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Climate Change Vulnerabilities, Social Impacts, and Education for Autonomous Adaptation

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Preface

Climate change stands as one of the foremost challenges to global economic development. Unchecked, temperature increases can lead to lower crop yields, glacier melt, altered trade routes, and reduced water supply, posing the risk of permanent displacement for millions due to rising sea levels. The densely populated Southeast Asia region, reliant on natural resources, is particularly vulnerable, facing irreversible damage to ecosystems, threats to livelihoods, and increased vulnerability to natural disasters.

As nations strive to mitigate climate change through mitigation measures like Nationally Determined Contributions (NDC) and Net Zero Targets (NZT), with a limited impact in the short term, adaptation and resilience becomes paramount. The IPCC 6th Assessment Report emphasises that, in the coming decades, adaptation is the primary response before mitigation measures take effect.

Adaptation involves coping with potential climate impacts, spanning planned and reactive autonomous strategies. While adaptive capacity naturally strengthens with resources and socio-economic development, it's also influenced by experience and knowledge. Developing countries, with limited resources, require a stakeholder-negotiated autonomous adaptation approach that builds on local knowledge and international support.

Building on ERIA's previous study on climate change resilience, this book, stemming from a workshop in collaboration with the Government of Cambodia, addresses climate change education in ASEAN. Papers presented at the workshop form the basis of this publication, aiming to share good practices in autonomous adaptation, assessment, and education.

This book aligns with ERIA's commitment to producing knowledge products for sustainable economic growth. It promises to contribute to policy development and academic understanding of crucial aspects of climate vulnerability, social impacts, and adaptation education.

Effective action requires a holistic consideration of economic development, climate vulnerability, and autonomous adaptation across key sectors. Failure to integrate these elements may lead to maladaptation. Mainstreaming, the integration of climate risk assessment and education into ongoing policies and infrastructure development programmes, is crucial for long-term sustainability and minimising negative impacts of climate change on economic development.

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ADB	Asian Development Bank
AF	Adaptation Fund
AIS	Agriculture Innovation Systems
ASAP	Smallholder Agriculture Programme
ASEAN	Association of Southeast Asian Nations
CACCI-Asia	Comprehensive Action for Climate Change Initiative in Asia
CAREC	Central Asia Regional Economic Cooperation Program
CCCSP	Cambodia Climate Change Strategic Plan 2014–2023
CEP	Committee for Environmental Protection under the Government of the Republic of Tajikistan
CIFs	Climate Investment Funds
CTF	Clean Technology Fund
DCCM	Department of Climate Change Management
DoNRE	District Office of Natural Resources and Environment
DPF	Department of Planning and Finance
EPF	Environment Protection Fund
ERIA	The Economic Research Institute for ASEAN and East Asia
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility
FIP	Forest Investment Program
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Find
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GoL	Government of Lao PDR
GWP	Global Warming Potential
IFAD	International Fund for Agricultural Development

IFPRI	International Food Policy Research Institute
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IRAS	Improving the Resilience of the Agriculture Sector
IUCN	International Union for Conservation of Nature
ODA	Official Development Assistance
Lao PDR	Lao People's Democratic Republic
LDC	Least Development Country
LDCs	Least Developed Countries
LDCF	Least Developed Countries Fund
LUCF	Land Use Change and Forestry
ODA	official development assistance
MAF	Ministry of Agriculture and Forestry
MAFRA	Korea's Ministry of Agriculture, Food and Rural Affairs
METI	Ministry of Economy, Trade, and Industry of Japan
MONRE	Ministry of Natural Resources and Environment
NAMAs	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plans
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contribution
NTFP	Non-Timber Forest Products
NSEDP	National Socio-Economic Development Plan
OECD	Organisation for Economic Co-operation and Development
PoNRE	Provincial Office of Natural Resources and Environment
PPCR	the Pilot Program for Climate Resilience
REDD+	Reducing Emissions from Deforestation and forest Degradation
SCF	Strategic Climate Fund
SCIRO	Commonwealth Scientific and Industrial Research Organisation
SREP	Scaling-Up Renewable Energy Program
UN	United Nations
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

Chapter 1

Climate Change Vulnerabilities and Socio-Economic Impacts in Southeast Asia: A Framework for Assessing Vulnerability and Education for Autonomous Adaptation

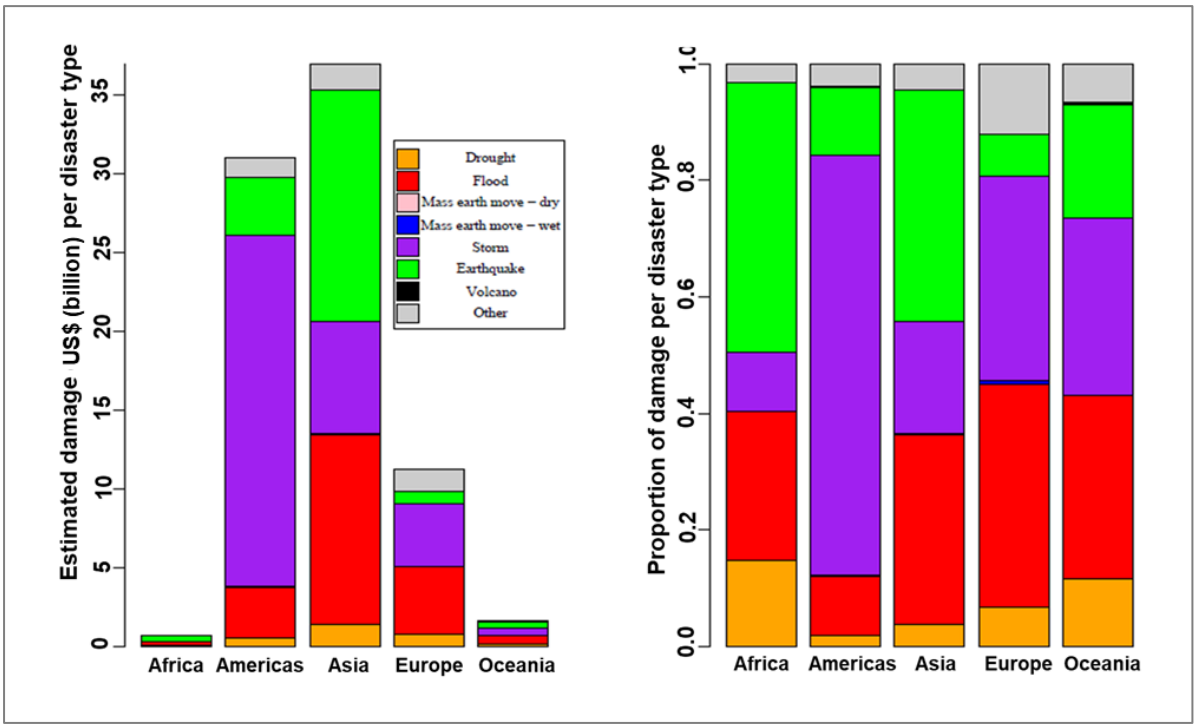
Venkatachalam Anbumozhi, Koji Hachiyama, Citra Endah Nur Setyawati, and Nava Manickam

1. Introduction

Climate change is becoming a major challenge to economic development. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment report stated that 'warming of the climate system is unequivocal, as is now evident from observations of increases in global temperatures, widespread melting of glaciers, and rising sea level' (IPCC, 2022: 24). Increases in temperature could lead to lower crop yields in many parts of the world, which will increase flood risks, alter trade routes, and reduce water supply, while several hundred million people may face permanent displacement due to rising sea levels.

In terms of the economics of climate change in Asia, the agriculture, water, and health sectors will be the most impacted due to drought, floods, storms, and other climate-induced events (Figure 1.1). According to various studies (ADB, 2009; OECD, 2014), the region will see a 30-centimetre rise in sea level by 2040, which could create about 12% of agricultural production loss due to 193,000 hectares of agricultural land. Along with the 2.6 million tonnes of crop production that could be lost annually owing to saltwater intrusion, export revenue could fall by $1.22 billion because of the loss of 295,000 hectares. Cultivars cannot tolerate the climate stress caused by the abrupt influence of weather fluctuation and alterations. The level of production will be significantly impacted by the temperature increase above the threshold value.

Figure 1.1. Impacts of Climate Change and Climate-Induced Natural Disasters
(US$ billion)



Note: Average annual damage caused by reported natural disasters from 1900 to 2010.
Source: Modified from Centre for Research on the Epidemiology of Disasters (CRED) (n.d.), The International Disaster Database (EM-DAT). https://www.emdat.be/ (accessed 17 January 2023).

Climate change affects the poor disproportionately. Environmental, socio-economic, and health factors that contribute to climate vulnerability vary widely within the ecological zones. Rural people, who comprise nearly 67% of the population in Southeast Asia, are particularly vulnerable due to their dependence on rain-fed agriculture and other climate-sensitive natural resources such as non-timber forest products. Improved planning and appropriate investments in climate change adaptation are needed to safeguard the livelihoods of local communities and the economic development of the region.

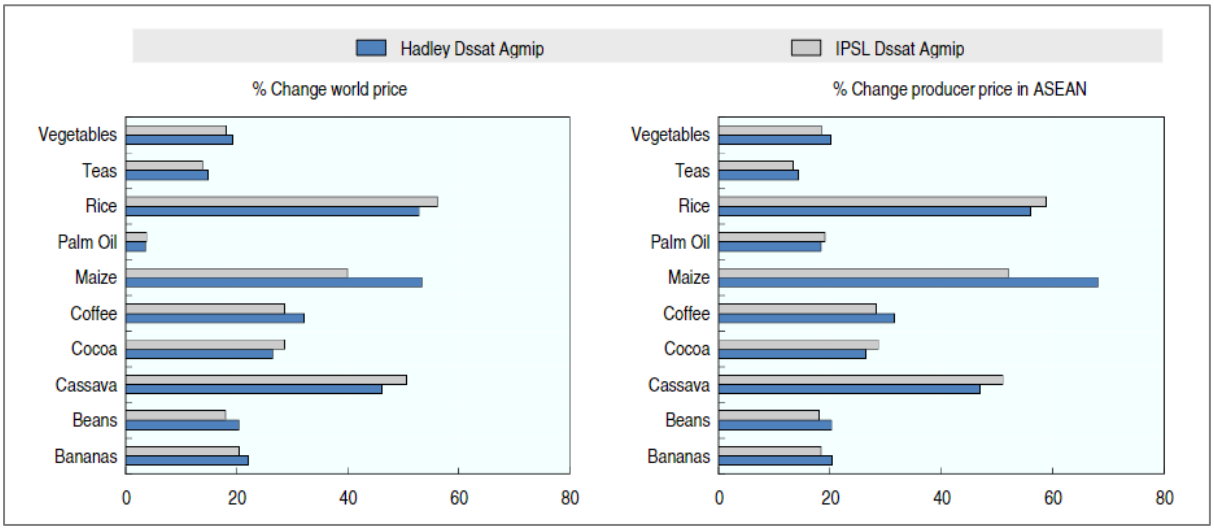
2. Concepts in Assessing the Impact of Climate Variability

Globally, two concepts are employed in studying and practising climate change: vulnerability and adaptation. According to UNFCC (n.d), vulnerability to climate change refers to 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes'. Vulnerability can also be considered as the underlying exposure to damaging shocks, perturbation, or stress, rather than the probability or projected incidence of those shocks themselves. In simple terms, vulnerability can be understood as the likelihood of being harmed. For example, a coastal community is more vulnerable to sea level rise and cyclones than a community located further from the coast. Similarly, an agriculture-dependent

community is more vulnerable to droughts and floods than a community with more access to non-farm income opportunities. The vulnerability of an individual, community, or system to climate change is determined by three components:

(i) Exposure. Biophysical impacts of climate change, which can vary in magnitude, frequency, and duration.
(ii) Sensitivity. Degree to which a system is affected, either adversely or beneficially, by climate variability or change.
(iii) Adaptive capacity. Ability or potential of a system to respond successfully to climate variability and change.

Figure 1.2. Climate Vulnerability and Its Impact on World Food Prices



Source: OECD (2017).

As shown in Figure 1.2, it has been established that the interrelated factors of interregional commerce, food security, and climate change may negatively impact countries' efforts to achieve the Sustainable Development Goals (SDGs), mainly due to an increase in vulnerability (Breiling and Anbumozhi, 2020; OCED, 2009). Climate change impacts, such as higher temperatures, floods, droughts, and altered pH, have increasingly disrupted the food supply chain as well as food production and processing, harming its availability and accessibility. The increased number of disasters has impacted food security by affecting food production, availability, and prices globally while restraining industrial trade policies. Additionally, increased trade leads to higher rates of consumption and economic growth as well as carbon dioxide emissions. Regarding intra-regional trade, several nations rely on imports and exports to maintain their food supplies. With more wealth and a rise in food demand, this can encourage export-focused economic growth. The supply of food at a regional level may also be impacted by such national regulations.

3. Adaptive Capacity for Building Resilience Against Climate Change

The IPCC (2022:34) defined adaptation as 'initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects'. In essence, climate change adaptation is about reducing vulnerability to future climate risks. Vulnerability can be eased by decreasing exposure to future impacts and risks, reducing sensitivity, and increasing adaptive capacity to deal with future impacts and risks. Adaptation measures may be infrastructure-based (e.g. building a sea wall) or ecosystem-based (e.g. mangrove rehabilitation to mitigate storm surges). These measures can be complemented by actions focusing on information sharing, capacity building, and policy improvement (e.g. changes in land zoning laws), sometimes referred to as 'soft' adaptation.

Adaptation is also defined as a process of coping with the potential impacts of climate change, and encompasses both planned and reactive autonomous strategies. Although the adaptive capacity is naturally strengthened through greater resources and socio-economic development of a country, it also comes with factors such as experience and knowledge. Current climate policies adhere to a management approach, where planned adaptation is central. Such a top–down climate change policy is necessary for all countries. However, for developing countries that have limited financial and technological resources, a stakeholder-negotiated autonomous adaptation approach that builds on existing knowledge systems, local coping strategies, and international support is crucial.

Table 1.1 explores the different practices that have evolved as autonomous adaptation in Southeast Asia. These strategies include modifying cropping calendars and patterns, altering farming management, intercropping, and crop rotation, as well as diversified farming. Additionally, heat-resistant cultivars have been used in crop strategic planning. Index-based insurance, early warning system creation, and irrigation efficiency improvement at the local and regional levels through proactive testing and autonomous execution have all been widely implemented.

Table 1.1. Climate Change Adaptation Measures in Southeast Asia

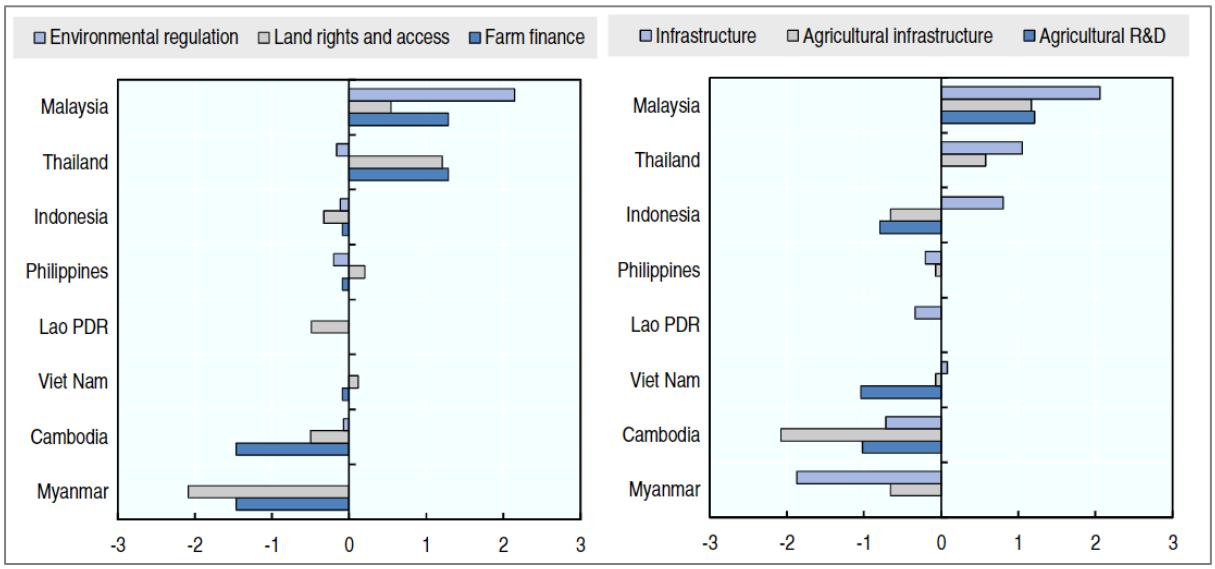
Practice	Scale	Reactive/ Proactive	Planned/ Autonomous	Example
Adjustment of cropping calendar and pattern	Local	Reactive	Autonomous	Widely used
Changes in management and farming techniques	Local	Reactive	Autonomous	Widely used
Use of heat-resistance varieties	Local/Subregional	Proactive	Autonomous	Widely used
Diversified farming, intercropping, crop rotation	Local	Proactive	Autonomous	Widely used
Utilisation of SOI in designing cropping strategy	Local/Subregional	Proactive	Planned	Indonesia
Implementation of index-based insurance	Local/Regional	Proactive	Planned	Thailand, Viet Nam
Development of early warning systems	Local/Regional	Proactive	Planned	Philippines, Thailand, Viet Nam
Improvement of irrigation efficiency	Local	Reactive	Planned	Viet Nam

SOI = Southern Oscillation Index.
Source: Authors.

Outside Southeast Asia, along with planned adaptation, the provision of climate information has considerably benefited adaptation strategies that focus on a 100% decrease in vulnerability. For instance, in China, farmers were given drought-resistant varieties and taught how to use water-saving techniques. In India, government employees were trained to gather climate data and incorporate them in their planning decisions. Shelters were built in Bangladesh in reaction to recurrent cyclones, while vegetative buffers such as mangroves were used to protect the coastal zone in Fiji.

As illustrated in Figure 1.3, according to OECD (2014), Malaysia has the highest levels of agricultural research and development (R&D) and infrastructure, followed by Thailand, in terms of policy areas of innovation that have increased productivity and resilience. Myanmar appears to have the least innovative agricultural infrastructure policies.

Figure 1.3. Effects of Policy Innovations on Climate Resilience in Southeast Asia



R&D = research and development.
Source: OECD (2017).

4. Climate Assessment Approaches to Identify Autonomous Adaptation Pathways

Various approaches may be taken in assessing climate change impacts, adaptation, and vulnerability, including impact assessments, vulnerability assessments, adaptation assessments, integrated assessments, and risk management-based assessments. The integrated approach is a simplified way to understand the current risk and vulnerability of communities and to use climate projections as information to determine risk and vulnerability. The future context is based on the expected consequences of ongoing and foreseeable development plans and socio-economic changes, as well as the changing future climate. Based on the understanding of vulnerability in a plausible future context, adaptation is then formulated as a strategy that can be mainstreamed into local development plans. Emphasis on mainstreaming ensures that development plans do not increase vulnerability, while achieving the SDGs and related targets under the current and future climate, based on currently available knowledge.

In Southeast Asia, many climate shocks have been found to cause various forms of psychosis – a health impact on the general population due to climate change-related disaster incidents such as hurricanes and wildfires. The shock initiates the damage that is inflicted upon either a community or a population of individuals. The specified harm to

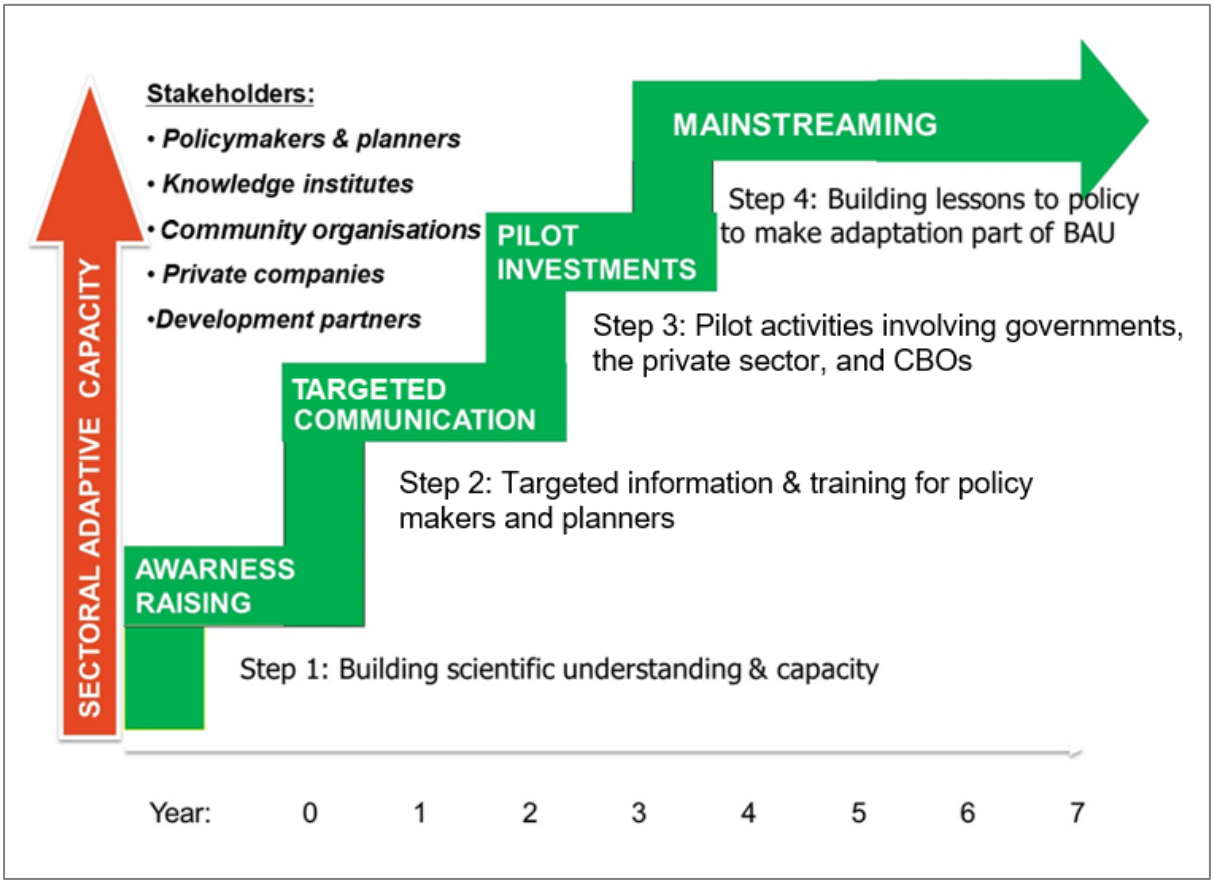
the community or person can be broken down into various forms of indirect impacts. Psychological harm alters the natural psychological well-being of the person or community. If the psychological harm persists, it may take the form of a clinical diagnosis or psychosis. Certain diagnoses are common in people who survive natural catastrophes.

Autonomous adaptation may be defined as measures that do not constitute a conscious response to climatic stimuli but are triggered by ecological changes in natural systems and by market or welfare changes in human systems at the community level. An integrated approach to the assessment and development of autonomous adoption plans has the following steps: (i) assessing the current socio-economic context, which involves the collection of data on communities' basic socio-economic conditions, agricultural production, and livelihood strategies; (ii) assessing the current risk and vulnerability to significant shocks and the interlinkages of agricultural, water, and health systems within communities; (iii) formulating a plausible scenario for communities by assessing the potential consequences of foreseeable changes in socio-economic conditions, based on an analysis of development plans and changes in key climate risks; (iv) assessing the future risk and vulnerability, focusing on understanding how a community's vulnerability profile might change in the new climate and socio-economic context; and (v) formulating an autonomous adaptation strategy, by identifying an adaptation strategy that could help communities minimise future vulnerability.

5. Challenges in Mainstreaming Climate Change Adaptation into Sectoral Adaptation Plans

Mainstreaming autonomous adaptation into sectoral planning has the potential to improve the resilience of development outcomes, contribute to more efficient use of resources, and avoid investments that unintentionally lead to maladaptation. Adaptive capacity building at the sectoral level could take several years, as indicated in Figure 1.4. This figure shows how the difference between various levels of target and acceptable limits can be narrowed collectively to recover capacity utilisation in a relatively short period.

Figure 1.4. Four Steps in Building Adaptative Capacity at the Sectoral Level



BAU = business as usual, CBO = community-based organisation.
Source: Authors.

The four-step process – developing scientific understanding, communicating the scientific information to planners and communities, implementing pilot projects, and upscaling optimised in a modular way – can help planners and sectoral experts (i) assess vulnerability; (ii) draw up plans that increase resilience; (iii) protect investments from climate risks; (iv) conduct economic and feasibility analyses of adaptation efforts; and (v) implement, monitor, and evaluate these initiatives. The four-step process to enhance sectoral adaptive capacity involves a concerted effort to develop decision-making capacity: increasing awareness and understanding; focusing on communications; training policymakers; executing pilot projects with governments, the private sector, and community-based organisations (CBOs); and developing lessons to mainstream policies to make adaptation part of business as usual. Policymakers, planners, research institutions, CBOs, private businesses, and development partners will be the primary stakeholders involved in this process.

Although the uptake of tools and these steps is increasing in Southeast Asian countries, few CBOs and local governments use the full range of mainstreaming tools in their day-to-day functioning. Greater effort is needed to incentivize, support, and build the capacity

of line ministries to move beyond vulnerability assessments to the planning, implementation, and evaluation of mainstreaming efforts.

Mainstreaming climate change faces further issues. Due to a knowledge gap, public understanding is lacking and uncertainty is prevalent regarding economic impacts and climate change science. Because of this capacity gap, there are insufficient structural and non-structural measures as well as inadequate human resources. Additionally, financial inequalities have grown because of poor public and private financing, which is exacerbated by costlier adaptation.

