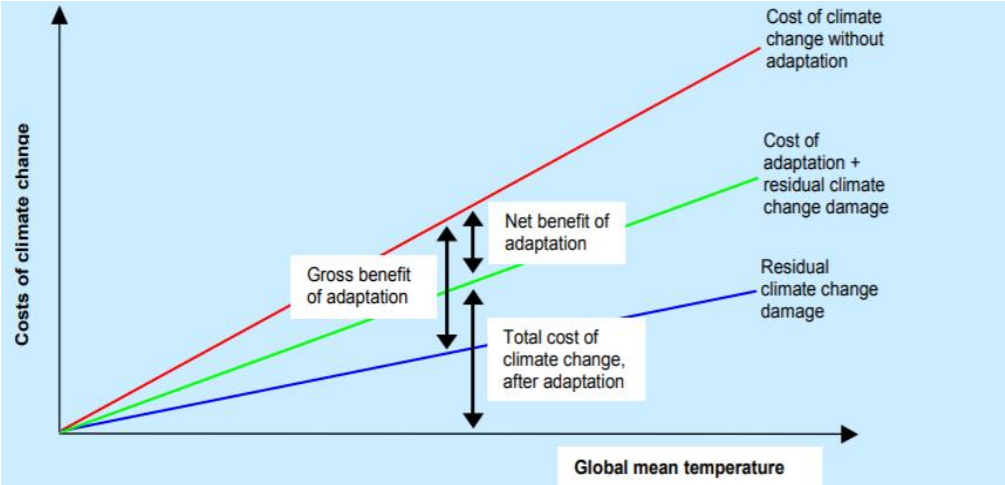
Appendices

Appendix 1: Annual Cost of Climate Damage and Net Benefit of Adaptation



Source: Stern (2007).

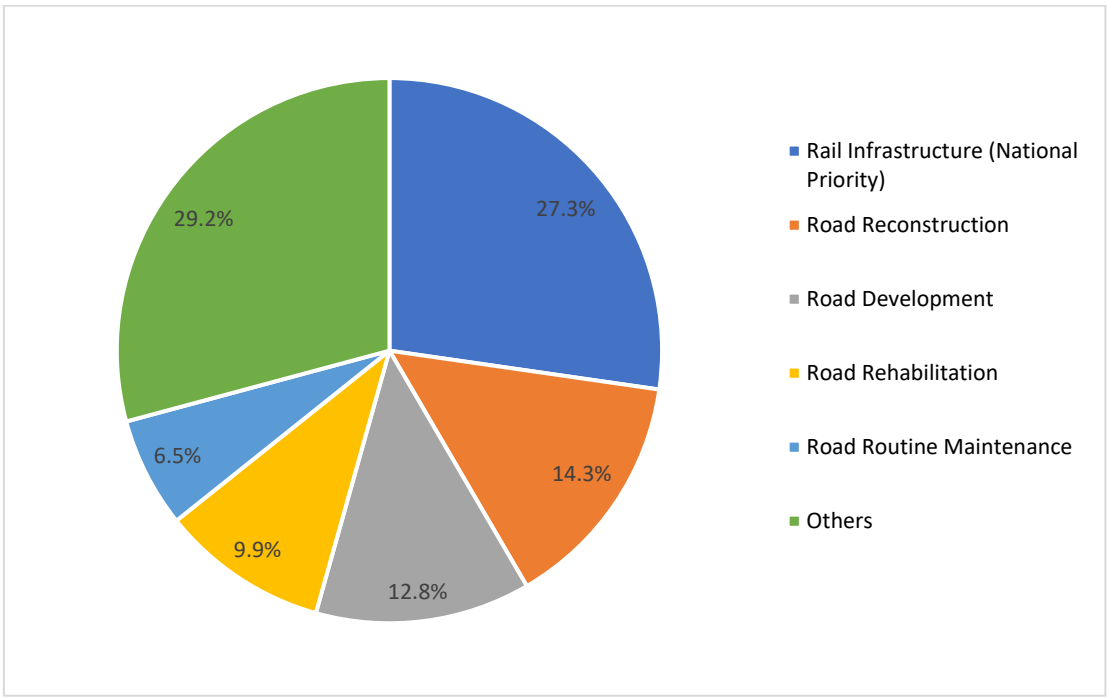
Appendix 2: Estimated Financing Needs to Achieve the Nationally Determined Contribution Target

Sector	**Policies and Programmes**	**Potential Emission Reduction**	**Financing Needs** (Rp billion)	**Financing Needs** ($ billion)
Forest and land use	Forest conservation and protection programme Forest fire prevention	655 million tonnes of CO_2	77,824	5.557
Energy and transport	Construction of renewable energy power plants Clean technology investments	398 million tonnes of CO_2	3,307,197	236.214
IPPU	Mostly for cement and steel industries	3.25 million tonnes of CO_2	40,774	0.379
Waste	Solid and liquid waste management at household and industrial levels	26 million tonnes of CO_2	30,339	2.907
Agriculture	Low-emission rice varieties, improving irrigation, biogas use, and feed additives	4 million tonnes of CO_2	5,175	2.164
		Total	**3,461,309**	**247.221**

CO_2 = carbon dioxide.
Note: To achieve the 2030 target based on the business-as-usual scenario.
Source: Government of Indonesia (2018).

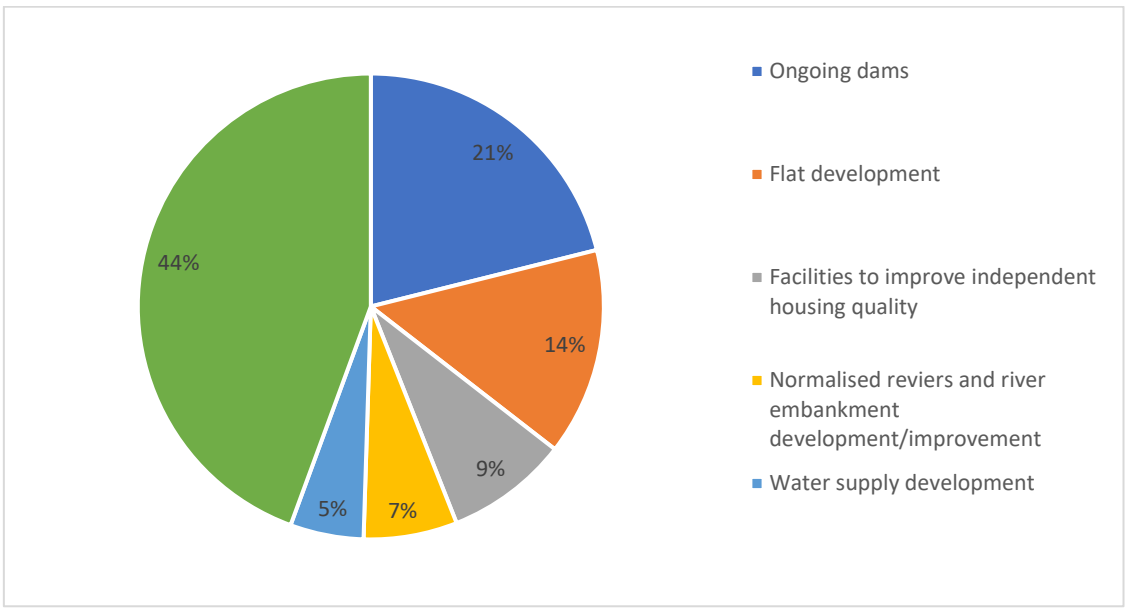
Appendix 3: Top Mitigation and Adaptation Programmes Percentages to Budget, 2018

Appendix 3.1: Mitigation Programmes (share of budget, 2018)



Source: Fiscal Policy Agency (2019).

Appendix 3.2: Adaptation Programmes (share of budget, 2018)



Source: Fiscal Policy Agency (2019).

Chapter 4

Malaysia

Alizan Mahadi and Darshan Joshi

1. Climate-Change Policy Landscape

Across the world, concern is growing over the ability of countries to cope with the various impacts that climate change will have on economies and societies. Increased average surface temperatures are projected to trigger various climate-linked consequences that will, in turn, cause significant economic damage, including in Malaysia. These involve sea-level rise; extreme weather events (e.g. droughts, floods, and storms); as well as adverse consequences on health and mortality, ecosystems and biodiversity, and agricultural yields. In response, governments around the world have taken steps towards reducing greenhouse gas emissions, which are the primary cause of climate change, as well as towards improving their resilience to its effects.

In Malaysia, many of the climate-change adaptation efforts made to date relate to flood-mitigation and -prevention measures. The biggest threats that climate change poses to the country are extreme rainfall, in terms of both its frequency and severity, and sea-level rise. Yet, Malaysia's current approach to climate-change adaptation – let alone to the financing of these efforts – is scattered, under the purview of various ministries, government agencies, and departments. Indeed, one of the greatest impediments to building Malaysia's resilience to climate change is the lack of a comprehensive and coordinated national adaptation action plan.

This chapter begins by reviewing all major planned and existing climate-change mitigation and adaptation policies in place in Malaysia. While intended mitigation actions are clearly defined in various guiding policy documents and include initiatives across a variety of sectors under the purview of several ministries, the same cannot be said for adaptation actions. This means that policy implementation for climate-change adaptation will continue to be fragmented across ministries and to comprise ad-hoc efforts.

The main policy guiding government agencies, industry, communities, and other stakeholders in addressing the challenges of climate change in Malaysia is the *National Policy on Climate Change,* which was approved by the Cabinet in 2009 (MNRE, 2009). This document recognises the need for both mitigation and adaptation activities and is based on five principles: sustainable development, conservation, coordinated implementation (i.e. climate-change considerations incorporated into all development programmes), effective participation, and the notion of common but differentiated responsibilities and respective capabilities in the context of Malaysia's involvement in international climate agreements.

Since the formulation of this policy, Malaysia's climate-change commitments and targets have been driven by its international commitments. Malaysia submitted its first nationally determined contribution (NDC) in 2015 and updated it in 2021. The first NDC submitted to the United Nations Framework Convention on Climate Change (UNFCCC) included a pledge to reduce by 35% – relative to 2005 – the emissions intensity of gross domestic product (GDP) in Malaysia by 2030. Another NDC, of a 45% reduction in the emissions intensity of GDP, is conditional on the provision of international climate funding and technology transfer. This was subsequently updated and enhanced to achieve 45% carbon-intensity reduction unconditionally in 2021. Malaysia provided information on adaptation strategies in an annex, including focussing on seven sectors – water, coasts, agriculture, infrastructure and cities, public health, forestry and biodiversity, and disaster management (Government of Malaysia, 2021).

Malaysia plans are important policy plans, mobilising resources for 5-year periods. The current plan, the *Twelfth Malaysia Plan*, strengthens adaptation by defining more dimensions and various strategies, such as taking evidence-based and risk-informed actions, incorporating the whole cycle of the Sendai Framework, and adopting a nature-based approach to flood management (EPU, 2021). The plan also continues the agenda of developing the national climate-change adaptation plan from the previous plan.

Table 4.1. Targets Related to Climate Action and Disaster Risk Reduction

Eleventh Malaysia Plan (2020 targets)	Twelfth Malaysia Plan (2025 targets)
At least 10% of coastal and marine areas and 17% of terrestrial and inland water areas gazetted as protected areas	At least 10% of coastal and marine areas and 20% of terrestrial and inland water areas gazetted as protected areas and through other effective area-based conservation measures
40% reduction in greenhouse gas emissions to GDP by 2030 relative to the level in 2005	45% reduction in greenhouse gas emissions to GDP by 2030 relative to the level in 2005
2,080 megawatts of renewable energy installed	10 integrated river basin management plans implemented
22% recycling rate of household waste	25% government green procurement
Establishment of national crisis and disaster management centre	40% recycling rate of household waste
2 million people protected by flood-mitigation projects	67% reduction in hydrochlorofluorocarbon consumption
	Disaster risk management policy launched
	31% renewable energy share of total installed electricity generation capacity
	Net-zero emissions by 2050

GDP = gross domestic product.
Sources: EPU (2015, 2021).

Malaysia has enacted numerous policies across industries and sectors that assist in both climate-change mitigation and adaptation. In the energy sector, policies are guided by the *National Renewable Energy Policy and Action Plan*, which was passed in 2009, along with the creation of the Sustainable Energy Development Authority (SEDA) (Ministry of Environment and Water, 2018). This plan sets the framework for key renewable energy policies that Malaysia has since enacted, including feed-in tariffs, net energy metering, and large-scale solar, all of which are under the purview of SEDA. Additionally, energy-efficiency improvements are emphasised through the *National Energy Efficiency Action Plan,* which aims to promote 5-star-rated appliances, set minimum energy performance standards, require energy audits and energy management in buildings and industries, and promote cogeneration and energy-efficient building design (Ministry of Energy, Green Technology and Water, 2015).

In the transport sector, several policies have the potential to have positive climate impacts. The *National Land Transport Master Plan*, as well as the *Greater Kuala Lumpur/Klang Valley Public Land Transport Master Plan*, emphasise the importance of public transport, in terms of infrastructure development and usage as well as reduced use of private vehicles. The *National Biofuel Policy* calls for higher biodiesel blends to reduce Malaysia's reliance on fossil fuels as a transport fuel, while national automotive policies of recent years have promoted energy-efficient and electric vehicles. Within the waste sector, two policies have the potential to reduce Malaysia's climate footprint – the *National Solid Waste Management Plan* and the Entry Point Project on developing biogas facilities at palm-oil mills. These strive to reduce the quantity of solid waste sent to landfills as well as to promote circularity by using by-products of the palm-oil industry to generate renewable energy (Ministry of Environment and Water, 2018).

Finally, Malaysia has enacted several policies within the land-use sector that have implications for climate-change mitigation and adaptation. The *National Forestry Policy* – as well as state-level forest policies – provide guidelines for the management, conservation, utilisation, development, and protection of Malaysia's rainforests. The National Forestry Council ensures the sustainable harvesting of timber products. At the same time, the *Eleventh Malaysia Plan* called for efforts to improve degraded forests, and the *National Policy on Biological Diversity, 2016–2025* aims to ensure that 50% of Malaysia's land mass remains forested (MNRE, 2020).

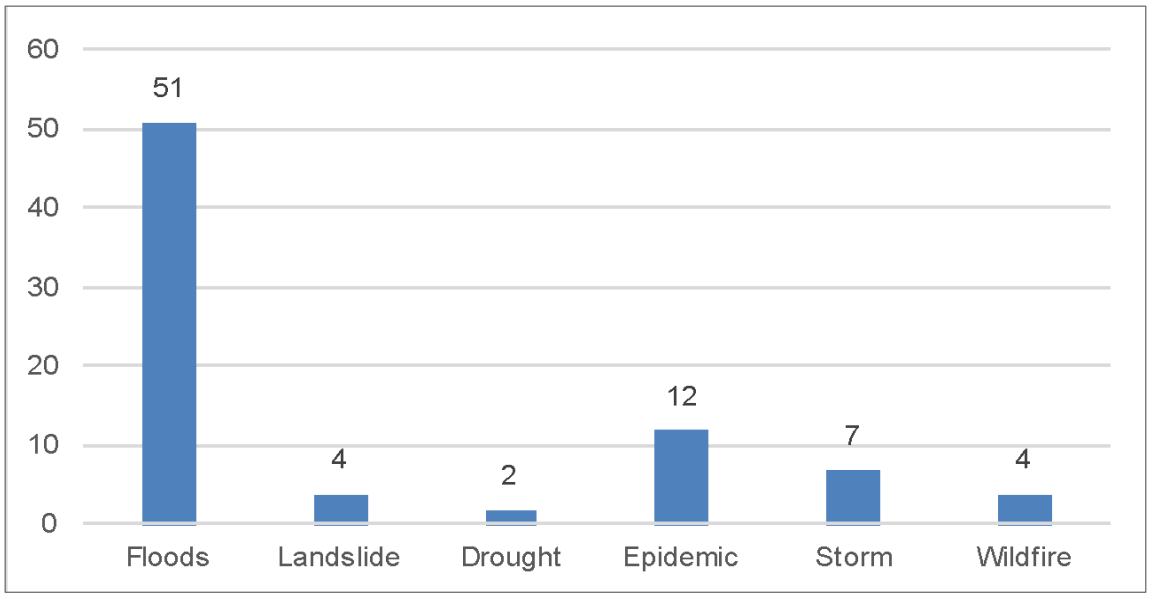
A review of climate change-related policies demonstrates that no clear action plan for climate-change adaptation is in place, however. Policy implementation for climate-change adaptation is fragmented across sectoral policies and enshrined in the budgets of multiple ministries. The next section reviews the scenario and policies related to adaptation.

2. Climate-Change Adaptation Challenges and Actions

Data indicate that 80 natural disasters – consisting of biological, climatological, hydrological, and meteorological disasters – have occurred in Malaysia since 1975, with the majority of these having occurred in the 21st century.[1] In total, 51 have been floods, including 42 that occurred from 2000 onwards – a figure (and share) that is projected to increase as the impacts of climate change are increasingly felt. Since 1975, flooding has affected almost 3.3 million residents in Malaysia and caused at least $1.79 billion in economic damages.

Of all climate change-driven natural disasters, flooding is the most significant threat to Malaysia. **Error! Reference source not found.** shows how much more frequent floods are in the country r elative to other natural disasters. The increasing frequency of these disasters is also apparent and highlighted in Figure 4.2, which exposes the sharply rising trend in the number of natural disasters since 1975.

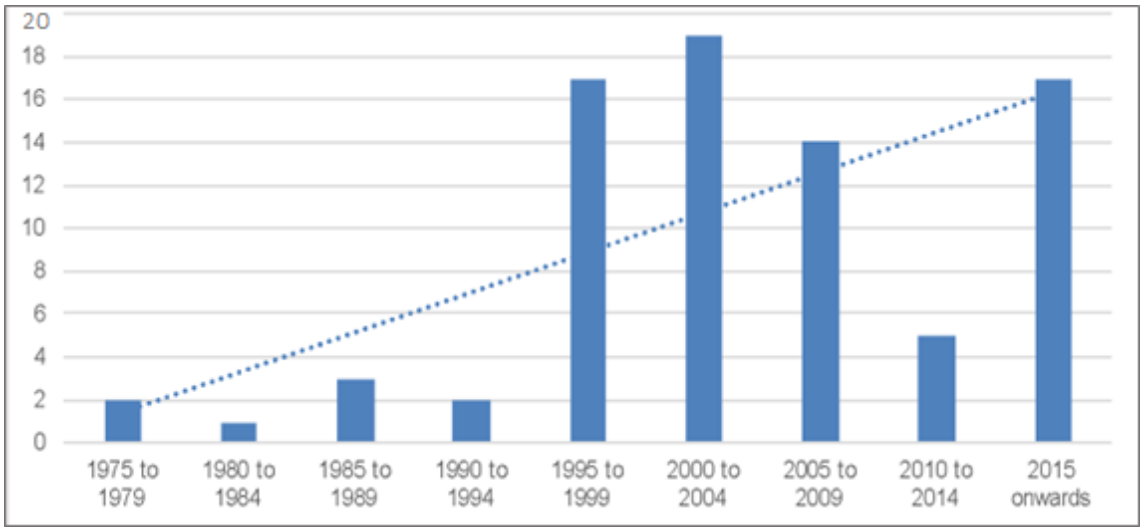
Figure 4.1. Types of Natural Disasters in Malaysia



Source: CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed 20 December 2022).

[1] CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed 20 December 2022).

Figure 4.2. Number of Natural Disasters in Malaysia since 1975



Source: CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be (accessed 20 December 2022).

The damages that have accumulated to date, however, are dwarfed by projections of future damages that Malaysia will accrue as temperatures continue to rise. Rasiah et al. (2016) estimated that without improvements to existing mitigation efforts, annual climate change-related damages in Malaysia will rise from RM11.9 billion in 2020 to RM456.3 billion in 2050. By 2110, cumulative damages will reach RM40.0 trillion. In contrast, strong mitigation actions – such as Malaysia meeting its emissions reduction pledge to the UNFCCC – would truncate total damages by 87.5% to a total of RM5.3 trillion by 2110 (Rasiah et al., 2016).

However, further research is required on the localised effects of rising temperatures on different components of the economy over time, and these localised effects must then be translated into measurements of economic damage. Further research is also needed on the relationship between climate change and economic damages because of changing weather patterns and extreme weather events on a host of variables, including crop yields and agricultural production, mortality and health outcomes, economic productivity, sea-level rise in coastal areas, flooding and saltwater intrusion, and vector-borne diseases. Such a detailed, bottom-up approach to establishing future climate change-driven damages would put policymakers in a strong position to enact pre-emptive measures. This approach also lowers the cost of expensive adaptation infrastructure projects, especially when compared against the magnitude of the future climate damages.

While the process of putting monetary values on future costs will take time, there is already a preliminary understanding of some climate-change impacts on Malaysia. These physical impacts and vulnerabilities are reviewed as follows.

2.1. Water and Coastal Resources

Climate change is projected to cause increases in the frequency and severity of rainfall in Malaysia along with sea-level rise. As a result, concern is growing over flood vulnerability, saltwater intrusion, droughts, and coastal erosion, all of which will have negative effects on the security of Malaysia's water and coastal resources. Furthermore, the excess water has also impacted water security and infrastructure. This includes more frequent occurrences of excess water release in dams, which in turn increases the risks of flooding (Ministry of Environment and Water, 2018).

Numerous adaptation measures have been implemented to cope with these impacts. Most prominently, the *National Water Resources Policy* is a key policy that addresses water resources security, water supply, and water-related disasters with an aim to ensure that 'the security and sustainability of water resources [is] made a national priority to ensure adequate and safe water for all, through sustainable use, conservation and effective management of water resources enabled by a mechanism of shared partnership involving all stakeholders' (MNRE, 2012:20). The approach of integrated water resources management, supported by integrated river basin management and integrated flood management, is central to improving watershed planning due to 'consideration of their unique application ranging from facilitating allocation to addressing hazards' (MNRE, 2012:17).

There are other policy instruments, mainly informational, that can strengthen climate-change adaptation in the water sector. In 2018, the Department of Irrigation and Drainage prepared an integrated river basin management master plan for 25 river basins, but it is unclear if climate change is considered in the plans (Ministry of Environment and Water, 2018). It also developed *Malaysia Dam Safety Management Guidelines*, which include measures to ensure the safety of dams during construction and operation due to natural hazards such as floods (Jabatan Pengairan dan Saliran Malaysia, 2017). However, the guidelines do not account for climate change, explaining that understanding the effects of climate trends on Malaysia floods is still in its infancy. Lastly, the National Water Research Institute of Malaysia prepared the *Climate Change Adaptation Framework for Water Sectors* to strengthen adaptation in managing water resources, water utilities, and water-related disasters (NAHRIM, 2021).

Moving forward, the water sector will likely remain focussed on climate-change adaptation and on hard infrastructure in terms of mitigation and information for adaptation. Little evidence of nature-based or holistic solutions, such as sponge cities, has been introduced.

2.2. Food Security

Due to changes in the frequency and severity of rainfall, solar irradiation, and the rise in average temperatures – along with associated flood concerns – Malaysia is projected to suffer from significant reductions in average rice yields. Droughts are also projected to play a role in these decreasing yields, while saltwater intrusion into rice paddies remains a concern, particularly during the Southwest Monsoon. Flooding is also a threat to certain palm-oil cultivation areas (Ministry of Environment and Water, 2018).

The latest *National Agrofood Policy, 2021–2030* clearly acknowledges climate-change adaptation. Indeed, it aims for a paradigm shift towards a sustainable food system and adapting to climate change. Nonetheless, concrete actions are unclear, as there is no action plan towards meeting these policy statements (MNRE, 2012).

Adaptation in food security is also enshrined in the *National Policy on Biological Diversity, 2016–2025,* which seeks to improve the climate–biodiversity link (MNRE, 2016)**.** It aims to develop and to implement appropriate agriculture landscape planning to ensure that agricultural activities are aligned with long-term biodiversity targets and minimise human–wildlife conflicts by providing extension services and technical support to smallholder farmers to improve productivity while conserving biodiversity.

Key agricultural policy instruments that may be linked to climate-change adaptation are incentive structures, such as subsidies for smallholders, tax mechanisms, guaranteed minimum prices, research, and budget for drainage and irrigation and other agricultural facilities and services. In 2020, the Ministry of Finance funded urban farming of various scales to improve community resilience during the COVID-19 pandemic and future shocks. However, these are not directly related to adaptation.

2.3. Forestry and Biodiversity

The health of Malaysia's forests is projected to be adversely impacted by droughts and temperature increases, with expectations of decreases in biomass growth and increases in mortality rates. Drained peat swamps are expected to be particularly susceptible to forest fires, while mangrove forests are prone to sea-level rise and saltwater intrusion; another significant concern is habitat loss (Ministry of Environment and Water, 2018).

The main policy to address biodiversity and natural resources is the *National Policy on Biological Diversity, 2016–2025,* which identifies climate change as an emerging threat to biodiversity, noting that it 'is well-established although its actual impacts on biodiversity are not easily predicted' (MNRE, 2016:30). The policy aims to close this knowledge gap by expanding the evidence base of climate-change effects on biodiversity and assessing vulnerabilities of species and habitats to adaptation efforts (MNRE, 2016:90).

Similarly, the recently revised *Malaysian Forest Policy* identifies forest resources as integral in addressing mitigation and adaptation. Climate-related action plans in this policy are heavily skewed towards mitigation due to forests' carbon sequestration potential, more so in Sabah through REDD+ (MNRE, 2021:45,86). However, adaptation receives little attention. The closest strategy with adaptation benefits is 'enhancing effectiveness of water catchment management' under Strategy 1 (MNRE, 2016:44), which primarily addresses water resources conservation.

2.4. Infrastructure

Again, the primary climate vulnerability of infrastructure in Malaysia is flooding. This impacts buildings, roads, drainage, transport infrastructure, sewerage facilities, and solid waste disposal facilities or sites. Haze is another concern, particularly to airports and seaports across the country (Ministry of Environment and Water, 2018).

There is no overarching policy that guides infrastructure planning in a holistic manner in Malaysia. Instead, it relies on sectoral strategies, such as that described under the water sector. Most environmental impacts and disaster risks are addressed at the project level –during feasibility study stages and environmental impact assessments as required by regulations such as the Environmental Quality Act 1974.

Seasonal storms and flooding are expected to continue to cause damages to energy sector infrastructure. In 2014, 2,788 of the 66,321 substations in Peninsular Malaysia were affected by flooding, and this figure is projected to rise over time. Transmission towers are also expected to be at risk of flooding. Sea-level rise, meanwhile, will affect energy sector infrastructure in low-lying coastal areas, while droughts will adversely affect hydropower plants due to limitations of water resources (Ministry of Environment and Water, 2018). The actions to address these are the responsibility of the electricity company, Tenaga Nasional Berhad.

2.5. Public Health

Flooding also concerns public health infrastructure, with events in 2014 causing damages to 168 public health care facilities. Such instances of flooding are expected to continue, especially in flood-prone areas, as extreme rainfall becomes more common. Sea-level rise is also expected to be a cause of damages, particularly in coastal areas. To address these issues, health care facilities frequently affected by flooding have been allocated funding for upgrades, relocation, and redesign, as per the 5-year plans (EPU, 2015, 2021). The closest policy that may strengthen adaptation in the public health sector is the *National Disaster Risk Reduction Policy* that is currently being drafted by the National Disaster Management Agency.

3. Future Infrastructure Adaptation Requirements

Studies have indicated that Malaysia must continue to enhance the climate-change resilience of many industries and sectors. Further steps were identified in EPU (2021) and Government of Malaysia (2018):

(i) **Water and coastal resources.** Climate change must be considered in the design and construction of infrastructure such as dams, irrigation systems, and flood-mitigation structures.

(ii) **Fisheries and aquaculture.** The resilience of critical marine habitats, such as mangroves, seagrasses, and coral reefs, must be improved through prevention of habitat loss, habitat rehabilitation, biodiversity restoration, enforcement of regulations, and establishment of additional marine protected areas.

(iii) **Forestry and biodiversity.** Forest network areas should be extended, and management and rehabilitation of vulnerable ecosystems should be improved.

(iv) **Buildings and flood relief centres**. Design standards and guidelines for buildings should be revised periodically. For developments in coastal areas, these standards and guidelines must be stricter to account for sea-level rise.

(v) **Roads and drainage.** More technically advanced designs must be developed to enhance the durability and safety of roads, drainage, and bridges, particularly those in flood-prone or coastal areas.

(vi) **Transport.** The design of hill slopes and track embankments must consider threats from climate change, particularly flooding and extreme weather events.

(vii) **Water supply facilities**. The number of integrated multipurpose dams should be increased to reduce flood risks. Existing water catchment areas must be protected, and others identified and gazetted. Lastly, a water demand management master plan must be designed.

(viii) **Other adaptation measures.** The Malaysian Meteorological Department should enhance its short- and medium-range weather- and flood-forecasting systems. The Department of Irrigation and Drainage should enhance its capacity in flood and drought forecasting. Training courses covering climate-change adaptation should be conducted by the Ministry of Agriculture and Agro-Based Industry. The Department of Veterinary Services should develop action plans to protect the livestock industry from extreme weather events.

4. Financing Infrastructure for Climate Change Adaptation

To review the implementation of infrastructure financing for climate-change adaptation in Malaysia, four areas were assessed across the policy cycle – budget, mainstreaming, regulations, and reporting. Opportunities and challenges are identified towards implementing infrastructure financing for climate-change adaptation.

4.1. Budgeting

Given the absence of a national climate-change adaptation action plan, as well as the lack of a single domestic authority on climate-change adaptation, Malaysia's budgetary allocations to relevant ministries for this purpose are based on specific policies on threats that climate change poses. As highlighted in the previous section, much of the adaptation action pertains to flood-mitigation efforts. Therefore, most resources and finance are channelled to address these. Under the Malaysia plans, allocations for flood-mitigation projects have substantially increased over the years. Indeed, under the *Twelfth Malaysia Plan*, RM16 billion is allocated for flood-mitigation projects, similar to the RM17 billion allocated in total from the *Ninth Malaysia Plan* to *Eleventh Malaysia Plan* (EPU, 2015, 2021; Ministry of Economic Affairs, 2018).

A more detailed analysis is challenging, as Malaysia does not practice climate budget tagging. Nonetheless, reviews of past annual budgets revealed that almost RM2.5 billion has been allocated since 2018 towards budgetary line items that seem to relate to the adaptation policies described in the previous section (Table 4.2).

The amount of annual budget allocations for climate-adaptation programmes steadily increased from RM282 billion in 2018 to RM308 billion in 2021. The increase is also reflected in the share of adaptation-related activities to the overall budget, which increased from 0.24% to 0.44% in the same period. This demonstrated that the expenditure and – arguably – commitment to adaptation has increased in recent times, not only in absolute terms but also in relative terms.

Secondly, the largest allocation is for flood mitigation plans and urban drainage. The second largest is for modernising paddy irrigation, which is only about one-fifth of the cost allocated to flood mitigation. Furthermore, the budget allocated to flood mitigation continued to increase from RM388 million 2018 to RM569 million in 2021. This is largely because the focus on flood mitigation is often through large infrastructure and engineering solutions, which require high investments.

Thirdly, however, without the use of a comprehensive system of climate budget tagging in Malaysia's annual budgets, it is impossible to deduce whether each of these line items are devoted entirely to climate-change adaptation activities. For example, Malaysia's adaptation policies include the training of agricultural sector workers to be conducted by the Ministry of Agriculture and Agro-Based Industry; while such an item can be found in the budgets, it does not necessarily mean that the entire allocation for this budgetary line item is towards the training of workers on the topic of climate-change adaptation. The same can be said of other budgetary line items, including programmes on sustainable forest management and green technology projects.

An additional consideration not captured in the analysis is the fact that Malaysia, as a federation, has different budget allocations at both the federal and state level and in the Constitution.

Table 4.2. Annual Budget Allocations for Climate-Change Adaptation Programmes, 2018–2021

Ministry	Programme	Budgetary Allocation (RM)			
		2018	2019	2020	2021
Agriculture and Agro-Based Industry	Modernisation of Paddy Irrigation Systems	72,593,708	152,111,846	131,455,400	115,217,000
	Agriculture Drainage System Development Plan	4,855,255	12,500,000	16,700,000	10,540,000
	Agriculture Zone Flood Control Programme	520,335	7,200,000	16,000,000	6,800,000
	National Agricultural Training	9,201,185	13,050,014	15,514,100	7,082,000
Natural Resources, Environment and Climate Change	Sustainable Forest Management	22,857,958	36,782,922	45,290,000	80,620,000
	Coastal Planting of Mangroves and Others	1,989,856	2,000,000	2,000,000	10,000,000
	Heart of Borneo Project	5,720,979	5,230,500	5,700,000	6,000,000
	Sustainable Forest Resource Development Programme	3,303,481	4,600,000	8,666,100	
	Dam Restoration	9,295,736	24,252,990	37,500,000	30,400,000
	Flood Hazard Alert and Control Plan	18,384,466	15,649,000	30,000,000	32,300,000
	Upgrade of Urban Infrastructure and Drainage, Flood Mitigation	12,886,575	32,000,000	22,000,000	51,000,000
	Coastal Erosion Prevention	28,935,524	31,670,000	35,500,000	57,275,000
	Flood Mitigation Plans and Urban Drainage	387,623,209	445,339,010	443,923,400	569,320,200
	Sustainable Drainage Management Plan	36,513,060	69,900,000	175,126,500	83,257,000
Environment and Water (formerly Natural Resources and Environment)	Green Technology Projects			1,000,000	4,200,000
	Department of Environment	42,503,270	71,228,000	67,595,000	83,250,000
	Environmental Conservation Division		360,860	3,400,000	4,180,000
	Energy Efficiency and Renewable Energy Programs	5,078,206	26,000,000	26,000,000	7,000,000
	Malaysia Green Technology Corporation	4,500,000	4,500,000	3,800,000	3,250,000

Ministry	Programme	Budgetary Allocation (RM)			
		2018	**2019**	**2020**	**2021**
	Environmental Management and Climate Change		118,715,000	120,968,300	195,491,600
Total		666,762,803	1,073,090,142	1,208,138,800	1,357,182,800
Total Annual Budget		282,250,000,000	316,550,000,000	299,020,000,000	307,540,000,000
Share of Total Budget Accruing to Environmental Operations and Programmes		0.24%	0.34%	0.40%	0.44%

Source: Authors.

Malaysia has also received external funding for six adaptation projects (Ministry of Environment and Water, 2020). This includes funding from the United States Agency for International Development (USAID) to support the Coral Triangle Initiative; from the Asia-Pacific Network for Global Change Research for strengthening the capacity for policy research on mainstreaming adaptation to climate change in agriculture and water sectors; from Sida to establish a mechanism to integrate climate-change adaptation into national and regional planning; from the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) to build capacity for adaptation in the agriculture and natural resources sector; from the Asian Development Bank (ADB) for sustainable management of the Coral Triangle; and from Conservation International as part of the Asia Pacific Climate Change Adaptation Project Preparation Facility (ADAPT) to increase access to financial resources for climate-change adaptation investment projects. Note that these are largely capacity-building projects rather those that specifically enhance Malaysia's resilience to the effects of climate change. Sources indicated that Malaysia also requested $3 million from the Green Climate Fund amid the deadly floods that occurred in late 2021 to early 2022 to develop a national climate-change adaptation plan. However, the status of these funds is unclear.

Table 1.3. International Assistance for Climate-Change Adaptation, 2014–2019

Source	Project Description	Implementing Agencies	Approved Amount
GEF/UNDP	Third National Communication to the UNFCCC and Biennial Update Reporting for Malaysia	MNRE	$852,000
GEF/UNDP	Second Biennial Update Report on Climate Change	MNRE	$352,000
GEF/UNDP	Green Technology Application for the Development of Low Carbon Cities	Ministry of Energy, Green Technology, and Water	$4,354,790
GEF/UNIDO	Greenhouse Gas Emissions Reductions in Targeted Industrial Sub-Sectors through Energy-Efficiency and Application of Solar Thermal Systems	Ministry of Energy, Green Technology, and Water	$4,000,000
GEF/UNIDO	Energy-Efficient Low Carbon Transport	Malaysia Green Technology and Climate Change Corporation; Ministry of Energy, Green Technology, and Water	$2,000,000
UNDP	Preliminary Study on Demand-Side Management	Economic Planning Unit	$480,000
UNEP	MyCarbon Web Portal Planning, Design, and Pilot	MNRE	$25,000

Source	Project Description	Implementing Agencies	Approved Amount
UNEP	National Climate Change Web Portal Content Development	MNRE	$25,000
UNEP	Vulnerability Assessment and Adaptation Study of Climate Change Impacts on Floods in Sarawak River Basin	National Water Research Institute of Malaysia	$48,000
United Kingdom	Green Growth Strategy Paper for the Preparation of Malaysia's National Sustainable Development Blueprint, 2015–2030	UNDP, Economic Planning Unit	£40,000
United Kingdom	Low-Carbon Cities Malaysia – Accelerating Local Government Leadership on Carbon Reduction in Petaling Jaya City Council	Carbon Trust, Petaling Jaya City Council	£99,000
United Kingdom	Accelerating the Rate of Deployment of Cost-Effective, Energy-Efficiency Solutions in LED Lighting Solutions	Carbon Trust, Malaysian Green Technology and Climate Change Corporation, SME Corporation Malaysia	£78,650
United Kingdom	Development of a Roadmap for the Effective Implementation of Malaysia's Intended Nationally Determined Contributions	UNDP, MNRE	£73,686
European Union	Tackling Climate Change through Sustainable Forest Management and Community Development	Sabah parks, Sabah Forestry Department	€3,250,000

GEF = Global Environment Facility, MNRE = Ministry of Natural Resources and Environment, UNIDO = United Nations Industrial Development Organization, UNDP = United Nations Development Programme, UNEP = United Nations Environment Programme.
Source: Government of Malaysia (2018).

External funding has demonstrated that the focus of financing is still mostly on mitigation, while adaptation funding is focussed on information and policy or flood-mitigation infrastructure.

4.2. Mainstreaming Climate-Change Adaptation Finance

From a policy perspective, the *National Climate Change Policy* balances adaptation and mitigation measures. However, it does not contain any specific actions for adaptation nor, as previously discussed, an action plan. It identifies 12 sectors related to climate-change adaptation, however – agriculture and food security; natural resources and environment (i.e. water, biodiversity, forestry, minerals, soil, coasts and sea, and air); energy security; industries;

public health; tourism; transport; infrastructure; land use and land-use change (including land reclamation); human settlements and livelihoods; waste management; and disaster risk reduction.

After the Paris Agreement in 2015, Malaysia's NDC[2] is guiding actions, includes both mitigation and adaptation, and highlights public expenditure to enhance resilience against climate change. It also states that a national adaptation plan would be developed for future coordination. Five objectives are included as the primary focus for adaptation: assessing flood risks, ensuring water security, ensuring food security, protecting coastlines, and preventing vector-borne diseases.

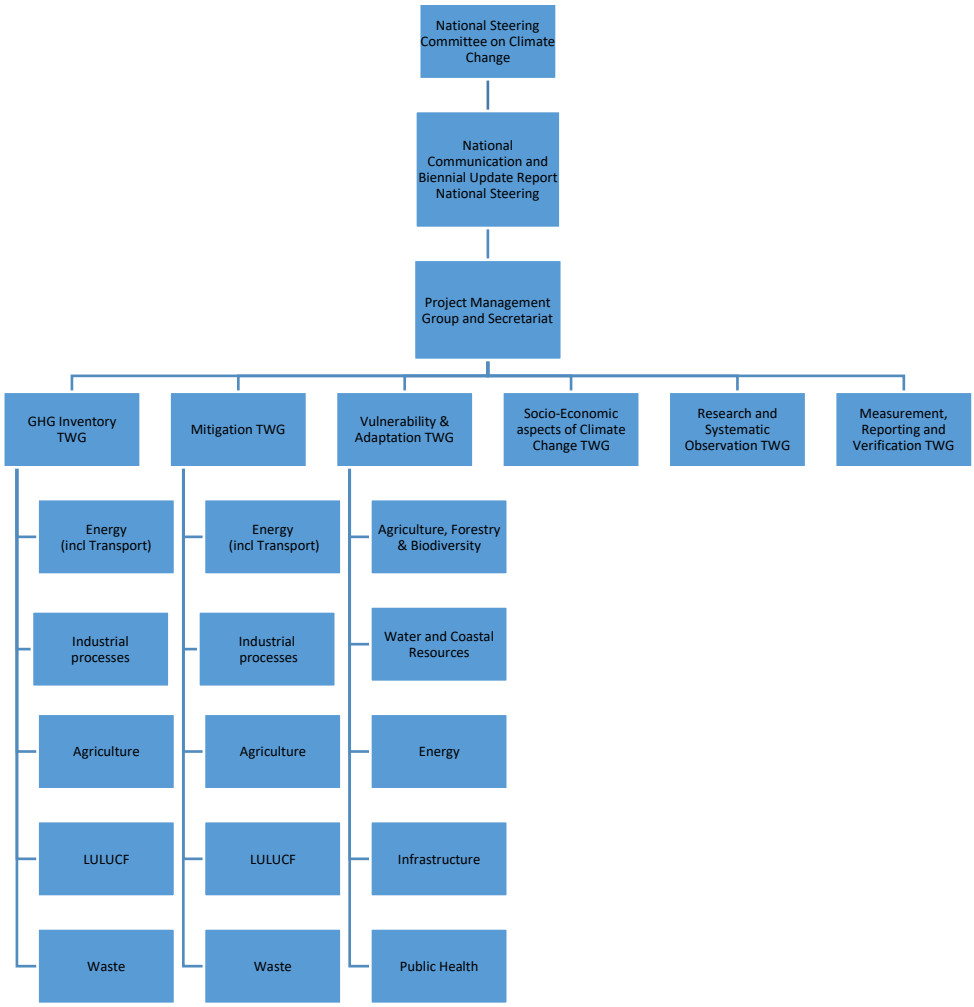
As the key guiding document for resource mobilisation and allocation, the Malaysia plans set the agenda for policymaking in Malaysia as well as for public financing. In this sense, they are the key documents for mainstreaming climate-change adaptation infrastructure funding, as they mobilise resources across all line ministries. Under the *Tenth Malaysia Plan* (2011–2015), the government provided RM5 billion for flood-mitigation programmes. In the *Eleventh Malaysia Plan* (2016–2020), a focus area on resilience against climate change and natural disasters was included as well as explicit strategies on improving flood-mitigation efforts and enhancing climate-change adaptation.

In terms of policy instruments to facilitate financing, the government has included various fiscal instruments and sources of funding for green initiatives, such as a green investment tax allowance, green income tax exemption, Green SRI Sukuk Grant Scheme and further green sukuk issuances, Green Technology Financing Scheme, and budgetary allocations to ministries. However, the focus is mainly on climate-change mitigation, especially large-scale renewable energy projects.

A comprehensive institutional structure also exists to mainstream climate change. The National Steering Committee is chaired by the secretary-general of the Ministry of Natural Resources and Environment (now Ministry of Environment and Water) with multistakeholder members including ministries, agencies, the private sector, and civil society organisations. Technical working groups were established to communicate with the UNFCCC, including one on vulnerability and adaptation as well as a sub-group that focusses on infrastructure. However, the groups were established mainly for international reporting rather than for the implementation or mainstreaming of climate action. Indeed, institutional arrangements are ad hoc, where meetings are only undertaken to coincide with national communication updates. Nonetheless, a degree of mainstreaming has been established through the structure of the international reporting process.

[2] Interviews with government officials indicated that the government is updating the NDC after the 2021 Climate Change Conference.

Figure 4.3. Institutional Arrangements under the National Steering Committee



LULUCF = land use, land-use change, and forestry; TWG = thematic working group
Source: Ministry of Environment and Water (2020).

Generally, private finance has been growing in Malaysia in relation to projects aligned with the Sustainable Development Goals as well as value-based intermediation; socially responsible investing; and environmental, social, and governance practices in investment. This includes Bursa Malaysia supporting climate-related financial disclosures for its mandatory sustainability reporting for all listed companies. The challenge, however, is that there is a lack of capacity and guidelines on climate change. Bank Negara produced a discussion paper on developing a taxonomy and included climate-change adaptation as Guiding Principle 2 (Bank Negara Malaysia, 2021):

> The objective of climate change adaptation is to increase resilience in order to withstand the negative physical effects of current and future climate change. An economic activity can be considered to meet climate change adaptation through … measures to increase own resilience; … other economic activities to adapt to climate change; … measures to increase own resilience (e.g. implement early warning system to reduce risk of flooding); or contribute to the adaptation of other economic activities to mitigate physical effects of climate change (e.g. develop flood sensor technology).

As with public finance, due to the lack of a clear taxonomy and the inherent complexity of climate-change adaptation that cuts across multiple sectors at various levels, finance related to climate change from the private sector has focussed on mitigation through large-scale renewable energy projects. Efforts are ongoing to develop clear taxonomies on climate change generally and on adaptation more specifically. In principle, climate-change adaptation is already incorporated in existing guidelines towards principle-based and climate-related investments.

4.3. Regulations

There are no clear regulations on financing for climate change. The government is preparing a green procurement plan, but it is unclear whether adaptation will be included. Currently, there are no detailed criteria for climate-change adaptation.

In terms of regulations, there are various efforts to review building codes as well as infrastructure related to climate change. However, it is difficult to assess whether this review will be directly related to adaptation. For example, the building-code review is to, in part, increase energy efficiency of buildings (i.e. mitigation).

4.4. Reporting

Two means of reporting are assessed: domestic and international. As indicated in previously, the main reporting mechanism for climate-change adaptation is internationally through the national communication to the UNFCCC. The report includes an in-depth assessment on adaptation in Malaysia as well as adaptation needs. The main gap highlighted is the need for a national adaptation plan. This requires resources. The lack of a national adaptation plan is a major obstacle for reporting on financing specifically for infrastructure financing for climate-change adaptation.

Domestically, while the Malaysia plans monitor allocations through outcome-based budgeting, it is challenging to distinguish which budgets are allocated for climate-change adaptation as there is no climate budget tagging. Consequently, Malaysia should begin to employ a comprehensive set of indicators that highlight budgetary line items that address climate-change mitigation and/or adaptation and the extent to which they do so. Such climate budget tagging would allow key stakeholders to assess the state of financing for both mitigation and adaptation actions and allow policymakers to design the appropriate policy mechanisms, if necessary, to further Malaysia's efforts to mitigate climate change and adapt to its consequences.

5. Synthesising Malaysia's Adaptation Planning, Financing, and Institutional Environment

This section synthesises the assessment and challenges in the context of Malaysia's infrastructure financing for climate-change adaptation ecosystem. This is produced by undertaking a SWOT analysis on internal strengths and weaknesses (i.e. challenges) and external opportunities and threats.

The section is split into three parts. The first of these focusses on climate-change adaptation planning in the context of the Malaysia plans, the twelfth of which applies from 2021 to 2025, as well as the development of any specific national adaptation plans. The second focus is on financing for climate-change adaptation, emphasising its expansion of sources. The final part synthesises the institutional environment surrounding climate-change adaptation in Malaysia.

5.1. Planning Analysis

Strengths. The strength in terms of planning in Malaysia is in having a systematic development planning system. This consists of a 5-year plan at the federal level that coordinated by a central body, the Economic Planning Unit (EPU). The unit is also responsible for infrastructure planning. With a twin focus on infrastructure for attracting investment and for domestic socio-economic development, this centralised planning has been largely effective.

In terms of infrastructure quality, according to the World Economic Forum's Global Competitiveness Index, Malaysia performs relatively well, ranking 35th globally in overall infrastructure quality (Schwab, 2019). This demonstrates the strength in terms of availability and capacity in planning and coordination for infrastructure.

Weaknesses. Despite the impressive trajectory of infrastructure development planning, addressing more complex challenges that require long-term planning – such as for climate-change adaptation – is more challenging. As infrastructure planning is driven by EPU, addressing the long-term benefits of infrastructure relies on its coordination with and input from line ministries. In this sense, challenges arise from long-term planning for climate-change adaptation, as there is no reference point such as a national adaptation plan. Similarly, the lack of sectoral or downscaled risk assessments and information on the vulnerability levels of different contexts means that planning for specific infrastructure for adaptation measures is a challenge.

Opportunities. The Ministry of Environment and Water is developing a national adaptation action plan that will provide a reference point for infrastructure financing for climate-change adaptation. A large-scale and long-term study, *Water Services Transformation 2040,* which includes climate change as a focus area, provides a model for future planning that is based on evidence.[3] Moving forward, the availability and quality of information and evidence for infrastructure financing for climate-change adaptation must be improved.

Threats. The first threat is in terms of capacity. While Malaysia has relatively high research capacity on climate-change adaptation, linking adaptation, infrastructure, and finance is still a

[3] Water Services Transformation 2040, https://wst2040.my/

major challenge. Secondly, in terms of long-term planning, recent years have seen political instability whereby changes in government have also brought about changes in policy agendas, and therefore, planning. To mitigate this, there is a need to institutionalise the capacities and policies on long-term climate action, specifically on infrastructure development.

5.2. Financial Analysis

Strengths. Infrastructure financing for climate-change adaptation is still largely from public expenditure. The centralised coordination and resource mobilisation by EPU is again a strength in terms of the ability of mainstreaming such funding across multiple sectors. This ability for mainstreaming is demonstrated in recent budgets, including for 2021 that has allocations related to flood alerts, control, and mitigation programmes conducted by the Department of Irrigation and Drainage and forestry programmes under the Department of Forestry.

Secondly, Malaysia's financial system is highly reputable with a high level of capacity. This is evidenced by the World Economic Forum Global Competitiveness Index ranking Malaysia 15th in the world in terms of its financial system (Schwab, 2019) as well as consistently ranking it 1st in terms of Islamic finance in the world (Refinitiv, 2022).

Weaknesses. In terms of public expenditure, despite the ability to mainstream across various sectors, a few weaknesses remain. Firstly, it is difficult to ascertain the exact amount of expenditure on climate-change adaptation financing due to the lack of climate budget tagging. Secondly, resources are mainly focussed on the water sector, in particular for flood mitigation, rather than on other sectors of climate-change adaptation. Thirdly, a review of public expenditure shows that the allocation for environmental sustainability overall is still relatively low, with a total allocation of 0.66% of the overall budget for 2021.

In terms of private sector financing, despite the capability of the private sector and the industry's recent efforts towards climate finance, there is little evidence of such financing for climate-change adaptation infrastructure. The focus has been largely on large-scale mitigation projects.