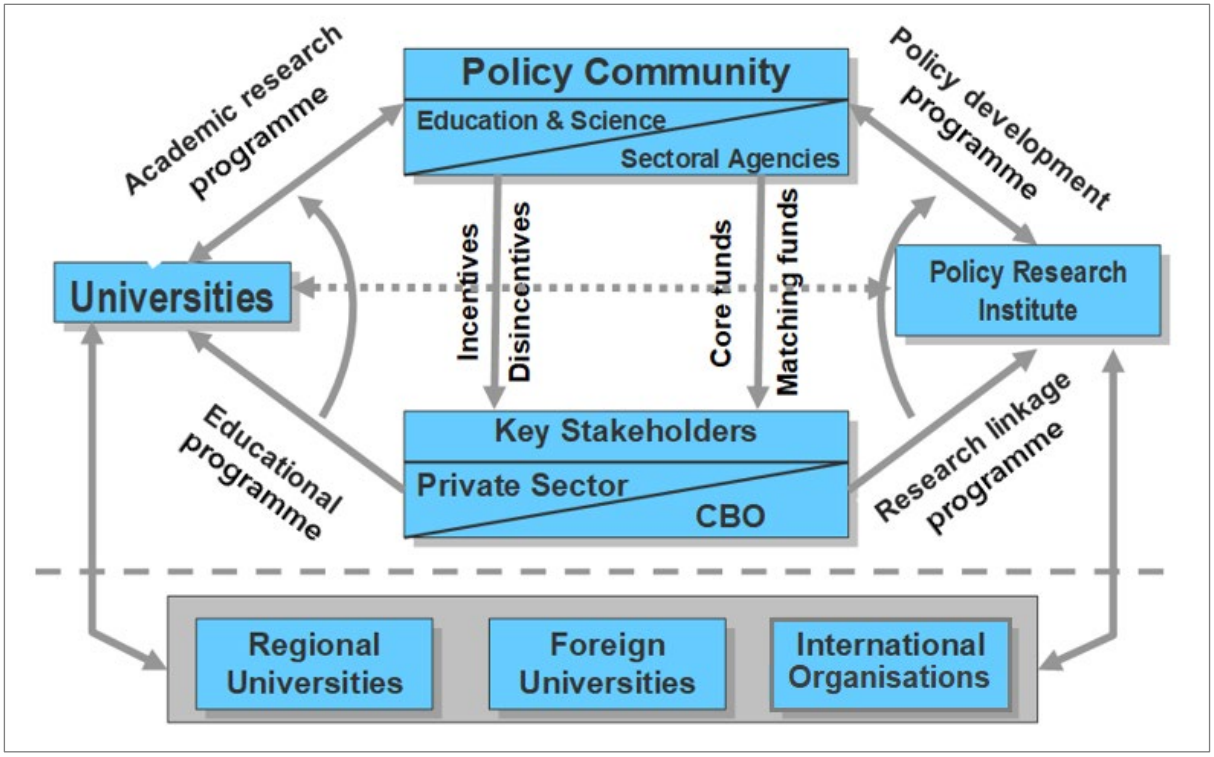
6. Education for Autonomous Adaptation

Efforts to mainstream autonomous adaptation or even planned adaptation measures into sectoral policies have been slow to translate into robust actions – undermining the ability to prepare Southeast Asia's most vulnerable populations and communities for the climate risks that lie ahead. A review of more than 100 published cases of mainstreaming efforts found that although most addressed mainstreaming in policies and plans, only half reported concrete projects and activities (Runhaar et al., 2017). Since mainstreaming requires coordination amongst multiple actors, institutions, and processes, the journey from a plan on paper to action on the ground can be slow. Research suggests that key barriers to implementing mainstreaming efforts include lack of education, inadequate coordination amongst stakeholders, and sustained commitment.

To tackle knowledge or information barriers, many obstacles must be overcome and significant resources are needed. The most common difficulties encountered include lack of horizontal and vertical information flows as well as inadequate monitoring, reporting, and accountability relating to the risk of catastrophes and other climate change objectives. An imbalance in data supply and demand needs to be corrected to support mainstreaming at all levels of government, particularly in local governments, which do not generate, manage, or utilise information in an optimal manner.

This suggests the need to develop the ability to adapt in gathering, analysing, and disseminating local-level disaster and climate data to all stakeholders, with effective management and application of climate information. Along with producing and exchanging such data across multiple sectors and other subnational stakeholders or ministries, it is essential to enable public access to research material and reports. This could be carried out by a network of knowledge institutes in charge of achieving these objectives. Figure 1.5 illustrates such an educational network.

Figure 1.5. Educational Network for Upscaling Autonomous Adaptation



CBO = community-based organisation.
Source: Authors.

As a result, several networks have been established through different universities and research policy institutions, including regional, foreign, and international organisations, to promote and increase education on climate-related concerns. Several policy communities for education and science communication have also been included, as have important stakeholders from the corporate and public sectors. Various academic research, educational, research linkage, and policy development projects have been organised as a result, with specific incentives and funding made available.

To mainstream decision-making, various obstacles must be overcome and certain skill sets are needed. Short-term views, strategies, and programmes that disregard long-term perspectives create gaps and difficulties. Most planning is done based on the budget, without enough supporting data. Few procedures have been established for involving stakeholders in planning, which limits the potential for international collaboration and the exchange of quality standards for mainstreaming resilience.

To decentralise policy formulation and planning to improvise vertical communication, the matching capability of institutions must be tailored and integrated into decision-making systems and procedures. To institutionalise such multi-perspective planning and analysis, some systems require sectoral and integrated planning. Indicators, networks, communities, and data sets can be developed to support procedures for mainstreaming evidence-based planning.

Utilising specific risk management methods to evaluate, minimise, and manage such residual risks enhances adaptive capacity. This incorporates crucial elements such as identifying the known or present dangers by tying them to local expertise and technical analyses. Regular updates to risk data are required, together with scenario planning and management of uncertainty. After that, it is possible to evaluate the catastrophic risk when developing the supply chain, minimising potential exposures and fixing current vulnerabilities. Therefore, residual risks can be controlled through techniques such as risk pooling and contingency planning.

Education for autonomous adaptation also involves a cycle of risk assessment, prevention, preparedness, reaction, and recovery in sectoral planning and decision-making. A better risk-based strategy entails several activities, including monitoring, reviewing, communicating, and consulting.

Mainstream elements such as finance also face several difficulties and capacity constraints. The difficulties include lack of funds and insufficient private sector investment to pursue mainstreaming and choices for resilient infrastructure. This highlights the need to enhance sectoral agencies' ability to convey the significance of mainstreaming at the political level. Utilising links and evidence-based resource prioritisation on allocation and investment creates the capability for investment packages that may be leveraged to generate co-benefits. Most of the corporate sector can be involved in the creation of SDG policies and programmes. This may result in improved incentive programmes and the capacity to interact with private sector interests.

7. Moving Towards a Climate-Resilient ASEAN

Various analysis methods have led to an understanding of the options available for climate change adaptation. Despite making headway in several sectors, the Association of Southeast Asian Nations (ASEAN) has not been able to accomplish autonomous and planned adaptation. To address the problem's fundamental cause, it is necessary to understand how to put these concepts into practice in a coordinated manner. Despite broad consensus on the building blocks that must be in place, several have been challenging to establish or implement on a regional or sectoral scale.

There are four ways to achieve successful cross-sectoral coordination: (i) establishing a national platform, with the head of state serving as chair and providing high-profile leadership; (ii) creating subcommittees within the organisation; (iii) demonstrating political commitment by informing the head of state of the resilience situation; and (iv) publishing white papers. Budget allocation; seconding staff to other ministries, and receiving or recruiting staff from other ministries; and decentralisation from national to local governments are also part of the plan to achieve adequate resilient capacity at the national level.

Enhanced resilience is based on four pillars of (1) expanding the frontiers of climate information, (2) improved decision-making capacity, and (3) increased finance, which are attained through (4) regional cooperation.

Drawing on the evolving policies and practices, the papers in this book – the proceedings of the workshop – suggest ways that countries can close the implementation gap on those three fronts. Country case studies and expert insights identify several areas where countries can work together, like a set of gears, to help accelerate the move from climate change commitments and plans towards implementation.

The following is a summary of the key messages from the chapters.

(i) Autonomous planning for climate-smart development requires a move away from a 'predict then act' approach towards a 'no-regret' approach. The latter calls for an understanding of the drivers of vulnerability and investments in resilience that would be justifiable under a wide range of climate scenarios or even in the absence of climate change. The 'no-regret' approach does not depend on detailed climate projections.

(ii) The vulnerability of supply chains, economies, and local communities to climate change must be considered in a broader socioeconomic context. As climate change may unfold over decades, economic and trade-related changes may have a larger impact on communities in a much shorter timeframe, potentially changing the vulnerability context completely. It is crucial that climate change vulnerability assessments analyse economic, environmental, and social development dynamics.

(iii) To inform and implement adaptation planning, a climate vulnerability assessment framework should be as practical as possible. Such a framework should be accessible to diverse users and applicable to local contexts. This requires a balance between the use of climate information to frame the context and a simple step-by-step approach that enables non-technical practitioners to apply the framework to identify projects in a people-centric adaptation setting. A framework that does not incorporate scientific information is less robust, while one that is not pilot tested may be less cost-effective and not replicable, especially for community-level application.

(iv) Coordination mechanisms across sectors and amongst government departments, such as interministerial steering committees or task forces, support shared mainstreaming goals. These systems can cut across policy levels, encompass public and private institutions, and encourage ongoing public engagement.

(v) Supportive financial processes encourage decision-makers to consider climate risks as well as identify, track, and cover costs to adapt. These processes could include expenditure-tracking initiatives, budget-tagging efforts, and special funds that governments establish to support autonomous adaptation and climate mainstreaming.

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Chapter 2

Modernising Infrastructure in the Agriculture Sector: Climate Change Vulnerability and Adaptation

Hyeon Tae Kim and Jayanta Kumar Basak

Increasing farm production by improving productivity and efficiency to meet the growing food demand is crucial. At the same time, concerns regarding climate change, environmental sustainability, and labour shortage must be considered. Governments worldwide are, therefore, working to solve this issue by implementing cutting-edge technologies and upgrading infrastructure in the agriculture sector, like smart farming. For instance, the Korean government has already allocated a lot of funds for research purposes to invent and implement advanced technologies and infrastructure for smart farming. Therefore, cutting-edge technologies, including artificial intelligence (AI) applications, are considered for smart farming in the Republic of Korea (henceforth, Korea). Due to the enormous accomplishments of AI and its intelligent analysis tools, the current digital transition in agricultural production is significant. In Korea, production has increased due to the convergence of agriculture and information and communications technology through intelligent analysis, modelling, and enhanced infrastructure management. Additionally, identifying plant and animal activities and behaviours has been accomplished by applying precision agricultural technologies, including biometric sensors, 3D imaging systems, big data, and blockchain technology. Real-time data from biometric sensors are processed and integrated using huge data analytics systems that rely on machine learning algorithms, enabling farmers to use the information as a decision-making tool. Additionally, they are frequently used to monitor disease outbreaks and pandemics associated with food safety and prevent related financial losses. Accordingly, AI-based infrastructure modernisation in the agricultural sector increases productivity and profitability in Korea while also addressing the difficulties brought about by climate change, environmental unsustainability, and labour shortages.

1. Introduction

One of the most significant issues for the world is climate change. It is the condition where the meteorological parameters, such as the average rainfall and temperature values, show significant deviations from the mean values that have been determined over several years (Malhi, Kaur, and Kaushik, 2021a). The last few decades have seen a significant change in the global climate due to increased human activities that changed the atmosphere's composition (Parry et al., 2007). Since 1750, the concentrations of methane

(CH_4), nitrous oxide (N_2O), and carbon monoxide (CO_2) have increased by 20%, 40%, and 150%, respectively (Pachauri and Meyer, 2014). A consequence of the increase in greenhouse gases is the rising temperature of the atmosphere. Probabilistic calculations using the range of climate sensitivity determined by the Intergovernmental Panel on Climate Change predicted that the global average temperature will increase by 2°C by 2100, followed by 4.2°C by 2400 (Malhi et al., 2021b). The increasing temperature trends and changing precipitation patterns will threaten farm productivity severely, which may hamper food security.

Climate change may affect the agricultural sector in many ways, including rainfall variability, increasing temperature, rising intensity and frequency of extreme weather events, ecosystem disturbances, and water availability. Due to the severe effects of climate change, corn and wheat production was predicted to decline by 5.5% and 3.8%, respectively (Lobell, Schlenker, and Costa-Roberts, 2011). Moreover, plants and animals may feel numerous stresses such as heat and cold, salinity and drought, etc. (Malhi, Kaur, and Kaushik, 2021b). The scarcity of fresh water, reduction of soil fertility, and rising pest infestations are the significant undesirable impacts on crops and livestock production (Baul and McDonald, 2015). Therefore, modernising infrastructure in the agriculture sector is one of the best adaptation techniques to cope with the challenges resulting from climate change.

Venkateswarlu and Shanker (2009) classified the main adaptation approaches of mitigation into cropping system technologies, resource conservation technologies, and socioeconomic or policy interventions. These adaptation approaches are somehow closely related to the modernisation of infrastructure in the agriculture sector. Due to the changing climatic condition and huge food demand within limited cropland, farmers in different countries are constantly adapting and implementing new infrastructure in agriculture, mainly information and communications–based technologies. The advantages of the modernisation infrastructure in the agriculture sector are twofold: (i) crop production will increase by maintaining a proper environment within limited cultivable lands, and (ii) it will minimise the difficulties due to labour shortages in the sector. For instance, Korea's 50.4% of the total workforce contributed to agriculture in 1970, whereas it was only 4.8% in 2017, while simultaneously, the agricultural gross domestic product showed an increment of 5.7% per year (Im, 2019) (Table 2.1). At the same time, new technologies and infrastructures have also been introduced in the agriculture sector. Recently, many countries had strategies and targets to improve, develop, and optimise the use of infrastructure in the agriculture sector for increasing productivity and considering the adverse climate change effects in the near future.

Table 2.1. Status of Agriculture in the Republic of Korea

	1970	1980	1990	2000	2017
Total employment (million)	9.6	13.7	18.1	21.2	26.7
Agricultural employment (million)	4.8	4.6	3.2	2.2	1.3
Total land (million ha)	9.84	9.89	9.92	9.94	10.04
Agriculture land (million ha)	2.29	2.20	2.11	1.89	1.62
Agriculture production (KRW trillion)		6.34	17.7	31.97	48.17
Rice		2.18	6.54	10.50	6.62
Livestock		1.27	3.95	8.08	20.12
Fruits		0.25	1.31	2.58	4.74
Vegetable		1.44	3.32	6.74	11.03
Others		1.20	2.61	4.07	5.66

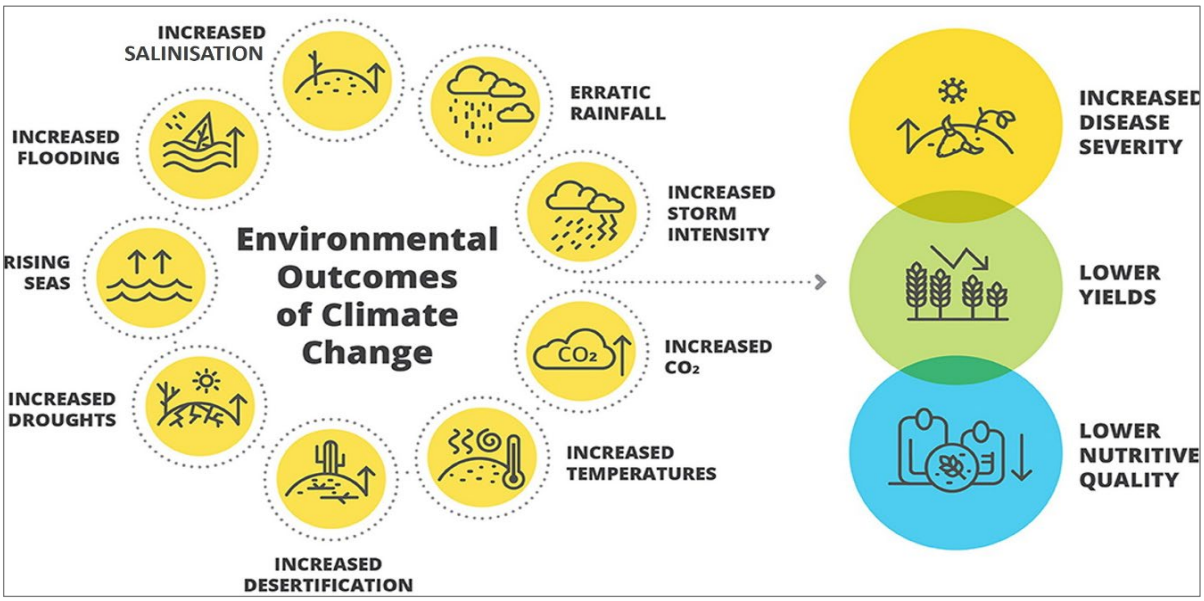
Source: Ministry of Agriculture, Food and Rural Affairs (MAFRA) (2018), Major Statistical Yearbook.

This chapter attempts to deal with modernising infrastructure in the agriculture sector vis-à-vis climate change vulnerability and adaptation.

2. Agriculture and Climate Change

The agriculture sector always suffers from the adverse impacts of weather and climate conditions. The global climatic conditions are changing evidently, and the effects of the changes have started to emerge and will undoubtedly worsen. Rising temperatures diminish yield; however, rising precipitation levels are expected to mitigate or offset the effects of increasing temperatures (Adams et al., 1998). Moreover, photosynthesis and carbon assimilation increase when carbon dioxide (CO_2) concentration rises (Wang et al., 2020). However, concurrently, increased CO_2 causes a decline in the nutritious value of food (Shukla et al., 2009). The crop sector is expected to be most impacted by climate change because of the previously noted rise in extremely high temperatures and rainfall events (Figure 2.1), the shifting incidence, and the spread of diseases (Bett et al., 2017).

Figure 2.1. Climate Change Impacts on Agriculture Production and Food Systems



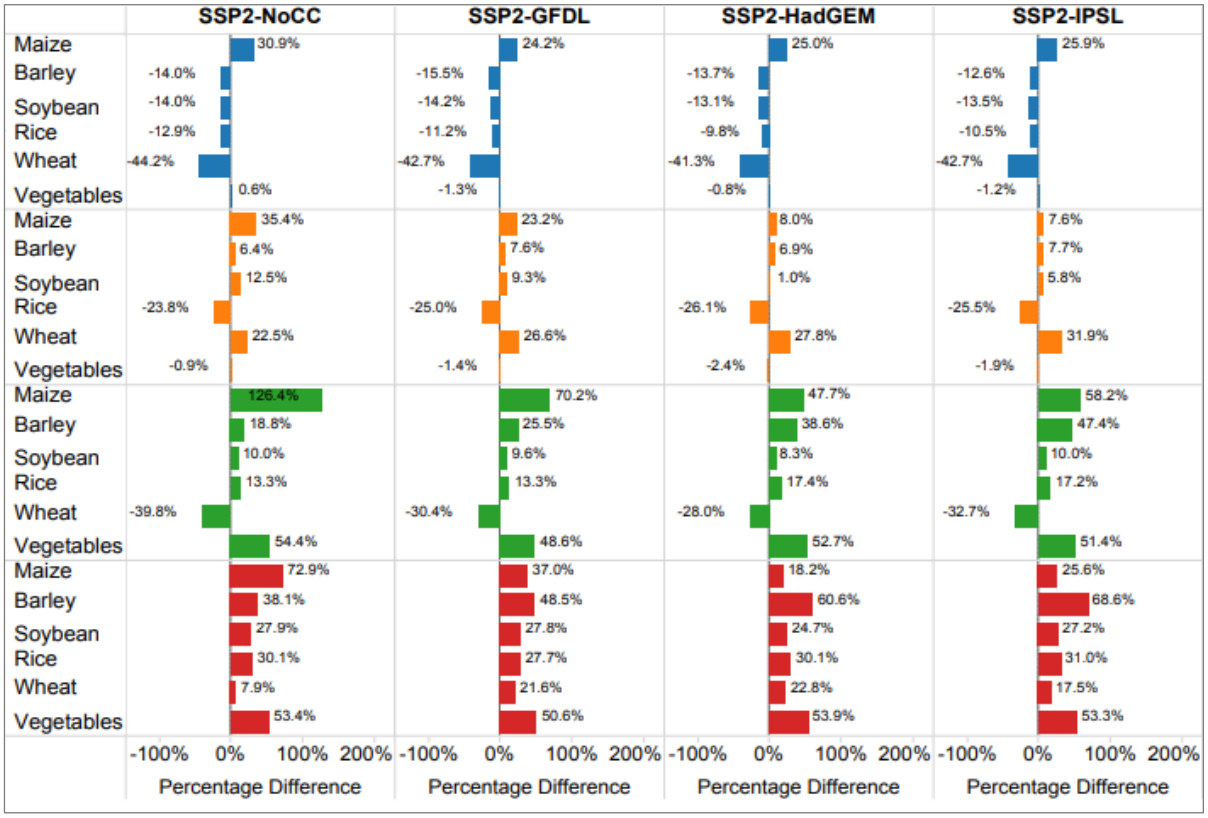
Source: Karavolias et al. (2021).

In Korea's economic growth, the agricultural sector provided capital, land, and labour to the secondary and tertiary industries, which helped economic development and contributed to preserving land and environmental resources. The Korean Climate Change Assessment Report (2014) suggested that the impact of climate change in Korea seems to be accelerating quickly, with temperatures increasing approximately twice as quickly as the global average. The rapidly rising temperature will be emerging as a major threat to crop and livestock production in Korea. The effect of climate change on crop production, mainly on cultivable land and yield, using different climatic scenarios between 2010 and 2050 in Korea is shown in Figure 2.2. Crop models under different scenarios suggested long-term and negative impacts on crop yield in Korea due to climate change. Temperature increases, changes in rainfall patterns, and variations in the frequency and intensity of extreme climatic events have significantly impacted the simulation of those models. In addition, the economic model simulations also proposed that intrinsic productivity growth and market effects can minimise the magnitude of climate change losses when adopting improved technologies and modernising infrastructure in the agriculture sector are considered for crop production.

Beyond crop production, the livestock sector will also experience the negative impacts of climate change. Variations in rainfall patterns and rising temperatures directly impact animals and the crops cultivated for their feed, and the diseases that infect livestock (Rojas-Downing et al., 2017). The most probable and significant effects of rising temperatures on livestock will be the experience of heat stress, affecting the animals with alteration in feed intake, limited weight gain, diminishing reproductive efficiency, and increasing mortality by introducing numerous health issues in many livestock species (Rojas-Downing et al., 2017). This chapter, therefore, focuses on how modernising

infrastructure in the agriculture sector can cope with the effects of climate change while maintaining the importance of applying infrastructure technologies to the totality of production systems threatened by climate change.

Figure 2.2. No-climate-change Reference along with Three Climate Change Scenarios (GFDL, HadGEM, and IPSL), Predicting the Changes in the Harvested Area, Demand, Production, and Yield for Major Crops in the Republic of Korea, 2010 and 2050

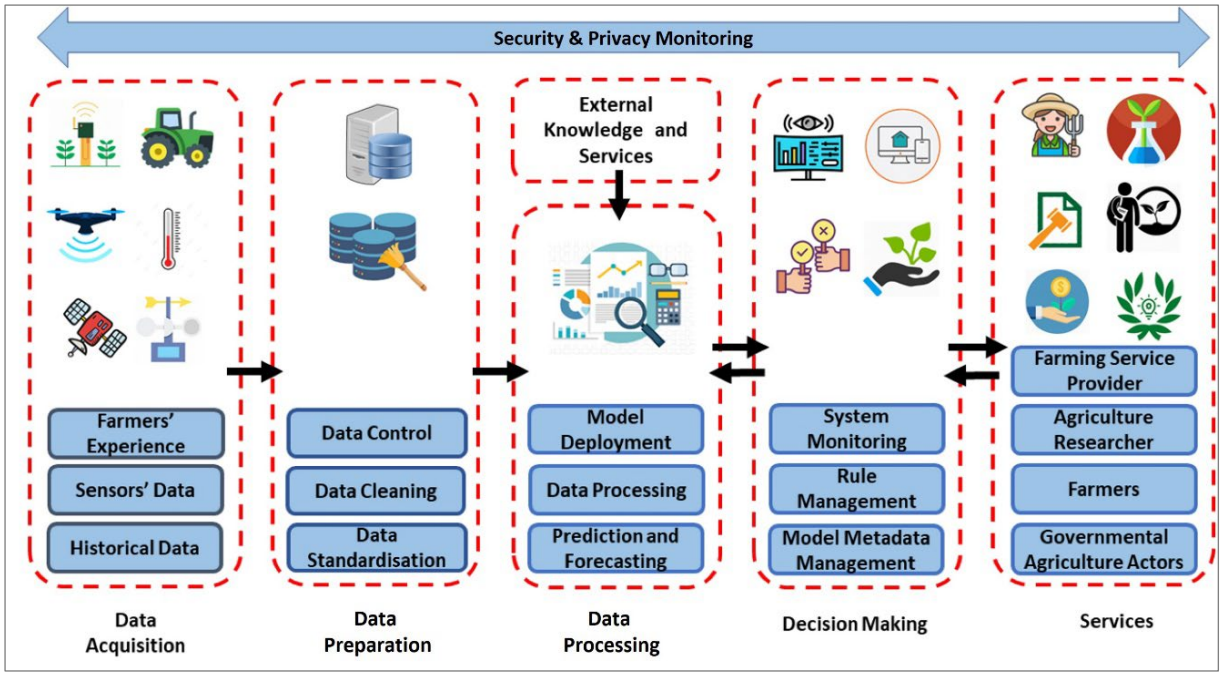


SSP2 = Shared Socioeconomic Pathway 2, NoCC = no climate change, GFDL = Geophysical Fluid Dynamic Laboratory, HadGEM = Hadley Centre's Global Environment Model, IPSL = Institut Pierre Simon Laplace).
Source: Cenacchi et al. (2016).

3. Modernising Infrastructure in Korea's Agriculture Sector

Most nations are working to develop and use cutting-edge technologies in the agriculture sector to improve productivity and profitability while employing the minimum number of natural resources possible. In Korea, modernising infrastructure in agricultural production systems integrates information, data software applications, and technologies to enhance productivity and income. Recently, modern agricultural practices like smart or digital farming have been the most popular and advanced concept in Korea (Eastwood et al., 2019).

Figure 2.3. Farm Data Integration, Processing, and Use: Facilitating Elements for Smart Farming



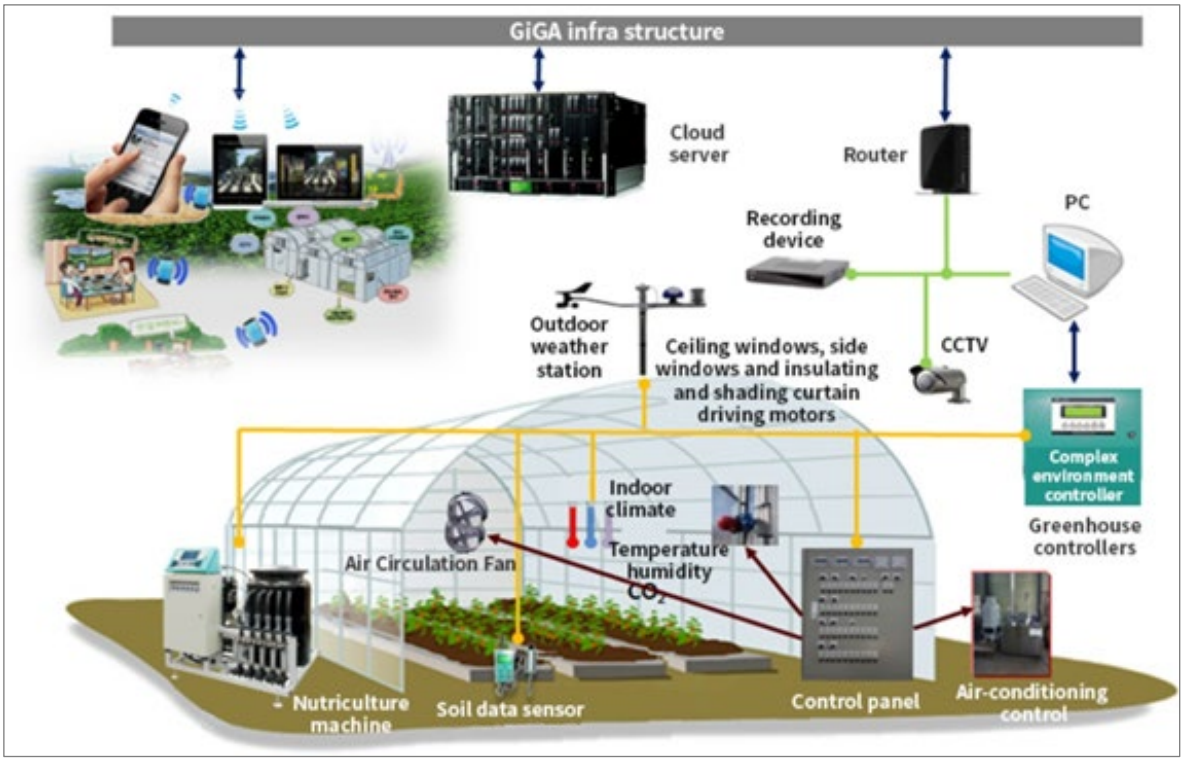
Source: Amiri-Zarandi et al. (2022).