Opportunities. The 2021 budget highlights its ambition to leverage Malaysia's capability in the financial industry to make Malaysia a sustainable finance hub. This includes issuing the first sovereign sustainability bond in Malaysia. Combined with the leadership of key institutions such as the Ministry of Finance, Bank Negara, and Securities Commission Malaysia as well as key private financial institutions, leveraging private finance is crucial. Institutionally, this includes the establishment of the Joint Committee on Climate Change, which aims to pursue collaborative actions for building climate resilience within the Malaysia financial sector, co-chaired by Bank Negara and Securities Commission Malaysia. To ensure its feasibility and sustainability, the budget and issuance of sovereign sustainability bonds pave the way for blended finance mechanisms across private and public resources.

Threats. Despite positioning Malaysia as a sustainable financial hub, the capacity within the industry is lacking, in particular, on assessing the risks associated with climate-change adaptation in financing infrastructure projects. Moving forward, there is a need for intensive capacity building to both realise this agenda as well as including climate-change adaptation as a priority in financing options.

5.3. Policy and Institutional Environment Analysis

Strengths. EPU has the mandate and capacity to mainstream planning across all lines and implementing agencies at the federal level. Specifically, for infrastructure financing for climate-change adaptation, the EPU structure consists of cross-sectoral sections, the Division on Economy of Environment and Natural Resources, Infrastructure Division, and Development Budget Division. This structure allows for the mainstreaming of such funding in terms of planning and resource mobilisation. Beyond EPU, planning of physical infrastructure is also undertaken by the Federal Department of Town and Country Planning, in particular in relation to green infrastructure, which also includes nature-based solutions in terms of climate-change adaptation. Line ministries also provide the policy direction for implementation at the state and local levels. This systematic enabling environment allows for coordination across the various scales and levels of government.

Weaknesses. Despite the systematic planning structure, the implementation level suffers from various challenges. Firstly, as highlighted repeatedly, the lack of an adaptation action plan is the main obstacle, as there is no overarching plan as to guide implementation and resource mobilisation. Secondly, because Malaysia has a federal system, challenges arise in translating it down (and vice versa) to the state level. Physical planning and projects are the responsibility of states. The agenda on climate-change adaptation is, however, largely driven from the federal level, and there is little evidence of it being implemented at the state and local levels except for on specific flood-mitigation projects. Institutionally, there is still a lack of space for interactions between the state and federal levels.

Opportunities. The Ministry of Water and Environment is planning to set up the Climate Action Council, which includes the state governments. This provides an opportunity to address the federal–state institutional challenge and an avenue for both inputs from the state level on the adaptation needs as well as coordination at the federal level.

Threats. Firstly, the threat is the capacity at the state and local levels in mainstreaming understanding and awareness of climate-change adaptation challenges. Through interviews, many challenges – such as the increasing frequency and intensity of floods – are usually not attributed to climate change. Secondly, there is a lack of information to guide decision-making on adaptation, which results in non-evidence-based assessments on climate-change adaptation.

In terms of the enabling environment for private finance, the economic impact of COVID-19 remains a threat for the government to provide strong support for its intention to become a sustainable financial hub. There is a risk that the focus and policy incentives are directed to more tangible social initiatives or continue to focus on climate-change mitigation projects rather than adaptation projects.

6. Policy Recommendations

Using the information covered in previous sections, below is a set of policy recommendations that strive to enhance Malaysia's financing frameworks for climate-resilient infrastructure development and climate-change adaptation more broadly.

Table 4.4. Summary of Preliminary Policy Recommendations

Area	Recommendations
Planning	• Produce a national adaptation plan, including for specific infrastructure needs • Produce risk assessments and vulnerability maps for key sectors and vulnerable localities to aid infrastructure planning • Provide a road map to go beyond the water sector for climate-change adaptation
Financial	• Leverage Malaysia's intention to become a sustainable financial hub to find blended finance mechanisms to address funding climate-change adaptation infrastructure • Improve taxonomy related to climate-change adaptation infrastructure • Build capacity of the financial industry to address risks related to climate-change adaptation
Policy and Institutional	• Leverage the proposed Climate Action Council as an avenue to promote state-level financing for climate-change adaptation projects • Provide informational guidance at the state and local levels on vulnerability and infrastructure needs • Build capacity and awareness on climate-change adaptation at the state and local levels • Provide incentives for private financial institutions to incorporate climate-change adaptation in sustainable financing initiatives

Source: Authors.

7. Effects of COVID-19 Pandemic

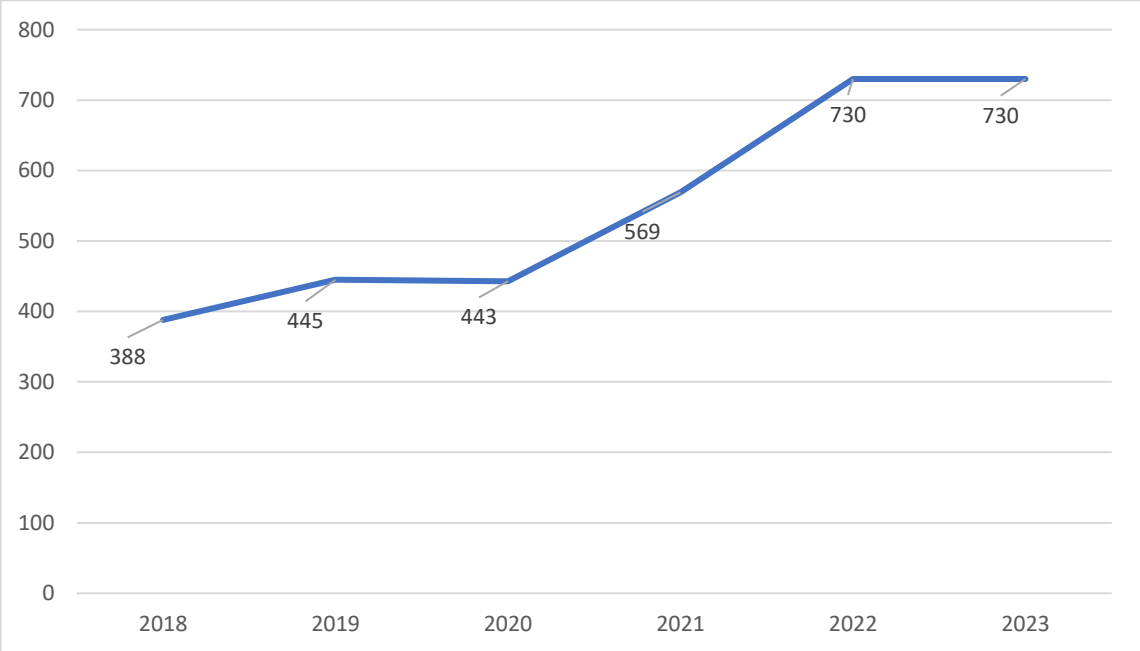
The COVID-19 pandemic has been detrimental to achieving sustainability in the region. The progress towards the Sustainable Development Goals has stalled and even been reversed (UNESCAP, 2022). Environmental sustainability, in particular, has been undone, including progress towards climate change. This is due to the changing priorities despite the need to build back better (UNESCAP, 2022). The 2022 budget totals RM730 million, and although the exact amount is unclear, the 2023 budget is estimated to be RM700 million.

The devastating 2021–2022 floods were a result of various factors. Tropical Depression 29W caused heavy rainfall, which reportedly was a 1-in-100-year event. Many natural geological processes – like landslides – thus occurred, as the volume of rainfall exceeded the absorption capacity of the soil. While these are natural phenomenon, it was exacerbated by development, in particular, due to land clearing in the highlands (Lim, Jamaluddin, Komoo, 2019). The floods

were also blamed on anthropogenic impacts, such as deforestation, development, and urbanisation. Although these linkages with climate change and adaptation are not completely proven, the narrative has resulted in an increased focus on adaptation, especially in relation to flood mitigation. Finally, as the floods occurred during the pandemic, awareness of the need to ensure resilience in light of disasters and shocks was highlighted.

In line with this, Malaysia's focus and expenditure on flood protection has increased. However, it is difficult to ascertain whether an increase in expenditure for other climate-change adaptation measures have been made.

Figure 1.4. Budget Allocation for Flood Mitigation Plans and Urban Drainage, 2018–2023
(RM million)



Source: Authors.

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WST2040, https://wst2040.my/

Chapter 5

Philippines

Adoracion M. Navarro

1. Introduction

The Philippines, an archipelago in South-East Asia consisting of 7,641 islands, was ranked as the ninth-most at-risk country in 2019 in terms of disasters arising from earthquakes, cyclones, floods, droughts, or sea-level rise (Day et al., 2019). It is exposed to an average of 21 typhoons per year and associated disasters such as floods, landslides, and storm surges. It also experiences earthquakes and volcanic eruptions, as well as tsunamis following earthquakes, because it is in the Pacific Ring of Fire. The Philippines is vulnerable to occurrences of prolonged drought due to the El Niño phenomenon and increased rainfall and subsequent flooding due to the La Niña phenomenon.

Around 60% of its 109 million population[1] lives in coastal areas and is vulnerable to climate change-induced disasters. A 2016 report stated that sea surface temperature near the Philippines had been increasing by a range of 0.210°C to 0.250°C per decade from 1981 to 2014. This is higher than the estimated global mean sea surface temperature increase of 0.094°C to 0.154°C for every decade from 1979 to 2012. Moreover, future changes to the climate in response to various emission scenarios have been studied, and the mid-range emission scenario predicts increases in annual mean temperatures ranging from 0.9°C to 1.1°C in the 2020s and 1.8°C to 2.2°C in the 2050s (Villarin et al., 2016). This means that the country will be exposed further to extreme weather events in the coming decades.

The Philippines is considered a lower middle-income country, with a per capita gross national income of $3,860.97 in 2019. Economic growth performance in the past decade has been robust, with gross domestic product (GDP) increasing at an annual rate of over 6% from 2012 to 2019. The COVID-19 pandemic, however, reversed this trend. The economy contracted for the first time since 1998 by 0.2% in the first quarter of 2020, then by 16.9% in the second quarter (the lowest recorded growth in 39 years), and by 11.5% in the third quarter. This will have devastating impacts on poverty, the estimates of which will be collected in 2021 and released in 2022, which will add to the impacts that the country has been experiencing due to various disasters. Walsh and Hallegatte (2020) estimated that the average annual well-being losses due to disasters in the Philippines is $3.9 billion per year, more than double the asset losses of $1.4 billion.

The primary government agency responsible for climate adaptation advocacy is the Climate Change Commission (CCC). It is tasked by Republic Act No. 9729, as amended by Republic Act No. 10174, to coordinate, monitor, and evaluate government programmes on climate change and to ensure the mainstreaming of climate-change concerns in national, sub-national, and sectoral development plans. It is composed of the President as chair, and three commissioners

[1] Based on the official 2020 census, which placed the population of the country at 109,035,343 (Philippine Statistics Authority, 2021).

appointed by the President, one of whom serves as the vice-chair. As a policy authority and science-based agency, the CCC has two supporting bodies: an advisory board and a technical experts panel.

The advisory board is composed of the heads of the following national government agencies: Department of Agriculture, Department of Energy, Department of Environment and Natural Resources (DENR), Department of Education, Department of Foreign Affairs, Department of Health, Department of Information and Communication Technology, Department of the Interior and Local Government, Department of National Defense, Department of Public Works and Highways, Department of Science and Technology, Department of Social Welfare and Development, Department of Trade and Industry, Department of Transportation, National Economic and Development Authority, National Security Council, and Philippine Commission on Women. It also has representatives from associations of sub-national or local governments, including the president of the League of Provinces, president of the League of Cities, president of the League of Municipalities, and president of Liga ng mga Barangay. Finally, it has sectoral representatives, one each from academia, the business sector, and non-governmental organisations, provided that at least one of the sectoral representatives comes from the disaster risk reduction community.

The technical experts panel consists of the country's leading climate scientists and authors on the Intergovernmental Panel on Climate Change (IPCC).

Aside from the CCC, the interagency National Disaster Risk Reduction and Management Council tackles climate-change issues as they relate to disasters. It is chaired by the secretary of the Department of National Defense, who, in turn, is assisted by four vice-chairs: the secretary of the Department of Science and Technology as vice-chair for disaster prevention and mitigation, secretary of the Department of the Interior and Local Government as vice-chair for disaster preparedness, secretary of the Department of Social Work and Development as vice-chair for disaster response, and secretary of the National Economic and Development Authority as vice-chair for rehabilitation and recovery. As the national government agencies have counterparts in the country's administrative regions, this structure is replicated in regional disaster risk reduction and management councils at the regional level. This council also has counterparts at the local government unit (LGU) level but with a slightly different structure; the chair is the sitting local chief executive (i.e. a governor in the case of provincial councils and a mayor in the case of city or municipal councils).

Those responsible for implementing infrastructure projects for climate-change adaptation include the Department of Energy, Department of Information and Communication Technology, Department of Public Works and Highways, Department of Transportation, Local Water Utilities Administration, and National Irrigation Administration. Depending on the type of project, implementation efforts are complemented or spearheaded by other agencies, such as the CCC, DENR, Department of Science and Technology, or Department of Trade and Industry.

2. Financing Infrastructure for Climate-Change Adaptation

The Philippines uses the following definitions of climate-change adaptation and adaptation responses for the purposes of climate-change expenditure tagging in the government budget. Climate-change adaptation is a response that intends to reduce the vulnerability of humans or natural systems to the impacts of climate change and climate-related risks by maintaining or increasing adaptive capacity and resilience. Responses include:

(i) **Measures that address the drivers of vulnerability.** Vulnerability is the degree to which people or systems are susceptible to the adverse effects of climate change but are unable to cope with them. It depends both on the exposure to the climate hazard and the sensitivity and coping capacity of the people and systems. Vulnerability can be addressed by reduced exposure (e.g. shifting populations or assets to less risky areas through zoning regulations) or by increasing coping capacity (e.g. well-targeted poverty reduction, income and livelihood diversification, health programmes, and dissemination of climate-risk information).

(ii) **Measures that directly confront climate-change impacts.** These types of expenditures directly address the impacts or potential impacts of climate-change variability such as construction of infrastructure that incorporates climate-change risks in the design; or programmes, activities, and projects implemented to minimise impacts from climate-change risks.

(iii) **Measures that build resilience to current and future climate risks.** Building resilience means increasing the capacity of the social or ecological system to reach or to maintain an acceptable level of functioning while undergoing changes. Expenditures in this category include reducing land degradation, developing reforestation programmes, upgrading roads to climate-resilient design standards, using climate-resilient crop varieties or farming techniques, installing effective early-warning systems, and other investments specifically designed to respond to projected climate changes and variability (Government of the Philippines, DBM, CCC, and DILG, 2015).

Of particular interest to the Philippines are adaptive measures fit for coastal systems and low-lying areas and with the potential to make coastal resources more adaptive to accelerated sea-level rise. The *Philippines' Initial National Communication on Climate Change* that was submitted per the United Nations Framework Convention on Climate Change (UNFCCC) identified six adaptive measures related to accelerated sea-level rise: (i) selecting coastal protection measures informed by comprehensive cost–benefit analyses, (ii) long-term planning using the perspective of coastal zone management, (iii) tying up disaster mitigation and preparedness with climate-change issues, (iv) establishing and enforcing policies and regulations on human settlements and construction, (v) including climate-change measures in the integrated coastal zone management programme, and (vi) developing an information and education campaign (Cruz et al., 2017).

The types of infrastructure for climate-change adaptation in the Philippines so far cover green buildings, green construction, sustainable transport, renewable energy, energy-efficiency enhancements, waste management (including recycling), and sustainable water use. The topic of infrastructure for climate-change adaptation in the Philippines also covers cross-cutting topics such as standards, information systems, and technological tools.

Energy and transport sectors are covered because in the Philippines, data show that projected greenhouse gas emissions will be dominated by the energy and transport sectors due to expected population and economic growth. Effective mitigation and adaptation therefore entail early and vigorous actions to curb these emissions.

Moreover, in the country's nationally determined contribution (NDC) submitted to the UNFCCC in 2021, five major economic sectors were identified as priorities – agriculture, waste, industry, transport, and energy (Government of the Philippines, 2021). By infrastructure in the waste sector, the government means solid waste management facilities, recycling facilities, and liquid waste management facilities. All types of infrastructure for climate-change adaptation are present in the agriculture and industry sectors.

As disaster preparedness and climate-change adaptation are intertwined, infrastructure projects on disaster resilience-building are also seen as adaptation projects. These include construction, rehabilitation, and retrofitting of resilient evacuation centres; construction of shore protection infrastructure; and flood-control projects.

The basic laws on climate-change measures, including mainstreaming climate-change adaptation, are Republic Act No. 9729 (Climate Change Act of 2009) and Republic Act No. 10174 amending Republic Act No. 9729. Pursuant to Republic Act No. 9729, the CCC formulated the *National Framework Strategy on Climate Change (NSFCC) 2010–2022,* which is a road map for a national programme on climate change (CCC, 2010). The NSFCC frames climate-change planning, research and development, extension services, monitoring of activities, and financing. It was crafted based on climate-change vulnerabilities, specific adaptation needs, and the mitigation potential of the Philippines, and it is based on international agreements.

The CCC detailed the NSFCC through the *National Climate Change Action Plan (NCCAP) 2011–2028*, which is an action plan detailing government actions for the short, medium, and long term under seven thematic outcomes: food security, water sufficiency, ecological and environmental stability, human security, climate-smart industries and services, sustainable energy, and knowledge and capacity development (CCC, 2011). The NCCAP also serves as the basis of the different climate reports that the Philippines communicates to international bodies, such as its NDC.

Another law that is enhancing climate-change adaptation is Republic Act No. 10121 (Philippine Disaster Risk Reduction and Management Act of 2010). Among the policies under the law are building the resilience of local communities to disasters, including climate-change impacts, and mainstreaming disaster-risk reduction and climate change in development processes. In accordance with this law, the *National Disaster Risk Reduction and Management Plan, 2011–2028* is being implemented through projects and activities under four mutually reinforcing themes – disaster preparedness, disaster response, disaster prevention and mitigation, and disaster rehabilitation and recovery (Government of the Philippines, 2012).

Both the Climate Change Act, as amended, and the Disaster Risk Reduction and Management Act are instruments for mainstreaming climate-change adaptation. The Climate Change Act requires LGUs to prepare local climate-change action plans, and the Disaster Risk Reduction and Management Act requires LGUs to prepare local disaster risk reduction and management plans.

Since climate-smart industries and services are a thematic priority under the NCCAP, strategies related to the promotion, development, and sustainability of climate change-resilient, eco-efficient, and environment-friendly industries and services – as well as sustainable towns and cities – necessitate green design for infrastructure. There is also a current proposal to develop standards for climate-smart buildings, which would be aligned with existing international standards. There is also a proposal to develop and implement standards for climate-smart hospitals.

Another relevant law is Republic Act No. 9153 (Renewable Energy Act of 2008), as it supports green initiatives in the energy sector. It offers incentives to renewable energy projects such as income tax holidays for the first 7 years of commercial operation; duty-free importation of machinery, equipment, and material; special tax rates on facilities and equipment; and 0% value-added tax rates.

The Philippines officially acceded to the Paris Agreement when former President Rodrigo Duterte signed the Instrument of Accession in February 2017, and the Senate ratified the signing in March 2017. Before the Paris Agreement was declared in December 2015, the government submitted its intended NDC in October 2015. It expressed an intention to undertake a 70% reduction in greenhouse gas emissions from its 2000 level by 2030, but this is conditional on external support. The Paris Agreement requests countries to communicate by 2020 a new NDC and to do so every 5 years thereafter. On 15 April 2021, the Philippines submitted its first NDC, committing to 'a projected [greenhouse gas] emissions reduction and avoidance of 75%, of which 2.71% is unconditional[2] and 72.29% is conditional[3]' (Government of the Philippines, 2021:4).

3. Climate-Change Adaptation Finance

The financing of infrastructure for climate-change adaptation is mostly through the government budget. The Philippines also accesses various international finance sources. There are also private sector initiatives, which take the form of financial intermediary programmes and activities by non-governmental organisations set up by the business sector.

3.1. Government Financing and Budgeting

The government is practicing climate-change expenditure tagging in national agency budgets and LGU budgets, where the tags are for climate-change adaptation and mitigation. There are also funds dedicated to climate-change adaptation, such as the People's Survival Fund. The National Disaster Risk Reduction and Management Fund and local disaster risk reduction and management funds are also sources since some resiliency measures can be considered adaptation responses.

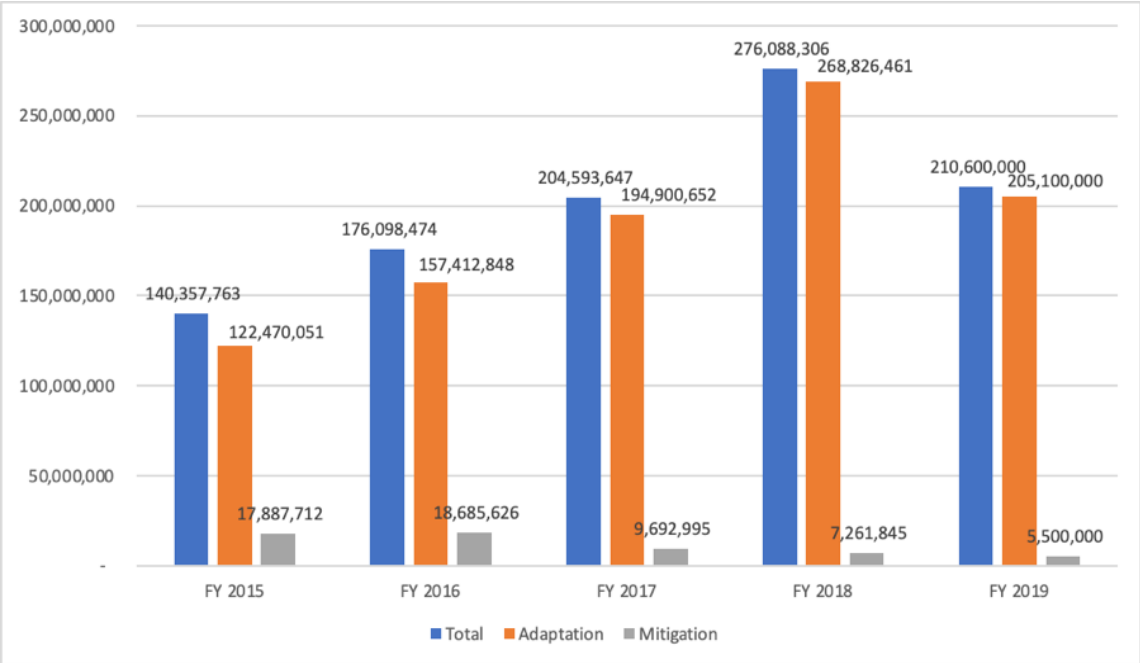
The tagging helps the Philippines understand, assess, and adjust how much of the country's budget is allocated to climate action. At the national government level, tagging is done by

[2] 'Unconditional' refers to policies and measures that can be undertaken using nationally mobilised resources.

[3] 'Conditional' refers to policies and measures that require support or the means of implementation under the Paris Agreement.

national government agencies, government-owned and -controlled corporations, and other government institutions (Figure 5.1). At the LGU level, tagging is done by local governments, but not all LGUs have the capacity to do so.

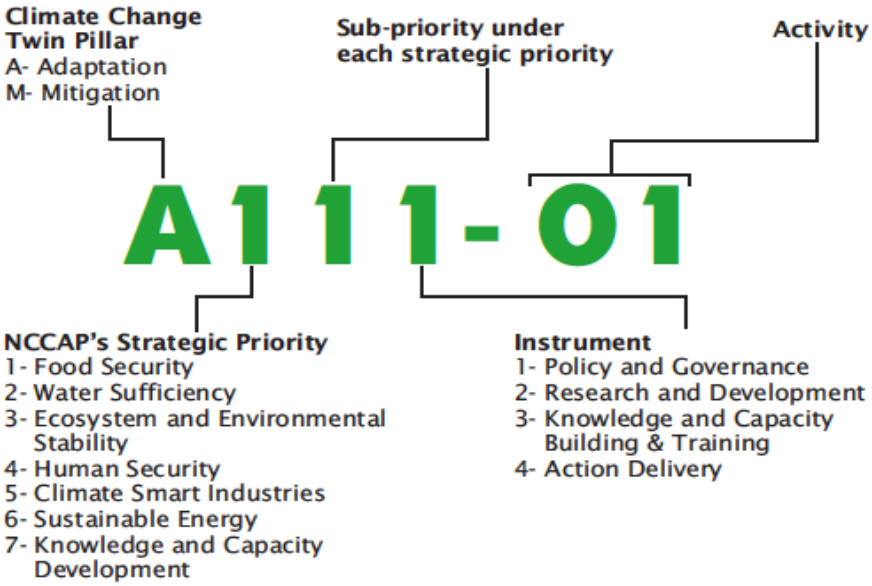
Figure 5.1. National Government Climate-Change Expenditure Tagging, 2015–2019
(P '000)



FY = fiscal year.
Source: CCC.

The CCC reported that LGUs tagged, in 2018, P92 billion in climate-change initiatives related to either adaptation or mitigation, and in 2019, P76.1 billion for climate-change adaptation and P2.2 billion for climate-change mitigation (CCC, 2018, 2019). It is not clear, however, how much is for climate-change adaptation infrastructure, because the typology for tagging employs categories in terms of seven outcomes (i.e. food security, water sufficiency, ecosystem and environmental stability, human security, climate-smart industries, sustainable energy, and knowledge and capacity development), which are contained in the NCCAP, and four instruments (i.e. policy and governance, research and development, knowledge and capacity building and training, and action delivery) (Figure 5.2).

Figure 5.2. Typology for Climate-Change Expenditure Tagging



NCCAP = National Climate Change Action Plan.
Source: Government of the Philippines, DBM, and CCC (2020).

3.2. People's Survival Fund

Republic Act No. 10174 established the People's Survival Fund to support LGU and community climate-adaptation actions. The law allotted an opening balance of P1 billion for the fund in the General Appropriations Act and provided a balance of the fund from all sources of not less than P1 billion thereafter. Under the law, the allotment for the People's Survival Fund may be augmented through donations, endowments, grants, and contributions.

The adaptation projects that can be supported by the fund include adaptation activities concerning ecosystems; improvements on the monitoring of vector-borne diseases triggered by climate change; forecasting and early-warning systems; support of institutional development; strengthening or establishing regional centres and information networks; guarantees for risk insurance for farmers, agricultural workers, and other stakeholders; and community adaptation support programmes by local organisations accredited by the CCC. Projects approved as of 2019 include:

(i) Siargao Climate Field School for Farmers and Fisherfolk (Del Carmen municipality in Surigao del Norte Province),

(ii) Disaster Risk Reduction and Mechanism Response as a Coping Mechanism to Resiliency (Lanuza municipality in Surigao del Sur Province),

(iii) Promoting Resiliency and a Climate-Informed Gerona (Gerona municipality in Tarlac Province),

(iv) Building Resilience through Community-Based Ecological Farming (San Francisco municipality on Camotes Island, Cebu Province),

(v) Saub Watershed Ecosystem Rehabilitation and Flood Risk Reduction for Increased Resilience (Sarangani Province), and

(vi) Establishment and Sustainable Management of River Ecosystem (Kitcharao municipality in Agusan del Norte Province).

The annual utilisation of the fund is not immediately available, but it was reported that a monitoring and evaluation system is currently being developed to enable online proposal submission and tracking (CCC–Office of the Deputy Executive Director, 2019). Nevertheless, figures from the CCC show that the People's Survival Fund had earmarked 31% of funds for approved projects and 1% for project development grants; 68% of funds remained for 2019.

3.3. National Disaster Risk Reduction and Management Fund

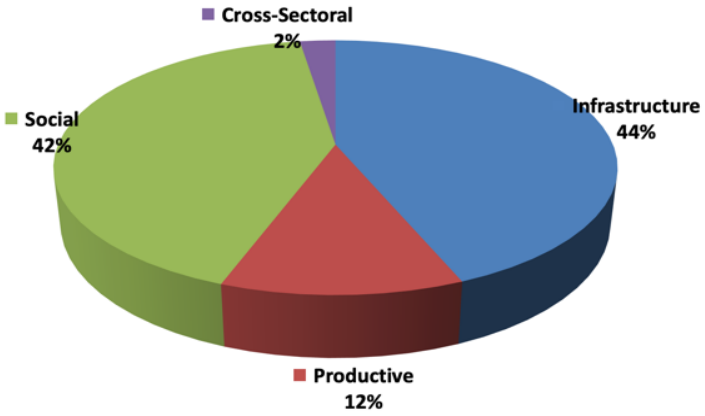
The National Disaster Risk Reduction and Management Fund was created by Republic Act No. 10121 to support activities pertaining to emergency relief and response, disaster preparedness, post-disaster rehabilitation and recovery, and disaster prevention and mitigation. Of the annual amount allocated, 30% is allotted through the Quick Response Fund, a stand-by fund for relief and recovery programmes in communities or areas stricken by disasters, calamities, epidemics, or complex emergencies. The remaining 70% is for preparedness, prevention and mitigation, and rehabilitation and recovery.

To the extent that some projects funded by the National Disaster Risk Reduction and Management Fund are for building back better (in the case of post-disaster rehabilitation programmes) or for pre-disaster resilience building, the fund can be considered another source of financing infrastructure for climate-change adaptation. The fund administrator, the Office of Civil Defense, however, does not categorise which projects can be strictly considered infrastructure climate-change adaptation projects.

From 2016 to 13 November 2020, P103 billion was released for disaster risk reduction and management projects. Figure 5.3 shows the breakdown by sector, and Figure 5.4 shows the breakdown by project type.

Figure 5.3. National Disaster Risk Reduction and Management Fund by Sector, 2016–2020 (P)

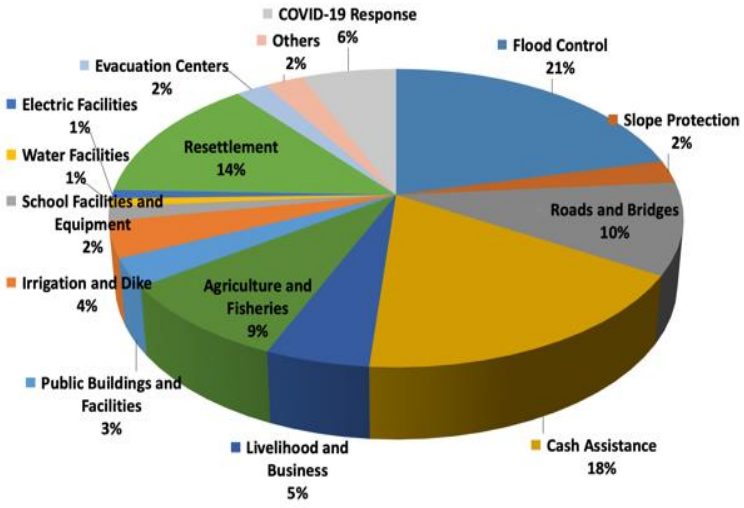
SECTOR	AMOUNT
Infrastructure	45,173,211,879.71
Productive	12,122,952,124.13
Social	43,332,869,125.81
Cross-Sectoral	2,503,683,431.27
TOTAL	103,132,716,560.00



Note: As of 13 November 2020.
Source: Office of Civil Defense.

Figure 5.4. National Disaster Risk Reduction and Management Fund by Project, 2016–2020 (P)

PROJECT TYPE	AMOUNT
Flood Control	**21,824,309,930.55**
Slope Protection	2,551,212,819.00
Roads/Bridges	**10,255,709,047.09**
Cash Assistance	**18,251,882,570.00**
Livelihood and Business	5,242,802,163.98
Agriculture and Fisheries	**9,168,234,569.75**
Public Buildings and Facilities	3,141,920,546.58
Irrigation/Dike	4,013,595,199.40
School Facilities and Equipment	1,597,049,444.57
Water Facilities	902,253,940.45
Electric Facilities	951,588,426.73
Resettlement	**14,110,421,845.86**
Evacuation Centers	2,139,508,942.00
Others	2,620,911,468.24
COVID-19 Response	6,361,315,646.00
TOTAL	103,132,716,560.00



Note: As of 13 November 2020.
Source: Office of Civil Defense.

The National Disaster Risk Reduction and Management Fund, however, does not capture the total national government investment on disaster risk reduction and management. There are disaster risk reduction projects implemented by government line agencies that are funded under their regular agency budgets. These include those related to early-warning systems, flood-control projects, and other resiliency-building projects. Some of these are captured in the climate-change expenditure tagging system described previously.

3.4. Local Disaster Risk Reduction and Management Funds

At the LGU level, the Local Disaster Risk Reduction and Management Fund of each LGU complements national government financing for disaster risk reduction and management, some of which can be considered adaptation responses as argued earlier. As directed by Republic Act No. 10121, LGUs should set aside not less than 5% of their revenues from regular sources for their funds, 30% of which are for the stand-by Quick Response Fund for relief and immediate response activities in times of disasters, and 70% for disaster preparedness, prevention and mitigation, and rehabilitation and recovery.

Currently, there are no aggregate data on Local Disaster Risk Reduction and Management Fund utilisation from the 1,715 LGUs in the country (i.e. 81 provinces, 146 cities, and 1,488 municipalities), but the Commission on Audit includes these funds in its annual audit of each LGU.

3.5. International Climate Finance

International climate finance sources being tapped by the Philippines thus far include the Climate Investment Funds (CIFs), Green Climate Fund (GCF), and Global Environmental Facility (GEF). Potential additional sources being explored include the Adaptation Fund, through a regional project proposed by the United Nations Development Programme (UNDP) and the Joint Crediting Mechanism (JCM) with Japan.

The CIFs aim to bridge the financing and learning gap in international climate-change agreements. They consist of two distinct funds: the Clean Technology Fund, which provides financing for demonstration, deployment, and transfer of low-carbon technologies, and the Strategic Climate Fund, which aims to provide financing to pilot new approaches with potential for scaling up, especially by helping more vulnerable countries adapt their development programmes to confront the impacts of climate change. The CIFs are considered additional existing official development assistance from multilateral development banks, and the World Bank acts as the trustee.

The Philippines is accessing both the Clean Technology Fund and Strategic Climate Fund. Under the Clean Technology Fund, the Philippines is focussing on low-carbon public transport systems and renewable energy generation (Table 5.1). The Strategic Climate Fund is implementing the Pilot Program for Climate Resilience, and the Philippines is currently in the process of accessing the programme through a project on risk resiliency and sustainability.

Table 5.1. Clean Technology Fund Projects in the Philippines

Project	Funding ($ million)	Co-financing ($ million)	Multilateral Development Bank
Cebu Bus Rapid Transit Project	25.00	203.50	International Bank for Reconstruction and Development
Market Transformation through Introduction of Energy-Efficient Electric Vehicles Project	8.38	399.00	Asian Development Bank
Philippines Manila BRT	23.90	85.51	International Bank for Reconstruction and Development
Renewable Energy Accelerator Program	25.09	476.90	International Finance Corporation
Renewable Energy Development	44.00	516.00	International Bank for Reconstruction and Development
Sustainable Energy Finance Program	0.77	76.95	International Finance Corporation

Source: Climate Investment Funds, Philippines, https://www.climateinvestmentfunds.org/country/philippines.

The GCF is a stand-alone multilateral financing facility created by the UNFCCC to support low-emission (i.e. mitigation) and climate-resilience (i.e. adaptation) projects and programmes in developing countries. The support can be in the form of grants, loans (concessional), equity, and guarantees. The CCC is the National Designated Authority for the Philippines, and the Land Bank of the Philippines, a government financing institution, has been accredited by the GCF as the country's first direct access entity. The CCC ensures that all project proposals are aligned with the country's development objectives and issues the no-objection letter for funding proposals. It also nominates direct access entities for accreditation by the GCF. The CCC also nominated the Development Bank of the Philippines, another government financing institution, and the Foundation for the Philippine Environment, a non-governmental organisation, as direct access entities. The Land Bank of the Philippines facilitates the fund flow by signing a legal instrument called the Funded Activity Agreement with the GCF. The direct access entity should ensure that when a project or programme moves into the implementation period, the funds are transferred against agreed criteria and the GCF's fiduciary standards. Moreover, it should monitor and evaluate the projects or programmes until they are closed and exit the GCF portfolio.

In December 2019, the GCF Board approved the project, Multi-Hazard Impact-Based Forecasting and Early Warning System, for the Philippines. The primary executing entity for the project is the Department of Science and Technology–Philippine Atmospheric Geophysical and Astronomical Services Administration, and the co-executing entities are DENR–Mines and Geosciences Bureau; Department of the Interior and Local Government; Office of Civil Defense; Tuguegarao City LGU; Legazpi City LGU; Leyte LGU; New Bataan LGU; Davao de Oro LGU; and the World Food Programme.

The GEF is an independently operating financial organisation that provides grants for projects in six main areas: biodiversity, climate change (mitigation and adaptation), chemicals and waste, international waters, land degradation, and sustainable forest management/REDD+. [4] The overall focal point for the GEF in the Philippines is DENR, and the focal point agency for climate change-related projects is the CCC. According to the CCC, the ongoing projects under the GEF are:

(i) Development of Renewable Energy Applications Mainstreaming and Market Sustainability Project (by the Department of Energy),

(ii) Promotion of Low-Carbon Urban Transport System in the Philippines (by the Department of Transportation), and

(iii) Global Partnership for Improving the Food Cold Chain in the Philippines (by DENR).

To date, the Philippines has benefited from $674,603,274 from the GEF (Table 5.2).

Table 5.2. Access to the Global Environment Facility by the Philippines

Fund	Project Type	Number of Projects	Total Financing ($)	Total Co-Financing ($)
GEF	National	59	251,221,015	3,023,411,702
GEF	Regional/Global	61	416,079,720	2,708,783,155
GEF-SCCF	National	2	6,024,000	66,700,000
GEF-SCCF	Regional/Global	1	1,278,539	3,350,000
Grand Total			674,603,274	5,802,244,857

GEF = Global Environment Facility, SCCF = Special Climate Change Fund.
Source: GEF, Philippines, https://www.thegef.org/country/philippines

The Adaptation Fund is a facility that derives its main income from the Clean Development Mechanism under the Kyoto Protocol and finances projects that help vulnerable communities in developing countries build resilience and adapt to climate change. It is an emission reduction crediting system that allows developing countries to earn one emission reduction credit for every tonne of carbon dioxide emissions reduced and then to sell these to industrialised countries to help them meet a part of their emission reduction targets under the Kyoto Protocol. The Philippine project, Harnessing the Water–Energy–Food Nexus to Address and Adapt to Climate Change Impacts in Tawi-Tawi, is in the pipeline of the Adaptation Fund.

The Japan Fund for the JCM is a single-donor trust fund managed by the Asian Development Bank. It provides grants and technical assistance to projects utilising the JCM. The JCM is a bilateral, project-based, carbon-offset crediting mechanism initiated by the Government of

[4] REDD+ denotes actions on reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries.

Japan wherein the result of emission reduction from projects is assessed as contributions by both partner countries and Japan. Japan is supposed to contribute low-carbon technologies and implement mitigation actions in host-country JCM projects.

The Philippines entered into a bilateral agreement with Japan for the JCM in 2017. Part of the requirements is to define the methodology for calculation and verification before JCM projects are funded. Methodologies for electricity generation through run-of-river hydropower-generation systems and installation of solar PV systems were approved in 2020.

Reporting and evaluation for the climate-change adaptation projects funded by government funds and international climate funds are shared responsibilities of the CCC, Office of Civil Defense, and DENR. The CCC is mainly responsible for the People's Survival Fund, and the Office of Civil Defense is mainly responsible for the National Disaster Risk Reduction and Management Fund. The CCC and DENR share responsibilities in reporting and evaluating projects funded through the international climate funds.

3.6. Private Sector Initiatives

The private sector is also doing its share in climate-change adaptation. Examples include:

(i) **Sustainable Energy Finance Program by the Bank of the Philippine Islands**. This programme provides financing to businesses that will invest in technologies that improve energy generation, energy distribution, and energy use and reduce carbon emissions. The types of eligible projects include those related to energy efficiency, renewable energy, and climate-resilient structures. The programme's target client businesses include industries, manufacturing, agri-business, construction, and development of renewable energy plants.

(ii) **Activities of the Philippine Business for Social Progress.** The Philippine Business for Social Progress has more than 200 private companies as members. Among the projects and activities that the organisation supports are watershed rehabilitation, small water impoundment, and disaster risk reduction and management.

(iii) **Activities of the Philippine Disaster Resilience Foundation.** The Philippine Disaster Resilience Foundation is an active partner of the government in disaster risk reduction and management and has been coordinating its member-corporations' support for disaster preparedness, business resilience, and continuity planning of small enterprises in their supply chain. It also provides support to communities for response, relief, and recovery efforts in times of disaster.

4. Challenges and Opportunities

A major challenge in optimising infrastructure financing for climate-change adaptation is the difficulty of mainstreaming climate-change adaptation at the LGU level. For instance, the complicated climate finance application of the financing facilities combined with the lack of competence or sophistication of LGUs is hindering them from applying. This is apparent in the previously low application rate in the People's Survival Fund, which the CCC is trying to resolve. One method of flexibility that was introduced is a sub-financing window called the Project

Development Grant, which is 6% of the P1 billion fund. The grant can be used for project preparation and development, such as site-specific risk and vulnerability assessments, benefit analyses, and studies and surveys needed for environmental impact assessments or environmental impact studies. The grant to LGUs for project development is capped at P2 million per LGU and has the condition that grant utilisation must be completed in 1 year.

In the access to both national government funds and international climate finance, LGUs vulnerable to climate change are often at a disadvantage. The LGUs that are most vulnerable are usually lower-income municipalities, which have limited resources for hiring consultants or building their capacity in packaging project proposals. Aside from providing sub-facilities for project development, another possible solution is easing the technical requirements for the submission of proposals. However, this is easier to do for national government funds and more difficult for international climate funds.

Another challenge is how to motivate national government agencies to optimise access to international climate finance. Previous inter-agency discussions focussed more on compliance with international treaties, such as the NDC, and less on how the country can benefit from arrangements like climate finance and carbon offsetting or emission trading schemes. There had also been political tensions in the past, as the signing of the Instrument of Accession to the Paris Agreement was held in abeyance for a few months in 2017 because of the view that the NDC submitted by the Philippines was too high and would stymie economic growth and development. The numerous climate diplomacy travels of government officials were also questioned, leading former President Duterte to restrict bureaucrats' climate change-related travels in 2019.

It is also challenging to motivate greater private sector participation in climate-change adaptation infrastructure financing or implementation. Given the dearth of examples in this area, it seems that the public sector has not yet strategically identified potential synergies with private sector efforts.

However, these challenges can be transformed into opportunities through greater dedication to improvements in access to financing facilities, more vigorous project conceptualisation activities – especially with LGUs that need financing the most – and strategic partnerships with private-sector entities. These activities are short-term investments with a long-term gain. Indeed, the economics of climate-change adaptation infrastructure is about investing in the short term to ensure the survival of humanity and the planet in the long term. It has been claimed that the country stands to lose 6.0% of its GDP annually by 2100 if its disregards climate-change risks, and that if the Philippines invests 0.5% of its GDP by 2020 in climate-change adaptation, it can avert losses of up to 4.0% of its GDP by 2100 (ADB, 2013). This is clearly a long-term, eight-fold gain from a short-term investment.

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Chapter 6

Singapore

Youngho Chang

1. Introduction

Like other countries in South-East Asia, Singapore is located along the equator. Its temperature ranges from 24°C to 35°C throughout the year. It has achieved tremendous economic growth since its independence in 1965. The gross domestic product (GDP) in 2015 constant prices was S$8,170.2 million in 1965 and S$475,279.5 million in 2019, increasing about 58 times. Indeed, Singapore has become one of the highest per-capita income countries in the world. Its per capita GDP was S$1,581in 1965 and S$88,991 in 2019.[1]

Singapore's carbon dioxide emissions were 218.9 million tonnes in 2019 (BP, 2020). It ranks 126th of 142 countries in terms of carbon dioxide emissions per US dollar of GDP and 27th out of 142 countries in terms of emissions per capita (NCCS, 2020).

Unlike other member countries of the Association of Southeast Asian Nations (ASEAN), Singapore has not been affected by any major natural disasters such as earthquakes, tsunamis, or tropical storms. However, Singapore has suffered from flooding due to torrential and heavy rains. It also had four incidences of viral disease outbreaks since its independence in 1965 – encephalitis in 1998; hand, foot, and mouth disease in 2000; severe acute respiratory syndrome (SARS) in 2002; and dengue in 2016.[2]

The National Climate Change Secretariat (NCCS) published a report in 2020 that presents the structure of the Inter-Ministerial Committee on Climate Change (IMCCC), a list of relevant legislation on climate change, and relevant climate-change publications (NCCS, 2020). The list of the relevant publications includes United Nations Framework Convention on Climate Change (UNFCCC) submissions, master plans, and road maps.

The IMCCC, which is tasked to enhance whole-of-government coordination on climate change policies, is chaired by Teo Chee Hean, senior minister and coordinating minister for national security. Consisting of seven ministers, it has three working groups: the Long-Term Emissions and Mitigation Working Group, International Negotiations Working Group, and Resilience Working Group.

Examples of key legislation are the Carbon Pricing Act 2018, Energy Conservation Act 2012, Environmental Protection and Management Act 2019, and Resource Sustainability Act 2019.

Examples of UNFCCC publications are *Singapore's Initial National Communication* in 2000, *Singapore's Second National Communication* in 2010, *Singapore's Third National Communication and First Biannual Update Report* in 2014, *Singapore's Second Biannual Update*

[1] Department of Statistics Singapore, https://www.singstat.gov.sg/ (accessed 15 September 2020).
[2] EM-DAT Public, https://public.emdat.be/ (accessed 6 October 2021).

Report in 2016, *Singapore's Fourth National Communication and Third Biannual Update Report* in 2018 and *Enhanced Nationally Determined Contribution* in 2020. Examples of master plans and road maps are *Singapore Green Plan 2030* in 1992, *Sustainable Singapore Blueprint* in 2009, *National Climate Change Strategy* in 2012, *Singapore's 2nd National Climate Change Study – Climate Projections to 2100 Science Report* in 2014, *Climate Action Plan: Take Action Today, for a Sustainable Future* in 2016, and *Zero Waste Masterplan* in 2019.

The *Singapore Green Plan 2030* is a national sustainability movement that seeks to rally bold and collective action to tackle climate change. It comprises five key pillars: City in Nature, Energy Reset, Sustainable Living, Green Economy, and Resilient Future. It also sets out concrete sectoral plans and targets for the next 10 years. It is a 'living' plan, which will evolve and be refined over time.[3]

2. Financing Infrastructure for Climate-Change Adaptation

This section describes adaptation efforts in Singapore and presents three cases of implementing climate adaptation in Singapore: coastal protection, water resources management, and drainage and flood protection.

2.1. Adaptation Efforts

Singapore has always adopted whole-of-government efforts; at the centre is the NCCS. To address the projected effects of climate change over the next 50 to 100 years, the government has introduced a resilience framework for safeguarding Singapore. Singapore's adaptation approaches compromise two pillars – risk assessment and adaptation planning. The former identifies and categorises climate-change risks along with advances in climate science. The latter formulates options to tackle the risks identified in a dynamic and flexible manner.

Early adaptation efforts are reflected in the *Singapore Green Plan 2030* and *Sustainable Singapore Blueprint 2015* (CLC, 2015). Singapore strives to maintain a balance between development and conserving the environment in adaptation plans. Along with early preparation to adapt to the impacts of climate change, Singapore established its resilience framework along three key themes – an open economy, overcoming limitations to create a sustainable environment, and maintaining a multi-cultural and diverse city.

2.2. Climate-Change Study

Singapore's 2nd National Climate Change Study examines anticipated climate change impacts on the country (MSS, 2014; 2015). The study has two phases. Phase 1 projected the changes in the main climate variables of interest to Singapore (e.g. temperature, rainfall, and sea-level rise). A key consideration was to understand the intended uses of the climate projections to tailor them as far as possible into the future to address the needs of key stakeholders. The centre of this report thus became downscaled climate and sea-level projections for the 21st century in the region centred around Singapore, derived from the latest available climate models. A brief

[3] Singapore Green Plan 2030, https://www.greenplan.gov.sg/

overview of plausible longer-term changes for sea-level rise, temperature, and precipitation to 2300 was also provided (MSS, 2014).

Phase 2 of the study, which began in 2014, made use of these projections to examine the climate-change impacts on water resources and drainage, biodiversity and greenery, network infrastructure, and infrastructure. This, in turn, will guide government agencies in their planning and serve as inputs to help shape Singapore's resilience plans. The Phase 2 study also aims to provide the best available scientific information on the spatial and temporal scales most relevant to Singapore. This will inform the discussion and decision-making around the actions required to safeguard its population, environment, and infrastructure. Measures that address physical vulnerabilities in Singapore are included in Phase 2 as well as the Building and Construction Authority's risk map study.

2.3. Implementation of Climate-Change Adaptation

Singapore is within 15 metres above sea level, and 30% of the land is less than 5 metres above sea level. A rise in sea level due to climate change will thus cause an immediate threat. Protecting the coastline and improving drainage are amongst Singapore's priorities in dealing with the effects of climate change. The construction of walls and stone embankments cover 70%–80% of Singapore's coastline. Plants, like mangroves and seagrasses, can be used as natural barriers to inundation. The minimum level of land reclamation in Singapore was raised in 2011 from 3 metres to 4 metres above sea level. To protect Singapore's coasts in the long term, Singapore continues to assess the possible impacts of coastal inundation under various scenarios of climate change and to develop long-term strategies and adaptation measures applicable to its coasts.

Singapore has very limited water sources. There are five sources – local catchment, imported water, NEWater (i.e. the brand name of highly treated reclaimed wastewater), reclaimed water, and desalinated water. Ensuring the sustainability of these water resources through appropriate measures is a top priority. NEWater and desalinated water are not dependent on rainfall and will meet 70% of Singapore's water demand by 2030. The capacity for these two sources of water will be further increased to meet up to 80% of water demand by 2060.

Securing the water supply and enhancing flood resilience come in tandem. Singapore is taking a holistic approach in managing its drainage system, considering its need for water and flood risks. Flexibility and adaptability are the two key pillars in its approach to stormwater management, known as 'Source-Pathway-Receptor'. Measures are developed and applied to ensure that pathways, such as drains and canals, function through widening and deepening; sources perform the key role of retaining water while running off stormwater; and receptors work as buffers to floods.