Smart farming facilities employ technologies and information to enhance the efficient and sustainable output from livestock and crop production by optimising farming resources and practices, which get enhanced through the transport systems, marketing, and trading stages of the food supply chain (Idoje, Dagiuklas, and Iqbal, 2021). These smart farming technologies mostly rely on big data analytics and include modern cyber systems, which enable tracking, intelligent prediction, real-time monitoring, autonomous control, and long-term planning. Smart farming practices include cloud computing, geographic information system or GIS technology, unmanned aerial vehicles, satellite images, robotics, and information and communication technologies (ICT). The ICT sector introduces new technology, such as the Internet of Things algorithms, to accomplish modern farming practices effectively and thoughtfully (Boursianis et al., 2022). Additionally, smart farming is anticipated to improve agricultural yield by enhancing nutrient application to the soil and minimising the use of irrigation water and pesticides. Furthermore, the application of smart farming technologies can minimise labour demand and improve productivity and time management. With smart farming practices, the threat of crop failure and loss resulting from climate change could be reduced. However, it requires fast and accurate decisions and actions for proper application in the smart farming system.

Furthermore, one of the biggest challenges to utilising the advantages of smart farm technologies is the lack of integration amongst data, technologies, and data processes. Thus, it needs a common platform that assists farmers in taking the right actions at the

correct time. Thus, the Korean government has been emphasising research on securing essential components and technologies to establish the best smart farm model.

Figure 2.4. Smart Farm Concept in Korea



Source: O'Shaughnessy et al. (2021).

The Korean government wants to expand ICT use in smart farming to increase productivity and quality through teaching, consultation, and follow-up management (O'Shaughnessy et al., 2021). It is also crucial for minimising the effects of climate change on agricultural production. Korea's Ministry of Agriculture, Food and Rural Affairs (MAFRA) has supported these measures by promoting agriculture by modernising agricultural infrastructure, addressing farmer ageing, and supporting new farmers.

By 2022, MAFRA wants to expand support of ICT convergence initiatives in agriculture sectors, including livestock, fruit trees, and facility horticulture development through the Korean smart farm models. A technologically advanced concept is employed to create this Korean smart farm model with various levels (Table 2.2).

Table 2.2. Korean Smart Farm Classification According to Generation

Class	First Generation	Second Generation	Third Generation
Period	Current	The year 2030	The year 2040
Target	Convenience enhancement, 'more convenient'	Productivity improvements, 'low input, high production'	Enhance sustainability, 'everybody with better production with higher quality'
Main function	Remotely controlled facility	Precise growth management	Life cycle intelligence, automatic management
Basic information	Environment factors	plant growth	Production
Core technologies	Telecommunication	Telecommunication, Big data/Artificial intelligence (AI)	Telecommunication, Big data/AI, Robot
Decision-making/control	Human/Human	Human/Computer	Computer/Robot

Source: Adopted from O'Shaughnessy et al. (2021); Yoon et al. (2017).

4. Modernising Infrastructure to Address Climate Change Adaptation in the Agriculture Sector

Modernising production systems in the agriculture sector through smart farming techniques may help with adaptation plans for climate change effects. Notably, carbon pricing and technology policy in modernising production systems in the agriculture sector is essential for implementing effective climate change adaptation practices. Climate Smart Agriculture is also an approach towards the smart farming model. Using the smart farm model, farmers can plan to choose the crop for maintaining net profitability using real-time information and utilise the decision support models, along with precision management, during extreme climatic events like drought, floods, heat, or cold stress.

The Korean government developed a strategic plan for achieving carbon neutrality by 2050 to cope with the devastating effects of climate change. The goal is to integrate digital advancements with green technologies to enhance their Digital New Deal and Green New Deal programs more effectively (Lee and Woo, 2020). Green innovation includes promoting farmers to use low-methane feeds for livestock and improved irrigation in agriculture production, expanding clean energy to enhance energy use efficiency. It also integrates recycling waste, commercialising carbon removal techniques, and increasing carbon sinks by reforestation with better forest management.

Moreover, there are several adaptation practices to minimise the severe threats of climatic risks in the agriculture sector using climate-smart farming technologies. Some common agricultural technologies and practices, including minimum tillage operations, different cropping practices, and residue assimilation, can improve nutrient and water use efficacy and reduce the emission of greenhouse gas from agricultural activities (Sapkota et al., 2015). Table 2.3 summarises some important applications of smart farming practices, which can increase agricultural productivity concerning climate change effects.

Table 2.3. Smart Farming Applications to Improve Agricultural Productivity

Smart Farming Practices	Adaptation/Mitigation Potential with Specific Examples
Water management ▪ Cover crops method ▪ Furrow irrigated bed planting ▪ Drip irrigation ▪ Drainage management ▪ Rainwater harvesting ▪ Laser land levelling	Initiatives in improving water use efficiency ▪ Field levelling ensures uniform water distribution and reduces water loss in the field. ▪ It provides more effective drainage, irrigation, and monsoon rainwater management, which improves nutrient uptake efficiency. ▪ Collection of rainwater in monsoon season and allowing to apply during irrigation period for agricultural purposes ▪ Direct irrigation of crops' root zones to reduce water loss ▪ The water control structure can remove the excess water in the field. ▪ Reduce the soil moisture loss due to evaporation.
Energy management ▪ Minimum/Zero tillage	Initiatives in improving energy use efficiency ▪ Decrease the amount of energy used for land preparation. It enhances soil organic matter retention and water infiltration in the long term.
Nutrient management ▪ Intercropping with legumes ▪ Green manuring ▪ Leaf colour chart ▪ Site-specific integrated nutrient management	▪ Initiatives in improving nutrient use efficiency. ▪ Cultivation of legumes in mixed or alternate rows with other major crops. Both the soil's quality and nitrogen supply are enhanced by this method. ▪ Legume crop cultivation in the cropping system improves the nitrogen supply and soil quality. ▪ Determine the amount of nitrogen required on the field based on the crop's greenness. ▪ Optimal soil nutrients supply over space and time can fulfil the requirement of the nutrient demand

Smart Farming Practices	Adaptation/Mitigation Potential with Specific Examples
	of crops at the right time and place with the right amount.
Carbon management ▪ Concentrate feeding for livestock ▪ Integrated pest management ▪ Agroforestry ▪ Fodder management	Initiatives in reducing GHG emissions ▪ Reduce nutrient losses and require less feed for livestock. ▪ Encourage the sequestration of carbon through sustainable land management. ▪ Reduce the use of chemicals in farm production.
Weather management ▪ Crop insurance ▪ Climate-smart livestock housing and crops ▪ Weather-based crop agro-advisory	Initiatives that offer farmers weather advisories and services connected to economic security. ▪ Insurance is specifically designed to cover crop losses caused by weather events. ▪ Livestock and crop protection from severe climate threats, such as cold and heat stress ▪ Climate and weather information to the farmers based on agro-advisories.
Knowledge sharing ▪ Improved crop varieties ▪ Improved livestock breeding ▪ Seed and fodder banks ▪ Contingent crop planning	Combined use of scientific and local knowledge ▪ Improved livestock and crop breeds that can tolerate severe climatic events like droughts, floods, and heat and cold stresses. ▪ Climatic risk management plan to cope with significant climate contingencies such as floods, droughts, heat, and cold pressures. ▪ Seeds and fodders conservation to mitigate the climate risks.
AI and ICT application ▪ Better management of agricultural inputs ▪ Disease/vector surveillance and ▪ monitoring ▪ Better assessment of ▪ climate change vulnerability	Application of AI and ICT in the adaptation process ▪ ICT with AI applications such as GIS and remote monitoring can provide improvement in management practices and monitoring of resources. ▪ Reduce the disease and pest infection of plants and animals through real-time monitoring. ▪ Climate models can predict climate change's impact in agriculture sectors as well as suggest a good decision-making process and raise awareness.

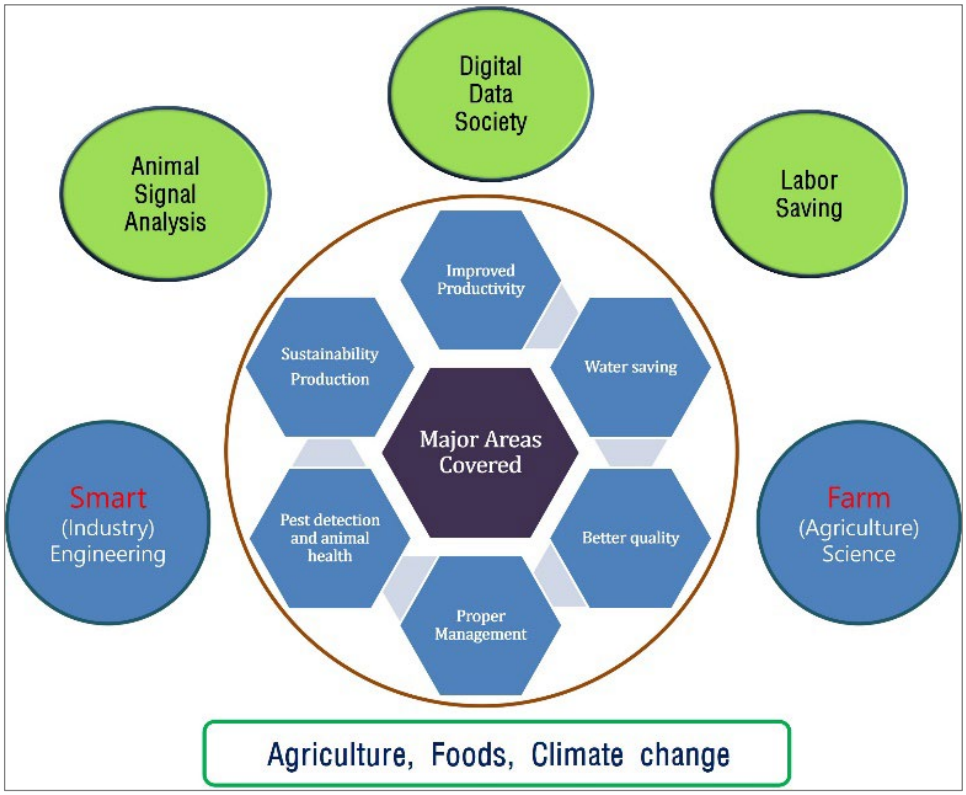
Smart Farming Practices	Adaptation/Mitigation Potential with Specific Examples
▪ Early warming and response	▪ Rapid data gathering and analysing for prioritised decision-making and proper management practices.
Adaptation strategies	Intervention to manage climate change impacts
▪ Climate change adaptation strategies	▪ Reduce agricultural inputs by encouraging best management methods. ▪ Reduce the risk of entire production failure. ▪ Predict future crop/meat demands. ▪ Create carbon sequestration credit programs.

AI = artificial intelligence, GHG = greenhouse gas, GIS = geographic information system, ICT = information and communications technology.
Source: Adopted from Khatri-Chhetri et al. (2017); O'Shaughnessy et al. (2021).

5. Concluding Remarks and Policy Implications

This chapter discussed the difficulties of the agricultural sector in ensuring food and nutritional security, which are becoming more severe due to climate change. Many uncertainties concerning the future climate change scenarios and the possible impacts on agriculture production may hamper agricultural productivity in the coming years. The two primary consequences of climate change, mainly rising temperatures and variability precipitation, have a range of impacts on the agriculture sectors. Due to changing climatic conditions, their impacts on production systems, and huge food demand within limited cropland, governments in different countries always adapt and implement new modernisation infrastructure in the agriculture sector, mainly information and communications-based technologies. Recently, modern agricultural practices like smart farming are the most popular and advanced concepts in Korea, which may also help with adaptation plans for coping with climate change.

Figure 2.5. Policy Guidelines for Climate Change Adaptation



Source: Authors.

Several potential adaptation practices can be used to reduce the negative influences of climatic change in the agriculture sector using climate-smart agricultural technologies. In this chapter, we summarised some important technologies in smart farming applications that may improve agricultural productivity regarding climate change vulnerability and adaptation/mitigation potential with specific examples. These technologies may substantially minimise the effects of climate change on crops and livestock sectors and make them more appropriate to the climate by reducing unfavourable impacts. However, adapting technologies, procedures, and protocols are the key challenges in applying smart farming practices. The chapter suggests developing a common platform approach employing fundamental requirements to enhance collaboration amongst various services in a smart farming system. Moreover, an integrated approach is necessary to address the many challenges ASEAN countries are currently confronting, including food shortages, environmental degradation, and the effects of climate change. The challenges and several measures are recognised. Now is the moment to face reality and respond quickly to address those problems to move in a sustainable, inclusive, and resource-efficient way. In the basic framework of climate change adaptation by modernising infrastructure in agriculture sectors, the following issues should be included: (i) develop smart farm technology trade-off between ASEAN countries as an initiative for ensuring food security; (ii) protect agriculture production from the rapid climate change factors through microclimate controlled farming practice;

(iii) collect and correlate the various environmental and growth parameters data using AI-based analysis to make intelligent climate controllers; and finally (iv) apply intelligent control system for environmental and nutrients management that maintain an optimum environment through big data based AI decision-making systems.

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Chapter 3

Climate Change Vulnerabilities, Social Impacts, and Institutional Strengthening through CACCI: Frameworks and Lessons from Tajikistan*

Suresh Babu, Sino Tohirzoda, Nandita Srivastava

This chapter highlights climate change challenges in the Asian region and their impact on food systems. With the aim to promote transformation in food systems, it presents a conceptual framework that discusses different integration aspects within agriculture innovation systems. Climate-smart agriculture is recognised as a key integration dimension from the perspective of achieving the Sustainable Development Goals, including zero hunger. Given this backdrop, the chapter identifies critical capacity-related challenges in the Association of Southeast Asian Nations (ASEAN) countries concerning climate change adaptation and mitigation. A solution in the form of the Comprehensive Action for Climate Change Initiative in Asia (CACCI-Asia) of the United States Agency for International Development (USAID) is presented, which addresses different dimensions of the recognised capacity gaps. The initiative aims to strengthen capacity for country-level policy modelling and analysis, enhance multi-stakeholder coordination and engagement, and create a stronger evidence base by developing institutional, regulatory, tracking, and reporting capacity and leadership for implementation of Nationally Determined Commitments and National Adaptation Plans, under the Paris Agreement. To

* The core ideas for this chapter were presented at an inception workshop held in Dushanbe, Tajikistan, in August 2022, titled 'Implementation of Climate Change Commitments in Tajikistan'. It was organised by the Committee for Environmental Protection (CEP) under the Government of the Republic of Tajikistan, in cooperation with the United States Agency for International Development (USAID) Mission to the Government of the Republic of Tajikistan and its technical partner, the International Food Policy Research Institute (IFPRI). The ideas were also presented at a workshop titled 'Climate Change Vulnerabilities, Social Impacts, and Education for Autonomous Adaptation'. This workshop was organised by the Department of Climate Change, the Ministry of Environment, Cambodia, and the Economic Research Institute for ASEAN and East Asia (ERIA) in Cambodia on 12–14 September 2022. Inputs from the workshop participants are reflected in this chapter.

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illustrate the support provided under CACCI, Tajikistan is presented as a case study where CACCI is currently implemented.

1. Introduction

Climate change has led to a rise in global temperature and heat waves. It has resulted in losing livelihoods and increased vulnerability due to extreme events such as floods, cyclones, droughts, and climate-related food and waterborne diseases (Intergovernmental Panel on Climate Change [IPCC], 2022). This paper highlights the impact of climate change on the agriculture sector in the Asian region. It discusses a conceptual framework focusing on different integration aspects within the agriculture innovation framework for food systems transformation. Climate-smart agriculture is highlighted as an important integration aspect. The chapter identifies key challenges in implementing nationally determined contributions (NDCs) by ASEAN countries and proposes a solution in the form of a recently implemented initiative of the United States Agency for International Development (USAID), the Comprehensive Action for Climate Change Initiative in Asia or CACCI-Asia. The case study of Tajikistan, where the CACCI is being implemented, is presented.

Across the globe, the food security challenge is intensified by agriculture's extreme vulnerability to climate change. Increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops, and pests contribute to reduced crop yields, nutritional quality, and livestock production. Events such as droughts affect the crops and livestock sub-sectors disproportionately relative to all other sectors of the economy, resulting in food insecurity and hunger crisis. The rise in the frequency of severe extreme climate events is disrupting supply chains, especially in low-income countries. Given this, climate adaptation is becoming central to the future of food. Climate adaptation refers to changes in processes, practices, and structures to moderate potential damage or benefit from opportunities associated with climate change. Investments in climate adaptation solutions take many shapes and forms, depending on the unique context of a community, business, organisation, country, or region. Substantial investments in adaptation and mitigation innovations and technology will be required to maintain yield levels, achieve food demand, and enhance food quality. Agriculture also contributes to rising climate change by generating greenhouse gas (GHG) emissions. Thus, action is required to address this and related food loss and waste (World Bank, 2021; FAO et al., 2022). The USAID's Strategy for Climate Change 2022 and President Biden's Emergency Plan for Adaptation and Resilience or PREPARE highlight the need for urgent action. Some critical aspects of the USAID strategy focus on mitigation, adaptation, country support, and finance support (USAID, 2022).

Due to the rising adverse effects of climate change, world leaders at the United Nations (UN) Climate Change Conference (COP21) in 2015 reached an agreement, also called the 'Paris Agreement, a legally binding international treaty to set long-term goals to guide all

nations on addressing climate change issues (UN, 2021a). At COP26 in 2021, countries reaffirmed the Paris Agreement goal of limiting the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5 °C. Countries stressed the urgency of action 'in this critical decade'. Countries acknowledged that climate change is having increasing impacts on people, especially in the developing world. One of the major objectives set by COP26 was to build defences, warning systems, and resilient infrastructure and agriculture to avoid loss of homes, livelihoods, and even lives (UN, 2021b). As a follow-up to the goals set out by COP26, the recent COP27 aims to make crucially needed progress and urge all parties to demonstrate the necessary political will if we are to capture and assess our progress towards enhancing resilience and assisting the most vulnerable communities. Since its launch at COP26, the Global Methane Pledge has gained momentum. The pledge focuses on voluntary actions to contribute to a collective effort to reduce global methane emissions by at least 30% from 2020 levels by 2030, which could eliminate over 0.2˚C warming by 2050. This is a global reduction target. The pledge has received growing political and financial support, landmark national methane plans and policies, and major new initiatives are driving action in energy, agriculture, and waste (Global Methane Pledge, 2022). Another crucial decision was establishing new funding arrangements and a dedicated fund to assist developing countries in responding to loss and damage (UNFCCC, 2022a). COP27 recognised that the world's agriculture sector is increasingly vulnerable to climate change-rising temperatures, heat waves, droughts, floods, changes in rainfall patterns, and extreme events that affect agriculture more than any other sector. Given this, a new initiative – Food and Agriculture for Sustainable Transformation (FAST) – was launched in November 2022 by more than 20 agriculture ministers and the Egyptian COP27 presidency. The programme aims to step up finance to transform agriculture, contribute to adaptation efforts, and pursue the Paris Agreement's 1.5°C global warming limit while supporting economic and food security (UNFCCC, 2022b).

2. Conceptual Framework: Integration Aspects

Governments across the globe face interconnected challenges such as improving livelihoods; tackling climate change; mitigating biodiversity loss; and addressing food insecurity, shortages, and waste, which are often dealt with in a disjointed manner (OECD, 2019). In this regard, the Agriculture Innovation Systems (AIS) approach provides the opportunity to integrate a subset of innovation entities in agriculture with the policy and institutional environments and then connect them to the larger investment strategies and frameworks at the national levels (World Bank, 2012).

Poor coordination of policies and investments within the AIS constitutes a significant challenge in enhancing food systems' innovation, productivity, and sustainability. In this regard, the International Food Policy Research Institute (IFPRI), in collaboration with the Food and Agriculture Organization (FAO), has reviewed available guidelines and frameworks for strengthening integrated policies and investments across sectors within

AIS. This includes a review of existing frameworks and analysing several existing country experiences. Based on this effort, an analytical framework has been developed identifying critical aspects of integration within AIS to accomplish food systems transformation. These include political economy integration, institutional integration, monitoring and evaluation framework integration, market system integration, and global integration. The framework also provides questions to consider within each integration aspect to ensure that these aspects are fully integrated into broader AIS (FAO and IFPRI, 2019). Climate-smart agriculture is an important aspect of AIS as it offers the opportunity to focus on sustainably increasing agricultural productivity and incomes; building resilience and adapting to climate change; and reducing and removing GHG emissions, which is in line with one of the targets of Sustainable Development Goal 2 (FAO, 2021). Tables 3.1 and 3.2 highlight the overall and specific integration of AIS aspects from the food systems transformation perspective.

Table 3.1. Conceptual Framework: Broader Integration Aspects

Policy Integration
Policy domain (innovation systems/natural resource management/digital/agricultural research)
Overview of the innovation
Geographical classification (global/regional/national)
Thematic area (examples: overall innovation policy, digital, extension, ICT, and natural resource management)
Development status of the nation (developed/developing)
Sector initiating the innovation (public, private, PPP, IGO, NGO)
Is this policy integrated with the general innovation framework of the country?
Is the policy backed by investment?
Was any ex-ante assessment done to understand the level of need for the innovation?
Were any pre-sensitisation activities conducted before the launch of the policy/initiative?
Supporting Mechanisms Integration
Are there any initiatives for filling infrastructural gaps/improving infrastructure?
Are there any initiatives to access information and skills training/education?
Are there any initiatives to improve technologies and technology access?
Are there any initiatives to improve natural resource management?
Are there any initiatives to improve access to key inputs?
Are there any initiatives to address regulatory barriers/improve regulation enforcement?

Political Economy Integration
Is there political will to implement the policy/initiative?
Are there any transparency and accountability mechanisms?
Is there state capacity, including budget and technical capacity, to implement the policy/initiative?

ICT = information and communications technology, IGO = intergovernmental organisation, NGO = nongovernmental organisation, PPP = public–private partnership.
Source: FAO and IFPRI (2019).

Table 3.2. Conceptual Framework: Specific Integration Aspects

Risk Management Integration
Are there any initiatives for climate-smart agriculture?
Are there any initiatives for resilience building (including disaster management)?
Is agroecology integrated?
Are there any initiatives for risk management (production, sale, and price risk)?
Monitoring and Evaluation Framework Integration
Is the policy/initiative inclusive?
Are targets /indicators for policy/initiative performance clearly defined and measurable?
Institutional Integration
Are there initiatives to improve human and technical capacity at the institutional level to implement the policy?
Are the roles and responsibilities of all involved institutions clearly defined?
Are there initiatives to integrate agriculture research and innovation into the Agriculture Innovation Systems (AIS)
Are there initiatives to improve/ensure coordination across institutions integrated into the policy?
Are there initiatives to improve access to credit and insurance?
Market System Integration
Are there initiatives to improve access to farmers/sellers to potential local buyers?
Does the policy provide any price-setting mechanism?
Value Chain Integration
Is investment integrated across the value chain?
Global Integration
Is there investment integration to ensure that domestic products are recognised and competitive in global markets?

Nutrition Integration
Are there initiatives to ensure the integration of nutrition/health priorities in the policy?
Aquaculture and Forestry Integration
Are there initiatives to ensure the integration of aquaculture and forestry?

Source: FAO and IFPRI (2019).

One of the critical integration aspects that is part of the framework is 'risk management'. Aside from including mechanisms to address production, sale, and price risk, it focuses on integrating climate-smart agriculture, resilience building, and agroecology to strengthen AIS. Relatedly, natural resource management, such as sustainable land use management, minimises biodiversity and mitigates climate change–related impact while achieving the goal of zero hunger (OECD, 2020). Resilience building for climate change–related disaster risk reduction and disaster management is also necessary to create sustainable AIS policies and programmes, which can withstand shocks. Integrating climate-smart agriculture investments across the value chain and improving market access will enhance market competitiveness. Alongside building the capacity of relevant stakeholders to conduct high-quality research and analysis to create sustainable solutions and produce high-quality research that can help create sustainable solutions, the government should also develop a policy system that incentivises stakeholders to undertake climate-smart initiatives. Since AIS is a multi-stakeholder system, institutional integration through effective coordination is critical. A monitoring and evaluation system should also be developed to track the progress made through initiatives within AIS.

3. Climate Change Challenges in the Asian Region

Asian countries are highly susceptible regions to climate change. Countries like Myanmar, the Philippines, and Thailand have suffered massive fatalities and economic losses because of climate-related disasters. Industrialisation based on fossil-fuel energy and the loss of tropical forests and peatlands rich in biodiversity-associated land use are critical contributing factors to this rise in greenhouse gas (GHG) in the region. The Association of Southeast Asian Nations (ASEAN) region's energy-related GHG emissions are predicted to increase by 34%–147% between 2017 and 2040. Southeast Asia also faces a natural capital crisis – an estimated 48% of mangroves were lost in 1996–2020 and projected 50% of forest cover will be lost by 2050 at current deforestation rates. Expected costs incurred from damage related to climate change will be much larger than the investments needed to mitigate such damage. While countries in the region have made efforts to mitigate emissions and build adaptive capacity to climate-related disasters, major areas for improvement still exist (Ding and Beh, 2022; ASEAN, 2022; ADB, 2022).

In the most updated nationally determined contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC), many ASEAN countries

have set more ambitious carbon emission reductions conditional upon assistance from advanced economies (Martinus and Jiahui, 2022). But major challenges continue to exist. Since climate risks are not systematically integrated into sector-specific plans, climate-related investments are not prioritised. The limited availability of information on local climate vulnerabilities reduces the impact of adaptation measures. Other important challenges include low awareness of green technologies, regulatory uncertainties, and insufficient finance. Besides, there is a limited capacity to identify and design green projects and a lack of technical capacity to assess and mitigate climate risks from projects (ADB, 2022).

A 2021 report by ASEAN highlights that lack of capacity is a crucial challenge in meeting NDC-related goals for ASEAN countries. Some of the critical capacity-strengthening dimensions in this regard are the following:

- ❖ administrative, legal, technical, and institutional capacity building
- ❖ collaboration between the national and local governments and the private sector
- ❖ policy design and readiness support for the implementation of NDCs (e.g. measurement, reporting, and verification; data collection, processing, and management for GHG); modelling of climate, climate change, and mitigation; carbon pricing; enhanced mainstreaming of climate change into national and subnational policies, including through climate action planning tools such as climate risk screening and climate budgeting)
- ❖ developing a coherent policy

Given these challenges in the region, a comprehensive roadmap is required to ensure the fulfillment of the NDCs. The next step discusses a USAID-funded initiative that can potentially support addressing the capacity gaps to meet climate change–related goals in the region.

4. Solution: CACCI Approach

In this regard, as part of their commitment to addressing climate change challenges, Asian countries submitted their NDCs and have developed national adaptation plans (NAPs) that identify strategies to meet their NDCs. USAID supports Asian countries in translating their commitments into specific activities through CACCI-Asia. CACCI aims to strengthen coordination between key stakeholders involved in NDC implementation; enhance evidence-based policy process and investment analysis for climate change; and develop tracking, measurement, and reporting systems to analyse the status and progress on climate change measures.

Governments in Asia have recognised the importance of sectoral strategies in their NAPs and are developing interventions to achieve their mitigation and adaptation goals. Asian countries are in different stages of implementing their NDCs and NAPs. Overall, this

initiative will create transformational policies, strengthen human capacity, and improve institutional infrastructure towards a net-zero carbon Asia that is food secure and resilient to climate change (USAID, 2022).

The following broad activities are planned as part of the project:

- Accelerate action to tackle the climate crisis through collaboration between governments, businesses, and civil society. The first activity maps the policy system, partners, institutions, resources, and stakeholders involved in NDC implementation.
- Through consultative workshops and processes, strengthen institutional capacity for national-level coordination for NDC implementation, including project development, a national network of partners, resource mobilisation, and policy and strategy integration.
- Promote innovation and strengthen the analytical capacity of the network partners in generating evidence for the project and programme design through specific skill development workshops, including policy analysis and preparing evidence-based programming for NDC implementation.
- Develop a strategy for a prototype monitoring, tracking, and reporting system by compiling the existing data sources and developing a dashboard for real-time progress reporting.

5. Case Study: Tajikistan

The demand for natural resources from Tajikistan since the collapse of the Soviet Union has increased, resulting in increased pressure on agricultural lands, reduced forest cover and wildlife populations, soil degradation, biodiversity loss, and an overall reduction in the adaptive capacity of the ecosystems (WFP, 2017; Vakulchuk et al., 2022). High dependency on climate-sensitive sectors like water resources and relatedly the agriculture sector, makes the country extremely vulnerable to climate change and climate-induced events (CAREC Institute, 2022). Climate change has also adversely impacted food and nutrition security and overall population health (USAID, 2021). The NDC Implementation Roadmap 2020–2030, which sets out a clear pathway for the execution of concrete mitigation and adaptation actions leading to emission reductions and increases resilience against climate change over time to protect sectors like agriculture and promote sustainable food systems. It guides stakeholders on the activities necessary to achieve the NDC targets by the envisaged deadlines (Government of the Republic of Tajikistan, 2022).

Several donors and nongovernmental organisations – including the Asian Development Bank; the European Union; the Food and Agriculture Organization; the German Agency for International Cooperation or GIZ; Swiss Agency for Development and Cooperation; United Nations Development Programme; World Bank; Foreign, Commonwealth & Development Office; Green Climate Fund Global Environment Facility; and the Adaptation Fund – have

invested in climate-smart agriculture projects in the country. Project-focus areas include an integrated landscape approach to enhancing the climate resilience of small-scale farmers and pastoralists, planting material systems, investing in horticulture centres, and strengthening the public capacity for crisis prevention, transboundary landscape restoration, and integrated pasture management. Other important focus areas are climate adaptation in rural regions with modern information technology, geodata management, building a measurement, reporting, and verification system, and strengthening the capacity to support the government in developing its economy-wide or sector-specific GHG reporting programmes. Conducting community-based disaster risk management activities, developing village disaster management, and installing early-warning systems have also been happening in the country.

The USAID Mission in Tajikistan and the International Food Policy Research Institute (IFPRI) will support the following activities under CACCI-Asia:

- To establish the NDC Secretariat, provide technical assistance and directly work with the national institutions, including the Committee for Environmental Protection (CEP) under the Government of the Republic of Tajikistan and the Ministry of Finance
- Strengthen the evidence generation, project development, coordination, resource mobilisation, monitoring, and tracking capacity of the NDC Secretariat through already-established partnerships and stakeholders
- Facilitate a consultative process for developing multisectoral collaboration and coordination in establishing procedures, policies, and plans required to deliver NDC goals in line with the national and sectoral development objectives
- Provide technical support in conducting in-depth analysis for generating policy options to address medium- and long-term challenges to monitor policy implementation
- Support the deployment of an in-country facilitator to support the coordination and implementation of NDC-related issues

With support from CACCI, an NDC Secretariat was established under CEP. It will support the government in implementing the NDC by providing administrative support through coordination, documentation preparation, monitoring, and reporting of the NDC implementation status. It will also ensure that the information generated is transparent, accurate, consistent, comparable, and complete. It will provide a coordination link between the country's international funds for climate change and the necessary support for NDC implementation (Government of the Republic of Tajikistan, 2022).

The activity on mapping relevant actors and players, which supports NDC implementation, was also completed. This is the first step to understanding the technology and innovations regarding climate change adaptation and mitigation in various sectors, including agriculture. It also highlights the specific roles and responsibilities of stakeholders. It also

discusses vital interventions, coordination mechanisms, and interlinkages between stakeholders in the country.

As a next step, under CACCI, several consultative workshops and processes are planned to strengthen institutional capacity for national-level coordination for NDC implementation. Additionally, workshops are being planned to strengthen the analytical capacity of the network on policy analysis and prepare evidence-based programming for NDC implementation.

6. Conclusion

The Association of Southeast Asian Nations (ASEAN) region is significantly vulnerable to climate change–related adverse impacts. Agriculture is one of the important sectors in the region significantly impacted by climate change–related shocks. While adaptation and mitigation measures have been taken to address these challenges, capacity remains weak at the policy, institutional, analytical, and monitoring and tracking levels.

This chapter provides a conceptual framework highlighting several integration dimensions within agriculture innovation systems for food systems transformation. These integration dimensions relate directly to addressing climate change challenges and building resilience. The framework highlights that aside from focusing on specific risk management and natural resource management initiatives, it is also essential to consider institutional, capacity, monitoring and evaluation, and policy-related integration dimensions. With this background, the chapter discusses the USAID-funded CACCI-Asia initiative, which provides a comprehensive solution to the challenges experienced by ASEAN countries regarding climate change action–related capacity gaps in the analytical, policy, institutional, and coordination levels. Some strategies highlighted as part of CACCI focus on supporting the design and implementation of NDCs and national adaptation plans (NAPs) by building institutional, analytical, and stakeholder coordination capacity and developing a monitoring, evaluation, and mutual accountability infrastructure to track progress towards targets and commitments. The initiative is already underway in Tajikistan. Based on consultative meetings, the project is expected to expand to Cambodia, the Lao PDR, Thailand, and Viet Nam in the ASEAN region. In the future, support from regional bodies like the ASEAN Secretariat, national-level ministries, and other stakeholders will be sought.

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Chapter 4

Climate Vulnerability Assessment and Agriculture Sector Adaptation

R. Jagannathan

Climate change is considered to be one of the important phenomena given attention globally because it influences every sector. A region's climate is the average of atmospheric variables, which decide its fauna and flora and related development. Various internal and external factors started influencing the climate, resulting in a considerable change in the atmosphere, thus, affecting the normal behaviour of the ecosystem. This created inequality amongst countries in their livelihood worldwide and would worsen if the climate-influencing factors are brought to their original level or sustained at a level acceptable for the well-being of humankind. This leads us to assess the vulnerability because of a change in the climate, thereby understanding the extent of its influence and finding ways towards adaptation. This chapter analyses the vulnerability assessment scenario and possible adaptation in the agricultural sector.

Understanding a few terms used in this article is needed to overcome the misconception problem. Firstly, the terms 'weather' and 'climate' are attributed to atmospheric phenomena in which the former refers to the conditions of the atmosphere at a particular place and at a given point of time while the latter refers to the average state of the atmosphere typically for 30 years as defined by the World Meteorological Organization (Prasad Rao, 2008). For example, Jakarta's recorded maximum temperature of 33^{o} Celsius (C) on 11 November 2022 is referred to as weather, while the average (30 years) maximum temperature of the same place is 32.8^{o}C for 11 November is referred to as climate. Climate change refers to a significant and persistent change in the mean state of the climate, driven by changes in the earth's environment. A rise in global temperature of nearly 1^{o}C compared to the pre-industrial period is a typical example of the term 'climate change'. This is often confused with 'climate variability', which refers to the range of fluctuations around long-term climatic conditions, i.e. variations in the state of climate typically depend on natural drivers. The year-to-year variation in receipt of rainfall without any significant change over some regions of the globe is an example of climate variability. Sometimes even the media translates and reports climate change as seasonal change, which is only a part of climate change.

The Intergovernmental Panel on Climate Change (IPCC) is an independent body established under the auspices of the World Meteorological Organization and the United Nations Environment Programme. The three working groups associated with the IPCC assess the scientific literature and provide vital scientific information to the climate

change process. The information generated by climate modellers for the historical and future periods and impact studies based on them form the basis for the reports brought out by the IPCC. The IPCC had submitted six reports (FAR, SAR, TAR, AR4, AR5, and AR6) until 2021, which were made available to the public. The climate modellers use the scenarios recommended by the IPCC for their predictions, which are done for the past, present, and the future. The term 'forecast', a subset of prediction, is used for anything predicted for the future. Here, we need a set of initial conditions of current situation to run the model to get the forecast. The predictions done for the past are termed 'hindcast'. However, in climate studies, we use 'projections', which is a probabilistic statement that something may happen in the future if certain conditions develop. This set of conditions often termed 'boundary conditions' used in conjunction with making a projection is often called a 'scenario', and each scenario is based on assumptions about how the future will develop.

The IPCC, which assesses the scientific, technical, and socioeconomic information relevant to understanding the risk of human-induced climate change, suggests these scenarios to the scientific community for ingesting them as boundary conditions in their models. Only in the last three assessment periods – AR4 released in 2007 had Special Report on Emission Scenario, AR5 released in 2014 had Representative Concentration Pathways, and AR6 released in 2021 employed Shared Socioeconomic Pathways. Further details on these scenarios can be obtained from various IPCC websites. The climate projections are developed using the global climate models (GCMs) by the scientific community worldwide. These projections were run in supercomputers, and the outputs were made available through the IPCC portals hosted in different nodes of the researchers involved in the network. The horizontal resolution of the GCMs is coarser, usually more than 100 kilometres (km) (Table 4.1). However, the scientific community involved in impact studies requires finer-resolution data sets for their analysis. This requirement paved the way for downscaling methods, such as using regional climate models (RCMs) for dynamic downscaling and/or employing different statistical techniques. The author and his team at Tamil Nadu Agricultural University, Coimbatore, India, used RCMs (RegCM4) and downscaled AR4 and AR5 models for impact studies in agriculture (Table 4.1) to a resolution of 25 km x 25 km. These data sets can then be used in the impact of climate change on the future yields of crops using crop simulation models and for understanding a region's vulnerability to the changing climate.

Table 4.1. Resolution of Global Climate Models Used in AR5 Assessment Report

GCM	Resolution (Degrees)	Institute
GFDL-ESM2M	2.0 X 2.50	Geophysical Fluid Dynamic Laboratory
HadGEM2-ES	1.25 X 1.875	Hadley Centre, UK Met Office
CCSM4	0.9424 X 1.25	National Centre for Atmospheric Research, USA
MIROC5	1.4 X 1.4	Japan Met Agency, Japan
MPI-ESM-MR	1.865 X 1.875	Max Plank Institute, Germany

Source: Authors.

1. Vulnerability Assessment

Many global studies have established that the productivity of crops, livestock, and fish will likely have negative implications for food security, livelihoods, and sustainability in agriculture. The changes in mean climate over a region and the associated variability expected therein have been observed to affect the growth and productivity of crops and livestock. Though, in general terms, rising temperature and or declining rainfall will adversely affect agricultural productivity, there can be certain exceptions, such as increasing temperature in the temperate hilly regions may help improve the productivity of crops. The impacts of rising temperature on crop yields are stronger than the positive impacts of rising atmospheric CO_2 levels (Jayaraman, 2011), the latter being often referred to as the carbon fertilisation effect. Many crop simulation studies indicated that crop yields are decreasing for future climate change without any adaptation.

Adapting to changing circumstances is necessary to deal with climate change in every sector, such as agriculture, infrastructure, urban planning, and public health (Wamsler, 2015). The adaptation response can be effective by mainstreaming or integrating into the existing development programmes or developing dedicated climate change–focused programmes. Both ways need information on what to adapt to and how to adapt; more specifically, information on what future climate will look like in terms of changes in temperature, rainfall patterns, etc., as well as the conditions or features of the system of interest that predispose to climate change impacts. Such an analysis, a useful initial step in adaptation planning, is called vulnerability analysis (Rama Rao et al., 2019).

Vulnerability is the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards. The same is indicated by the IPCC (2013) in terms of climate change vulnerability as the susceptibility of a species, system, or resource to the negative effects of climate change and other stressors. Vulnerability is seen as the residual impact and framed as a result of sensitivity, exposure, and adaptive capacity and considered as components for vulnerability assessment. The first two dimensions of vulnerability determine the potential impact, which will be

moderated by adaptation, a manifestation of adaptive capacity. The term 'sensitivity' is the ability or propensity of the system to be adversely or positively affected by an external shock such as climate change, referred to as 'exposure'. Adaptive capacity, a precursor to adaptation, refers to the ability of the system to respond to climate change to avoid or minimise the impact and is a function of factors such as wealth, technology, education, skills, infrastructure, access to resources, etc. (McCarthy et al., 2001).

Need for Vulnerability Assessment (Rama Rao et al., 2019)

- Assessing the vulnerability of any sector to climate change is the prerequisite for developing and disseminating adaptation technologies.
- Planning and decision-making need this information to prepare strategies for addressing the adverse impacts of climate change.
- This will also help identify vulnerable regions for allocating resources.

The IPCC conceptualises the vulnerability framework differently in its reports, viz., AR4 and AR5. Rama Rao et al. (2019) suggested that the relationship between three risk components – vulnerability, hazard, and exposure – is more explicit and policy-relevant. Thus, they considered the AR5 vulnerability framework closer to the disaster management conceptualisation, which is regarded as more appropriate in the context of climate change. Results of vulnerability assessment obtained by adopting the IPCC AR5 framework are more helpful in reducing current vulnerability in preparedness to deal with an uncertain future (Sharma and Ravindranath, 2019).

Vulnerability is one of the components of risk, as pointed out under the AR5 paradigm, and the remaining components of the risk are 'exposure' and 'hazard'. Vulnerability encompasses sensitivity and adaptive capacity as its elements. Some terms associated with vulnerability, as brought out in AR5 (IPCC, 2013), are presented below for understanding.

Risk refers to the potential for consequences where something of value is at stake, and the outcome is uncertain, recognising the diversity of values. Risk is often represented as the probability of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

Vulnerability is the propensity or predisposition to be adversely affected. It encompasses various concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Hazard is the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems,

and environmental resources. Hazard also refers to climate-related physical events or trends or their physical impacts.

Sensitivity refers to characteristics of a species or system dependent on specific environmental conditions and the degree to which they will likely be affected (e.g. temperature or hydrological requirements).

Adaptive capacity is the ability of a species to cope and persist under changing conditions through local or regional acclimation, dispersal or migration, adaptation (e.g. behavioural shifts) and/or evolution.

Impact primarily refers to the effects of extreme weather, climate events, and climate change on natural and human systems. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific period and the vulnerability of an exposed society or system.

The vulnerability assessment requires various data sets like atmospheric, demographic, bio-physical, socioeconomic, etc., either from secondary sources or primary collection through samples. Atmospheric data downscaled from climate models or otherwise can be used for bio-physical parameters by simulations. The data thus collected is further utilised for vulnerability analysis.

2. Vulnerability Assessment Steps

The Indian subcontinent took many initiatives for vulnerability assessment to address climate change for adaptation planning. The Indian Institute of Technology and Indian Institute of Science at the national level made a climate vulnerability assessment (Dasgupta et al., 2019) following a common framework in which they indicated the steps adopted. The Centre for Climate Change and Disaster Management, Anna University, Chennai, Tamil Nadu, was also part of the assessment. Pavithrapriya and Ramachandran (2022) also made a similar attempt to assess the district-wise vulnerability of Tamil Nadu, India. Their work was taken as a case study for understanding how the vulnerability assessment is being made. Each step is described below with the work conducted by the case study authors.

(1) Setting the scope

Every assessment and case study should set the scope 'to calculate vulnerability indices, rank the districts with these indices, and highlight the drivers of vulnerability'.

(2) Selection of the type of vulnerability assessment

Here we need to indicate the type of assessment to be done and if the case study authors did an 'integrated vulnerability assessment' (based on bio-physical, socioeconomic, and institution and infrastructure–related vulnerability indicators).

(3) Selection of tier methods

Three tier methods are described based on the source of data used. Tier 1 uses only the secondary data, Tier 2 uses a mix of primary and secondary data, while Tier 3 employs only primary data. In the case study, they used only secondary data; naturally, they selected Tier 1.

(4) Selection of sector, spatial scale, community/system, and period of assessment

Here we need to indicate which sector you are assessing, the spatial scale, which is the community/system involved, and the period for which the vulnerability assessment is to be made. The assessment covered the farming community or the agricultural sector from 2011 to 2020, with the district serving as the spatial scale.

(5) Identification, definition, and selection of indicators for vulnerability assessment

Indicators must be identified based on our need, sector, etc. Further selection must be made; hence, the expertise of the persons involved in the relevant field is important. The case study here used socioeconomic, bio-physical, institutional, and infrastructural factors, and the associated indicators were selected. The details of indicators for each aspect are given separately below the description of the assessment steps.

(6) Quantification and measurement of indicators

All indicators were quantified using secondary data sources.

(7) Normalisation is based on the indicators' functional relationship with risk

Normalisation is done based on the indicators' functional relationship with vulnerability. The following formula is used for positively related indicators, i.e. where vulnerability increases with an increase in the indicator's value.

$$x^{P}_{ij} = \frac{Xij - \text{Min}_i\{Xij\}}{\text{Max}_i\{Xij\} - \text{Min}_i\{Xij\}}$$

The following formula can be used for negatively related indicators, i.e. vulnerability decreases with an increase in the indicator's value.

$$x^{N}_{ij} = \frac{\text{Max}_i\{Xij\} - Xij}{\text{Max}_i\{Xij\} - \text{Min}_i\{Xij\}}$$

Where Xij is the value of the j^{th} indicator for the i^{th} district, Mini{Xij} is the minimum value of the j^{th} indicator across districts, and Maxi{Xij} is the maximum value of the j^{th} indicator. $x^{P}ij$ and $x^{N}ij$ are the normalised values of the indicators, respectively, for positively and negatively related indicators. Normalised values of an indicator will lie between 0 and 1. The value 1 will correspond to a district with maximum vulnerability, and 0 will correspond to a district with minimum vulnerability to a particular indicator.

(8) Assigning weights to indicators

A weight assignment technique based on principal component analysis (PCA) can be explored to assign differential weights to indicators. Depending upon the outcomes of the PCA, either differential or equal weights shall be assigned. In the case study, 16 indicators were used and assigned equal weightage (i.e. 1/16 = 0.0625) to all indicators.

(9) Aggregation of indicators' vulnerability index

Vulnerability indices are constructed using a simple arithmetic mean of all the normalised scores. The same is also followed in the case study.

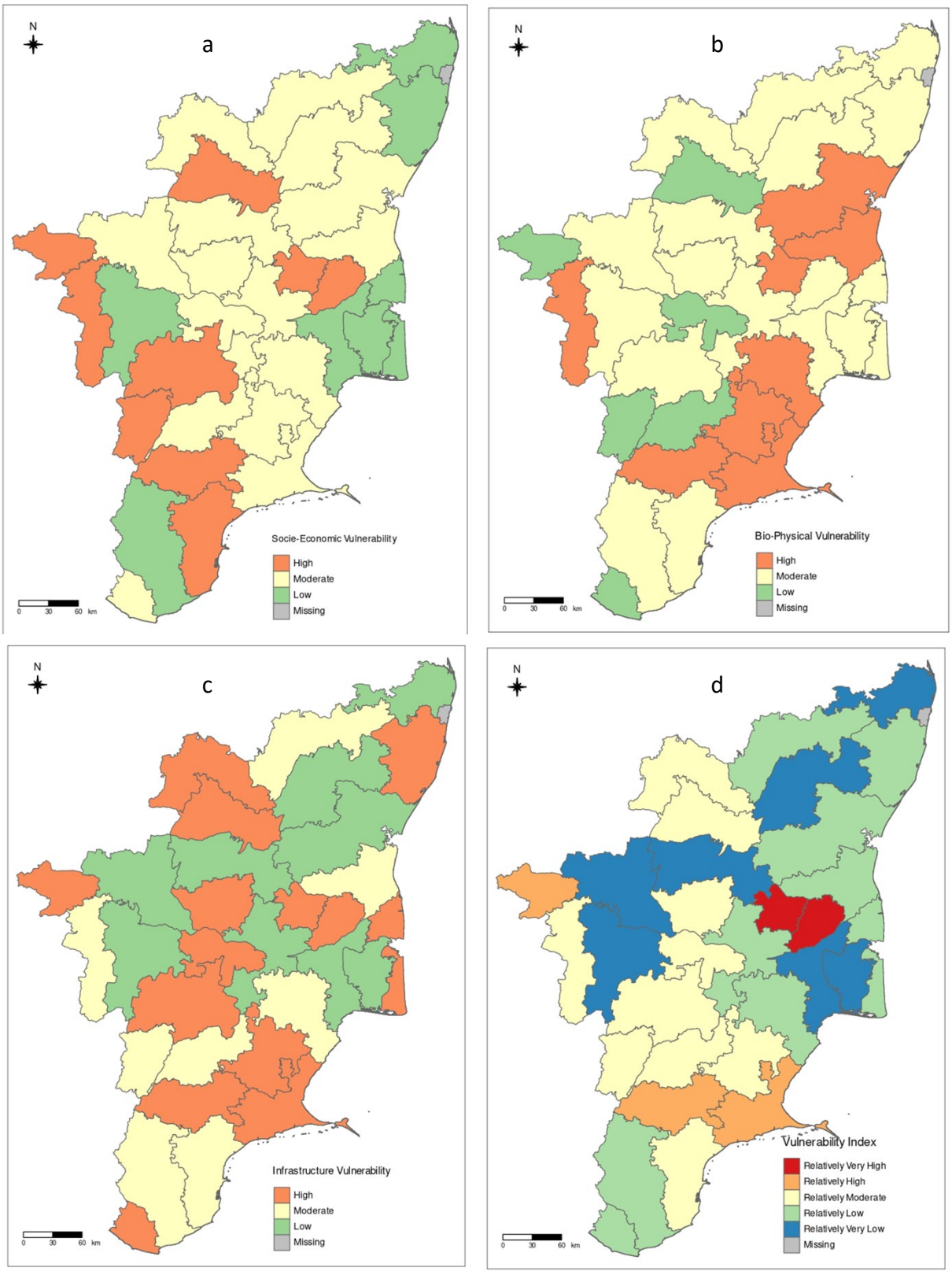
(10) Vulnerability ranking and representation

Tables, graphs, and spatial maps shall be used to represent vulnerability and its drivers. The indicators shall also be categorised as 'very high', 'high', 'moderate', 'low', and 'very low' for ranking purposes. The 'R' software was used to construct the maps in the case study. The indicators were ranked 'very high', 'high', 'moderate', 'low', and 'very low'.

3. Selection of Indicators for Agricultural Vulnerability (Case Study 1 and Figure 4.1)

A set of 16 vulnerability indicators was used to assess sensitivity and adaptive capacity. The district-level indicators were collected based on bio-physical, socioeconomic, and institutional cum infrastructure aspects.

Figure 4.1. Case Study 1: District-wise Vulnerability Mapping of Tamil Nadu State of India (i) Socioeconomic Vulnerability, (ii) Bio-physical Vulnerability, (iii) Infrastructure Vulnerability, and (iv) Agricultural Vulnerability Index



Source: Author.

(1) Socioeconomic aspects

Crop insurance, total number of livestock population, percentage of small and marginal farmers, average person-days/household employed under Mahatma Gandhi National Rural Employment Guarantee Act over the last 5 years, cropping intensity, rural population, and percentage of female participation.

(2) Bio-physical aspects

Soil fertility index, percentage area under rainfed agriculture, variability in food grain crop yield (tonne/ha), groundwater availability and value added to horticulture/agriculture and fertiliser consumption.

(3) Institutional and infrastructural aspects

Road connectivity, market availability, and rural banks are considered here.

The 16 indicators listed above in the three aspects are furnished in Table 4.2, with the rationale for selecting indicators, the vulnerability category it belongs to, and its functional relationship with sectorial assessment. The case study authors or consultant experts selected these indicators. Hence, depending on the sectorial assessment, one can select these indicators, which are also expected to vary with the experts' opinion for the chosen region. For example, based on the Drought Severity Index (DSI), another case study is presented here to understand the different approaches in vulnerability assessment.

Table 4.2. Rationale and Functional Relationship of Indicators Used in the Case Study for Vulnerability Assessment in Agriculture

Particulars	Indicators	Rationale for Selection	Adaptive Capacity/ Sensitivity	Functional Relationship
Socio-economic	Crop insurance	Crop insurance helps farming households mitigate losses caused by climate risks.	Adaptive capacity	Negative
	Total number of livestock population	An alternative source of income/asset; agricultural loss due to climate events can be compensated from their income.	Adaptive capacity	Negative
	Percentage of small and marginal farmers	Marginal and smallholding farmers experience immediate hardship in the face of any climatic hazard	Sensitivity	Positive

Particulars	Indicators	Rationale for Selection	Adaptive Capacity/ Sensitivity	Functional Relationship
	Average person days/household under MGNREGA over the last 5 years	The alternative source of income helps in building adaptive capacity	Adaptive capacity	Negative
	Cropping intensity	The higher area under cultivation implies the higher relative importance of agriculture.	Adaptive capacity	Negative
	Percentage of the rural population	More people are available to farm	Sensitivity	Positive
	Percentage of female participation	Higher participation ensures increased adaptation	Adaptive capacity	Negative
Bio-physical	Soil fertility index	Direct relation to the crop yield	Sensitivity	Negative
	Percent area under rainfed agriculture	Rainfed agriculture highly sensitive to vagaries of weather. Lack of irrigation indicates a lack of adaptive capacity	Sensitivity	Positive
	Variability in food grain crop yield (tonne/ha)	A high variability in crop yields indicates difference in agroclimatic conditions.	Sensitivity	Positive
	Groundwater availability	Exploit groundwater resources for irrigation	Sensitivity	Positive
	Value added to horticulture/ agriculture	Horticulture trees are hardy and more resilient to climate variations compared to field crops.	Adaptive capacity	Negative
	Fertiliser consumption	Higher fertilisers are an indicator of improved adoption.	Adaptive capacity	Negative
Institutional & Infra-structure	Road connectivity	The role of transport becomes crucial for development of a region.	Adaptive capacity	Negative

Particulars	Indicators	Rationale for Selection	Adaptive Capacity/ Sensitivity	Functional Relationship
	Market availability	Access to market helps farmers receive better prices and higher income	Adaptive capacity	Negative
	Rural banks	Mobilise resources locally and lend the same to the people in the area	Adaptive capacity	Negative

MGNREGA = Mahatma Gandhi National Rural Employment Guarantee Act.
Source: Authors.