3. Challenges and Opportunities for Better Implementation of Climate-Change Adaptation Measures

Singapore has aligned its climate-change adaptation efforts with green growth. This presents challenges as well as potential opportunities for better implementation of climate-change adaptation measures. Green growth is pursued through five thematic areas – clean technology, test bedding, clean information and communication technology (ICT), carbon services and climate finance, and climate risk management.

2.1. Clean Technology and Test Bedding

The clean-energy industry is a strategic growth area for Singapore. Singapore has implemented a comprehensive blueprint to develop the industry and to ensure key investments in several areas, such as high-value manufacturing, engineering, biofuels, research and development, and regional headquarters. However, a long lead period for such investments – and the ensuing uncertainties – are challenges.

Singapore has created a suite of supporting services and opportunities for firms and researchers to develop, test, and validate clean-energy technologies in real-world settings. Test bedding facilitates the commercialisation process for new technologies and positions Singapore as a 'living laboratory' to evaluate, pilot, and commercialise innovative solutions for Asian and global markets. There are several examples of test beds in Singapore:

(i) **CleanTech Park**. CleanTech Park is the first eco-business park in the region. It clusters clean-technology companies together and serves as a platform for test bedding and prototyping of clean technologies and sustainable urban solutions. The 50-hectare Park at Nanyang Avenue is planned to be fully developed in three phases over the next 20 years. Upon completion, it will house a population of 20,000 'green-collar' workers.

(ii) **Floating solar**. A photovoltaic (PV) pilot is a joint project between the Singapore Economic Development Board and Singapore water agency, PUB. It aims to assess the feasibility and cost-effectiveness of installing floating solar PV systems on freshwater reservoirs.

(iii) **Renewable Energy Integration Demonstration in Singapore**. The Renewable Energy Integration Demonstration in Singapore (REIDS) is a large-scale offshore test and demonstration microgrid located in Semakau Landfill that integrates renewable energy production from solar, wind, tidal, biofuel, and fuel cells with smart-grid technologies.

(iv) **Punggol Eco-Town**. This eco-town demonstrates sustainable urban planning and design, green technology adoption, and active community partnership. Social, economic, and environmental considerations have been formulated by the Housing Development Board (HDB) to steer its development. LED lighting and elevator energy-regenerative systems, renewable solar energy, water conservation and rainwater harvesting systems, and recycling solutions are some of the technologies being test-bedded. HDB is also working with government agencies such as the Energy Market Authority to pilot an intelligent energy system smart-grid project, and with industry partners such as Panasonic to test-bed home energy management systems to monitor energy consumption to reduce overall energy consumption within the town.

(v) **Housing Development Board Greenprint**. This is a framework of goals and strategies to guide town development, aligned with *Sustainable Singapore Blueprint 2015* targets, to reduce the consumption of resources from current business-as-usual levels. Greenprint aims to create sustainable homes with the community in both existing and new HDB towns. HDB will pilot the Greenprint in 38 blocks of flats in Yuhua Estate in Jurong, refining the framework to suit the needs of different towns.

(vi) **Electric vehicle test bed**. The electric vehicle test bed is driven by a multi-agency taskforce co-led by the Energy Market Authority and Land Transport Authority. It aims to assess different electric vehicle prototypes and charging technologies in Singapore's urbanised environment and road conditions. Phase 1 was launched in June 2011 and completed in December 2013. Phase 2 will be a car-sharing programme, which will introduce up to 1,000 electric vehicles and charging infrastructure to trial the viability of implementing electric vehicle fleets and to catalyse their widespread adoption. It was launched in 2016.

(vii) **Zero-energy building.** This is a 4,500-square metre Building and Construction Authority flagship project under the *Green Building Masterplan.* The building generates its own electricity from solar panels and reduces its energy needs using green-building technology and design. It now serves as a test-bedding facility for the integration of green-building technology into existing buildings. Since its launch in October 2009, the building has achieved net-zero energy consumption for 3 consecutive years.

(viii) **Jurong Lake District**. Jurong Lake District is a new area identified in the Urban Redevelopment Authority's master plan to support Singapore's economic growth for the next 10 to 15 years and to decentralise commercial activities out of the city centre by bringing jobs closer to where people live. The district is envisioned to be a model for a mixed-used urban precinct that is sustainable, smart, and connected. The government will collaborate with industry to conduct pilots and trials of smart technologies within the district.

(ix) **Nanyang Technological University EcoCampus**. In partnership with the Economic Development Board and JTC Corporation, the EcoCampus initiative will transform Nanyang Technological University's 200-hectare campus into a super test bed for research projects in cutting-edge green technologies. These range from smart building systems and renewable energy to electric transport and water conservation technologies, complementing the vibrant sustainability research and development community in the adjoining 50-hectare CleanTech Park developed by JTC Corporation.

(x) **Smart Campus Platform**. Temasek Polytechnic, in January 2015, announced its collaboration with private sector firms, such as Cisco, EMC, Johnson Controls, and NCS, focussing on ICT solutions for education. The platform will utilise innovative technologies to collect and to analyse data to improve decision-making on campus, enhancing the work and education experience.

3.2. Clean Information and Communication Technology

With a vibrant and thriving green ICT industry comprising more than 80 of the top 100 software and services companies in the world, Singapore is at the forefront of green ICT development. The Infocomm Media Development Authority routinely works with industry partners and companies to advance Singapore's position within the ICT industry. This makes Singapore the perfect location for companies looking to develop and to test new solutions.

The Green Data Centre Innovation Programme has three sub-programmes – the Research Programme, Innovation Programme, and Hub Programme. The Research Programme provides funding to research entities to improve green data centre technologies and to translate them into actual products or solutions that can be adopted to produce positive economic impacts. The Innovation Programme focusses on driving the prototyping, integration, and demonstration of technologies. This is done by inviting companies to form a consortium to develop and to pilot innovative solutions that will significantly improve the energy efficiency of local data centres. The Hub Programme complements the two programmes by establishing Singapore's first Green Data Centre Hub. It will be a test bed that mirrors a data centre environment to develop, prototype, demonstrate, and benchmark energy-efficient data centre technologies.

In addition, a tax incentive was introduced in 2012 to encourage data centre operators to become more energy efficient. Under the Investment Allowance Scheme for Energy Efficiency Projects (Data Centres), eligible companies will be granted an investment allowance to offset 30% to 50% of the fixed capital expenditure incurred when implementing energy-efficiency retrofits for their data centres.

3.3. Carbon Services and Climate Finance

This has two specific areas:

(i) **Commodities trading hub**. Singapore aims to be the region's top commodities trading hub. Indeed, it is home to many energy traders, who make up most of the clientele for carbon services companies. This makes Singapore an ideal location for companies working on carbon projects in the region – especially since it is close to the biggest sources of carbon credits, India and China. The Economic Development Board and Enterprise Singapore have engaged carbon companies to establish a presence. These companies offer low-carbon project development, consulting and verification services for the Clean Development Mechanism (CDM), carbon footprinting, project financing, and legal services.

(ii) **Carbon credits trading**. To curb carbon emissions caused by industry and businesses, many developed countries enable companies to purchase carbon credits. These carbon credits can then be used to meet part of their emissions reduction requirements. As the main source of carbon credits, the CDM allows emissions reduction projects in developing countries to earn certified emission reduction (CER) credits, which represent 1 tonne of carbon dioxide each. CER credits can be traded, sold, and used by developed nations to help them meet their obligations for emissions reduction under the Kyoto Protocol. As of 31 December 2012, more than 5,511 CDM projects have been registered worldwide since 2006, leading to over 2.191 million CERs issued by the UNFCCC. Asia is a key supplier of

carbon credits, with more than 82% of registered CDM projects originating in the region. Its strategic location and ideal business environment make Singapore a prime location for trading and services companies wanting to develop carbon projects in the region.

3.4. Climate Risk Management

The impact of climate change has been increasingly felt in recent years, adding to the growing importance of climate risk assessment. Climate risk assessment helps nations prepare for the effects of climate change by evaluating the distribution of resources, diversification, risk pooling, insurance, and infrastructure and capability development.

As a major financial centre, Singapore is an ideal launch pad for leading insurance, reinsurance, and insurance brokerage companies to meet the region's insurance needs for climate-related risks. Currently, there are more than 200 insurance players in Singapore tapping into Asia's market potential. Moreover, the following Singaporean institutions conduct research on the risks of climate change: Nanyang Technological University's Institute for Catastrophe Risk Management, which studies the vulnerabilities and potential damages of catastrophic events; Earth Observatory of Singapore, which forecasts the regional consequences of global climate change by assessing global climate drivers that are active in the region; and National University of Singapore's Centre for Hazard Research, which studies the long- and short-term effects of natural disasters.

3.5. Singapore's Adaptation Strategy for Infrastructure

Singapore has developed a low-emissions development strategy for adaptation focusing on six areas: coastal protection, water resources, and drainage; buildings and infrastructure; network infrastructure; biodiversity and greenery; public health and food security; and the urban heat island effect.

Singapore is also preparing a road map to develop the capabilities needed to regulate its urban climate. The project, New Cooling Singapore 2.0, is funded by the National Research Foundation Campus for Research Excellence and Technological Enterprise (CREATE). It is led by the Singapore-ETH Centre, a collaboration between ETH Zurich and the National Research Foundation. It brings together researchers from the Singapore–Massachusetts Institute of Technology Alliance for Research and Technology, TUMCREATE (established by the Technical University of Munich) and the National University of Singapore.

4. Key Long-Term Climate Actions

Singapore prepared and implemented climate actions over the long term under eight thematic areas: the future electricity grid, Energy Efficiency Fund, transport, buildings, Green Towns Programme, waste and water, Energy Grid 2.0, and sustainable finance.

4.1. Future Electricity Grid

Singapore will work to ensure a sustainable, reliable, and affordable energy supply. Its vision for a sustainable energy future not only builds on past and existing efforts but also considers future possibilities that could enable its electricity grid to be significantly decarbonised. Singapore will

harness the four supply switches of natural gas, solar, regional power grids, and emerging low-carbon alternatives, together with greater energy-efficiency, to accelerate its energy transformation.

4.2. Energy-Efficiency Fund

The government expects revenue of about S$1 billion from carbon tax revenues over the first 5 years, and it is prepared to spend more than that amount during this period to support companies, including small and medium-sized enterprises (SMEs) and generation companies, in improving their energy- and carbon-efficiency by adopting greener and cleaner technologies and practices.

The Energy Efficiency Fund and the Resource Efficiency Grant for Energy cover costs for equipment, materials and consumables, technical software, and professional services towards this goal. To further support industrial facilities in being more energy-efficient, the funding support for both initiatives was increased in 2019 from a cap of 30% to a cap of 50%. In October 2019, the government launched a new grant to encourage companies to implement energy management information systems. These systems can help companies more accurately monitor and analyse their energy usage using real-time data to identify performance gaps and opportunities for improvement.

4.3. Transport

Singapore aims to reduce carbon emissions in the transport sector via the walk-cycle-ride mode. It also intends to expand the active mobility network by expanding and improving mass public transport and shared transport, introducing cleaner and greener vehicles, and establishing greener transport infrastructure.

4.4. Buildings

Singapore aims to reduce energy use and to increase sustainability in the building sector through the adoption of super low-energy (SLE) buildings (i.e. net-zero energy buildings). SLE building initiatives include the Green Mark Scheme for SLE Buildings, SLE Challenges, and *SLE Building Technology Roadmap*. Singapore aims to sustain optimal performance throughout the life cycle of buildings.

4.5. Green Towns Programme

Singapore is targeting reducing carbon emissions in the household sector by putting more energy-efficient appliances into homes and promoting energy-conservation habits. The Mandatory Energy Labelling Scheme (MELS) and Minimum Energy Performance Standards (MEPS) are key policies to reduce energy consumption and emissions in households using energy-efficient appliances. The government provided incentives to purchase climate-friendly appliances by introducing the S$24.8-million Climate Friendly Household Programme in 2020. This programme is a joint initiative by the National Environment Agency and PUB to encourage households to reduce energy and water consumption while saving costs in the long run.

Since 2005, HDB has been driving sustainability efforts in public housing estates, which provide affordable housing to 80% of Singaporeans. Over the years, Singapore has managed to achieve

a 10% reduction in annual energy consumption in these public housing estates. Through the Green Towns Programme, HDB aims to reduce annual energy consumption by a further 15% by 2030. The programme will focus on addressing three areas on sustainability and liveability: reducing energy consumption, recycling rainwater, and cooling HDB towns.

4.6. Waste and Water

Singapore's inaugural *Zero Waste Masterplan* launched in 2019 outlines a changing approach to managing waste to achieve the vision of a zero-waste nation. Under the plan, the government announced a new target to reduce the amount of waste sent to Semakau Landfill per capita per day by 30% by 2030 (MEWR, 2019). This is in addition to existing recycling targets under the *Sustainable Singapore Blueprint 2015.* Collectively, these targets would extend Semakau Landfill's lifespan beyond 2035.

Singapore promotes sustainable waste management through its Resource Sustainability Act. It also is upgrading its waste management infrastructure to increase the efficiency of recycling and waste incineration. To reduce water consumption and energy use in water treatment, Singapore is promoting water conservation in households. It is also working to reduce energy use in producing desalinated water along with promoting water efficiency in businesses and industries.

4.7. Energy Grid 2.0

Over the next 5 years, Singapore will be investing S$55 million in Energy Grid 2.0, a next-generation grid system that will transform how energy supply and demand are managed by consolidating gas, solar, thermal, and other sources of energy into a single intelligent network that is more efficient, sustainable, and resilient. The research for Energy Grid 2.0 will focus on power distribution; district cooling; and the design, intelligence, management, and optimisation of energy systems.

To push the boundaries of innovation in the energy sector, National Research Foundation and Energy Market Authority launched two consortia in 2019 under Energy Grid 2.0, and both have set aside up to S$9 million over 3 years for this. The Smart Grid and Power Electronics Consortium Singapore (SPECS) and Cooling Energy Science and Technology Singapore (CoolestSG) Consortium will bring together research institutes, companies, and the government to develop solutions in smart grids and green cooling.

4.8. Sustainable Finance

Singapore aims to support the financial sector in mobilising global capital for the green economy and channelling it to new investments in green businesses, technology, and infrastructure, which reduces emissions while creating jobs and growth opportunities. Its goal is to be a leading centre for green finance in Asia and globally.

Singapore is trying to build a financial system that is resilient to environmental risks. The Monetary Authority of Singapore has included banks' sustainability practices in its supervisory assessment. This aims to strengthen banks' efforts to integrate sustainability into their business models and risk management functions. Environmental risk management guidelines are also being developed for the banking, insurance, and asset management sectors to reinforce industry standards on governance, risk management, and disclosure of environmental risks.

Singapore's financial institutions are also taking action to make financing practices more environmentally responsible. Local banks have implemented policies aligned with guidelines on responsible financing issued by the Association of Banks in Singapore in 2015 to evaluate their borrowers' environmental, social, and governance (ESG) risks and to help borrowers improve their sustainability profiles. Several asset managers in Singapore have signed the United Nations Principles for Responsible Investment and developed the *Singapore Stewardship Principles for Responsible Investors* (Stewardship Asia Centre, 2022). Singapore is continuing to work with the asset management industry to foster good stewardship amongst investors and to drive sustainable investments based on ESG considerations.

In 2016, in line with the practice of other leading stock exchanges, the Singapore Exchange (SGX) introduced a requirement for its listed issuers to produce annual sustainability reports. In these reports, listed issuers must disclose ESG parameters on a comply-or-explain basis. The number of SGX-listed issuers communicating their sustainability disclosures has increased significantly, with almost all listed issuers publishing their sustainability reports for 2018. Moving forwards, SGX plans to provide more guidance on ESG data disclosure to make such data more meaningful for investors.

Singapore is developing solutions and markets for green finance by introducing and promoting green finance instruments such as green bonds. To catalyse more green bond issuances, Singapore launched the Green Bond Grant Scheme in 2017 to level the cost associated with issuing green bonds compared to that of a conventional bond and to promote the adoption of internationally accepted standards on sustainability. The scheme was renamed to the Sustainable Bond Grant Scheme after its expansion to include social and sustainability bonds in 2019. To date, more than S$6.5 billion of green bonds have been issued in Singapore.

To encourage green and sustainable bond issuance in ASEAN, Singapore supported the development of *ASEAN Green Bond Standards*, which reference the *International Capital Market Association Green Bond Principals.* Building on the *ASEAN Green Bond Standards*, the Second ASEAN Capital Market Forum launched *ASEAN Social Bond Standards* and *ASEAN Sustainability Bond Standards* in October 2018 to provide issuers and investors with a wide-ranging set of green, social, and sustainability bond standards that are aligned with international standards. These standards provide guidance to ASEAN companies seeking to raise financing through green, social, and sustainability bonds, and to raise the profile of ASEAN as a region that is committed to sustainable finance.

To further promote environmentally sustainable projects in Singapore and the region, Singapore launched the US$2 billion Green Investments Programme in November 2019, which places funds with asset managers committed to drive regional green efforts beyond Singapore and to contribute to other national green finance initiatives. As part of the programme, Singapore will allocate US$100 million to the Bank for International Settlements Green Bond Fund in support of its global green finance initiatives.

Singapore also supports a greener global financial system. The Monetary Authority of Singapore is one of the founding members of the Network for Greening the Financial System, which aims to enhance the ability of the financial system to manage the risks of climate change and to mobilise capital for green and low-carbon investments. The Monetary Authority of Singapore

also actively participates in the Sustainable Insurance Forum, which is a network for leading insurance supervisors and regulators seeking to strengthen their understanding of and responses to sustainability issues pertaining to the insurance sector. SGX is a member of the Financial Stability Board's Task Force on Climate-Related Financial Disclosures, which develops recommendations for voluntary climate-related financial disclosures for organisations. The task force is actively promoting and monitoring the adoption of its recommendations, which were released in June 2017.

5. Key Long-Term Adaptation Actions

There are three key adaptation actions in the long-term: developing Singapore's resilience framework, building Singapore's climate science capabilities, and establishing Singapore's adaptation measures.

5.1. Resilience Framework

To address the effects of climate change on Singapore's physical environment effectively, Singapore has already begun working on long-term infrastructure adaptation plans. The multi-agency Resilience Working Group, set up under the IMCCC, oversees the study and implementation of measures to address the physical vulnerabilities to climate change and serves as the coordinating body on climate-change adaptation efforts across government agencies.

The government established the *National Resilience Framework* (Centre for Liveable Cities, 2018) to guide the Resilience Working Group in identifying and assessing climate-change risks and impacts and formulating adaptation plans to address Singapore's physical vulnerabilities to impacts.

5.2. Building Singapore's Climate Science Capabilities

Singapore has been systematically building up its climate science capabilities. The Centre for Climate Research Singapore (CCRS) was established in 2013 to develop research expertise on the climate of Singapore and South-East Asia and has since grown to be one of the region's most advanced tropical climate research centres. Some of the key research works by CCRS are *Singapore's 2nd National Climate Change Study* and Convective Scale Numerical Weather Prediction model (SINGV).

In 2015, CCRS published results from the *2nd National Climate Change Study,* which analysed future climate change scenarios for Singapore and South-East Asia at high spatial resolution. The findings from this study provide the scientific basis to inform Singapore's current climate adaptation plans. CCRS is currently working on the third study, and the results are expected to be released in 2022.

Many weather models are developed for temperate regions and hence, are not customised to Singapore's local conditions. CCRS is undertaking cutting-edge research to develop weather models tailored to Singapore. One such model is the convective-scale numerical weather prediction model known as SINGV. The SINGV model will provide prediction of heavy rainfall at longer lead times and over higher spatial resolutions. Today, Singapore can provide advance

warnings of heavy rains about 15–30 minutes before a downpour. With this model, the Meteorological Service Singapore will be able to provide an earlier assessment of the risk of heavy rain, giving people more time to prepare for flash floods.

5.3. Singapore's Adaptation Measures

The government has implemented a variety of adaptation measures to enhance its climate resilience and to minimise the adverse impacts of climate change on the community, economy, and people's daily lives. *Singapore's Climate Action Plan*: *Take Action Today, for a Sustainable Future* details how Singapore may be affected by climate change as well as strategy to prepare for its effects (NCCS, 2016).

Adaptation measures have been developed, and seven ways forwards were identified: protect coasts; protect Singapore's water supply and alleviate floods; enhance climate and ecological resilience through greenery and biodiversity conservation management; strengthen resilience in public health, especially reducing risk of dengue; strengthen food security; keep cool in a warming world; and keep buildings and infrastructure in Singapore safe.

6. Conclusions

Singapore has always adopted whole-of-government efforts for adaptation to climate change. At the centre is NCCS. Early adaptation efforts are well reflected in the *Singapore Green Plan 2030* and *Sustainable Singapore Blueprint 2015.*

Climate-change adaptation in Singapore is occurring through coastal protection, water resources management and drainage, and flood protection. To protect Singapore's coasts in the long term, Singapore continues to assess the possible impacts of coastal inundation under various scenarios of climate change and to develop long-term strategies and adaptation measures that can be best applicable to Singapore's coasts. Singapore takes a holistic approach in managing its drainage system considering its need for water and managing flood risks. Flexibility and adaptability to the drainage system are the two key pillars in its approach to stormwater management.

The *2nd National Climate Change Study* provides information on anticipated climate change. Singapore has aligned adaptation efforts to climate change with green growth. Green growth is being pursued under five thematic areas – clean technology, test bedding, clean ICT, carbon services and climate finance, and climate risk management. Along with the five thematic areas, Singapore has developed a low-emissions development strategy for adaptation focussing on six areas – coastal protection, water resources, and drainage; buildings and infrastructure; network infrastructure; biodiversity and greenery; public health and food security; and the urban heat island effect.

There are three key adaptation actions in the long term – developing Singapore's resilience framework, building Singapore's climate science capabilities, and establishing Singapore's adaptation measures. For the climate actions in the long term, Singapore prepares and implements those actions under eight thematic areas – the future electricity grid, Energy

Efficiency Fund, transport, buildings, Green Towns Programme, waste and water, Energy Grid 2.0, and sustainable finance.

The COVID-19 pandemic has slowed the economic growth of Singapore, especially in 2020. However, there are signs of economic growth in Singapore. In 2019, Singapore pledged S$100 billion to protect itself from rising sea levels. How to finance the required amount has been debated in Parliament, and the government is considering various borrowing options (Lai, 2019).

The *Singapore Green Plan 2030* is a national sustainability movement that seeks to tackle climate change. Under five key pillars – City in Nature, Energy Reset, Sustainable Living, Green Economy, and Resilient Future – it sets out concrete sectoral plans and targets for the next 10 years. As a 'living' plan, the plan will evolve and be refined over time.

With the government's determined pledge and long-term commitments to protecting Singapore from negative impacts of climate change, Singapore has put tremendous efforts towards mitigation and adaptation. The pandemic may have slowed the pace, but the pledge to a long-term commitment is expected to continue through public–private partnerships.

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Chapter 7

Australia

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1. Introduction

Australia is a highly developed country with a population of over 25 million (ABS, 2020). Its economy is strongly integrated with high levels of international trade. Resources and energy exports comprise approximately 60% of exports by value, with more than half of the energy produced exported (OECD, 2020). The average household disposable income per capita is US$32,759 per year, less than the average of the Organisation of Economic Co-operation and Development (OECD). There is also a considerable gap in equity, with the top 20% of the population earning nearly six times as much as the bottom 20% (OECD, 2020).

Per capita greenhouse gas emissions are 20.8 tonnes and 0.3 kilograms per US dollar of real gross domestic product (GDP), and the electricity and energy sector accounts for more than half of these emissions (DISER, 2020). The emissions generated by Australian consumption is 17.7% less than emissions from production, due to high levels of energy and resources exports (DISER, 2020).

Australia is characterised by many unique geographic and demographic factors. It is one of the driest inhabited continents and has one of the lowest population densities per arable land area. It also has one of the highest population growth rates for OECD countries with a highly urbanised coastal population. Indeed, Australia's population has one of the most geographically distinctive distributions of any country, with 90% of people living in just 0.22% of the country's land area (Jackson et al., 2017). More than 85% of Australians live within 50 kilometres of the shoreline, and the coastal region generates most of the country's economic activity (Clark and Johnston, 2017).

Australia's environment is one of extremes – the vast land mass of the country leads to wide-ranging climate zones from the tropics in the north to the arid interior and temperate regions in the south. Australia's climate has warmed by over 1°C since 1910, leading to an increase in the frequency of extreme heat events and an increase in extreme fire weather (DEE, 2017). Rainfall and streamflow across Southern Australia have decreased, leading to water shortages, while rainfall has increased across parts of Northern Australia with evidence that some are becoming more intense (DEE, 2017). This variability in climate across the country results in different types of weather extremes like droughts, floods, cyclones, heatwaves, and bushfires, which affect different regions of the country to various degrees.

The governing structure of Australia is a federal system, with the federal government having legislative power over areas that affect the entire nation like defence, external affairs, fiscal and monetary policy, and interstate affairs (e.g. banking and insurance). All other powers rest with state governments, while some cascade down to local governments.

This chapter provides the context of climate change and infrastructure financing in Australia. It commences with its climate-change and -adaptation policies, followed by an understanding of infrastructure in the country and related climate impacts. Financing infrastructure for climate-change adaptation is discussed next, with internal funding mechanisms used in the country across various levels of government as well as overseas financing. An analysis of infrastructure-financing mechanisms for climate change leads to a discussion of the challenges in implementing such mechanisms. The impact of the COVID-19 pandemic on infrastructure financing is discussed next, and then the chapter concludes.

2. Climate-Change Adaptation Policies

With less than 2°C of warming, Australia is more likely to be able to adapt to impacts of climate change (Cleugh et al., 2011). However, if impacts become more severe, adaptation can be expected to become increasingly challenging and costly. The increased intensity and frequency of natural disasters across the country in recent years have led to a wider acceptance of climate impacts by the public, politicians, and industry practitioners. However, climate-mitigation and -adaptation actions are considered to lag behind those of other OECD countries, especially those in Europe.

In Australia, all levels of government develop and implement climate-change policies and measures. At the national level, the Department of the Environment and Energy (DEE) develops and implements the national response to climate change. State and territory governments also develop and implement climate-change policies relevant to their region. Policies at this level include land-use controls, waste recovery, energy-efficiency, and renewable energy programmes, and include renewable energy targets and emissions reduction goals. The national, state, and territory governments maintain direct links amongst their departmental counterparts to share knowledge, resolve policy issues, and collaborate on industry and community engagement. Ministerial discussions on climate change occur regularly through two forums: the COAG (i.e. Council of Australian Governments) Energy Council and Meeting of Environment Ministers (DEE, 2017).

Climate-change adaptation in Australia is underpinned by a series of agreements made amongst the federal, state, and territory governments through the COAG. These agreements set priority areas for adaptation actions and clarify roles and responsibilities for adaptation. The COAG agreed on the *National Climate Change Adaptation Framework* in 2007, which established priorities for adaptation actions and initiated a range of activities to build resilience and to adapt to climate-change impacts. A major aspect of this framework aimed to enhance national climate-change science and adaptation research capacity (DCCEE, 2007).

The National Climate Change Adaptation Research Facility (NCCARF) was established in 2008 to develop and to deliver the knowledge needed by decision-makers to effectively adapt Australia to the impacts of climate change (NCCARF, 2013). Settlements and infrastructure were one of nine priority themes under this facility, which focussed on the impacts of climate change on coastal settlements; infrastructure, including buildings, facility design, and construction; urban water security; and flooding and stormwater overflow. As part of this programme, funding support for these four research networks was available. This programme was primarily funded

through the government, while partner organisations contributed. However, government commitment to these programmes has been less than certain in recent years, and some – such as the Commonwealth Scientific and Industrial Research Organisation Climate Adaptation Flagship – have been decommissioned (DEHP, 2017).

The *National Climate Resilience and Adaptation Strategy 2015* (Government of Australia, 2015b) is the overarching strategy governing climate-change adaptation in Australia. The strategy identifies guiding principles, outlines the government's vision for climate resilience, and illustrates how Australia is managing and adapting to climate-change challenges at the national level. However, it does not articulate any specific goals or actions that need to be taken to achieve resilience; instead, such goals and actions are expected to be set and implemented by state and local governments.

Most state, territory, and local governments have their own adaptation plans and strategies in place and are managing their climate risks across a range of sectors and in government decision-making. Such various levels of adaptation policies seem suitable for Australia given the diverse climate-change challenges across the country. The South Australia Government has regional adaptation plans in place for each of its 12 government regions. In 2017, the Queensland, South Australia, Tasmania, and Victoria governments revised or implemented their state adaptation plans or strategies. For instance, the *Queensland Climate Adaptation Strategy* outlines how the state will prepare for current and future impacts of climate change in a way that reduces risk and increases resilience (DEHP, 2017).

In addition to governmental climate-change adaptation policies, industry bodies have developed adaptation policies and guidelines, focussing on specific industries and sectors. These include position statements and policies by a wide range of professional bodies like the Australian Institute of Architects (2008), Australian Institute of Landscape Architects (2017), Engineers Australia (2014), and Planning Institute of Australia (2015), as well as guidelines and frameworks developed by industry bodies like the Australian Green Infrastructure Council (2011), Australian Sustainable Built Environmental Council (2012), and Green Building Council of Australia (2019).

The lack of clear climate-change adaptation policy directions by the national government has led to multipronged policies being implemented across the country and industry sectors. These policies are developed typically from the ground up, where the importance of implementing adaptation actions in the long term has been identified by practitioners. Adaptation will also play a significant role for communities, as climate-change mitigation efforts at a national level have lagged behind other developed nations. This makes investment in climate adaptation and restructuring of economic activities essential elements in moving towards a more resilient society (Infrastructure Australia, 2019).

3. Infrastructure in Australia

Infrastructure plays a significant role in the Australian economy, with infrastructure industries accounting for 9.4% of the GDP and nearly half of new construction in the transport sector (BITRE, 2019). Australia has close to 900,000 kilometres of roads, 35,000 kilometres of rail track, over 40 airports, and 25 ports (BITRE, 2019). As a high proportion of the population lives on the coast, most of the transport infrastructure is situated there; therefore, it is more prone to

hydrometeorological disasters. Australia has a high reliance on automobile use with an elevated level of fuel consumption, in turn impacting emissions. In the year to March 2020, transport accounted for 18.9% of Australia's greenhouse gas emissions, with a steady decrease in the consumption of petrol and an increase in diesel consumption (DISER, 2020).

The ownership and management of public infrastructure fall under the different national, state, and local governments. The government finances the national rail network, partially funds major interstate roads, and regulates airports. State and territory governments own and manage some metropolitan rail networks, state roads, international ports, and airports, while local governments have control over access and facilities for local infrastructure, with the ability to impose restrictions on operations (Infrastructure Australia, 2016).

In some cases, ownership and management of public infrastructure – such as water supply, energy, and transport infrastructure – have been transferred to state-owned enterprises, which are ultimately owned by the respective state or federal government. Typically, building, maintenance, and adaptation measures for specific infrastructure are the responsibility of asset owners, and diverse funding mechanisms for these purposes are used. Some examples are grants from state and national governments, balance sheet financing through retained earnings, user charges or government revenues (e.g. rates or taxes), public–private partnerships (PPPs), and external financing through banks or issuance of bonds. The diversity of infrastructure financing mechanisms adopted in Australia provide a good opportunity to assess the applicability of these methods for climate-change adaptation projects in other countries.

The vulnerability of infrastructure to climate change depends on several variables such as the type of infrastructure; its location, design, age, and/or relative usage; and climate risks that the infrastructure faces. Key climate risks to Australian infrastructure include gradual impacts like sea-level and temperature rise and extreme events like floods, heatwaves, and bushfires. In the coastal zone, more intense storms, cyclones, and rising sea levels may cause or worsen storm surges, coastal inundation, and erosion. Table 7.1 summarises potential impacts to infrastructure due to climate risks in Australia.

Table 7.1. Potential Impacts to Infrastructure due to Climate Risks

Climate Risk	Risk Scenario	Infrastructure Systems Affected	Impacts
Increased extreme rainfall and wind intensity	Storm and floods	Transport, buildings, electricity, water, telecommunications	Damage to infrastructure assets, degradation of roads, overcapacity for sewage treatment, tunnel flooding
Sea-level rise	Coastal flooding	Transport, water	Damage to infrastructure assets, salt-water intrusion to water supply
Increased temperature and heat waves	Increased user demand	Electricity, transport, telecommunications	Increased peak-load demand, degradation and buckling of rail tracks, tarmac degradation, damage to infrastructure assets
Increased bushfire risk and lightning	Bushfires	Electricity	Damage to transmission lines
Decreased rainfall	Water shortages	Electricity, water	Lack of water for hydroelectricity and coal generation, decrease in water capacity

Source: Adapted from Maddocks (2011).

Although risks to infrastructure due to climate change have been highlighted, the level of adaptation practices at a national level seem to be minimal. This is evident in the national-level *Critical Infrastructure Resilience Strategy*, as it does not account for any climate-related risks to infrastructure (Government of Australia, 2015a). A reason may be that adapting to climate change is considered the responsibility of infrastructure planners, owners, and operators, which most often fall within the purview of state and local governments (Infrastructure Australia, 2015). However, the lack of a national strategy can be an impediment to effective climate-change adaptation in the infrastructure sector.

4. Financing Infrastructure for Climate-Change Adaptation

Climate finance has two main components, as articulated in the Lima Call for Climate Action (UNFCCC, 2014): (i) mobilisation of public and private finance towards mitigation and adaptation measures, and (ii) provision of public finance from developed to developing countries (also known as the North-South transfer). This section will explore both these types of climate finance, as Australia provides development assistance to East Asian countries.

4.1. Domestic Funding

The mechanisms used to finance climate-change adaptation infrastructure in Australia are different from those in the East Asian region due to Australia's high level of government revenue, international financial independence, access to competitive government finance options (i.e. government securities), and condition of infrastructure assets. The different mechanisms used to finance adaptation are discussed below.

4.1.1. Grant Funding

The majority of climate-change mitigation and adaptation measures in Australia have traditionally been funded by national, state, and local governments alone or in partnership (Banhalmi-Zakar et al., 2016). This funding is typically set aside in budgets and then allocated for a variety of climate-related projects. As recovery from natural disasters and adaptation to climate hazards is the responsibility of state governments, national government funding is allocated only in extreme cases of disasters or through national-level adaptation policies.

Protection from climate change is increasingly falling within the purview of local governments, creating new costs through such projects as building seawalls and increasing costs of existing responsibilities like upgrading roads, drainage, and water supply (Banhalmi-Zakar et al., 2016). Disbursement of such grant funding is generally administered through a separate organisation, at times specifically set up for this purpose.

One of the major national government-funded projects focussing on adaptation is water security in the Murray–Darling Basin, the largest and most complex river system in Australia. It covers 1 million square kilometres of South-Eastern Australia and spans across 5 states. The programme is thus funded at a national level, as individual state-level programmes would not be practical.

The Sustainable Rural Water Use and Infrastructure Program is another major climate-change adaptation-related programme funded by the national government. This programme is investing A$10 billion in rural water use, management, and efficiency; improved water knowledge; and market reform. Most of the projects are linked to, and focus on, the Murray-Darling Basin and include on- and off-farm irrigation upgrades and projects supporting rivers and wetlands.

The government has also committed A$2.5 billion towards two national programmes to fast-track the construction of various water infrastructure components: the National Water Infrastructure Development Fund (A$500 million) and the National Water Infrastructure Loan Facility (A$2 billion) (Parliament of Australia, 2017).

In addition to these national-level programmes, the government funds state-level programmes to improve water quality and sustainability issues. For example, the Basin Priority Project provided funding of up to A$85 million to the Australia Capital Territory to improve the long-term water quality in the territory and the Murrumbidgee River system.

Funding through the Australian Renewable Energy Agency (ARENA) and Clean Energy Finance Corporation (CEFC) supports clean energy innovation across the spectrum of research and development, demonstration, and deployment at the national level (DEE, 2017). In 2016, three separate funds were established for the CEFC to invest in nationally significant clean-energy projects targeting cities and the built environment, Great Barrier Reef, and emerging technologies.

ARENA and the Australian Energy Market Operator jointly funded 10 pilot projects from 2017 to 2020 under the demand response initiative to manage electricity supply during extreme peaks. The project objective was to free up temporary supply during extreme weather – such as prolonged summer heatwaves – and unplanned outages. Funding of A$35.7 million was provided, with the government committing A$28.6 million through ARENA to fund set-up and

operational costs, with A$7.2 million matched by the New South Wales (NSW) government for NSW-based projects.

The Natural Disaster Relief and Recovery Arrangements (NDRRA) initiative provides funding to state and territory governments for certain relief and recovery assistance measures in response to natural disasters such as bushfires, floods, and cyclones. Following the outcomes of the Productivity Commission (2012) inquiry into natural disaster funding arrangements, the national government has been consulting with state and territory governments to reform current arrangements as they relate to the reconstruction of disaster-damaged public infrastructure. The reforms give greater autonomy to state and territory governments to deliver practical reconstruction that best suits the needs of their communities. Where applicable, it enables them to apply funding towards disaster-mitigation activities that align with a set of overarching principles.

As previously mentioned, infrastructure adaptation is primarily funded by state governments as the infrastructure asset owners. State government funds can be allocated through adaptation strategies, where potential areas of investment are targeted or through requirements identified by relevant state government departments (DEHP, 2017). In most cases, the funds are allocated to local councils that are responsible for using them for the respective adaptation projects. Although much of such funding is allocated through state governments, national-level funding is also provided for some projects, which are typically delivered through state governments or other funding agencies.

Funded by the national government and delivered by the South Australia government, the A$265-million South Australian River Murray Sustainability Program includes A$120 million for irrigation-efficiency improvements and water purchase and A$120 million towards irrigation industry assistance. The remaining A$25 million is for regional economic development.

Building Resilience to Climate Change is a partnership between the NSW government and NSW Office of Environment and Heritage (OEH) to address identified climate-change risks and vulnerabilities. Two rounds, jointly funded by OEH and the NSW Environmental Trust, were awarded in 2014 and 2015. The third round in 2016 and further funding rounds over 2019–2020 were available through the Increasing Resilience to Climate Change grant funded by the Climate Change Fund (NSW Government, 2020). Jointly, these projects have funded over A$4 million worth of adaptation efforts in NSW.

The NSW government also invested A$1.4 billion from 2017 to 2022 through the NSW Climate Change Fund (DPIE, 2019). One of the key programmes under this fund is to increase resilience to climate change, with A$181 million invested in FY2018 and A$248 million invested in FY2019. During FY2019, through the fund, almost A$192 million was invested to enhance resilience to climate impacts. The fund's Coastal and Estuary Grants Program provides up to 50% funding to local councils for coastal management. The Floodplain Management Program typically funds A$2 for every A$1 contributed by the local council or land manager.

The fund's revenue is raised through annual contributions from utility providers, such as electricity and water distributors, and its costs are passed on to customers. The electricity distributors are requested to recover no more than 25% of costs from household customers; commercial, business, and industrial customers cover the remainder. Water distributors, such

as Sydney Water and Hunter Water, may also be asked to raise funds for water-related programmes, depending on the NSW government's priorities. The fund's FY2019 revenue was A$289 million (DPIE, 2019).

In addition, the NSW government coastal management programmes are investing around A$63 million to support local governments to implement actions that reduce exposure to coastal hazards. Local governments can receive up to 50% funding to implement coastal zone management plans, hazard assessments, and coastal management tools and to undertake environmental repairs and construction.

QCoast2100 is a Queensland government commitment to a A$13.234-million fund to assist local councils in advancing coastal hazard adaptation planning.[1] The Queensland government, in partnership with the Local Government Association of Queensland, is investing A$12 million over a 5-year period. The programme represents an opportunity for local governments impacted by coastal hazards to use adaptation planning to implement cost-effective mitigation measures over the medium and long term, plan for development and growth, budget for higher costs, collaborate regionally, and seek investment opportunities. A coastal hazard adaptation strategy is designed to assess risks from projected climate-change effects, propose adaptation measures, and establish an implementation programme. The Department of Environment and Science has committed a further A$1.234 million to QCoast2100 to support local councils that previously applied and missed out on required funding to complete their coastal hazard adaptation strategies. The councils who receive the funds are required to provide a co-contribution, although there is no requirement to match the approved funding.

Table 7.2 provides a summary of state and territory priorities for climate change across Australia.

[1] QCoast2100, https://www.qcoast2100.com.au/

Table 7.2. Climate Priorities for State Governments and Territories in Australia

State/Territory	Priority Areas
Australian Capital Territory	Disaster and emergency planning, community health and well-being, settlements and infrastructure, water, natural resources, and ecosystems
New South Wales	Energy-efficiency, advanced energy, transport, carbon farming, impacts on infrastructure
Northern Territory	Low-emissions transport, transition to low-emissions energy, heat in the urban environment
Queensland	Human health, biodiversity and ecosystems, tourism, business and industry, agriculture, human settlements and infrastructure, emergency services
South Australia	Building coastal resilience, implementing water-sensitive urban design, managing bushfire risk
Tasmania	Renewable energy, reducing transport emissions, climate-ready businesses, resilient communities
Victoria	Resilient transport, heat in the urban environment, water resources, land-use planning
Western Australia	Clean manufacturing, transforming energy generation and use, carbon storage, lower-carbon transport

Sources: DEWNR (2016), DWER (2020), Environment and Planning Directorate (2016), DEHP (2017), OEH (2016), Tasmanian Climate Change Office (2017).

4.1.2. Balance Sheet Financing

Another approach to finance infrastructure to prepare for climate change is balance sheet financing. Brisbane Airport Corporation, a private company that runs the Brisbane International Airport, factored in climate-change impacts on a new runway design and thus built in adaptation measures. Due to expected sea-level rise and increased frequency of cyclones, the site was raised above the projected 1-in-100-year flood level, building a new seawall and tidal channels. Consideration of temperature increases in future decades was accounted for by providing significant additional runway lengths available to be added in the future (ICAO, 2016). A large proportion – 75% of this project – was funded through shareholder funds and loans obtained by the Brisbane Airport Corporation, while 25% was funded through additional landing fees. In 2013, the airlines' contribution was an extra A$0.35 per domestic passenger, with a gradual increase per year to A$3.15 per international passenger in 2017 (BAC, 2013).

4.1.3. Financing through Revenue Streams

Following widespread damage to infrastructure due to floods in 2011, the national government imposed a flood levy to raise funds. It announced it would invest about A$5.6 billion to rebuild flood-affected communities, with most directed to rebuilding infrastructure. This was to be financed through three components: A$1.8 billion through a progressive flood levy on people

earning over A$50,000, A$2.8 billion in spending cuts, and A$1.0 billion by delaying specific infrastructure projects (Parliament of Australia, 2011).

The Gold Coast City Council financed the construction of a seawall adjacent to public land, mostly from general revenue through council rates, together with grant assistance from the state government. The city council has not taken responsibility for the construction and financing of the seawall where it would be adjacent to private property, however, leaving it to individual property owners to complete such work to approved design standards to protect their property (Ware and Banhalmi-Zakar, 2017).

Also in Queensland, a similar financing model was adopted by the Fraser Coast Regional Council to build the Toogoom Seawall Project in 2014. This seawall provides erosion protection for 15 properties through the construction of a rock-boulder revetment wall along 370 metres of shoreline. The council amended its FY2014 budget and sought additional borrowing to finance the costs of the project. However, it decided – as the benefits of the project accrue to a definable group of private property owners – that these property owners should also be responsible for funding the project. The council undertook the project through external debt finance, and the property owners were charged a special rate levy payable over 10 years to cover the costs (Ware and Banhalmi-Zakar, 2017).

There are also examples of private property owners pooling resources to self-fund the construction of coastal protection works, such as seawalls. Private property owners at the Belongil Spit in Byron Bay, NSW have taken legal action against the government to establish their rights to undertake coastal protection works.

4.1.4. Financial Incentivisation

Financial incentives have also been used to improve climate-change resilience, especially for housing-related infrastructure. The Australian Capital Territory government introduced a 10% to 25% reduction in lease variation charges for new developments and upgrades for commercial buildings built to the Green Building Council of Australia's Greenstar rating of more than 5 stars and for residential buildings with an average NatHERS rating of more than 6.5 stars. Although such incentives are not directly related to climate-change adaptation, Green Building Council of Australia ratings provide credits for climate adaptation and resilience plans.

Larger insurers, with substantial assets, can directly finance customer-side adaptation measures that improve the resilience of properties to natural disasters and climate hazards (Herweijer et al., 2009). However, such examples are sparse in Australia. One example is Suncorp announcing that it will contribute up to A$10,000 towards fittings that improve extreme weather resilience for strata insurance in North Queensland (Government of Australia, 2015a).

4.1.5. Financing at the Planning Stage

Another method of financing climate-change adaptation is to factor in adaptation mechanisms at the initial planning stages. This allows for funding requirements for adaptation mechanisms to be obtained with overall project funding. Including adaptation at the planning stage has, in some cases, been regulated through government guidelines. For example, in Queensland, new state roads and major road upgrades require a climate-change impact statement for submission

to the Queensland Cabinet. Furthermore, all projects requiring an environmental impact statement must accommodate adaptation responses (DTMR, 2014).

The NSW Treasury has prepared guidelines for the economic appraisal of assets and infrastructure assessments in terms of climate change. Potential risks to public assets from climate change should be assessed like any other risk factor that affects the economic life cycle of assets, as part of an agency's ongoing risk management and decision-making for both existing and new assets (NSW Treasury, 2017). Such policies and guidelines allow for the project proponent to build in adaptation at an early stage and thereby include the financing for such activities within the entire project financing strategy.

The Torres Strait Islands received A$26.2 million in 2014 to progress the installation of coastal defences. Lack of adequate external funding had been a barrier to adaptation; strategies often require funding partnerships with external stakeholders that are complex or unattainable. Seawalls were approved and construction is progressing, subject to funding, for priority communities under the Torres Strait Seawall Program, jointly funded by the Queensland government and national government (TSRA, 2016).

4.2. Overseas Financing

Australia's climate financing also includes that provided to other countries through official aid programmes. Official development assistance (ODA) is commonly used to identify development-related aid provided from developed to developing countries. ODA is defined as flows of official financing administered with the promotion of the economic development and welfare of developing countries as the main objective, which are concessional with a grant element of at least 25% (IMF, 2003). International aid typically includes ODA as well as official aid and other official flows that do not fall under development assistance.

Australia's international climate support is largely drawn from its development assistance programme and is tracked through AidWorks of the Department of Foreign Affairs and Trade (DFAT). Australia sources its overseas climate finance from new and additional aid budget appropriations from the Parliament's annual budget process. This finance flows to developing countries through targeted bilateral and multilateral climate investments.

The priority given to climate change in Australia's aid programme has varied over recent years. Since 2013, Australia has not provided dedicated additional climate financing, although climate financing was included along with other aid priorities in the budget process (ODE, 2018). Specific climate funding is directly linked to international agreements rather than internal decisions and is similar to building climate risk and adaptation at the planning stage.

The *Climate Change Action Strategy* outlines the DFAT approach to responding to climate change in its development assistance programme and recognises the need for further integration of climate-change adaptation and disaster resilience and for stronger engagement with the private sector in finding solutions (DFAT, 2019). The strategy sets three key objectives to make the best use of development assistance: (i) support partner countries to adapt to climate change, and to plan, prepare for, and respond to climate-related impacts; (ii) promote the shift to lower-emissions development in the Indo-Pacific region; and (iii) support innovative solutions to climate change, including those that engage private sector investment.

All of Australia's overseas climate finance is categorised as ODA. In FY2016, Australia budgeted A$4.051 billion for ODA, amounting to 0.25% of gross national income, well below the internationally agreed target of 0.70% (DFAT, 2017). Papua New Guinea and the Pacific received 48% of all Australian bilateral aid, a total of A$925 million. The government has pledged A$1 billion in climate development assistance from 2015 to 2020 and a further A$500 million from 2020 to 2025 to build Pacific climate change and disaster resilience. This is an increase in spending in the Pacific region, which was initially pledged at A$300 million from 2016 to 2020.

Developed countries pledged to mobilise A$100 billion in climate finance per year by 2020 (OECD, 2022). This includes a commitment of A$200 million to the Green Climate Fund (GCF) from 2014 to 2018 and A$300 million to address climate change in Pacific island countries over 4 years, comprising A$150 million in bilateral aid investments, A$75 million in disaster-resilience investments, and A$75 million in regional investments.

ODA related to climate-change investments was rebranded in 2014, some as food security, water security, or disaster preparedness, as climate was de-emphasised in the Australian policy context. This was due to change in the political climate as a more right-wing government came to power in late 2013. Climate-change investments were internally re-branded; reporting on climate-related outcomes was hindered, as these objectives and indicators were removed. Many other investments lost impetus and were closed early (ODE, 2018).

From 2016 to 2018, 74% of climate-specific funds through bilateral, regional, and other channels was for adaptation activities, while 18% was for mitigation and 8% was for both mitigation and adaptation measures (DEE, 2019). This was an increase in the funds allocated for adaptation measures from the previous 2 years, which totalled 61% (DEE 2017). Australia's climate finance through ODA was US$360,334,000 in FY2019, out of which US$100,132,000 was for economic infrastructure services (DFAT, 2019). Table 7.3 provides a summary of Australia's climate finance through ODA.

Table 7.3. Australia's Climate Finance through Overseas Development Assistance

Fiscal Year	**Economic Infrastructure and Services Portion of Climate Finance** (US$ '000)	**Total Climate Finance** (US$ '000)	**Total Overseas Development Assistance** (US$ '000)
2015	31,088	222,256	5,027,933
2016	41,713	249,471	4,032,558
2017	61,593	248,963	4,030,654
2018	72,269	267,880	4,082,328
2019	100,132	360,334	4,379,057

Source: DFAT (2019a).

Australia is placed approximately mid-range on the spectrum of OECD donor commitments to 2020. The allocation of Australia's climate-change finance between mitigation and adaptation is broadly in line with other OECD countries, although with a somewhat greater focus on

adaptation, reflecting the priorities of its developing partner countries. Australia tends to channel a much greater share of its climate-change finance through multilateral mechanisms relative to comparable OECD countries (ODE, 2018).

Reviewing 26 investments of DFAT that were targeted and mainstreamed as climate-change objectives representing a total value of US$641.2 million, the Office of Development Effectiveness found that around one-third of investments demonstrated outcomes relating to reduced vulnerability or increased resilience (ODE, 2018). Of the investments that commenced between 2006 and 2014, 35% demonstrated significant climate-related outcomes (ODE, 2018). Most of the benefits were delivered in a range of adaptation areas, with some on mitigation.