4. Vulnerability Assessment using Drought Severity Index (Case Study 2)

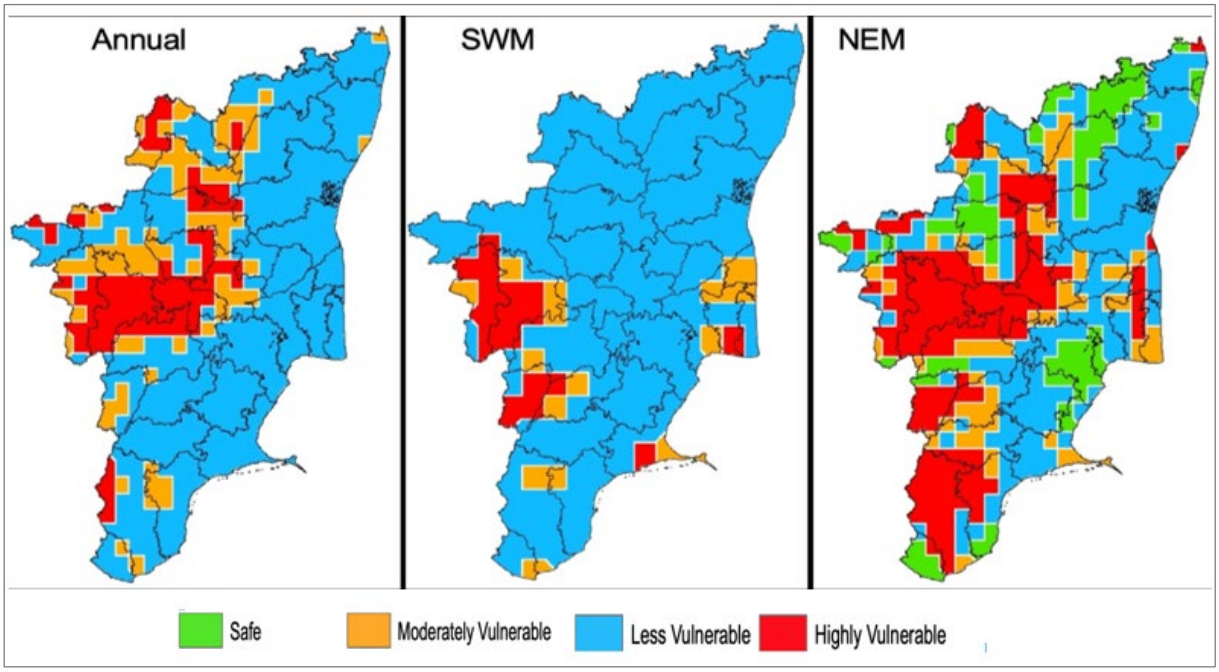
In drought studies, agricultural meteorologists use the Moisture Adequacy Index (MAI) as one of the criteria for delineating agriculturally favourable zones under rain-fed conditions. MAI is calculated as the ratio of Actual Evapotranspiration to the Potential Evapotranspiration, independently derived from various meteorological parameters. Based on the MAI threshold, drought is categorised as No drought (MAI > 0.75), Mild drought (MAI < 0.75 and > 0.50), Moderate drought (MAI < 0.50 and > 0.25), and Severe drought (MAI < 0.25). Then the DSI is calculated by the following formula.

$$DSI = \frac{(0.0 \times \text{No D} + 0.25 \times \text{Mild D} + 0.50 \times \text{Moderate D} + 0.75 \times \text{Severe D})}{\text{Total number of years}} \times 100$$

Here 'D' denotes drought. The calculated DSI is categorised as Safe (< Mean - SD), Less vulnerable (> Mean - SD and < Mean), Moderately vulnerable (> Mean and < Mean + SD), and Highly vulnerable (> Mean + SD) where SD is the standard deviation.

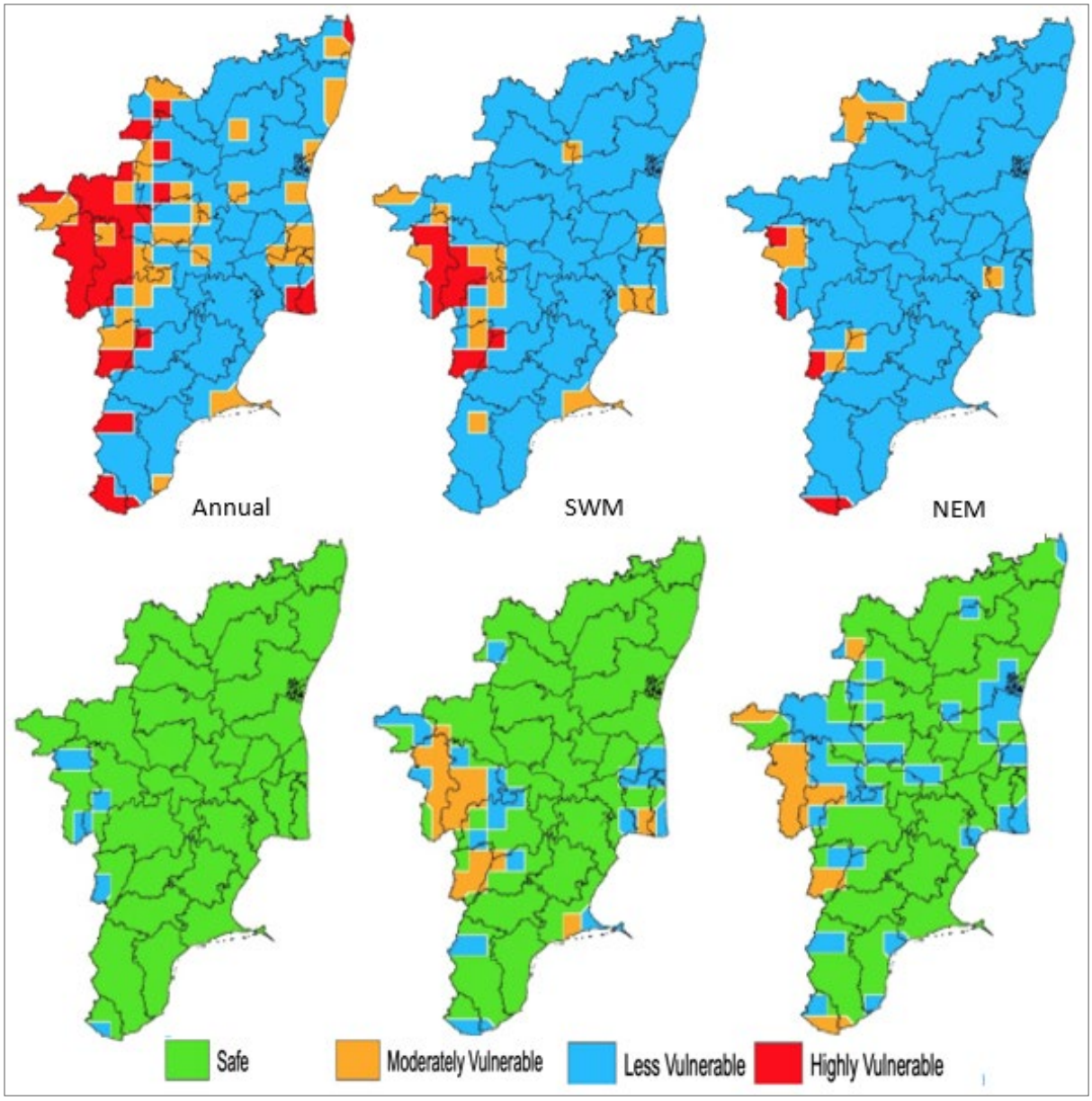
In this case study, the author (Vengateswari, 2019) used a 10 km resolution observed gridded data for the period 1981–2017 obtained from the King Abdullah Institute of Science and Technology, Saudi Arabia, which was used for the current vulnerability (Figure 4.2). Then for the future, the downscaled data from the AR5 CCSM4 Global Climate Model using the RCM RegCM4 with grid resolution of 25 km was used to estimate vulnerability using DSI. The estimation was done for two climate periods viz mid-century (2041–2070) and end-century (2071–2100) and depicted in Figure 4.3. Figures 4.2 and 4.3 depict the drought-related vulnerability for the current and future climate, which will help in planning towards adaptation.

Figure 4.2. Vulnerability Ranking of Drought Severity Index for Tamil Nadu State of India for 1981–2017 Southwest and Northeast Monsoons



NEM = northeast monsoon, SWM = southwest monsoon.
Note: 10 km Gridded data obtained from the King Abdullah Institute of Science and Technology, Saudi Arabia.
Source: Author.

Figure 4.3. Vulnerability Ranking of Drought Severity Index for Tamil Nadu State of India for the Future (25 km Gridded Data Downscaled Using RegCM4 Model by Ingesting Data CCSM4 GCM) – Upper Row for Mid-century (2041–2070) and Lower Row for End-century (2071–2100)



Source: Author.

5. Agriculture Sector Adaptation

One major objective of vulnerability assessment is planning for adaptation to climate change. Besides vulnerability, assessment impacts of climate change are being studied in various sectors, including agriculture. As indicated earlier, impact studies require higher (finer) resolution climate data for the region of interest, wherein downscaling plays a major role. A dynamical or statistical downscaling technique is used to obtain the required data, and impact studies are carried out. Based on the outcome of the impact

studies, one can design adaptation measures or evaluate different technological interventions through simulation modelling.

For example, one can study the impact of future climate change on rice yields of a region by ingesting the downscaled data into the crop simulation models. This can be done under a standard set of cultivation practices currently used to understand the impacts. Here the same models can be used to alter cultural practices like date of sowing, rate of fertiliser application, methods of irrigation, spatial arrangements, etc., towards finding adaptation measures for the changing climate. In another approach, the possibilities of storing water in the existing irrigation water storage structures can be simulated for the changing climate. Water allocation to feeder areas can be suggested to utilise stored water effectively to ensure better crop harvests. Even one can plan for a better plant canopy architecture for future climate, which means the adaptation practices can be derived based on requirements in several ways.

The IPCC (2001) defines adaptation as 'adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli, and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate' (McCarthy et al., 2001). Adaptation is classified into anticipatory, autonomous, and planned. Each one is described below.

Anticipatory adaptation

Anticipatory adaptation takes place before the impacts of climate change are observed (proactive adaptation). A typical example is land use planning for disaster exposure reduction.

Autonomous adaptation

Autonomous adaptation does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems (spontaneous adaptation). It might include practices such as altering agricultural inputs, introducing water-managing technologies, altering cropping cycles, or diversifying economic activities. They can be based on pre-existing 'risk management or production enhancement activities' but which 'have substantial potential to offset negative climate change impacts and take advantage of positive ones (Forsyth and Evans, 2013).

Planned adaptation

Planned adaptation is the result of a deliberate policy decision based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. Water conservation practices for improving the water table of a location are an example of planned adaptation.

In agriculture, endless adaptation practices are available for recommendation to farmers based on the requirements of an individual or a region. Some possible adaptation practices are listed below for understanding.

- Climate-ready crop varieties
- Water-saving technologies
- Changing planting date
- Integrated farming system
- Growing different crops or relocation
- Integrated pest management
- Crop insurance
- Organic farming
- Conservation agriculture
- Precision farming
- Improved nutrient management
- Use of efficient microbes
- Rainwater harvesting
- Wasteland management
- Improved weather-based agro-advisory
- Growing crops in greenhouse gas
- Increasing irrigation facilities
- Intercropping or mixed cropping
- Use of nanotechnology
- Intensifying crop production

Acknowledgement

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Chapter 5

Climate Change Challenges, Disaster Risks, and Successful Adaptation Measures through Standards and Infrastructure Design: Lessons from Japan and Thailand

Makoto Ikeda, Thawatchai Palakhamarn

Large-scale disasters occur yearly in the Asian region. When disasters occur, lives and property are lost, and infrastructure is severely damaged. Asia's growing population and poverty make it easy for a disaster to cause damage. Therefore, disaster risk reduction (DRR) activities are important to mitigate the damage caused by disasters. This chapter classifies DRR activity into structural and non-structural measures and shows examples of DRR measures in Thailand and Japan. In Thailand, urban development, such as disaster-resistant parks that consider climate change, was introduced. The importance of public–private–academic linkages is also explained. In Japan, DRR activity at the community level was introduced. And recommendations are made for activities that can be implemented at low cost for ASEAN countries, as raising residents' disaster awareness will lead to disaster mitigation.

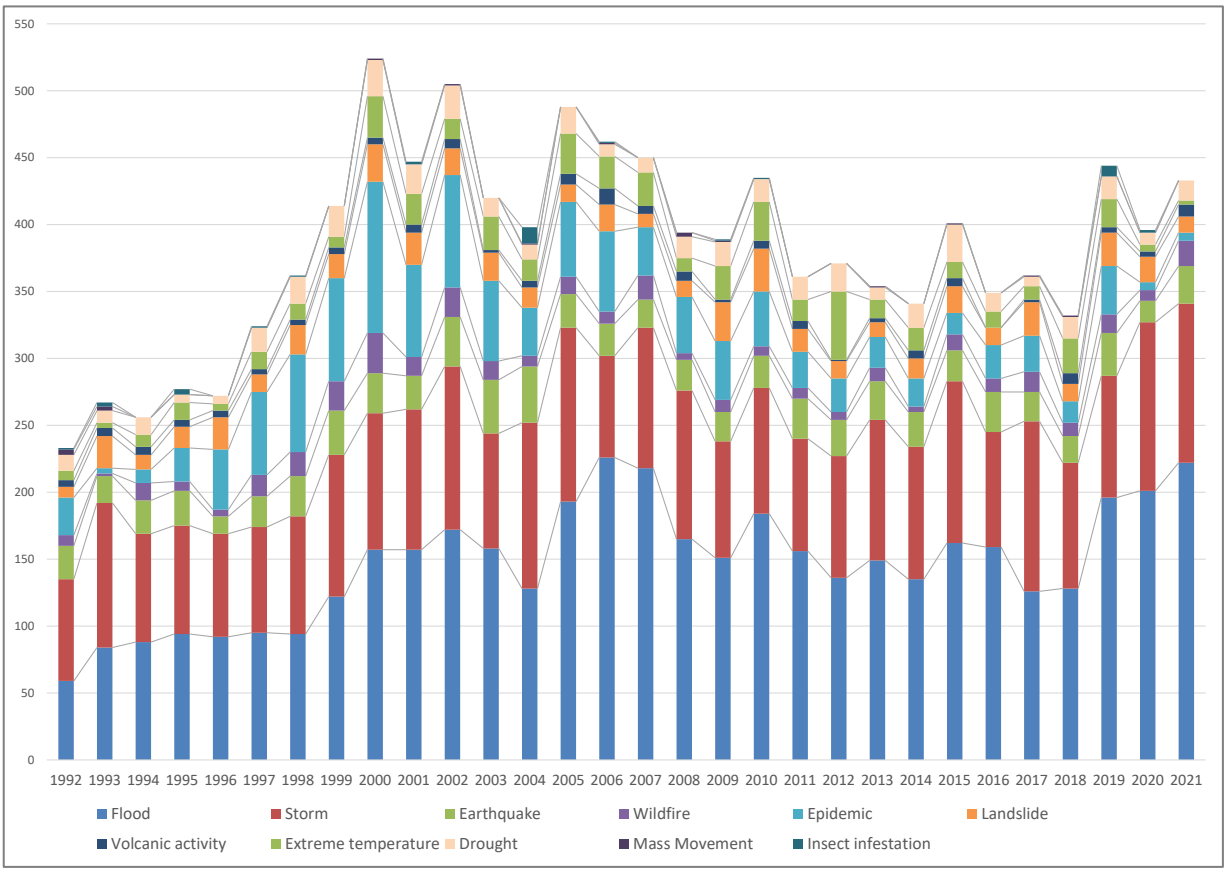
1. An Introduction: The Issue and Solution in Focus

A large-scale disaster occurs frequently every year worldwide, and the number of disasters has increased recently. Once a disaster occurs, many lives and valuable property are lost.

Due to its geographical environment, Japan faces the danger of various disasters, such as earthquakes, floods, tsunamis, and volcanic eruptions. However, large-scale disasters occur frequently in the countries of the Association of Southeast Asian Nations (ASEAN) whose economies are growing rapidly. Disasters occurring in Asia, where many areas are vulnerable, take away numerous lives and cause damage to infrastructure, such as roads, railways, and telecommunication systems.

Figure 5.1 shows data on the types of disasters that occurred worldwide. There was an increasing trend towards 1999 and a decreasing trend towards 2018. However, the number has risen again in the last few years. By disaster type, half of the disasters in 2021 are related floods and followed by storms.

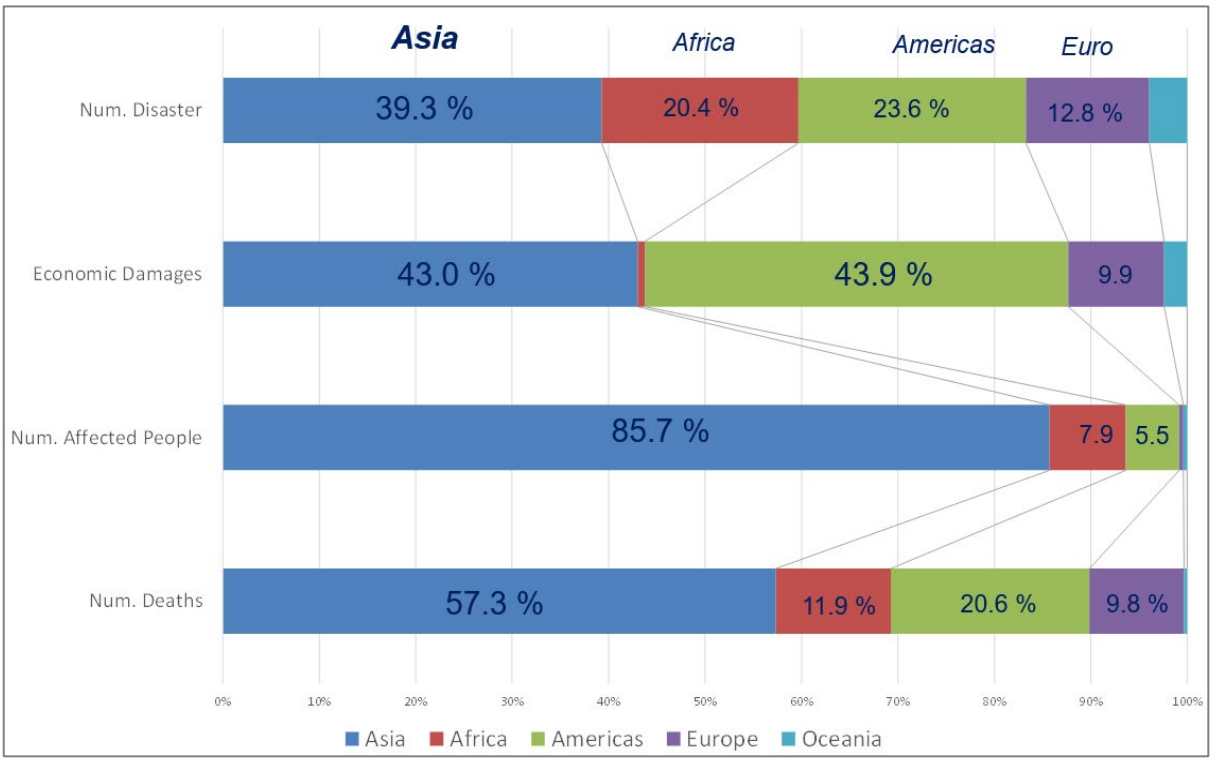
Figure 5.1. Number of Natural Hazards Worldwide, 1992–2021



Source: CRED, www.emdat.be.

Figure 5.2 shows data on disasters occurring around the world, organised by each continent. The continents are broadly classified into Asia, Africa, America, Europe, and others. The data are classified from the top into the following categories: the percentage of disasters that occurred, economic damage, number of affected people, and number of deaths. First, Asia accounted for 39.3% of the total disasters, followed by the Americas at 23.6%. Next, the share of economic damage in the Americas has increased to 43.9%. This is because the costs required for infrastructure investment are higher in the Americas than in Asia. And the damage inevitably increases when a disaster strikes. Next, the percentage of disaster victims in Asia, at 39.3%, jumps to 85.7%. This indicates that Asia's population growth and poverty rates are larger than other continents.

Figure 5.2. Damage of Hazards in Each Continental, 1992–2021

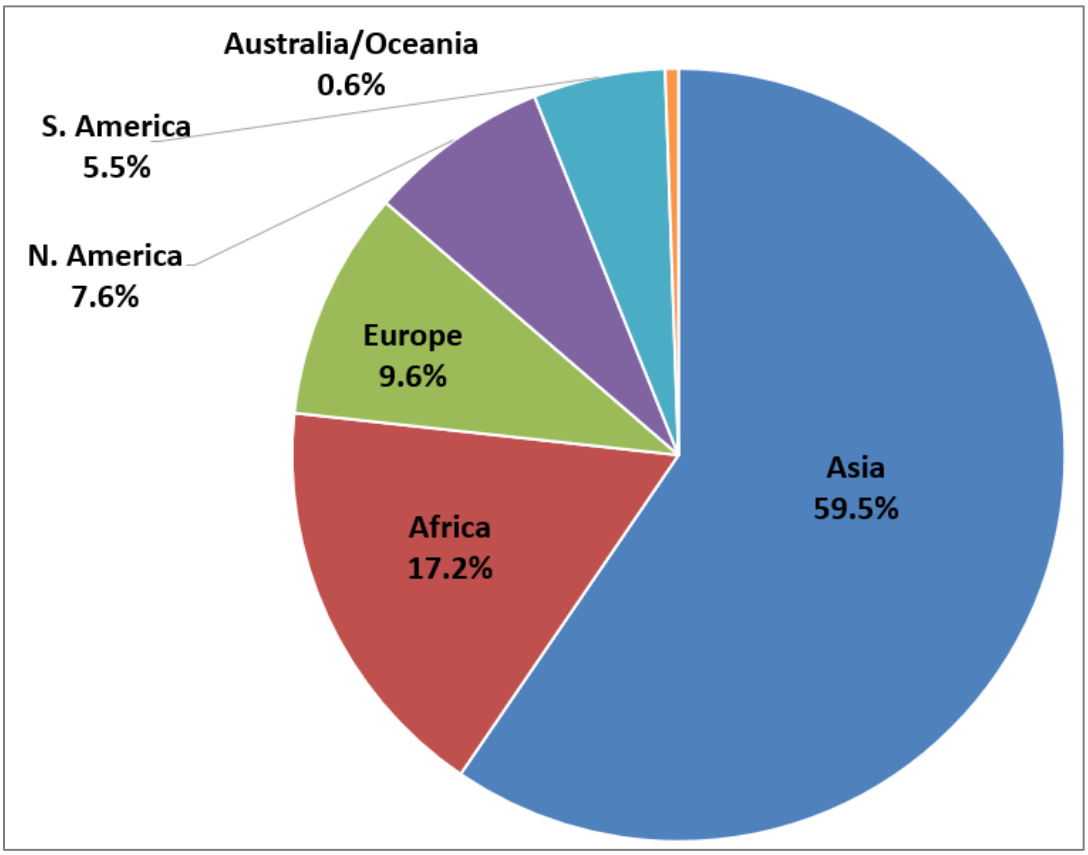


Source: CRED, www.emdat.be.

As mentioned above, human suffering tends to increase when disasters occur in the Asian region. One reason for this is Asia's population growth. Figure 5.3 shows the percentage of the world's population by continent (2020), with Asia accounting for 59.5% of the total population. Asia also has a population density of 147.31 people per square kilometre (km^2). This figure is much higher than that of Africa, the second-largest region, at 45.99 people/km^2.

Another reason for the increased human suffering is Asia's lack of disaster-resilient community development. The region is subject to frequent disasters. Residents who suffer damage to their homes and other structures rebuild their homes without government assistance. This results in the continued existence of houses that are vulnerable to disasters. And there is concern that the next disaster will damage residents' homes severely again.

Figure 5.3. Population in Each Continent, 2020



Source: UNISDR (2009).

Since Asia is vulnerable to disasters and prone to damage to infrastructure, human life, and property, it can adopt two approaches to reduce the damage caused by disasters in the region: structural measures to physically reduce the damage caused by disasters and non-structural measures to strengthen disaster awareness for people.

This chapter presents examples of structural and non-structural approaches to disaster reduction in Japan, which has experienced large-scale disasters in recent years, such as the Great Hanshin-Awaji Earthquake and the Great East Japan Earthquake. This chapter also mentions Thailand, which has experienced frequent large-scale flooding, to illustrate how these approaches are being taken.

2. Thematic Arguments and Evidence

2.1. [Lesson Learned from Thailand] Climate Change Challenges, Disaster Risks, and Successful Adaptation Measures through Standards and Infrastructure Design and Local Actions through Policy Design and Standardisation

Understanding global practices in DRR and climate change adaptation remains crucial for emerging local governments and communities in developing regions. In Southeast Asia, economic development and social considerations frequently dominate DRR and climate change adaptation substantially more. Or, if there is a priority and awareness at the

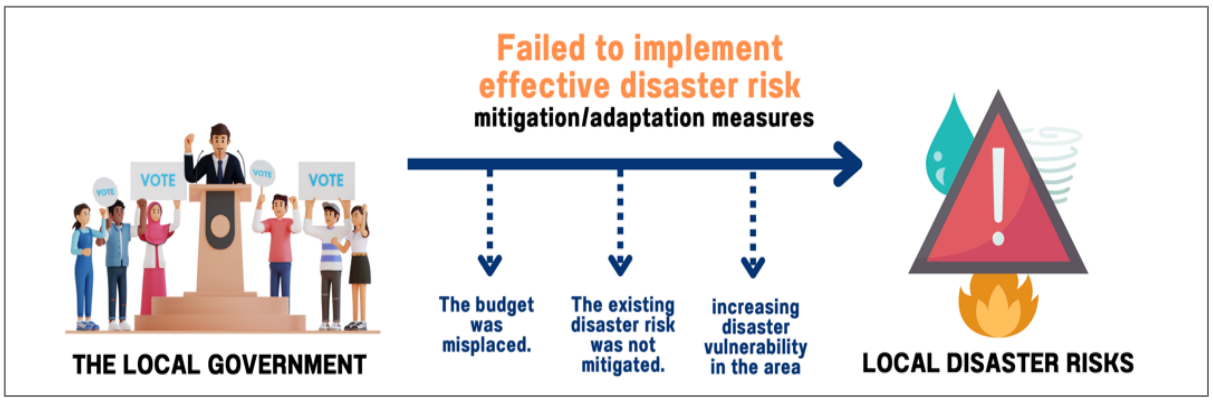
national and local levels, DRR and climate adaptation are regularly manifested in emergency management rather than intensive preparation and sustainable recovery following international practices, such as the Sendai Framework for Disaster Risk Reduction, etc.