Climate-change outcomes can be improved by linking internal outcomes to partner country needs and having explicit climate- or disaster-related outcomes, which are supported by appropriate technical expertise during the whole project investment cycle (ODE, 2018).

5. Synthesis of Climate-Change Adaptation Financing

The analysis of infrastructure financing for climate-change adaptation mechanisms in Australia show that the majority is obtained through federal and state government funding. These funds are typically provided through budgetary allocations and dispersed through a separate organisation, which has technical capabilities. The funds are allocated mainly to local government authorities who are responsible for the implementation of the projects. This is in line with the fact that the use of debt by Australian local governments was low when compared to other sectors with similar income stability and asset ownership (Comrie, 2014).

The analysis shows that the majority of climate-related financing is for mitigation rather than adaptation (Table 7.4). This contrasts with Australia's approach for overseas aid. For example, all projects financed through the CEFC focus on mitigation. Similarly, out of 566 projects funded by ARENA, worth A$1.63 billion, only 2% of the projects are adaptation-related (ARENA, 2020).

The lack of focus on adaptation is visible even at a policy level. The national review of climate change policies does not include adaptation in its terms of reference and only focusses on mitigation measures. With approximately 30% of Australia's national income vulnerable to economic disruptions due to climate-change impacts, it is estimated that the economic cost of doing nothing could cost close to A$3.4 trillion in GDP in present value terms and an additional 880,000 jobs (Deloitte, 2020). The focus on mitigation may be considered 'too little too late', given that impacts of climate change are being felt across Australia currently as well.

Recent scholarship on infrastructure financing for climate-change adaptation has focussed on the use of capital markets and the insurance sector to incentivise adaptation mechanisms. However, this type of financing is not common in Australia, at least in the infrastructure sector. One reason for this may be that financing public sector infrastructure does not bring in profits for companies. Market capitalist policies may not be the most effective in managing sustainability-related impacts, as they are mainly interested in profit motives (Colic-Peisker, 2011).

Regarding overseas climate financing, public reporting is largely dominated by the amount of climate-change financing it is providing rather than what outcomes have been achieved from

the aid investment portfolio. DFAT climate-change monitoring and public reporting systems do not effectively report on Australia's contribution to the efforts of developing countries to adapt to climate change and specific outcomes achieved (ODE, 2018).

Given that only 1% of climate-finance flows from developed to developing countries can be tracked to adaptation (Buchner et al., 2014), it is important to interrogate how Australia's climate-change financing has performed over the years. Although Australia ranks 12th in donor countries, ODA fell by 2.5% between 2018 and 2019, leading to a decrease in bilateral assistance. Australia's ODA has been cut annually for 6 years, with budget documents from FY2020 indicating a 28% decline in ODA since its peak in FY2014 (DFAT, 2019).

Table 7.4. Financing Mechanisms in Australia

Type	Infrastructure	Recipient(s)	Allocation	Funded
National government grants	Energy	National-level	Administered through ARENA	National and state government funds
National government grants	Overall infrastructure (mainly roads)	Disaster-affected regions	Disaster recovery authority	Special on-off income tax for individuals earning over A$50,000
National government grants	Water	State governments		Government department funding
State department funding	Overall adaptation projects	Local councils	Administered through state environmental trusts	Departmental funding
State climate change funds	Coastal adaptation	Local councils	50% of total project cost	Annual contributions from utility providers
State climate change funds	Floodplain management	Local councils	Funds A$2 for every A$1 contributed by the local council	Annual contributions from utility providers
Balance sheet financing	Airport	International airport operated by private company		75% from shareholder funds and loans; 25% additional landing fees
Reduction in government charges	Housing and commercial buildings	Individual developers in territory	Reduction of 10%–25% lease variation charge	
Direct private sector financing	Housing	Owners' corporation for common property	Contribute up to A$10,000 towards fittings that improve extreme weather resilience	

Type	Infrastructure	Recipient(s)	Allocation	Funded
Own revenue	Coastal protection infrastructure	Public land		Council rates and state government funding
Debt finance paid back through increase in rates	Coastal protection infrastructure	Coastal protection for private properties	Initial cost borne by council through debt finance	Debt paid back by charging a special rate levy

ARENA = Australian Renewable Energy Agency.
Source: Authors.

6. Challenges for Implementation

The first point in relation to challenges for better implementation is political commitment. A multipronged policy and strategy-setting approach like that adopted in Australia is mainly due to a lack of a clear direction at the national government level, however. As various state jurisdictions can develop the most suitable adaptation strategies, this benefits a country like Australia, where climate impacts vary drastically across the country. Yet for such localised policies to be effective, state and local governments need to have well-developed capacity on technical knowledge and have a good financial foundation.

This approach also leaves such strategies to the discretion of the states and territories, which can lead to non-action in some jurisdictions or in specific climate adaptation areas. The lack of harmonisation and fragmentation of approaches across jurisdictions can lead to less-than-optimal actions at a broader national level. The lack of political leadership and action at the national level have an even bigger impact, as Australia is seen as a world leader and can influence non-action from less-developed countries who are not as financially secure. The inertia to commit at a national level is also significant in relation to climate change, as it has impacts not only at the national level but at global scales where international cooperation is required.

Second, engaging the financial sector to develop financial and insurance mechanisms that incentivise the provision of climate-resilient products and services from the built environment and infrastructure sector has not been successful. The current disconnect amongst developer finance, owner insurance, and infrastructure assets creates a significant barrier to the infrastructure sector providing climate-adaptation mechanisms (Edwards, 2017).

Third, alignment of policy, planning, and implementation across all levels is needed. Most Pacific island countries have adaptation plans and policies in place, but few have clearly articulated lists of prioritised investments and technical assistance needs. This, when combined with the significant climate-change investment of other donors, tends to give rise to a situation characterised by short-term projects rather than strategic programming.

The strongest evidence of sustainable and strategic climate-change outcomes is found in Viet Nam (ODE, 2018). Twenty-two key attributes are in alignment with Viet Nam's climate policy, there is strong engagement in the climate-change policy dialogue process with the Government of Viet Nam (along with other donors), and there is good integration of climate and disaster risk reduction approaches under a single implementation strategy.

Beyond Viet Nam, no post-investment evaluations providing strong insights into impacts and sustainability are found. Where evaluations indicated evidence of enduring benefits, the common factors are sufficient time for delivery (i.e. over 5 years of engagement); the building of longer-term, enduring relationships; and working across the right parts of government. Alignment with national action plans and integrating disaster risk reduction and climate-change approaches are likely to enhance ongoing policy engagement and support more sustainable approaches (ODE, 2018). The strengthening of messaging and leadership from the highest levels through DFAT will be an important driver for effective integration.

The Productivity Commission (2012) identified that the most common capacity issues impacting climate-change adaptation are related to local councils having insufficient financial resources to implement adaptation actions, such as creating capital works to protect against the effects of sea-level rise or extreme weather events; potentially acquiring property in high-risk areas; and preparing for and responding to natural disasters. Several inquiry participants noted that competitive funding programmes are resource-intensive and disadvantage smaller councils that have fewer professional staff members to prepare grant applications and to implement funded programmes.

Local governments receive revenue from a range of sources, including own sources (e.g. municipal rates, user fees and charges, fines, and developer contributions) and recurrent grants from the national, state, and territory governments. There is considerable variation in the proportion of revenue received from the different sources across local governments, however. Councils, therefore, need to decide which revenue sources that they will use to fund council services. Moreover, if the local government service provides benefits to identifiable individuals or groups, then the costs of that service could be charged those who receive the benefit. However, if the service benefits are non-excludable (i.e. public goods), they may need to be financed through local rates and taxes or borrowings.

Fourth, national government funding for disaster recovery may also give rise to a barrier to effective adaptation to climate change by distorting the incentives that state and territory governments need to reduce their risks through disaster-mitigation measures (Productivity Commission, 2012). Such funding may lower the incentives to adequately maintain infrastructure and to manage climate-related risks — a form of 'moral hazard' — which can lead to a poor balance of disaster prevention, preparedness, response, and recovery. This arises because state and territory governments do not bear the full cost of rebuilding infrastructure after a disaster. Such funding typically encourages damaged infrastructure to be rebuilt without requiring an assessment of the costs and benefits to the community. This may also be a barrier to effective adaptation by discouraging states and territories from changing the design, location, or objectives of infrastructure to make it more resilient to future disasters.

7. COVID-19 Pandemic

The COVID-19 pandemic has had major implications on Australian society. The reduction in domestic demand and international travel pushed Australia into a recession for the first time in 3 decades, with unemployment reaching a record high of 7% (ABS, 2020). Both the national and state governments took measures to reduce the impact on the economy by increasing

government spending during this time. The government increased unemployment benefits and provided subsidies to keep businesses operating. Such measures were possible given that government budgets were in surplus and that Australia had the economic and political stability to take measures to curb the spread of the virus.

The state of Victoria was one of the hardest affected economically due to restrictions adopted by the state government due to a second wave of the virus. The implementation of stage 4 restrictions is estimated to have cost the Victorian state economy around A$25 billion (*Ibis World*, 2020). Victoria's gross state product is estimated to be about 14% lower in the June and September quarters relative to forecasts in the FY2020 state budget, dropping A$55 billion over an 18-month period (*Ibis World*, 2020). Increased government debt and business lockdowns also brought about a reduction in the credit ratings for both Victoria and NSW to AA and AA+. This was the first time since 2003 that either state did not receive the top-tier AAA rating held by the national government (Cranston, Shapiro, Kehoe, 2020).

The economic recovery has catalysed an infrastructure-led strategy. The national government maintained its A$100 billion spending for a 10-year infrastructure pipeline, while the Victoria government expedited some of its expenditure on infrastructure projects (Frydenberg, 2020). The national government unveiled HomeBuilder grants, which assist the residential construction sector by encouraging the commencement of new home builds and renovations. Similarly, the Victoria government announced a building works programme of A$2.7 billion and a combustible cladding replacement project (Premier of Victoria, 2020). Under the latter project, the government is accelerating the replacement of cladding from 100 buildings per year to 400 buildings in 2 years to generate more employment to help support the local economy.

Although an infrastructure sector recovery emphasises climate-change adaptation, the sustainability of these investments is lacking. For example, of the A$2.7 billion building works programme of the Victoria government, only A$129 million has been allocated to the state department of environment for projects.

This lack of climate action during the pandemic is not only visible in the allocation of funds but also in legislative action. Victoria's Climate Change Act 2017 requires the state government to develop a climate-change strategy every 5 years, setting out how Victoria will meet its targets and adapt to the impacts of climate change. As per the act, the first emissions reduction targets were supposed to be set in 2020. However, given the passing of emergency laws for the pandemic, the setting of these targets was delayed twice within 2020. Such a response illustrates that at a policy level, climate change is viewed as a separate 'nice-to-have policy' while the restoration of the economy in a business-as-usual context is given the highest priority.

Although emissions and environmental impacts could have been reduced during the pandemic due to depressed economic activity, as the economy rebounds, emissions can indeed increase. This shows similarities with the 2008–2009 global financial crisis; although carbon emissions declined by 400 million tonnes in 2009, they rebounded by 1.7 billion tonnes in 2010 (IEA, 2020). Therefore, it is imperative that smart policy decisions made post-pandemic will reduce emissions and improve adaptability to climate-change impacts.

8. Conclusions

Australia's response to climate change can be covered under four major areas: from a governance perspective, infrastructure ownership, financing infrastructure within the country, and providing overseas aid for climate change.

From a governance perspective, the country has a lack of leadership to deal with climate change, as there is no synchronised approach to proactively deal with associated impacts. This has led to many instances where local governments have responded to concerns of residents to respond quickly within their jurisdictions, particularly to deal with coastal erosion and storm surges. However, funding of coastal protection must also recognise the several significant non-governmental actors involved, including owners of properties exposed to coastal hazards as well as residents, tourists, and businesses.

Infrastructure plays a significant role in the Australian economy, as it contributes approximately 10% to the GDP. Infrastructure owned by the national government includes rail, airports, and some state roads. The state and territory governments manage state-owned rail, roads, and ports. Local governments have control over access and facilities for local infrastructure. Building, maintaining, and adapting these assets are in the hands of the relevant government authority. The level of adaptation policies at a national level is minimal, and there is limited coordination between national and state/local governments as discussed earlier.

To date, financing for infrastructure adaptation for climate change has typically been a combination of national, state, and local governments alone, or in the form of a partnership. Grants are usually set aside by the national government in cases of mass disaster, as in the instance of the COVID-19 pandemic. However, there is a lack of a coherent and coordinated strategy to prepare for climate change-related events across the country. Some specific cases, such as rural water use and infrastructure programmes, have been funded by the national government. Other instances include national agencies, such as ARENA and Australian Energy Market Operator, working with funding from the national government for specific projects, such as those for summer heatwaves impacting electricity demands. Some of these projects focus more on the mitigation of climate change rather than adaptation.

Some state and territory governments have also addressed identified climate-change and risk vulnerabilities, such as OEH in NSW, to enhance resilience due to heat or coastal management, or the Queensland government assisting its local councils with coastal hazard adaptation planning. There are also examples of private operators responding to climate impacts using a combination of funding approaches, including private sector funding. Other examples include incentivisation, especially for residential and commercial buildings, to meet certain energy-efficiency measures and climate-change adaptation plans.

When protection works provide a benefit to private landowners, the process for reaching an agreement to fund such projects can be a source of significant tension between state and local governments and between property owners who directly benefit from the project and other residents. For local governments, the relatively large cost of coastal protection projects can introduce the political risk of accusation of bias towards foreshore property owners and places a strain on available capital. State governments can be equally reluctant to provide funding, fearing that this may establish a precedent that could become unfeasible across large stretches

of coastline. These tensions can cause delays and add planning costs, compounding the already contested nature of many coastal protection and such similar projects.

The lack of clarity regarding roles and responsibilities has been widely recognised as a barrier to adaptation with attention directed at the national government to clarify roles. In the absence of this top-down approach, certain roles and responsibilities are emerging through practice. The responsibility of climate-change adaptation is deemed to be largely with local governments.

While the proportion of Australia's climate-change finance between mitigation and adaptation is broadly in line with other OECD countries, there is greater focus on adaptation, reflecting the priorities of its developing partner countries. Australia tends to provide a greater proportion of its climate-change finance through multilateral mechanisms compared to other OECD countries. Australia has provided support to its neighbours, with the most recent pledge of A$500 million from 2020 to 2025 to build Pacific climate change and disaster resilience, a measured increase from its previous funding by 40%.

The COVID-19 pandemic put a strain on Australia's economic trajectory over the last 30 years with high unemployment numbers, particularly in the worst pandemic-affected state, Victoria. This has provided some infrastructure-led opportunities for the state and the country. The Victoria government has expedited some of its infrastructure projects that continued to be operational during the pandemic, such as the Melbourne Metro Rail, with restrictions on the numbers of people operating at a given site to maintain social distancing and other pandemic-related measures. In addition, the national government provided incentives in the form of HomeBuilder grants to catalyse the economy. However, such examples demonstrate that the focus is on economic recovery rather than on climate change-related impacts. That said, the anniversary of the bushfires that took place in 2018 and 2019 provide a stark reminder of the very high temperatures during the previous summer directly related to climate change.

Going forwards, it is difficult to predict whether there will be any immediate impacts on Australia's response to climate change. As the political cycle in the United States changes to a new administration that recognises the importance of climate change and supporting more sustainable lifestyles, Australia's lack of leadership in this area is expected to be a focus, particularly as the next election cycle looms closer.

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Chapter 8

Japan

Yoshihiro Fujii

1. Overview

The number of natural disasters is increasing in Japan due to the acceleration of climate-change impacts. Japan placed the sixth globally in terms of the number of natural disasters occurring in the latest 2 decades per country, and fifth in Asia (CRED and UNDRR, 2020). The economic cost reached $439 billion, the third-highest value after natural disaster damage costs in the United States and China (CRED and UNDRR, 2020). In addition to earthquakes, floods and landslides are major causes of damage due to the intensification of typhoons and torrential rains. Therefore, expanding and strengthening climate-change adaptation projects and securing financing for climate-resilient infrastructure are key issues for Japan.

The latest weather data analysis in Japan showed that the current rate of torrential rainfall is in the 1-in-every-50-year class, which is occurring due to global warming. For example, in July 2017, damages caused by heavy rains in Kyushu increased 1.5 times and in Setouchi 3.3 times (Imada et al., 2020).

Potential damage from climate-related risks have not yet been officially indicated. In 2020, Mitsubishi UFJ Financial Group and other major banking groups estimated that the effects of torrential rains and floods in Japan will cause ¥125 billion in damages in their lending portfolios each year to 2050, decreasing the collateral value incurred by accounts for loans held and causing delays in loan repayments (Table 8.1). Based on these estimates, the annual amount of losses across the entire banking sector will be ¥306.5 billion per year, accumulating to ¥9.195 trillion. This estimate is limited to flood damage through the cost of climate-change adaptation; if damages other than flooding are included, the estimate is more than ¥10 trillion.

Table 8.1. Estimated Annual Climate Losses in Loan Portfolios of Selected Banks

(¥ billion)

	MUFG Bank	Mizuho Bank	Sumitomo Mitsui Banking Corporation
Transitional costs	30–270	120–310	60–300
Physical costs	38	52	30–40

Source: RIEF (2020).

However, despite identification of such massive global-warming impacts, Japan's policy response to climate-change adaptation is farther behind that of the European Union and other developed countries. A climate-change mitigation policy in Japan – the Law Concerning the Promotion of the Measures to Cope with Global Warming – was promulgated in 1998. It aims to

curb greenhouse gas emissions by introducing renewable energy and energy-efficient projects. However, it does not describe how to manage and to control such activities.

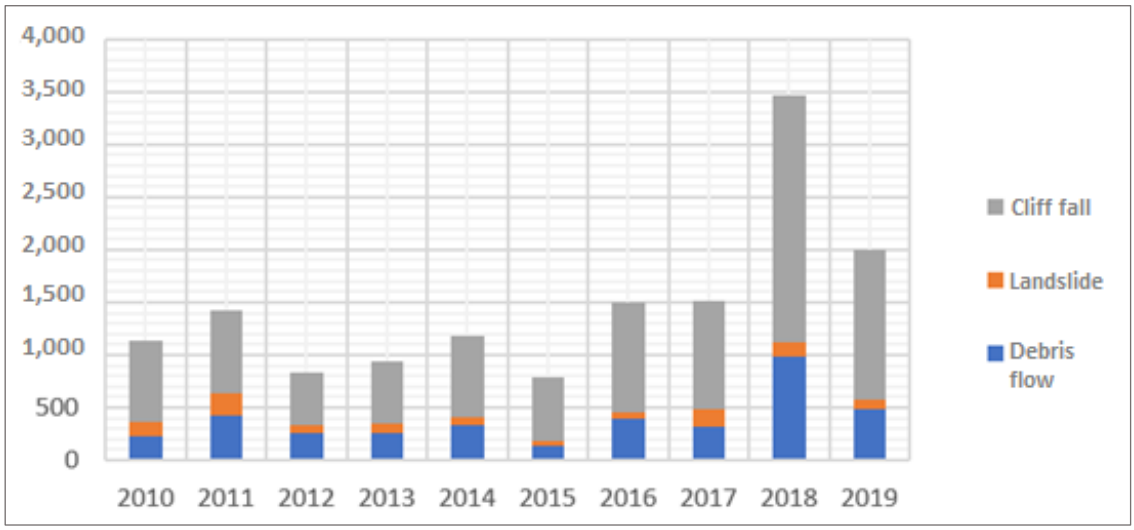
To ensure that Japan's climate-change framework was consistent with the 2015 Paris Agreement, Japan had two options: to revise the mitigation act to include adaptation measures, or to enact new laws for adaptation. The government decided to enact new adaptation laws, as it believes that mitigation and adaptation measures differ in their main objectives; therefore, the policy system should be separated. It also views the impacts of climate change as already in place and likely to expand, so it is necessary to proceed with adaptation measures regardless of mitigation measures.

Japan's climate-change adaptation plans were first established in November 2015. The Act on Adaptation to Climate Change, which guarantees the creation of a climate-adaptation plan, was, however, delayed until 2018. The adaptation act has four objectives: promoting climate-change adaptation, developing associated information infrastructure, strengthening adaptation in the region, and expanding adaptation measures internationally. Towards the first goal, it stipulates the roles of the national government, local governments, businesses, and citizens in adaptation activities. It states that prefectures and municipalities should deal with actual adaptation measures and activities. However, financing for these is not clearly indicated. The *National Adaptation Plan* mentions finance and insurance as part of industrial economic activities, but there is no indication of how to finance or to obtain insurance for adaptation projects by using private financial functions or markets (MOE, 2018).

The Basic Act on Disaster Countermeasures, from November 1961, was enacted after Typhoon Vera hit the Chūbu Region in 1959, causing more than 5,000 deaths; it is still considered one of Japan's worst natural disasters. The act focussed on the emergency response in the event of a disaster and post-disaster recovery projects and activities. The adaptation act was based on this law, which states that the cost of disaster relief and recovery will be covered by the disaster-affected municipalities through the issuance of municipal bonds, which the national government will take on in its fiscal investment and loan plan. Thus, based on this provision, prefectures and municipalities are expected finance adaptation activities. However, as the impacts of climate change increase, it has become clear that public finance alone cannot finance sufficient climate-change adaptation projects and activities. Thus, the development of adaptation finance initiatives has become urgent.

According to the Ministry of Land, Infrastructure, Transport and Tourism, which examined landslides caused by natural disasters, the number of incidents that happened in 2019 was the fourth highest since 1982, while 2018 saw the highest (Figure 8.1). In 2019, the number of occurrences was also 1.8 times higher than the average.

Figure 8.1. Landslides in Japan, 2010–2019



Source: Ministry of Land, Infrastructure, Transport and Tourism.

Climate change has also increased landslide scale and strength. A traditional landslide, known as a surface collapse, is normally a 0.5-metre to 2.0-metre collapse of the soil layer of the slope in a mountain area. Now, landslides known as deep collapses are happening. Sometimes, an entire mountain ridge may suffer collapses due to heavy rainfall. Once these deep collapses happen, a much larger amount of sediment loosens, creating enormous debris flow and river-road blockages (i.e. landslide dams). This occurred in July 2018 in Western Japan, claiming over 200 lives.

In 2018, the Ministry of Land, Infrastructure, Transport and Tourism investigated about 21,000 rivers across the country after torrential rains in Western Japan. Results showed that most of the 147 sites that caused the levee collapses were out of scope for additional measures. In 2020, the heights of 84 river levees in 147 sites in the upper part of 75 large rivers – including Abukuma River (Fukushima Prefecture), Yoshida River (Miyagi Prefecture), Kuma River (Kumamoto Prefecture) in Kyushu and Eastern Japan – met the official disaster prevention planning levels of both the national and local governments. (*Asahi Shimbun*, 2020). However, damages from Typhoon Hagibis in October 2019 and heavy rains in July 2020 caused some to collapse. A levee for the Chikuma River (Nagano Prefecture) collapsed and overflowed from its breaking point over a distance of 70 metres, despite being reconstructed in 1984 with additional soil-reinforcement.

Many levees or river dams, which were originally constructed with adequate flood prevention function measures, now face risk of collapse or overflow. Natural disasters have dramatically changed due to intensifying climate change. Various rural areas in Japan, which have large rivers, are therefore forced to rebuild these levees or dams and to change their total evacuation systems.

In urban areas, cities are forced to develop two types of disaster prevention measures. The first type is for suburban areas, where people have cultivated fields and are often surrounded by mountains. They face landslide risks; thus, prevention measures focus on adjustment between the developed area and the undeveloped areas on the slopes. The second type of prevention

measures is for urban areas, including city centres. Natural disaster risks comprise floods caused by heavy rains or typhoons, which bring intensified water flow to the lowest areas in cities. Disaster prevention measures here focus on flood avoidance.

The Sendai Framework, established in 2015, covers natural disasters; human-caused disasters; and related environmental, technical, and biological disasters and risks (UNDRR, 2015). It is an international disaster prevention framework based on the declaration of the 3rd United Nations World Conference on Disaster Risk Prevention. It has four priorities for action: understanding disaster risk, and sharing information; strengthening disaster risk governance to manage disaster risk; investing in disaster risk reduction for resilience; and enhancing disaster preparedness for effective response and to build back better in recovery, rehabilitation, and reconstruction. It defines the concept of resilience as 'the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions' (UNDRR, 2015). This concept is crucial to a range of other fields and disciplines, including sustainable development, poverty eradication, and climate-change adaptation.

The Sendai Framework also promotes international disaster prevention and reduction initiatives in response to increased natural disasters due to climate change. The priorities for action indicate investment to reduce the risk of disasters in its third point, but the development of adaptation finance based on the action continues to be insufficient.

By using artificial intelligence (AI)/machine-learning projects, disaster prevention and reduction initiatives can be piloted. Currently, these have been developed in three dimensions: simulating serious disasters, building an efficient and effective evacuation system, and developing useful communication tools for different languages other than Japanese. SOMPO Japan Insurance used an AI/machine-learning method to create a disaster prevention and reduction system with Kumamoto Prefecture in Kyushu, which suffered serious damages from the 2016 Fukushima earthquake and 2020 heavy rainfall. It is working to establish a resilience system throughout the city by estimating damage in three stages: before damage happens, by regional unit, and immediately after disasters happen. The United States start-up One Concern is responsible for the analysis through AI, and Weathernews, a private weather forecasting company in Japan, is responsible for providing and analysing the weather data. SOMPO provided its insurance data on the Kumamoto area.