The key findings and lessons derived from Thailand indicate notable insights concerning the alignment of global frameworks with local policies and practices. To establish adequate DRR policies and foster effective adaptation to climate change, it is essential to delve into the nuances of local institutional systems. However, it is pertinent to note that these systems present multiple issues and limitations, as outlined below:

1) Local governments have insufficient knowledge of the full spectrum of local risks. They usually focus only on hazards that are immediately observable or experienced. This approach can hinder a complete understanding of climate risks, as it may overlook potential issues that are not evident in short-term observations.
2) Budget, specialists, and resources are limited.
3) Without local climate change specialists, local capacity and risk understanding keep falling behind state agencies with extensive resources, expertise, and competence.
4) The risk mitigation and adaptation strategies currently in place do not adapt to the changing dynamics of climate risk. This static approach could potentially diminish the effectiveness of these strategies and simultaneously amplify local vulnerabilities.
5) Local governments often rely heavily on the opinions and desires of their constituents and political electorates when making decisions about risk reduction and climate change adaptation. As a result, these decisions might be primarily influenced by interpersonal needs and social pressures, rather than being grounded in solid empirical evidence and well-founded academic arguments. This approach can potentially overlook critical data and expert insights, which might otherwise lead to more informed and effective policies.

The five limitations are shown in Figure 5.4.

Figure 5.4. Local Governments' Failure in Design Disaster Risk Reduction and Climate Change Adaptation Measures



Source: Created by author.

However, critical gaps in advancing and enabling Thailand's local DRR and climate change adaptation efforts are postponed indefinitely. They are insufficient to keep up with the pace of the dynamics of the climate emergency, which is exacerbated by the constraints of institutional mechanisms. Due to a lack of capacity and institutional arrangements, the primary barrier is the inability of local governments to design DRR and climate change adaptation measures that strike a reasonable balance between structural and non-structural measures.

When local governments are equipped to make informed and reliable decisions in crafting policies and strategies for DRR and climate change adaptation, they can potentially achieve a harmonious balance between both structural and non-structural measures. In academic circles, this balanced approach is considered a pathway to enhancing risk reduction and facilitating smoother adaptation to the complexities of climate risks. Below, we share three inspiring narratives that illustrate how lessons from Thailand can be leveraged to bolster the ability of local governments to devise innovative and effective approaches in policy and practice formulation.

This section contains two major parts: (i) lessons from non-structural measures, with a case study of the 'Disaster Risk Reduction Solutions Index', providing risk-optimised non-structural measures for the design of earthquake risk reduction measures for local governments in Thailand; (ii) lessons learned from structural measures, the sample case of which is the Public Park as Urban Detention Area: Chulalongkorn University Centenary Park in Bangkok, intended to provide a comprehensive range of water management functions for both static and dynamic scenarios.

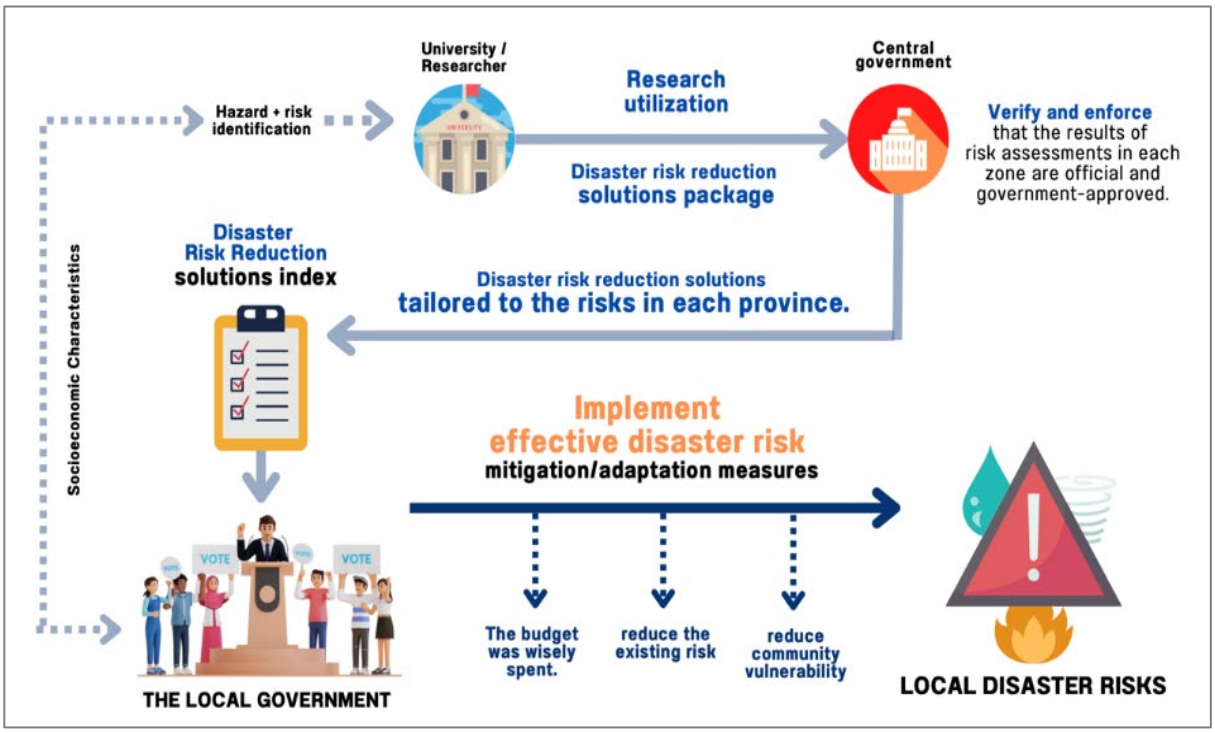
2.1.1. Disaster Risk Reduction Solutions Index

In the first case, the Disaster Risk Reduction Solutions Index is employed as a decision-making tool to guide the creation of social measures (non-structural) aptly suited for managing risks associated with earthquakes and structural failures within the specific

context of local governments' climate and disaster risk landscapes. Slated for testing in high-risk areas of Northern Thailand by 2023, this tool focuses on implementing non-structural measures that are in tune with local risks, capabilities, financial constraints, and grounded in scientific evidence. It serves as a critical resource in aligning community responses effectively with the nuanced challenges they face.

The initiative does not seek to introduce a revolutionary administrative solution at the periphery of this index. Instead, it emphasises the optimal use of a variety of existing tools for disaster risk reduction and management, particularly when established local governments and governmental agencies are already in operation. The central goal is to amalgamate pre-existing mechanisms into a cohesive and systematic ecosystem, thereby equipping local governments with robust tools to augment their disaster preparedness efforts. It is vital to integrate and utilise the diverse mechanisms and tools that are currently available across different disciplines, as illustrated in Figure 5.5, to foster a comprehensive approach to disaster management.

Figure 5.5. The Conceptual Framework and Process of Linking Management Tools in the Disaster Risk Reduction Solutions Index



Source: Created by author.

The tool's primary process consists of three parts: 'Design, Match, and Implement,' explained as follows.

First, it is essential to establish a comprehensive set of standardised measures for DRR, grounded in data and findings from credible scientific institutes and specialised government agencies. Agencies such as the Department of Mineral Resources,

Department of Groundwater Resources, Department of Water Resources, and the Department of Meteorology play a pivotal role in this process, offering invaluable insights into disaster risk assessments. Leveraging the expertise and data from these institutions, we can formulate a foundational understanding of the unique risks present in various locales. With this knowledge at hand, we can then explore tailored solutions to mitigate these risks, aligning our strategies appropriately with the identified levels of risk. This approach ensures a more informed, strategic, and effective response to the potential disasters each region may face, thereby fostering a safer and more resilient community.

Second, the pre-packaged measures must be validated in both theoretical and practical aspects by establishing a strong, unified platform in the form of a collaborative working group composed of scientists, authorities, and budgetary agencies to formalise such measures into disaster risk governance, enabling local governments to utilise them as fundamental evidence in prospective annual budget requests to the central government. Meanwhile, a set of pre-packaged measures developed in line with the requirement to minimise risks at the local level also considers the cost of adopting these steps over time. Specifically, local governments seem to have a meagre budget. Risk-matched measures are primarily restricted to fundamental, low-cost risk reduction methods. Thus, local authorities could continue to carry out these efforts for certain years, resulting in an acceptable level of risk. However, if local governments have a budget and other resources that exceed their requirements, the bundled measures will provide multiple features for the accelerated reduction of these risks.

Lastly, the Disaster Risk Reduction Solutions Index aims to personalise interventions by recommending actions that are specifically tailored to each local government's risk profile. This strategy facilitates a collaborative and transparent engagement between local governments and regulators, allowing for the systematic tracking of the implementation of preemptive risk reduction measures. Moreover, it encourages investment in localised risk reduction strategies, as suggested by the index, fostering a more targeted approach to managing the unique challenges faced in each region.

Furthermore, the application of the index promises to refine the precision of budget allocations designated for risk reduction efforts, ensuring that resources are deployed where they are most needed. This methodology seeks to diminish the sway of political pressure in decision-making processes, fostering a climate where choices are based more on data and empirical evidence than on external influences. This, in turn, serves to enhance the overall efficacy and impact of DRR initiatives, positioning communities to better safeguard their futures against potential risks.

In this initial case scenario, it is important to note that the necessity of implementing the Disaster Risk Reduction Solutions Index hinges on the existing capabilities of the local governments and the private sector. If they already command substantial financial resources, have a deep understanding of the prevalent risks, and house the expertise to mitigate these risks in line with professional standards and international norms, the introduction of the index might seem superfluous.

Nonetheless, for local governments that are actively striving to enhance their capacities and align with international guidelines for risk reduction, the index emerges as an indispensable administrative tool. It serves to bridge existing gaps, allowing local governments to proficiently 'create, match, and implement' DRR strategies that are highly congruent with their distinct local environments. Considering critical parameters such as operational efficiency, cost-effectiveness, and minimal disruption, the index aids in the crafting of strategies that aspire to deliver maximum benefits at the most reasonable cost, without sacrificing efficiency. It facilitates the identification and adoption of the most effective risk reduction measures, making sure that they are not only economically viable but also least disruptive to the local populace.

This approach holds significant value, particularly for local governments in developing countries that frequently grapple with numerous administrative constraints. Despite these challenges, the implementation of the index serves as a powerful enabler, empowering these governments to tailor their risk reduction initiatives effectively, fostering a safer, more resilient, and prepared community capable of facing the evolving risk landscapes with agility and foresight. Furthermore, by leveraging the index, local governments can facilitate transparent collaboration with various stakeholders, including regulators and the private sector. This synergy enables an environment where the execution of targeted risk reduction strategies is not only affordable but also maximises the potential for positive outcomes, fostering communities that are well-equipped to safeguard their future against potential risks.

2.1.2. Public Park as Urban Detention Area: Chulalongkorn University Centenary Park

The next case is about strengthening the capability of cities to adapt to climate change and changing disaster risks in Thailand. It is an example of Bangkok's urban infrastructure development. Thailand's capital is flood-prone. Bangkok has long been recognised as one of the cities most susceptible to climate change due to its geographical location below sea level (Germanwatch, 2021). Therefore, for several years, some urban centres have been plagued by flash floods caused by precipitation changes, such as heavy rainfall exceeding 150 millimetres/hour, particularly in the central and economic districts. Due to this concern, Bangkok initiated the development of public infrastructure, which combines natural solutions with modern engineering.

The Chulalongkorn University Centenary Park in Bangkok stands as a beacon of urban sustainability and climate adaptation, seamlessly weaving together people, natural, and collective aspects in its design and functionality. The 'people aspect' manifests as an inclusive space open to all, fostering community interaction and well-being. The 'natural aspect' is reflected in its green infrastructure and nature-based solutions, functioning as a vital lung in the urban landscape, rejuvenating the local ecosystem, and promoting environmental health. Meanwhile, the 'collective aspect' highlights the collaborative effort across various city sectors, including academia, commerce, local communities, and government, working synergistically to enhance the city's resilience to climate challenges.

This initiative showcases the park not merely as a recreational space but as a vibrant hub that embodies a harmonious blend of community engagement, ecological well-being, and cross-sector collaboration, propelling Bangkok into a new era of urban development that prioritises both environmental and societal harmony. It underscores the necessity of unified efforts to bolster climate adaptation capacities, serving as a living testament to the potential of collaborative innovation in addressing the multifaceted demands of a modern urban community.

On the other hand, the park serves as a linchpin in the city's strategies to mitigate climate change and water-related hazards, boasting features that enhance urban resilience in various critical ways. Notably, it amplifies the city's water absorption capacity during erratic weather events, functioning as a substantial catchment area spanning at least 5 km^2. This is facilitated through the strategic installation of detention ponds at each garden entrance, acting as massive temporary water reservoirs and adhering to the principles of retention pond design, resembling low-lying zones within the project. These, along with an integrated subsurface drainage system and a rain garden, form a comprehensive water management system capable of holding over 250,000 gallons of water. This system not only helps prevent flooding but also ensures a robust emergency water supply for the city, lasting up to 20 days during droughts or water shortages. Studies corroborate the efficacy of this design, indicating a 3- to 4-hour delay in rainwater flow into the city's drainage systems, thus reducing the strain on existing infrastructure. Furthermore, the park stands ready to serve as a temporary shelter and coordination centre during citywide emergencies or disasters, with the infrastructure to accommodate over a thousand individuals, emphasising its role as a multifaceted resource in enhancing urban climate resilience and preparedness.

Figure 5.6. Chulalongkorn University Centenary Park, Bangkok (Thailand)

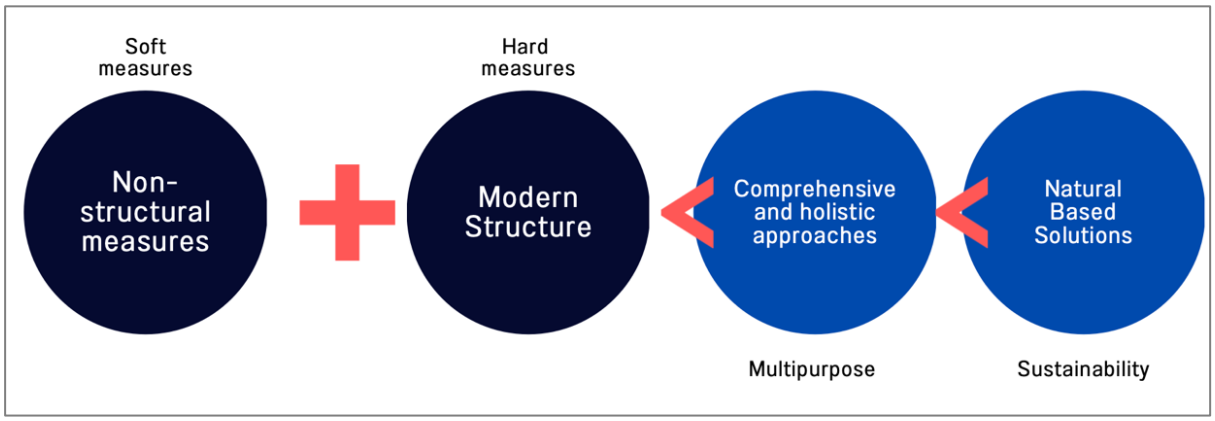
Source: Chulalongkorn University (2023).

While climate change has loomed as a formidable challenge for a considerable period, clearly a single park cannot mitigate flooding across an entire city. However, the inception of this park marks a significant and audacious step towards a sustainable future. As members of the academic community, we bear the responsibility to probe various viable alternatives and indications of potential progress, fostering a beacon of hope where possible. The Chulalongkorn Centenary Park has ignited a spark of optimism, presenting itself as a beacon of innovative solutions amidst growing challenges. It beckons researchers to discern emerging opportunities, propelling us to forge impactful initiatives to safeguard our gradually sinking city, and hence, stands as a testament to the potential of proactive urban planning in confronting the pressing issue of climate change.

The experiences discussed in the previous two stories are only some of many that have prompted efforts to minimise the impact of natural disasters and adapt to the ever-changing climate. This is not just a strong and serious commitment on the part of the city, especially Bangkok, but also a conscious and deliberate one to speed up the city's strengthening of all its capacities to interact with uncertainty and climate change, as well as for individuals, the environment, and the entire society.

Nonetheless, the insights gleaned from the two case studies underscore the necessity of a methodical approach in amalgamating both structural and non-structural initiatives, ensuring they complement each other effectively. It is evident that relying solely on structural strategies may not suffice in enhancing a city's adaptability to climate change in specific scenarios or communities. Therefore, it is imperative to weave in social strategies across various facets including education, behavioural science, management, and even within the realms of social culture. This multidimensional approach aims to maximise the benefits of physical interventions, fostering a harmony that yields positive outcomes for both society and the environment.

Figure 5.7. Combining and Balancing Structural Measures, Non-structural Measures, and Natural-based Solution Results in Urban Resilience Enhancement



Source: Created by author.

As illustrated in Figure 5.7, the formulation of strategies to mitigate disaster risks should embody flexibility and user-friendliness, primarily aimed at enhancing public spaces and augmenting community beautification initiatives. A continual and cross-disciplinary learning process is paramount, facilitating a comprehensive consideration of the various dimensions pertinent to local government involvements. Consequently, fostering dialogue and collaboration amongst diverse groups within society is essential, a factor that cannot be overlooked. This collaborative approach ensures the crafting of measures that resonate well with the diverse physical and social contexts, promoting a cohesive and effective response to disaster risk management (DRM) and urban development.

2.2. [Lesson Learned from Japan] Disaster Prevention Measures Learned from National and Local Disasters

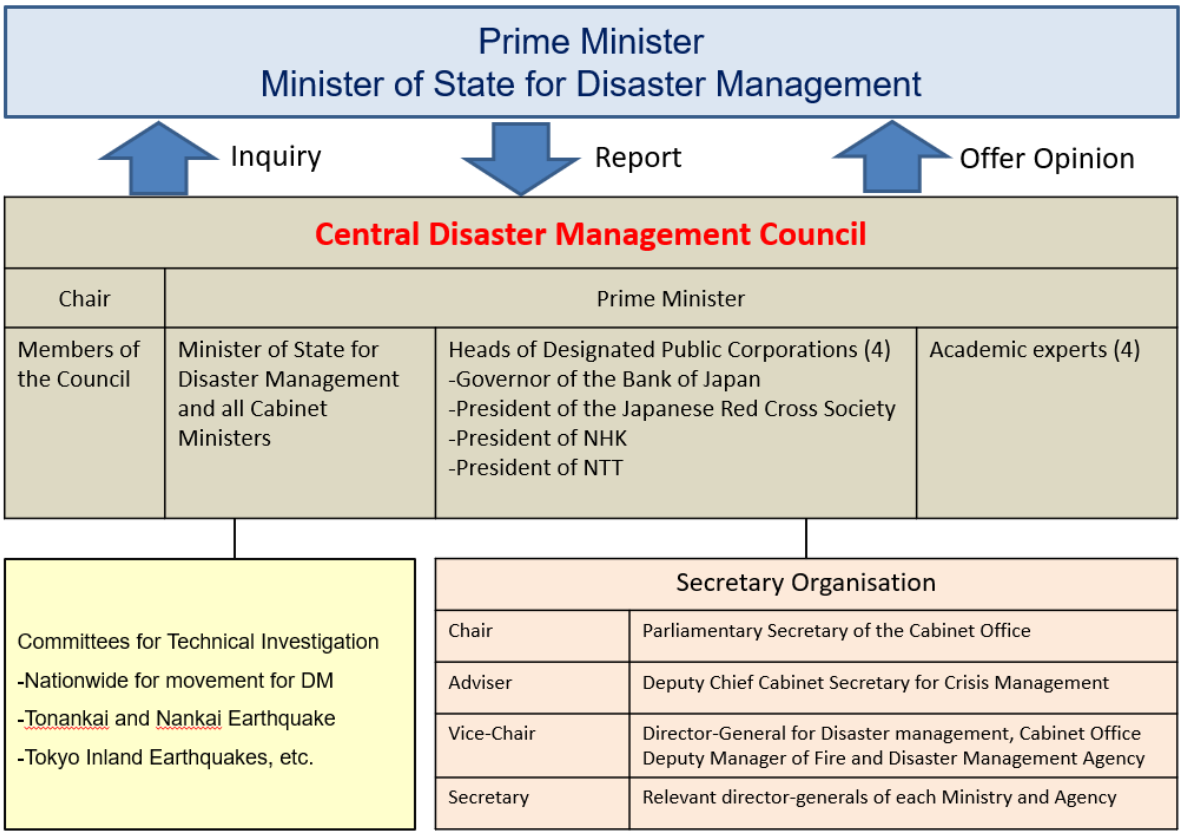
Understanding global practices in DRR and climate change adaptation remains crucial for emerging local governments and communities in developing regions. In Southeast Asia, economic development and social considerations frequently dominate.

2.2.1. Framework of Disaster Management in Japan

Japan's disaster management system addresses all phases of disaster prevention, mitigation and preparedness, emergency response, recovery, and rehabilitation. It specifies the roles and responsibilities of national and local governments and enlists the cooperation of relevant public and private stakeholders. Following the Great East Japan Earthquake, assessments were made of the capacity of existing DRM planning systems to prepare for and react to large-scale disasters. Revisions were proposed based on the lessons learned on 11 March.

In the 1940s and 1950s, Japan was repeatedly ravaged by typhoons and earthquakes. The 1959 Isewan Typhoon caused tremendous damage. In 1961, the Disaster Countermeasures Basic Act was passed. It created a Central Disaster Management Council to formulate the overall DRM policy and function as the national coordinating body for disaster management. The council was to be chaired by the Prime Minister, and its members came from the line ministries, semi-public organisations (such as Public Broadcasting, the Bank of Japan, the Japanese Red Cross, and a telecommunications company), and representatives from academia (Figure 5.8). The act also clearly defined the roles and responsibilities related to disaster reduction at the national, prefectural, and municipal government levels, community organisations, and citizens. It required the three levels of government to draw up master DRM plans. Also, it asked all ministries and semi-public organisations to prepare disaster management plans for their sectors.

Figure 5.8. Organisation of Central Disaster Management Council in Japan



Source: Asian Disaster Reduction Centre (n.d.).

2.2.2. Countermeasures against Sediment Disasters in Rokko Mountains

The Rokko mountain range in Hyogo Prefecture has often suffered from disasters. A major flood caused a landslide in the Mt. Rokko area in 1938, resulting in more than 700 deaths and missing persons. A similar flood and landslide occurred in 1967. The Great Hanshin-Awaji Earthquake occurred in 1995, causing great damage, leaving 6,402 people dead, 3 missing, and 40,092 injured. Mt. Rokko was also severely damaged. Because of lessons learned from these past large-scale disasters, many Sabo dams have been constructed in the Mt. Rokko area.

For instance, because of the anxiety of residents in the district about sediment disasters, a 'Liaison Meeting for Disaster Risk Reduction of Mountains behind Residential Area' connecting the residents with the government and contractors in charge of the construction was established in February 1995. The residents wanted restoration work to progress quickly and smoothly. Then the Ministry of Land, Infrastructure, Transport and Tourism urgently started restoration work, completing the emergency construction in about a year. All the construction work was completed in 1998.

Figure 5.9. Sabo Dam in Rokko Area

Source: Asian Disaster Reduction Centre (photo was taken in 2020).

2.2.3. Iza! Kaeru Caravan!

In addition to the methods to reduce damage caused by disasters through structural measures, as indicated earlier, there are also non-structural measures to improve residents' disaster awareness. The Iza! Kaeru Caravan! (IKC), started in 2005, is one of the well-known DRR activities to improve residents' disaster awareness, allowing children to learn about disaster prevention. This programme is practiced in Japan and other countries

such as Costa Rica, Indonesia, Myanmar, Panama, the Philippines, Turkey, etc. The IKC has various components. For example, there are fire extinguishing, jack-up rescue, card games to prepare for disasters, emergency tableware, puppet shows, etc. IKC's main participants are often children, and this activity is structured, emphasising 'having fun' as an important part of learning about DRR.

Figure 5.10. Iza! Kaeru Caravan!

Source: Asian Disaster Reduction Centre (photo was taken in 2020).

3. Conclusion and Policy Recommendations in the Context of a Community of Researchers and Decision-makers (Focusing on ASEAN Member States)

This chapter highlights a standard infrastructure design and local actions through policy design and standardisation as a good practice in Thailand.

In conclusion, notable outcomes that need to be achieved more quickly include upgrading and speeding up Thailand's DRR process in terms of meeting standards and the Global Agenda for Sustainable Development Goals. This is what must be achieved for local governments across the country to progress to reduce losses as much as possible, provide adequate disaster response capacity to save all lives, and adapt more accurately to climate emergencies. We believe this approach will be effective in other ASEAN countries where the risk of disasters due to climate change is significant.

It also highlighted Sabo dams against flood and landslides and the community-based DRM activity IKC as a good practice in Japan. A Sabo dam is a major structural approach to reduce disaster damage. It was constructed considering Kobe's geographical characteristics and experiences of past disasters. This has helped mitigate damage from

subsequent large-scale disasters. As an advanced example of DRR, IKC was also introduced as a major community-based DRM activity in Japan. The IKC is a very effective means of raising disaster awareness amongst children, which is then passed on to their parents and other family members. This programme is expected to spread effectively in ASEAN countries where family ties are strong. It is also inexpensive to implement and can be done on a community basis in each country.

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Chapter 6

Country Report on Climate Change Vulnerabilities, Social Impacts, and Education for Autonomous Adaptation in Lao PDR

Sonephet Phothisalat, Chanseng Phongpachith

Lao PDR is highly exposed and most vulnerable to flooding and drought. Observable climate changes, including higher-than-usual intensity of rainfall events during the rainy and extended dry seasons, induce these impacts. The related risks include sudden flash floods, large-scale land erosion on slopes, recent typhoons, cyclones, and storms from the Pacific Ocean. These events can be very destructive, altering the landscape, fauna, and vegetation and destroying public infrastructure, property, productive land, agricultural assets, and harvests. The people of Lao PDR are particularly vulnerable to climate change because 80% of their livelihoods are associated with some form of agricultural activity. Furthermore, poor farmers have a limited asset base and lack access to state support.

Climate change is also a key challenge facing rural livelihoods. The country is also most vulnerable to climate change due to its slow adaptability and dependence on climate-sensitive natural resources. The recently published *Climate Risk Country Profile: Lao PDR* of the World Bank Group and the Asian Development Bank (ADB) (2021) suggests that Lao PDR faces a projected warming of 3.6°C by the 2090s.

However, climate change impacts on the country are found to be most severe in the rural grassroots–level communities in the form of natural disasters. Indirect impacts of climate change are observed in the form of increasing poverty and health issues in different ecosystems. Although communities are equipped with traditional knowledge and wisdom, new practices and policies are required to enable them to cope with the changing climate, thereby providing them with means to sustain their livelihoods.

Social, economic, and environmental impacts include loss of life, population displacement, shelter destruction, and severe economic loss. About 2.8%–3.6% of Lao PDR's annual gross domestic product (GDP) is lost due to devastating floods in 2018 and 2019.

The 9th National Socio-Economic Development Plan (NSEDP) 2021–2025 was developed at a critical time when the country continues to face numerous challenges. The policy focused on 'Enhancing the management of natural resources and environment, implementing mechanisms and legislations effectively, and contributing to support green and sustainable development'.

1. Introduction

The Lao People's Democratic Republic (Lao PDR) is one of the countries that has the most vulnerability and impact of climate change, especially from floods, droughts, landslides, typhoons, cyclones, storms, unexploded bombs (cluster bombs between 1964 and 1973), cold waves in the northeast (in 2016), earthquakes, and so on. The country is in Southeast Asia, with a population of 7.2 million (2021). It is gifted with rich natural resources, such as forests, water, minerals, and biodiversity.

Over the past decades, the country has experienced positive economic growth. The country has been amongst the fastest-growing economies in Southeast Asia, moving from low-income to lower-middle-income status in 2011. In February 2021, the United Nations (UN) Committee for Development Policy recommended that Lao PDR be graduated from a least developed country (LDC) status with an extended 5-year preparatory period effectively, setting the graduation to 2026, assuming continued positive performance.

The 9th National Socio-Economic Development Plan (NSEDP) 2021–2025 was developed at a critical time when the country faced numerous challenges. The 9th NSEDP will guide the country's policy directions to advance sustainable and inclusive growth, human capital investment, infrastructure development, and progress towards the transition from LDC status. The Five-Year Plan of the Natural Resources and Environment Sector (2021–2025) focuses on 'enhancing the management of natural resources and environment, implementing mechanisms and legislations effectively, and contributing to support green and sustainable development'. The Five-Year Plan of the Agriculture, Forestry and Rural Development focuses on 'enhancing agricultural production to ensure food and nutrition security; diversifying and producing quality agricultural products; increasing people's income to reduce poverty and improve the lives of people in rural areas; protecting forests and resources, using a value-added manner; and generating higher revenues to the national economy'.

1.1. Objectives

1) To strengthen the capacity of officials of Lao PDR on climate change vulnerability assessment
2) To implement successful autonomous and planned adaptation measures
3) To share lessons learned and experiences on vulnerability assessment and adaptation at the national level
4) To assess the sources of climate finance funding.

1.2. Scenarios for Climate Change

According to the report of the Intergovernmental Panel on Climate Change on the revised Commonwealth Scientific and Industrial Research Organisation (SCIRO) (1996), the climate model to predict Southeast Asia's climate change scenarios for 2030 predicts a

change of rainfall of up to 10% in magnitude (decreases in winter, increases or decreases in summer, and an overall tendency for decreases). The projected changes for 2070 are about twice those of the 2030 changes. Increases in the intensity of heavy rainfall indicated in addition to the older non-coupled 'slab ocean' models have led to major changes in summer '*rainfall scenarios'* next to 2030. It will now vary from -10% to +10%.

The National Adaptation Program of Action (NAPA) process, under the United Nations Framework Convention on Climate Change (UNFCCC), highlights Lao PDR as one of the countries that has experienced the impacts of climate change, especially floods and droughts. From 1966 to 2005, floods and droughts resulted in significant losses to the national economy and people's livelihoods. About 80% of the Lao population of all ethnic groups relies on subsistence agriculture. The government has enhanced the national capacities on climate vulnerability and extreme events. The Department of Climate Change Management/MONRE reported that, over the past 40 years, the regression analysis shows that the annual mean temperature increases by more than 0.05°C per year, particularly in the southern part of the study area encompassing the two target districts of International Relations and Area Studies. It means that the temperature in the next 30 years (2040) will increase to 1.5°C, and the next 60 years (2070) will be approximately 3°C.

1.3. Economic Development of Lao PDR

At an economic level, the trajectory of Lao PDR's economy has been significantly affected by the COVID-19 pandemic. Following a growth of 7.02% in 2016, the rate of growth in real GDP gradually dropped over the following years to 6.89%, 6.25%, and then 5.46% in 2019. With the advent of the pandemic, real GDP decreased to 0.5% in 2020 but was predicted to increase to 2.53% in 2021 and 2.71% in 2022, providing that the global and local economies recover from the pandemic. Table 6.1 shows selected macroeconomic indicators as shown by the World Bank Data and global macrotrend of economic statistics.

Table 6.1. Economic Indicators of Lao PDR (2016–2022)

Year	GDP (US$ billion)	Per Capita (US$)	GDP Growth (%)	Inflation Rate (Annual % and $)	Government Gross Debt (US$ billion)
2022	15.72	2,088	2.71	23.00 (3,615,600,000)	16.50
2021	18.83	2,536	2.53	15.60 (4,330,900,000)	15.10
2020	18.98	2,593	0.50	22.96 (4,365,400,000)	13.80
2019	18.74	2,599	5.46	3.75 (4,310,200,000)	12.60
2018	18.14	2,553	6.25	5.07 (4,172,200,000)	11.60
2017	17.07	2,439	6.89	3.32 (3,926,100,000)	10.70
2016	15.91	2,309	7.02	2.04 (3,659,300,000)	9.80

Sources:
1) World Bank: https://data.worldbank.org/indicator/GC.DOD.TOTL.GD.ZS?locations=LA
2) Macrotrends https://www.macrotrends.net/countries/LAO/lao-pdr/economic-growth-rate
3) Laos Current Account Balance, 1994 – 2023 | CEIC Data: https://www.ceicdata.com/en/indicator/laos/current-account-balance

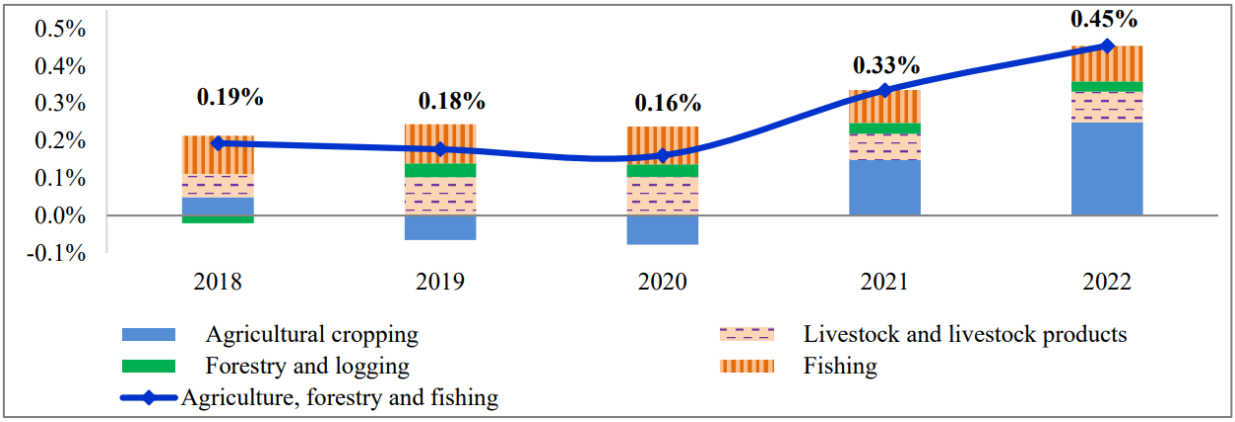
Actually, several macroeconomic factors constrain the budget for domestic development. Lao PDR has an increasing external debt that stood at $9.935 billion in 2019. A study in 2023 found that the country's debt-carrying capacity had deteriorated and its debt distress was assessed as high. The maturing of major sovereign debts and limited external financing options were the major factors causing the country to be downgraded in 2020 by both Moody's Investors Service and Fitch Ratings.

1.4. Economic Growth for Agricultural Sector

The agricultural sector expanded by 3.4%, with a value of 38.436 billion LAK , and contributed to 17.8% to the national economic growth. The main drivers of this sector were the plantations and livestock, which grew by 2.9% and 4.2%, respectively. According to the implementation of the national agenda related to the agriculture and forestry sector, the plantation was the most prominent, of which the rice output was 3,781,580 tonnes, 2.2% higher than the yearly plan and increased by 3.3% compared to last year. In addition, the output of commercial plants such as cassava was 4.8 million tonnes, 25% higher than the yearly plan, and increased by 31% compared to last year. This was followed by coffee beans, sugarcane, and fruits, which increased by 6%, 32%, and 15% (respectively) compared to last year. Furthermore, the main drivers of livestock were cattle for export to China and neighbouring countries, whose output of 2,425,000 cattle is 2.4% higher than the yearly plan and increased by 5.5% compared to last year. Then, 4,480,000 pigs and

50,118,000 poultry were produced and grew by 2.5% and 4.3% (respectively) compared to last year. The proportion of cultivated and fishery increased by 4.6% and 3.7% (respectively) compared to last year (Figure 6.1 and Gross Domestic Product Annex 2).

Figure 6.1. Agricultural Sector

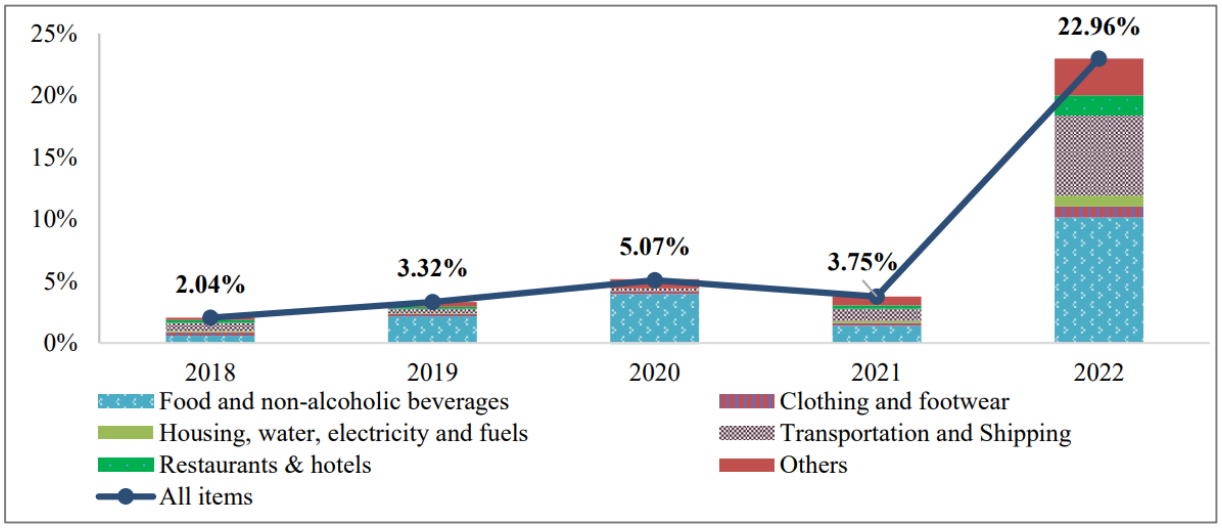


Source: Lao National Statistics Bureau, Ministry of Planning and Investment (2022). https://www.bol.gov.la/en/fileupload/29-06-2023_1688003428.pdf

1.5. Inflation

The annual headline inflation rate of Lao PDR increased dramatically to 22.96% from 3.75% in 2021 for headline inflation (Figure 6.2), due to the increase in fuel prices and the depreciation of the Lao kip against the main currency. Amongst the 12 categories of the consumer price index (CPI), transportation and shipping increased more than the others at 41.3%. In 2022, although the government had implemented some policies to stimulate the growth of the economy, including implementing the National Agenda to solve the economic-financial difficulties (2021–2023), the outcomes of the policies led to the increase in the country's revenue and narrowed the expenditures. As a result, the fiscal deficit was recorded at only US$92,016 million (₭736.13 billion [exchange rate in 2021 was $1 = ₭8,000) or around –1.09% of GDP, reduced from ₭2,329 billion or –1.3% of GDP in 2021.

Figure 6.2. Headline Inflation



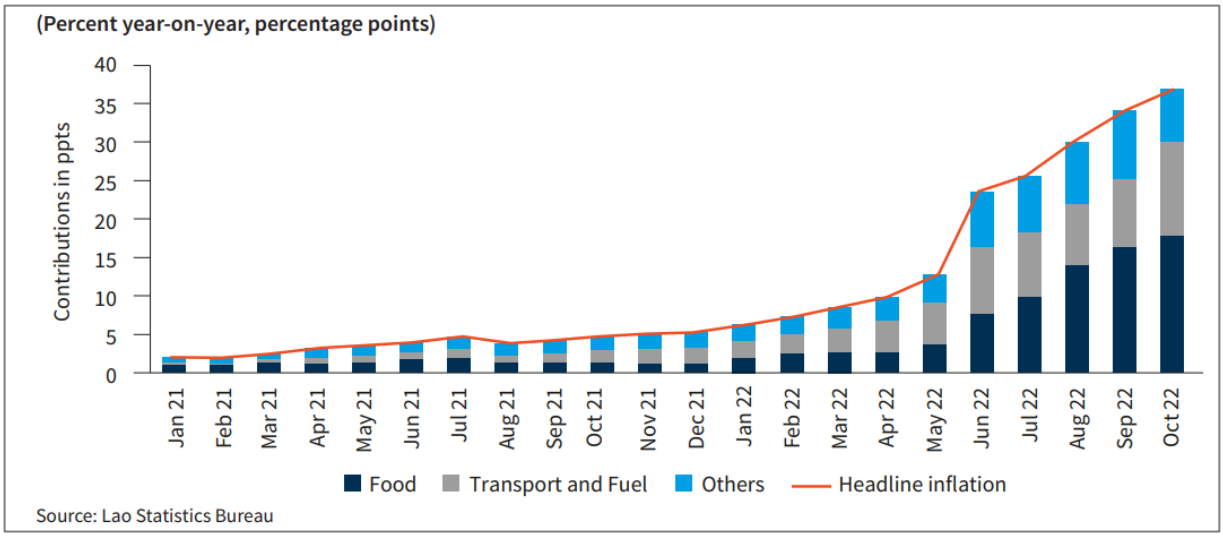
Source: Lao Statistics Bureau, Ministry of Planning and Investment, 2022 https://www.bol.gov.la/en/fileupload/29-06-2023_1688003428.pdf

1.6. The Exchange Rate of Domestic Goods and Imported Goods (January 2021–August 2023)

The domestic commodity exchange rate is calculated from 230 items covering 47.4% of the items. The sum amounts to 69.3% of the total weight. The commodity inflation rate in August is at 28.4%. Core Inflation Rate (Core-CPI) is a list of products that fluctuate regularly; some products are listed in Figure 5.2. Government control refers to the regulation and oversight of certain things that are not considered sensitive. There are a total of 402 articles that fall under this category in the entire country. These goods, which include ready-made food and starch, food preparation, non-alcoholic beverages, alcohol and tobacco, clothing and footwear, construction products and home repair equipment, household appliances, healthcare and pharmaceuticals, cars and auto parts, transportation services, education, entertainment, and personal use categories, account for 82.9% of all products and services and account for 55.6% usage weight. Non-core-CPI is a list of fast-sensitive products, with short-term volatility. These are shown in the data table is displayed see Annex 1).

The cumulative interest rate is calculated based on the monthly inflation rate and non-exponential inflation rate (expressed as a percentage per month). The domestic commodity exchange rate is derived from 230 items, representing 47.4% of the total items, and accounting for 69.3% of the total weight. In August, the commodity inflation rate reached 28.4%. Headline inflation surged to 37% in the year leading up to October 2022. Sharp spikes in food and transport prices were the primary drivers of inflation from January 2021 to October 2022 (see Figure 6.3).

Figure 6.3. Monthly Contributions to Headline Inflation (January 2021–October 2022)



Source: Lao Statistics Bureau, Ministry of Planning and Investment Data from World Bank (2022b). https://thedocs.worldbank.org/en/doc/df7b578ac035fe4dad0129a278b8c850-0070062022/original/LaoPDREconomicMonitorOctober2022.pdf

2. Study Areas for Climate Change Impact in Lao PDR, 2018–2019

2.1. Natural Disasters in 2018 in Lao PDR

Lao PDR is experiencing climate change impacts both in the form of an increasing occurrence of extreme weather events and changes in seasonal weather patterns. The most severe impacts are floods, landslides, tropical storms, cyclones, and droughts. Social, economic, and environmental impacts include the loss of life, population displacement, shelter destruction, and severe economic loss. About 2.8%–3.6% of the country's annual GDP is lost due to floods alone. Although extreme weather events are occurring with increasing frequency, particular years stand out regarding the damage sustained. Table 6.2 compares the impacts of disasters from 2008 to 2020, especially the severe losses from the devastating floods in 2018 and 2019.

The adaptive capacity of Lao PDR makes its population particularly vulnerable to the climate-related events to which it is exposed. MONRE, established only in 2011, is responsible for the country's adaptation, particularly climate change coordination.

Table 6.2. Losses from Disasters (Floods, Drought, and Typhoons), 2008–2020

Disaster Type	Year	People Affected	Deaths	Cost of Damages ($)
Flood	2008	243,342[1]	3[1]	17,157,224[1]
Typhoon Ketsana	2009	271,943[1]	28[1]	58,000,000[1]
Tropical Storms Haima and Nokten	2011	429,954[1]	42[1]	220,568,382[1]
Flood	2013	353,966[1]	25[1]	280,375,000[1]
Flood	2014	15,308[1]	1[1]	
Flood	2015	37,815[1]	0[1]	7,434,604[1]
Drought	2016	N/A	0[1]	126,200[1]
Floods after Tropical Storms Son Tinh and Bebinca	2018	616,145[2]	56 (as of Oct 2018)[2]	147,000,000 + losses of 224,500,000[2]
Floods	2019	1,000,000+[3]	19[3]	
Drought	2019–2020	67,800[3]		
Floods	2020	69,764[3]	2[4]	

Source:
[1]Laos Statistics Bureau, 'Laos Country Report', https://www.unescap.org/sites/default/files/Country%20Report_drought%20monitoring%20and%20early%20warning_Lao%20PDR.pdf.
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Adaptation is a pressing priority in Lao PDR, and providing socially inclusive and resilient housing can play a critical role in enhancing local resilience, advancing capacities to cope with climate change effects, and safeguarding rights to housing in times of climate change. Its strong focal point and technical support at the provincial and district levels hinder relevant sectors in progressing the integration of climate change adaptation into their plans and activities.

2.2. Natural Disasters in 2019 in Lao PDR

The survey explored the occurrence of floods, droughts, landslides, and storms in Lao PDR in 2019 (Figure 6.4; Annex 1, Map of Heavy Rain during Tropical Rainstorm Kajiki Cyclone). Said cyclone hit southern Lao PDR provinces, such as Khammouan, Savannakhet, Saravan, Xekong, Attapeu, and Champassak in 2019. The Lao News Agency, Khaosan Pathet Lao, reported on 5 September that two people died and two were missing after

floods in the central and southern parts of the country. Heavy rains brought about by the consecutive storms Podul and Kajiki led to severe flooding.

Earthquakes, not climate change–induced hazards, were also included in the analysis as they contribute to the increase in vulnerabilities. While there is no information on the impacts' intensity, preliminary results show that droughts were the primary hazard experienced in human settlements (in 25% of the villages affected), followed closely by floods (20%). The number of people affected by both hazards added up to 2,852,884, distributed in nearly 4,000 villages across the country.

Human settlements in Lao PDR are highly vulnerable: 46% of the villages have been exposed to at least one climate change–related hazard, representing about 3 million people affected, and 47% of the villages have been exposed to at least one hazard (including earthquakes). Geographical patterns in the distribution of the affected villages can be identified as follows, making a particular hazard more likely in specific areas of the country.

2.2.1. Impacts from Drought

Particularly in the north, with higher degrees of concentration in the provinces of Bokeo, 62% of the villages – Oudomxay, Luang Mantha, and Luang Prabang – experienced at least one episode in 2019. On the southern and central parts, Saravane, Champasak, Kammuane Provinces, and Vientiane capital have experienced droughts in less than 7% of their settlements.

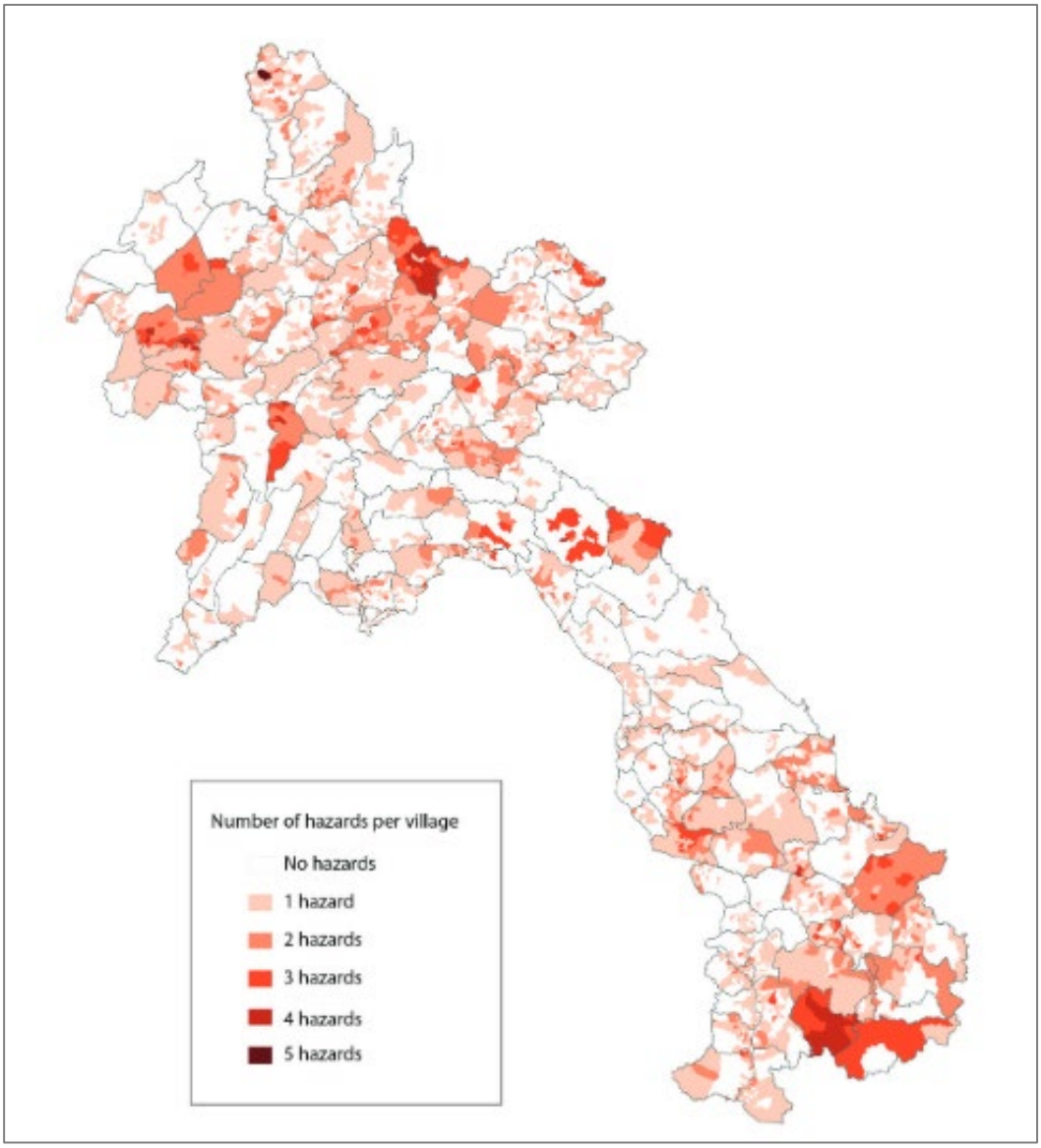
2.2.2. Impacts of Floods

The trend is quite the opposite, with the southern provinces registering the highest figures: nearly half of the villages of Champasak, Attapeu, and Sekong provinces registered impacts on at least one occasion last year. The recurrence of storms and landslides is significantly lower than other hazards, affecting 15% of the villages (less than a million people) in 2019. In both cases, southern Attapeu and Sekong provinces ranked first and second according to the number of villages affected.

2.2.3. Impacts of Earthquakes

Earthquakes affected only 2% of the villages surveyed and were in six provinces. Nearly half of the villages affected are part of northwestern Luang Namtha, Luang Prabang, and Xayaboury provinces. While 34% of the villages were affected by a single hazard in 2019, 13% of the settlements registered were impacted by two or more hazards that year, including earthquakes.The most common hazard combinations are (i) droughts and landslides; (ii) droughts and floods; and (iii) floods and landslides.

Figure 6.4. Natural Disasters in Lao PDR in 2019



Source: UN-HABITAT, 2021.

3. Climate Change Operation per Sector in Lao PDR

3.1. Climate Change Interventions

Responses from key line ministries of climate change operations suggested that the department of planning of each line ministry serve as an entry point for development cooperation. For example, at the Ministry of Agriculture and Forest (MAF), the Department of Planning and Cooperation is the entry point for all development projects from development partners.

Once the department and development partners agree on general project ideas and cooperation arrangements, they will assign technical departments to work with development partners in detail on project proposals. All development projects must be in

line with relevant sector strategies, sector 5-year development plan, and the NSEDP. With regard to submitting proposal to the Green Climate Fund (GCF) and Global Environment Fund (GEF), a project proponent has to submit the funding concept notes and proposals – which align with Nationally Determined Contribution (NDC), relevant sector plan, and the NSEDP – to the Department of Planning and Finance (DPF) of MONRE, who is the National Designated Authority (NDA) of the GCF and the operational focal point of GEF for the no objection certification. The DPF would request technical clearance from the Department of Climate Change Management of MONRE before issuing the certification.

3.2. Climate Change Vulnerability Related to the Agricultural Sector and Food Security

Although gradually declining in terms of its contribution to GDP in recent years, agriculture continues to play a major role in Lao PDR's economy. Agriculture accounts for 16.5% of the country's GDP in 2020 and employs about 70% of its population. Rice is the major crop of the country, accounting for 50% of the national agricultural output. Other major crops include maize, cassava, banana, and coffee, which are grown for subsistence and commercial purposes.

Climate change could cause unpredictable water levels and lead to reduced agricultural production. This may cause food insecurity and an increase in poverty as the livelihood of most Lao people relies on agriculture. Climate change may influence agricultural production via direct and indirect effects on crop growth practices. Direct effects include changes in carbon dioxide (CO_2) availability, precipitation patterns, and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and a decline in arable areas due to flooding or desertification.

Changes in the onset, length, and intensity of the rainy season, increased drought incidence, and increased frequency of heatwave, if coinciding with key phases towards the start and end of the cropping cycle, may have substantial negative implications for total rice production, as well as its reliability as a source of income and calories. Adaptations that may somewhat reduce these risks have been identified, but financial and technical barriers may prevent uptake by the poorest and most vulnerable smallholders. Livelihood-based natural resources will likely be the most vulnerable to changing climatic conditions. Recognising these important issues, Lao PDR government and development partners have initiated various steps to address the problems of sustainable agricultural growth, conservation of natural resources, and preparedness to cope with climate change and natural hazards.