Although such initiatives are limited in Japan, visualisation of disaster hazard areas using hazard maps has progressed. Based on the revised Flood Prevention Law (2015),[1] a flood area can be modelled based on when the levee or embankment collapses, as well as the inundation-assumed area based on the depth of water at that time. In addition, in the designated target rivers or flood-prone areas, information on special warning water levels must be released to the public. The Sediment Disaster Prevention Act (2000) also stipulates the designation of sediment disaster warning areas and their mapping. The disclosure of such information related to natural

[1] Government of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Land and Climate of Japan, https://www.mlit.go.jp/river/basic_info/english/land.html

disasters has helped prepare people and companies regarding disaster prevention and reduction actions.

2. Green Bonds

As municipalities manage and operate adaptation plans, they are willing to expand their adaptation activities if they receive money from the capital market by issuing bonds or receiving loans. Many municipalities are now facing a lack of financial resources for natural disasters. Almost every year, they have large expenses related to recovery or compensation due to disaster damages. Some have even run out of funds.

Thus, several municipalities are keen to connect with the capital market to induce money from investors through green bonds. So far, three prefectures, including the metropolitan city of Tokyo, have issued green bonds to finance their climate-change mitigation and adaptation needs. Tokyo was the first; it issued a trial version of a green bond in 2016; since that time, it has issued green bonds every year.[2] The proceeds from these green bonds have been focussed on climate-change mitigation projects.

In the case of a 5-year green bond issued in October 2020 in Tokyo at ¥10 billion for institutional investors, its proceeds are going to solar-power facilities and sewerage system maintenance. Proceeds of 30-year bonds are going to strengthening river walls, increasing adjustment ponds for natural disasters, and developing seawalls and flood gates for tsunamis. In the case of such long-term bonds, the majority of proceeds go to adaptation projects. The Tokyo government also issues green bonds for individuals denominated in foreign currency annually, and the use of these proceeds target both adaptation and mitigation projects.

Nagano Prefecture issued its first green bond in October 2020, and Kanagawa Prefecture issued its first green bonds in November 2020. Both issuances amounted to ¥5 billion. The proceeds of Nagano Prefecture's green bonds will be used for a river protection and renovation project regarding flood control, as well as mitigation projects such as the development of small hydroelectric power-generation projects and the introduction of energy-saving vehicles for third-sector railways (RIEF, 2020).

In March 2020, Kanagawa Prefecture declared a 'Kanagawa Climate Emergency', which followed a series of typhoons and torrential rains. It developed the *Kanagawa Prefectural Water Disaster Prevention Strategy*; all of the proceeds of its first green bonds will be used for adaptation projects within the prefecture, including emergency response river management projects, improvements to bottlenecks in watery areas and flow routes, development of coastal conservation facilities, and improvement of sediment disaster prevention facilities (Kanagawa Prefecture, 2020).

Table 8.2 details the adaptation projects and activities funded by the proceeds of these green bonds. They do not focus on building higher and stronger levees, dams, or coastal seawalls;

[2] Tokyo Metropolitan Government, Bureau of Finance, Tokyo Green Bonds, https://www.zaimu.metro.tokyo.lg.jp/bond/en/ir_library/tosai_ir_gb.html

instead, they focus on reinforcing and maintaining the weak points of the current disaster prevention infrastructure, which is a relatively soft approach.

Table 8.2. Climate-Change Adaptation Projects Covered by Green Bonds Issued by Kanagawa Prefecture

Project	Targets	Funds Allocated
Emergency response to rivers	Removal of sediment deposited in sections where the risk of flooding is particularly high (38 rivers)	11.2%
	Concrete raising work (3 locations)	3.2%
Development of bottlenecks in water and flow routes	Development of water-free areas (6 locations)	57.9%
Development of coastal conservation facilities	Establishment of facilities in front of coastal graves such as seawalls as a priority (4 locations)	1.9%
Development of a facility to prevent sediment disasters	Sabo dam construction (29 locations)	7.6%
	Slope construction in areas where cliffs collapsed (201 locations)	18.2%

Source: Kanagawa Prefecture (2020).

In addition to these projects, the prefecture has promoted adaptation measures that prevent people and companies from constructing buildings or houses in hazardous areas, as well as use hazard maps, direct regulations, and tax incentives. It has also prepared emergent evacuation systems for each region. These combinations of adaptation measures are also a soft approach.

Investors for these green bonds – mainly institutions including pension funds and insurance companies – are not limited to local companies and financial institutions related to the municipalities. Many institutional investors all over Japan have invested as part of their environmental social governance (ESG) investments. Fortunately, Japan has a huge amount of household assets, which are resources for insurance companies, pension funds, and deposits for financial institutions such as banks. The total amount of household assets was ¥1.883 trillion in the second quarter of 2020 (Bank of Japan, 2020).

For green bonds, it is usually difficult to push their proceeds to adaptation projects in comparison with mitigation projects. With mitigation projects, such as renewable energy, investors can see the cash flow quickly from the proceeds by, for example, selling their generated electricity to the market. Investors are satisfied with both the economic returns and green contributions. However, for adaptation projects, it is difficult to envision the expected direct cash flow from, for instance, improving river levees and preventing landslides. Institutional investors can be keen to invest in regional municipal bonds because of evaluation of their creditworthiness as public entities. However, increasing adaptation projects for municipalities raises their fiscal constraints. Thus, municipalities should introduce some kind of cash flow that does not influence their creditworthiness.

3. Adaptation Credits

To attract investors towards climate-change adaptation projects, adaptation credits can be created. There are several precedents from around the globe, such as those for protecting the environment or respecting social rights. One example is the REDD+ credit system, which results in cash payments.

In Japan, several local municipalities have tried to introduce similar concepts to the REDD+ scheme for local flood-control systems. The paddy field dam system uses the water reserve capacity of paddy fields as absorption sites when excess water emerges around towns or villages during heavy rains or typhoons. It is an economically viable solution compared to, for instance, constructing higher levees along a river bank. Niigata Prefecture and its capital, Niigata City, have collaborated with various stakeholders to manage a paddy field dam system since 2009.

In Niigata, around 3,000 hectares of paddy fields were used within Niigata City for a reserve. Cash contributions to the Niigata pilot project were about ¥11,200 per 10 acres per year (Miyazu et al., 2013). The cost of using paddy fields as a reserve totaled only ¥200 per 10 acres per year, which comprised mostly compensation payments to paddy field owners (i.e. rice farmers) for their damaged crops. These payments were quite small compared to disaster-prevention benefits.

Indeed, the total reduction of disaster expenditures by using the paddy field system have been calculated at about ¥327 million per year. If these monetary benefits are regarded as negative costs for investors who want to buy green bonds issued by municipalities for this purpose or to invest in the paddy field system themselves, the paddy field system can be transformed to a cutting-edge adaptation investment. To ensure the creditworthiness of the adaptation credit, governments or municipalities should set adaptation objectives and collaborate to develop cost-effective adaptation tools and adaptation finance with market players.

Recently, other players have emerged in the green bond market in Japan, including government-supported corporations, such as the Japan Water Agency and Central Nippon Expressway Company. Both have set their own green and sustainability bond frameworks, including adaptation activities in 2020. The former has operated and managed many hydro dams, including flood-control dams; the latter has operated and managed high-speed roads in Central Japan. Both have issued their own corporate bonds to finance their business and operations, which include construction and maintenance of the dams and high-speed roads. After setting their own ESG bond framework, their issuing bonds became known as green bonds or sustainability bonds. Both have created cash flow from their own businesses providing water or toll-road services. Therefore, it is relatively easy for them to issue green bonds with project cash flow to institutional investors.

4. Insurance and Catastrophe Bonds

Companies and corporations are keen to protect their properties and operations from the impacts of natural disasters. According to Sawada et al. (2015), 68.6% of responding companies thought that they would suffer from more severe disasters in the future, and almost 50.0% responded that they would see maximum damages to their properties. The disaster insurance participation rate amongst respondents was 58.9% for large companies and 47.0% for micro,

small, and medium-sized (SME) enterprises in Japan. These rates are lower than the average of other advanced countries. The traditionally strong relationships between companies and banks in Japan – rather than between companies and insurance companies – may help explain this.

The survey also asked respondents about planned measures to cover their cash-flow shortages at times of future natural disasters. Answers included bank loans (43.44%), self-financing (38.75%), and insurance (11.79%). Loans are usually used to cover daily business operations rather than to transform their business structures to be more resilient against disasters.

Insurance companies themselves have suffered from the increasing number natural disasters, which denotes increasing insurance payments to their policyholders. As mentioned before, the governmental adaptation plan has already categorised insurance companies as an 'adaptation risk industry'.

Table 8.3. Ranking of Insurance Payments Based on Cases of Wind and Flood Damage

Ranking	Disaster	Area	Number of Payments	Insurance Paid (¥ billion)
1	Typhoon No. 21 (2018)	Hyogo, Kyoto, Osaka	857,284	10,678
2	Typhoon No. 19 (2019)	East Japan	295,186	5,826
3	Typhoon No. 19 (1991)	National	607,324	5,680
4	Typhoon No. 15 (2019)	Kanto	383,585	4,656
5	Typhoon No. 18 (2004)	National	427,954	3,874
6	Snow (2014)	Kanto	326,591	3,224
7	Typhoon No. 18 (1999)	Fukuoka, Kumamoto, Yamaguchi	306,359	3,147
8	Typhoon No. 24 (2018)	Kanagawa, Shizuoka, Tokyo	412,707	3,061
9	Heavy rain (2018)	Ehime, Hiroshima, Okayama	55,320	1,956
10	Typhoon No. 15 (2015)	National	225,523	1,642

Source: General Insurance Association of Japan.

Table 8.3 shows the top 10 insurance payouts for typhoon and heavy precipitation damage in Japan in the past 3 decades; 7 have been within the past 10 years. Typhoon No. 21 (2018) recorded the highest amount of insurance payments at over ¥10 trillion. In the same fiscal year, due to Typhoon No. 24 and more heavy rainfall in July, annual insurance payments increased 6.7 times from the previous year and reached over ¥1.5 trillion. In FY2019, the total amount decreased 22% from FY2018 but also exceeded ¥1.220 trillion due to heavy rainfall damages

from typhoons No. 15 and No. 19 and October rainfall. Insurance payments over ¥1 trillion were recorded for the second consecutive year.

Therefore, major non-life insurance companies – such as Tokio Marine Holdings, SOMPO Holdings, and MS&AD Insurance Group Holdings – had to raise their insurance premiums by 6% to 7% from the national average in October 2019. These will be raised again in January 2021. In addition, they will shorten their insurance policy period of up to 10 years to 5 years to make it easier to change contracts when insurance payments increase over time. If insurance premiums become too high, there is a possibility that the number of people who do not have insurance will rise.

Under these circumstances, catastrophe bonds, which are directly linked to capital markets, are regarded as risk management measures for insurance companies to continue to insure and to reduce the risk of adaptation. In April 2020, MS&AD Group's Mitsui Sumitomo Insurance issued a $100-million catastrophe bond, Akibare Re 2020-1, in the Singapore market (Mitsui Sumitomo Insurance, 2020). This bond is the subject to two types of climate risk, typhoons and floods, in Japan. The period will be 4 years, until the end of March 2024. The yield on the issue amount of $100 million is high at +2.75% of the yield of the secured bond. Singapore is very keen to revitalise its market by subsidising the issuance of insurance-linked securities such as catastrophe bonds in its market. Mitsui Sumitomo Insurance is the first Japanese insurance company to issue such bonds in Singapore.

5. Business Continuity Plan Loan

In general, natural disaster damage covers large geographic areas. For this reason, regional financial institutions, such as regional banks, provide several types of loans to customers – both SMEs and individuals – in the event of disasters, based on traditionally strong relations with local companies.

Banks have provided various types of disaster-related loans to these entities, and most of them are short-term finance to cover periods of emergency. Among them, the Bank of Fukuoka, a regional bank in Fukuoka Prefecture in Kyushu, began to provide a new loan, a business continuity plan (BCP) support loan (Fukuoka Bank, 2020). For these loans, the bank formed a partnership with Tokio Marine Insurance, which provides insurance to a company when obtaining a secured loan from the Bank of Fukuoka when disaster happens. The BCP support loan is an adaptation measure undertaken by companies to prepare for future risks, including natural disasters. It is different from current disaster loans in Japan, which provide emergency finance when disasters occur. Under BCP support loans, the bank makes loan agreements with its customers before a disaster happens; companies can also secure additional finance when disasters or other types of difficulties occur. The bank often requests that the companies change their business structures to be more disaster resilient.

Other regional banks have followed in providing similar loans to their business customers. In addition to the collaboration with insurance companies, they can also use governmental resilience certification labels. This certification is provided by the National Resilience Promotion Headquarters to promote the development of disaster prevention measures for companies –

mainly earthquake countermeasures.[3] The government provides the certification to companies that prepared disaster prevention and reduction measures. Companies can then use their certification to verify their disaster prevention and mitigation management and to develop their evaluations into ESG marketing. Certified companies can also partake in public loans with lower interest rates[4] provided by the Development Bank of Japan, a public financial institution.

The Bank of Nagoya in Aichi Prefecture provides BCP loans using the governmental certification (Bank of Nagoya, 2017). It also collaborates with InterRisk Research and Consulting, a risk-consulting company under the MS&AD umbrella, to evaluate a customer's potential disaster risk before taking out a loan agreement. In addition, the bank provided a new type of flood-risk loan with a principal exemption special contract in the summer of 2020 (Bank of Nagoya, 2020). It was limited but focussed on seasonal flood risk in collaboration with insurance companies. Companies with this loan do not have to pay back their principal if any natural disasters match predetermined quantified conditions in the designated areas.

Shizuoka Bank, in Shizuoka Prefecture, provided a commitment line for targeting floods risk for its customers as a kind of BCP loan in March 2019 (Shizuoka Bank, 2019). It promised to provide a loan to a borrower when needed within a set period and loan limits. Within the limit, the borrower can borrow and repay funds as many times as it likes.

6. Estimation of the Climate Adaptation Finance Scale in Japan

Current adaptation financing amounts in Japan can be estimated based on adaptation activities by each sector. In the case of municipality green bonds, although adaptation costs depend on geographic differences or weather conditions, almost every prefecture or region cannot escape from climate change-related damages.

Kanagawa Prefecture issued ¥5.0 billion of adaptation green bonds, so potential adaptation costs in all 47 prefectures in Japan can be assumed to be ¥235.0 billion annually, accumulating to about ¥7.05 trillion by 2050. However, this estimate is for only damages by floods and torrential rains and does not include those from droughts, forest fires, and poor crop yields. Therefore, it is likely to exceed ¥10.00 trillion by 2050. This estimate is almost the same amount of the abovementioned total physical risks, which the Japanese banking industry has in its loan portfolio by 2050.

Issuance of catastrophe bonds by insurance companies means to change the adaptation risktaker from insurance companies to investors in the capital market – not the adaptation costs themselves. Therefore, the amount cannot be calculated as other financial products such as green bonds and BCP loans, both of which can reduce adaptation costs. In the case of BCP loans, the total of the amount of estimated climate-related physical risk should be used, which is calculated as ¥306.5 billion annually. Therefore, the total amount of both municipal green bonds and BCP loans by banks as adaptation finance is ¥541.5 billion per year. If the annual amount of

[3] Association for the Promotion of Resilience Japan, Resilience Certification Evaluation, http://www.resilience-jp.biz/certification/about/

[4] Japan Finance Corporation, Social Environment Facility Development Funds, https://www.jfc.go.jp/n/finance/search/19_syakaikankyotaiou_m_t.html

flood damage of ¥1 trillion per year continues at an accelerated pace, the total adaptation costs can be halved by both green bonds and BCP loans.

7. Overseas Financing

Article 18 of the Act on Adaptation to Climate Change states that Japan should promote technical assistance and other international cooperation for adaptation projects and activities in developing countries. This also denotes the need to increase financial resources from the financial market rather than from public funds.

At the 2019 Asia-Pacific Economic Community (APEC) Finance Ministers' Meeting, participating countries agreed to strengthen disaster risk finance insurance schemes. The joint statement said that 'disaster shocks increase government expenditure and hamper economic activities, and fiscal risks may arise in those economies where governments shoulder a significant share of disaster costs' (APEC, 2019). Following their meeting in September 2020, they expressed the possibility of adding future pandemics to the scope of disasters in disaster risk finance insurance.

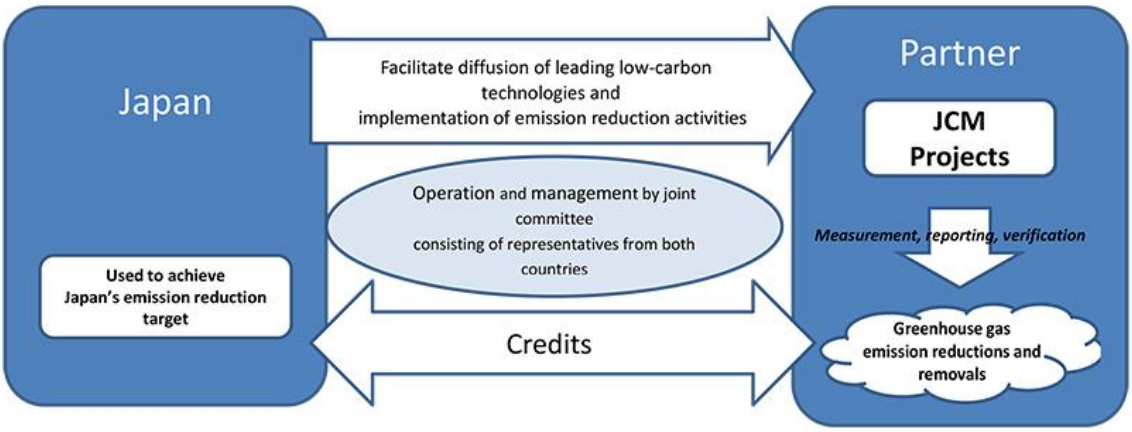
Developing qualified and resilient infrastructure, as well as risk transfer through insurance and capital markets, are common interests in the region. Financial instruments to achieve those common interests are catastrophe bonds and financial instruments linking insurance industries with capital markets. During the COVID-19 pandemic, the Pandemic Emergency Financing Facility was triggered to incorporate catastrophe bonds into the scheme. Financial assistance was provided by Germany, Japan, and other countries. The facility was set up in 2017 with maturity of 3 years. Just before it expired, the scheme was triggered, allocating $195.84 million to 64 of the poorest countries in the world with reported cases of COVID-19 (World Bank, 2020).

A similar scheme helped issue catastrophe bonds that collectively cover disaster risks in multiple countries in Asia, using financial contributions from developed economies and financial instruments linked to the capital market. In 2018, for earthquake countermeasures, Pacific Alliance countries in Central and South America issued collective catastrophe bonds in the amount of $1.36 billion supported by the World Bank (World Bank, 2018). By combining public contributions with capital market instruments, the credibility of those financial products can be increased for institutional investors.

Another possibility is the Joint Crediting Mechanism (JCM)[5] (Figure 8.2). Japan developed the JCM as its own policy contribution scheme for reducing international carbon dioxide emissions and transferring climate-related technologies, systems, products, services, and infrastructure to developing countries. It was introduced in the 2012 United Nations Climate Change Conference in Qatar in 2012 and was admitted in Article 6 of the Paris Agreement as a collaboration approach. So far, 17 countries, including as Indonesia, Thailand, and Viet Nam, have signed partnership agreements with Japan.

[5] Government of Japan, Ministry of Foreign Affairs, Climate Change: Joint Crediting Mechanism, https://www.mofa.go.jp/ic/ch/page1we_000105.html

Figure 8.2. Structure of the Joint Crediting Mechanism



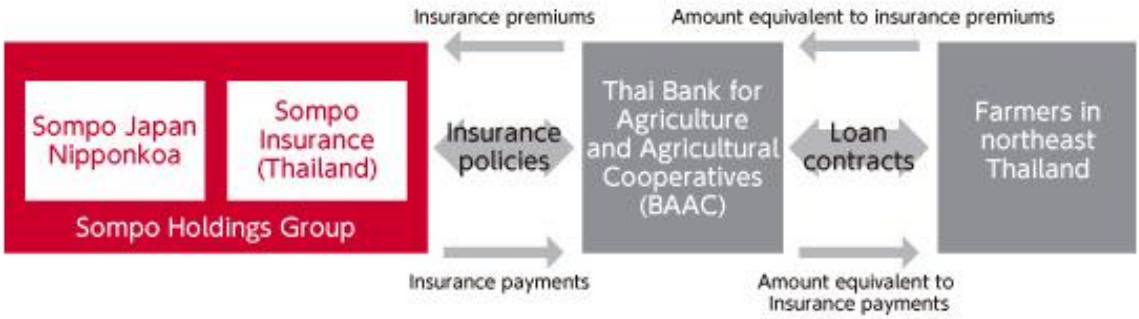
JCM = Joint Credit Mechanism.
Source: Ministry of Foreign Affairs.

Under the JCM, Japan provides leading low-carbon technologies or services – including financing – to mitigation projects in partnership countries, evaluates its contributions to greenhouse gas emission reductions, and then uses them to achieve Japan's emissions reduction target. It should also create adaptation credits from joint adaptation projects such as renovating levees, construction of hydro dams with flood-control functions, and revetment strengthening. If Japan and host countries agree to admit such adaptation credits through such joint adaptation projects, business entities and companies can obtain cash flow from their committed adaptation business to sell credits to the market or to other entities.

8. Private Sector Financing in Developing Countries

An example of adaptation finance in developing countries through Japanese financial institutions is weather index insurance developed by SOMPO Holdings in Thailand and Myanmar (Figure 8.3). It is a kind of micro-insurance for farmers using data-driven derivative methods. In 2010, SOMPO launched weather index insurance for farmers in North-East Thailand, aiming to reduce their damages caused by droughts. SOMPO Insurance Thailand, its subsidiary, developed the scheme with the Bank for Agriculture and Agricultural Cooperatives (BAAC) to offer the product to farmers who maintain loan contracts with BAAC. In the case of traditional agro-insurance, time – as well as technical experts – is needed to estimate the total amount of damage occurs due to natural disasters. These conditions are challenging, especially for low-income farmers. However, this insurance scheme sets a weather index, comprising weather data such as temperature, wind speed, rainfall, and hours of sunshine. If weather-related disasters happen and fulfil certain conditions on the index, the company pays out contractually predetermined insurance amounts to policyholders without estimating real damages by experts.

Figure 8.3. Weather Index Insurance



Source: SOMPO Holdings (2018).

In North-East Thailand, SOMPO supports rice farmers, expanding the insurance to longan farmers in 2019 using satellite data. It also developed the same agro-insurance product that covers drought risks for rice and sesame farmers in Central Myanmar as a pilot project in 2018. In Myanmar, weather-related data were collected to develop the insurance product, but it was not easy to get them due to insufficient meteorological station systems there. Thus, it collaborated with the Japan International Cooperation Agency to provide 30 automated weather acceleration systems and 3 weather radars to Myanmar's Department of Meteorology and Hydrology. The second collaboration was with Japan Aerospace Exploration Agency (JAXA); SOMPO used JAXA Global Rainfall Watch, which provides the world's rainfall distribution in partnership with the Remote Sensing Technology Center of Japan. According to its analysis in the targeted area, the correlation coefficient between the data from the ground rain gauge and satellite is 0.79 (Fukuwatari and Okada, 2019).

The company also sells weather index insurance in the Philippines due to the typhoons. There is no data shortage because Japan has a lot of typhoon-related weather data. Targeted companies include agri-businesses that are developing large-scale agriculture farming, such as for bananas in Mindanao. SOMPO is also planning to sell weather index insurance in Indonesia.

These experiences show that there are two key factors in expanding adaptation finance in Asian countries. One is to work with local partners such as BACC in Thailand to oversee sales. The second is to secure detailed and timely weather data.

9. Possibilities of Adaptation Finance

Another adaptation activity is by Tokio Marine Holdings, but it is a social contribution rather than a business activity. In 1999, Tokio Marine Holdings celebrated the 120th anniversary of its founding; it decided to undertake a commemorative planting project in Asian coastal areas to help deter damage from tidal waves or sea-level rise. So far, it has planted mangrove trees in nine Asian countries – Bangladesh, Fiji, India, Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam. The total planted area was about 10,930 hectares as of March 2019. It calculates its economic impacts to be ¥118.5 billion, which includes contributing to local fisheries, hiring local women in the tree-planting activities, and contributing to tourism and ecotourism in the areas. In addition, Tokio Marine Holdings is offsetting its carbon dioxide

emissions with the total carbon dioxide absorption of the trees. The company has enjoyed carbon neutrality for 1 decade.

The lesson from this social contribution activity is that it is possible to raise potential cash flow as well as carbon dioxide emissions reduction effects through voluntary activities. It may be possible to generate a certain amount of cash flow, which could be of interest to institutional investors. Adaptation credits should be regarded as cash flow; in addition, creating jobs in rural areas and avoiding or mitigating physical damages by natural disasters also may generate cash flow by reducing disaster costs.

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