For instance, the government introduced initiatives such as the National Adaptation Program for Action (NAPA) 2009, which aims to build capacity for climate-sensitive planning amongst Lao planners and decision-makers. NAPA identified four priority areas of response to climate change adaptation: agriculture, forestry, water, and public health.

The government is also developing the National Adaptation Plan to identify medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs. The 9th NSEDP also highlights the importance of mainstreaming climate change and community-based adaptation into sectoral development to protect the people from increasingly frequent and severe natural disasters.

3.3. Mitigation Options of the Forestry and Land Use Change

Forest cover in Lao PDR is a key determinant of differences in water use, quality, and quantity in the Mekong River basin. Land use change and forestry (LUCF) is the largest greenhouse gas (GHG) emitter in Lao PDR so the forests can sequestrate about five times the country's total GHG emissions. Therefore, it is essential to consider mitigation and sequestration opportunities because of (i) they have a large mitigation potential; (ii) they offer low-cost mitigation options; (iii) they provide significant environmental co-benefits such as biodiversity conservation and watershed protection; and (iv) they generate socioeconomic benefits such as employment, especially rural jobs, renewable forest products, and export earnings and import substitution potential.

Mitigation priorities include

1) Reducing 'slash and burn' agriculture by forest management, afforestation of degraded forests and reforestation to increase the forest cover to 65% by 2015 and 70% by 2020;
2) Enhancing carbon sink by making sustainable agricultural land available and encouraging alternative livelihood opportunities such as eco-tourism, non-timber forest products, and handicraft;
3) Reducing off-site burning by providing alternative fuels for forest-dependent communities, such as biogas, small hydro, energy-saving stoves, use of harvest residues, and community-based fuel-wood plantations;
4) Reducing forest fires by setting regulations and necessary measures to intercept and stop forest fires and providing awareness building and training to villagers on the harmful effects of forest fires and fire prevention;
5) Integrating forest management: including forest-food production systems, use of non-timber forest products, and community-based forest management;
6) Effectively mapping and planning land use for different purposes over the medium and long term to minimise land encroachment into the national protected area;
7) Pursuing carbon market opportunities and introducing pragmatic, flexible mechanisms, particularly REDD-plus (Reduced Emissions from Deforestation and Forest Degradation and Conservation in developing countries) by implementing more reforestation and afforestation programmes.

In addition, MAF is formulating Forest Strategy 2035 as an update to the Forest Strategy 2020. The draft strategy continues to set forth the vision of restoring forest cover to 70%, managing and developing forest resources, protecting biodiversity, conserving watersheds, improving environmental quality, and mitigating global warming.

3.4. GHG Emissions in Lao PDR

The National Greenhouse Gas Inventory, which aligns with the decision of the Conference of the Parties (COP), covered emissions and removals for four sectors: energy; industrial process and product use; agriculture, forestry, and other land use (AFOLU); and waste. The GHG emissions estimated were only CO_2, methane, and nitrous oxide. GHG emissions and removal expressed in CO_2 equivalents (CO_2e), and global warming potential in the Intergovernmental Panel on Climate Change Second Assessment Report were used to convert the unit, which aligns with the previous GHG inventories. The GHG inventory process included data collection and assessment, selection of tools and methods, calculation and reporting, review and validation, and endorsement. The Department of Climate Change Management-MONRE managed the process, which aligns with previous GHG inventories.

The result showed that the net emissions were 24,099.98 $GgCO_2eq$ in the inventory year 2014. AFOLU, especially remaining forest, cropland, and lands converted to forest, could remove an equivalent of about 13,000 $GgCO_2$. The AFOLU sector, the largest source of emissions, emitted 18,793.41 $GgCO_2eq$, accounting for about 78% of total emissions. The energy sector, the second-largest source, emitted 3,729.42 $GgCO_2eq$ (15%). The rest, industrial process and product use and waste, shared 5% and 2% of the national emissions, respectively.

3.4.1. The Scenario of GHG Emission Reduction in 2030

Lao PDR aims to accelerate the implementation of the national strategy to reduce emissions from deforestation and forest degradation; foster conservation, sustainable management of forests, buffer zones of protected areas, and other preserves; and enhance forest carbon stocks. The target is to reduce LUCF emissions by 1,100 $ktCO_2e$ annually between 2020 and 2030. The unconditional mitigation scenario and targets are the GHG emission reduction efforts that the country can commit to by 2030, considering its resources and existing levels of support from developed countries. The sectoral targets are presented in Table 6.3.

Table 6.3. Unconditional Mitigation Targets at the Sectoral Level, 2030

Sectors	Mitigation Target (2020–2030)	Average Abatement between 2020 and 2030 ($ktCO_2e/y$)
Land Use Change and Forestry	Reduced emissions from deforestation and forest degradation; foster conservation, sustainable management of forests, buffer zones of national parks, and other preserves; and enhance forest carbon stocks	1,100
Energy		
Hydropower	13 GW total hydropower capacity (domestic and export use) in the country	2,500
Energy Efficiency	Introduce 50,000 energy-efficient cooking stoves	50
Transport	• New bus rapid transit system in Vientiane capital and associated non-motorised transport component • Lao–China Railway	25 300

Source: Authors' compilation.

The conditional mitigation scenario and targets are the GHG emission reduction efforts that Lao PDR could achieve by 2030, contingent upon increased financial support from developed countries. Sectoral targets, including additional sectors compared to 2015 NDC, are presented in Table 6.4. In the LUCF sector, Lao PDR aims to increase the forest cover to 70% of the total land area, in line with the National Forestry Strategy.

Renewable energy capacity would be increased to 1 GW solar and wind power and 300 MW biomass power. The latter would also contribute to improving air quality by utilising agricultural residues and avoiding slash-and-burn practices. This new renewable energy target updates based on the 2015 NDC. Two conditional targets are brought forward in the transport sector: 30% electric vehicles penetration for two-wheelers and passenger cars in the national vehicles mix, and an increase in the share of biofuels to meet 10% of the transport fuels by 2030.

Table 6.4. GHG Emission Reduction in Each Sector, 2030

Sector	Mitigation Measure (2020–2030)	Average Target between 2020 and 2030 ($ktCO_2e/y$)
Land Use Change and Forestry	Increased forest cover to 70% of land area (i.e. to 16.58 million hectares) by reducing emissions from deforestation and forest degradation; fostering conservation, sustainable management of forests, buffer zones of national parks, and other preserves, and enhancing forest carbon stocks	45,000
Energy		
Other Renewables	Solar and wind: 1 GW total installed capacity in the country	100
	Biomass: 300 MW total installed capacity in the country	84
Transport	30% electric vehicles penetration for two-wheelers and passenger cars in national vehicles mix	30
	Biofuels to meet 10% of transport fuels	29
Energy Efficiency	10% reduction of final energy consumption compared to the business-as-usual scenario	280
Agriculture	50,000 hectares adjusted water management practices in lowland rice cultivation	128
Waste	Implementation of 500 tonnes/day sustainable municipal solid waste management project	40

Source: Authors' compilation.

The three sub-sectors of the energy sector – hydropower, energy efficiency, and transport – are mobilised to contribute to the mitigation efforts. The total target installed hydropower capacity in the country by 2030 is set at 13 GW by applying an 80% probability ratio to the 2030 anticipated installed capacity in the Ministry of Energy and Mines' 2016–2030 Power Development Plan. About 50,000 energy-efficient cooking stoves will reduce the use of non-renewable biomass for combustion. Then a new target in the transport sector is introduced to replace the M4 target (transport and urban development) in the 2015 NDC, which has not been implemented, namely, the construction and operation of a new bus rapid transit system in Vientiane capital and associated non-motorised transport

component, as well as the construction and operation of a Lao–China railway, which will displace the use of internal combustion engine private vehicles.

4. Climate Finance Funding Sources

4.1. Accessing Climate Finance Funding Sources

Lao PDR received climate finance sources from multilateral funds – UNFCCC and non-UNFCCC, and development partners such as the World Bank, the Asian Development Bank (ADB), and GIZ. UN agencies do provide funding, though often relatively small compared to others. UN agencies primarily work with relevant government counterparts to develop funding proposals to be submitted to the UNFCCC. Governments also provide funding for climate change to ministries, but there is no tracking system. The private sector does carry out investments related to climate adaptation and mitigation. However, they may not be aware that their activities contribute to climate mitigation and/or adaptation.

A tracking system on the private sector's climate change investment is not available. Responses from key informant interviews indicated that the government would continue focusing on mobilising climate-related funding from the mentioned multilateral funds, as they provide grants and large investment amounts. Some multilateral funds like the GCF are also open to the private sector for extremely low interest loans. In this regard, climate change–related support should also be extended to the private sector to facilitate and support them to access the funds. Overall, there is a lack of diversified sources of long-term financing. Public sector funding, including official and other development assistance, is the primary source of climate finance in Lao PDR.

To access multilateral funds, the government relies on development partners that are multilateral funds' accredited entities (for GCF), implementing entities (for the Adaptation Fund [AF]), or partner agencies (GEF/Least Developed Country Funds), as some of the funds require the government to meet the criteria set by the fund partners due to limited capacity and resources. Significant time and resources are needed to develop proposals for UNFCCC funding. For example, one of Lao's proposed GCF projects took 4 years to be approved.

4.2. UNFCCC Funds

With support from development partners, Lao PDR can access four out of five UNFCCC funds. At the time of writing this report, the government has been implementing two AF projects with UN-Habitat, AF's implementing entity. In 2019, the GCF approved two projects for Lao PDR, amounting to $28.5 million. In addition to these two projects, the GCF approved nine readiness activities totalling $3.2 million for Lao PDR. The government is preparing the Environment Protection Fund to be accredited as a direct access entity of Lao PDR. Since its inception, GEF has approved 30 projects for Lao PDR, including GEF projects and Least Developed Countries Fund projects. Since 2010, GEF has begun using the system for transparent allocation of resources (STAR), which provides indicative

grants for each country. Lao PDR is a STAR country with a resource allocation under GEF-7 of $8.07 million ($1.5 million for climate change, $1.5 million for land degradation, and $5.07 million for biodiversity).

4.3. Non-UNFCCC Funds

4.3.1. UN Funds

The International Fund for Agricultural Development (IFAD) Adaptation for Smallholder Agriculture Programme (ASAP) was established in 2012. ASAP grants are joined with IFAD baseline investments implemented by government entities. The programming of ASAP funds follows the IFAD project design cycle and is fully aligned with regular IFAD procedures and safeguards. Therefore, ASAP does not employ the call for application procedures like other funds.

The UN-REDD Programme is the UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries. Under the UN-REDD Programme, Lao PDR received a 6-month project amount of $178,000 in 2015. The support focused on monitoring, reporting, and verification activities.

4.3.2. Multilateral Development Bank Funds

The World Bank administers several climate funds, including Climate Investment Funds (CIF), comprising two trust funds: the Clean Technology Fund and the Strategic Climate Fund (SCF). The SCF has three targeted programs: The Forest Investment Program, the Pilot Program for Climate Resilience, and the Scaling-up Renewable Energy Program. CIFs are channelled exclusively through five multilateral development banks (MDBs), which work with national governments to prepare national investment plans, including individual projects and associated financing packages to achieve the national development agendas of participating countries. ADB, the World Bank, and International Finance Corporation have implemented three projects in Lao PDR under CIF's investment plan. Lao PDR government has accessed the World Bank's Forest Carbon Partnership Facility (FCPF) and has received $8.375 million of financial support from the FCPF/Readiness Fund, starting with a $200,000 grant to prepare a REDD+ Readiness Preparation Proposal approved in 2010. In 2014, the government signed a readiness grant agreement with the FCPF for $3.6 million. In its 2016 mid-term review, Lao PDR requested additional funding of $4.575 million. In January 2021, the country and FCPF signed an agreement to provide up to $42 million between 2021 and 2025 to support the country's efforts to reduce emissions from deforestation and forest degradation (REDD+). Other Mitigation-REDD+ funds that the World Bank administers are BioCarbon Fund Initiative for Sustainable Forest Landscapes (ISFL) and Partnership for Market Readiness (PMR). The ISFL supports programmes in Colombia, Ethiopia, Indonesia, Mexico, and Zambia, while the PMR is open to all interested countries to present an organising framework for the scoping of PMR activities.

The ADB Climate Change Fund was set up in 2008 to facilitate greater investments in developing member countries (DMCs) to effectively address the causes and consequences of climate change by strengthening support for low-carbon and climate-resilient development in DMCs. It provides financing through grant components of ADB investments, technical assistance (stand-alone and piggybacked or linked to loan), and direct charge. The fund allocated $1 million to Lao PDR in 2020 to support the preparation and design of the country's Flood and Drought Mitigation and Management Project. After that, there are other multilateral donor funds. For example, other multilateral funds reviewed under this analysis include the Global Agriculture and Food Security Program, NAMA Facility, and Nordic Development Fund.

5. Conclusion and Recommendations

For an LDC like Lao PDR, which is vulnerable to climate change impacts and with low coping capacity, adaptation has accounted for 71% of the total flows during 2015–2019. Grants accounted for 59% and 49% of the total flows in 2018 and 2019, respectively. Lao PDR situation contrasts with the global climate finance flows, where grants and adaptation flow only accounted for 5% of the total flows in 2017/2018. With a high debt-to-GDP ratio, grants will continue to be a priority for climate finance mobilisation. Under such circumstances, exploring innovative mechanisms to maximise grant utilisation is necessary. One possible option is to leverage grants to support private sector investment in NDC priority sectors. Monitoring and reporting on climate finance should be regarded as an urgent and priority area to pay attention to. A clear overview of climate finance flows and their use will allow targeted resourcing and planning of activities towards a country's NDC. This includes learning from the use of climate finance flows in the past. A good monitoring and reporting system will also enhance stronger confidence with climate finance donors. In this regard, Lao PDR must establish a standard definition of climate finance and a harmonised system for monitoring and coordinating climate change projects.

Obviously, there is a strong need to strengthen the government's capacity in mobilising climate finance. The current situation relies on support from development partners. Capacity-building initiatives should be designed for systematic, strategic, and continuous assistance, avoiding short-term one-off support.

Capacity-building programmes should integrate climate change, project cycle management, financial management, and environment safeguard topics, and target government and private sector entities. The primary emphasis of the educational trainings is on the continuous utilisation and evaluation of the 'Vulnerability Assessments and Master Plans', especially when more specific local climate change data becomes accessible. Floods, drought, cold waves, typhoons, cyclones, storms, landslides, earthquakes, unexploded bombs, and others are the most visible impacts of climate change in the target areas. Adaptive measures must be integrated into planning and implemented now before haphazard development that cannot be undone takes place.

The capacity-building activities are an important part of the project. There is a significant gap between the level of knowledge at the national and local levels. District-level workshops are a key part of this participatory project as they unite all local stakeholders. Lao PDR has a silo culture, where government offices in different sectors work independently. Stakeholders for this proposed project include provincial, district, and village authorities; provincial and district offices of natural resources and environment; departments of planning and investment; and community members, which will be included at all stages of the project.

Lao PDR government has a policy of raising awareness at ministries, educational institutions, and other public information meetings and consultation workshops to inform policymakers and the general public, including children, about existing risks and what to do in a crisis. It launches simulation exercises, especially on floods and landslides, to involve the local population and recommend behaviours and good practices in a crisis by making them face a specific situation.

The government promotes the development of resilient cities by investing in resilient and sustainable transport systems, infrastructure, water resources, and housing to avoid infrastructure disruptions and wide-ranging socioeconomic costs for institutions and households in the event of natural disasters.

The policy of Lao PDR government on the conservation of natural resources, especially biodiversity and the environment, is threatened by population growth, the expansion of agricultural land, climate change, illegal logging and poaching, and the unsustainable exploitation of natural resources. In particular, the impact on forests has been significant, with forest cover that had been estimated at more than 70% in the 1940s having dropped to 40% by 2010. In response to this rapid deforestation, in 2005 the government formulated the Forest Strategy 2020 to restore the forest cover to 70%. At the same time, the government was supported by the Japan International Cooperation Agency and other donors. Thus, Lao PDR's ecosystems are relatively intact compared to other Asian nations. Almost 60% of the country is covered by forests, which the government aims to increase to 70% by 2035.

Since 2022, the impact of inflation has been estimated to be larger for the urban poor than the rural poor who rely primarily on self-produced food for consumption; thus, the price impact is likely milder. Amongst households from the poorest quintile, food purchases account for only 22% of total consumption for rural households but constitute 40% of total consumption for urban households. Lao PDR is assessed to be in external and overall debt distress under the Low-Income Countries Debt Sustainability Framework. Compared to the 2019 Debt Sustainability Analysis (International Monetary Fund. Asia and Pacific Dept, 2019) the country's risk rating and debt sustainability have deteriorated due to an adverse macroeconomic environment (through a strong exchange rate depreciation), an expansion of debt coverage to include guaranteed debt, expenditure arrears, and the issuance of domestic debt to recapitalise state-owned banks.

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Annex 1

Key Economic Indicators of Lao PDR (2018–2022)

Items	2018	2019	2020	2021	2022(P)
Real Sector (Percent Change)					
Real GDP Growth*	6.29	5.46	3.28	3.48	4.40
Inflation (End of Period)	1.48	6.28	3.19	5.27	39.27
Inflation	2.04	3.32	5.10	3.75	22.96
Public Finance (Percent of GDP)	**2018**	**2019**	**2020**	**2021**	**2022**
Total Revenue	15.71	15.58	12.63	14.69	15.30
Revenue	14.30	13.48	11.11	12.70	13.80
Grants	1.41	1.74	1.48	1.99	1.5
Donations/Social contribution	-	0.12	0.04	-	-
Total Expenditure	20.34	18.83	17.85	15.95	15.60
Current Expenditure	12.09	12.63	11.41	10.84	10.68
Capital Expenditure	8.25	6.19	6.43	5.12	5.10
Budget Deficits	-4.63	-3.25	-5.21	-1.25	-0.3
Budget Deficits (Excluding Grants)	-6.04	-4.99	-6.73	-6.74	-1.8
Monetary Sector (Percent Change)	**2018**	**2019**	**2020**	**2021**	**2022**
Money Supply (M2)	8.37	18.85	16.33	23.98	36.85
External Sector (Percent of GDP)	**2018**	**2019**	**2020**	**2021**	**2022**
Overall Balance	-0.79	0.66	1.69	-0.30	-0.94
Current Account	-9.10	-6.99	-1,21	2.35	-0.07
Trade Balance	-5.00	-2.47	-3.90	7.48	6.34
Financial Account	-12.09	-10.30	-5.67	-1.62	-1.99
External Debt Outstanding	52.67	53.08	55.94	53.81	68.01
Gross Official Reserves (In millions of U.S. dollars)	876.17	997.25	1,319.7	1,262.51	1,120.74
In months of prospective goods and services imports (Excluding imports associated with large resource projects)	3.23	3.59	4.81	3.86	3.14

Source: Lao National Statistics Bureau, Ministry of Planning and Investment. (2022). https://www.bol.gov.la/en/fileupload/29-06-2023_1688003428.pdfsss

Annex 2

Gross Domestic Product (2018–2022)

(In billions of Kip)

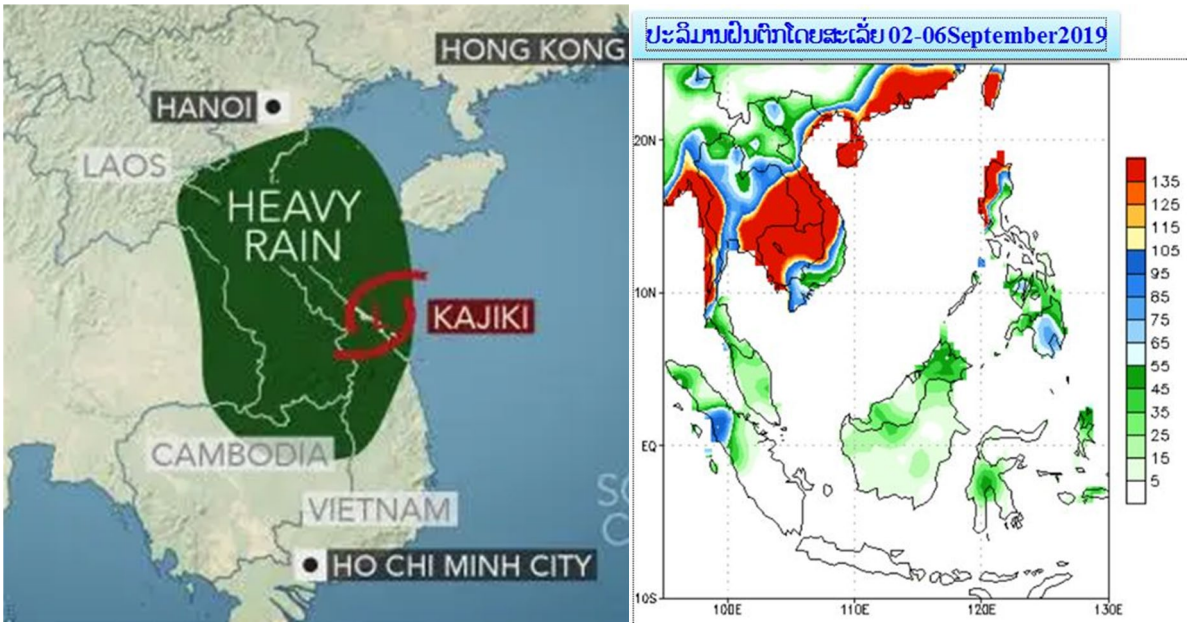
Items	2018	2019	2020	2021	2022(P)
Nominal GDP	**152,414**	**162,657**	**172,919**	**184,982**	**215,609**
GDP Per capita (USD)	**2,585**	**2,632**	**2,642**	**2,595**	**2,022**
Real GDP Growth*	**6.29**	**5.46**	**3.28**	**3.48**	**4.40**
Real GDP*	**123,696**	**130,447**	**134,720**	**139,408**	**145,574**
Agriculture	**17,975**	**18,194**	**18,404**	**18,855**	**19,488**
Agricultural cropping	11,767	11,686	11,584	11,784	12,130
Livestock and livestock products	2,510	2,637	2,772	2,866	2,982
Forestry and logging	1,066	1,111	1,154	1,194	1,232
Fishing	2,631	2,761	2,894	3,012	3,144
Industry	**44,119**	**46,591**	**50,880**	**53,986**	**56,356**
Mining and quarrying	9,891	9,885	8,233	8,362	8,596
Manufacture of food products	1,792	1,902	1,928	1,952	1,995
Manufacture of beverages and tobacco	1,703	1,814	1,870	1,894	1,977
Footwear and leather goods	1,413	1,457	1,464	1,460	1,499
Other manufacturing	5,044	5,449	6,724	7,042	7,457
Electricity	14,089	13,808	16,640	18,128	18,611
Water supply, sewerage, waste management and remediation activities	322	342	360	371	388
Construction	9,864	11,936	13,661	14,777	15,834
Services	**49,044**	**52,409**	**51,783**	**52,493**	**55,103**
Wholesale and retail trade, repairs	17,231	18,658	18,899	19,210	19,991
Transport and storage	1,798	1,944	1,888	1,897	2,443
Accommodation and food service activities	3,242	3,502	1,574	1,175	1,276
Information and communications	2,304	2,466	2,678	2,852	3,008
Financial and insurance activities	2,970	3,217	3,257	3,353	3,467
Real estate activities	8,031	8,660	8,869	8,972	9,303
Professional, Scientific & Technical Activities	1,677	1,827	1,904	1,945	2,007
Public administration and defense; compulsory social security	7,480	7,695	8,133	8,379	8,760
Education	1,963	2,004	2,048	2,086	2,128
Human health and social work activities	526	546	571	600	627
Other services	1,823	1,888	1,962	2,024	2,094
All industries at basic prices	**111,138**	**117,194**	**121,067**	**125,335**	**130,947**
Taxes on products and Import duties, net**	12,558	13,253	13,653	14,073	14,627

Remark: P: Preliminary data
*: At 2012 Price
** : Minimun Tax, Turover Tax, Value-Added Tax, Excise Tax and Customs Duties

Source: Lao Statistics Bureau, Ministry of Planning and Investment (2022) https://www.bol.gov.la/en/fileupload/29-06-2023_1688003428.pdf

Annex 3

Map of Heavy Rain during Tropical Rainstorm Kajiki Cyclone which Hit Southern Lao PDR in 2019



Note: Tropical Rainstorm Kajiki, expected to strengthen as it slowly tracks, with torrential rainfall reported where 150–300 mm (6-12 inches) of rain fell from 2–6 September 2019. The risk for flooding to parts of Lao PDR, Viet Nam, and northeast Cambodia.
Sources: Accuweather website USA, which provided weather forecasts and weather products and Climate Predict Center, National Weather Service, S.E. Asia, NOAA, USA.
https://www.accuweather.com/en
https://www.accuweather.com/en/weather-news/tropical-depression-to-unload-daily-downpours-on-vietnam-china-this-week/525372
https://www.cpc.ncep.noaa.gov/products/JAWF_Monitoring/SEAsia/index.shtml

Chapter 7

Strengthening Climate Change and Disaster Management Information Database for Risk Assessment and Building Adaption Road Maps: Case of Viet Nam

Lai Van Manh, Do Thi Thanh Nga, Ngo Dang Tri, Nguyen Tuan Anh

Viet Nam is one of the countries most affected by climate change. Ranked by the Climate Change Vulnerability Index, Viet Nam is one of 30 countries in the 'extremely risky' group. According to the Climate Risk Index for 2000–2019, Viet Nam ranked thirteenth globally and fourth in ASEAN. Recently, collected data shows that climate change will cost Viet Nam $10 billion in 2020, equivalent to 3.2% of its gross domestic product. To reduce greenhouse gas emissions and effectively respond to climate change, Viet Nam has developed and issued many policy documents, such as the National strategy for climate change until 2050, the national target programme on response to climate change, Resolution No 24 -NQ/TW on active in response to climate change, improvement of natural resource management and environmental protection, etc. These policies have helped improve Viet Nam's capacity and mitigate the negative impacts of climate change. However, the policy implementation process still faces many difficulties and challenges, such as population explosion, high urbanisation rate, limited resources, and poor infrastructure system. On that basis, to be able to propose appropriate policy solutions to overcome shortcomings and improve Viet Nam's capacity to respond to climate change in the future, this chapter will (i) present the impact of climate change on the economic and social growth in Viet Nam; (ii) synthesize some of Viet Nam's current strategies, policies, and legal frameworks to address climate risks; (iii) present experiences, limitations, and causes of the national strategy on climate change; (iv) provide policy recommendations and necessary activities in the future to solve the problem of climate change in Viet Nam.

1. Introduction

Viet Nam is one of the countries most affected by climate change. The Climate Change Scenario 2022, published by the Viet Nam Institute of Meteorology, Hydrology, and Climate Change, reported that the temperature increased nationwide and annual rainfall trends increased slightly by 2.1% from 1958 to 2018. The major extreme weather events related to rain are about 12 to 13 storms and tropical depressions a year. About 1.5% of gross domestic product (GDP) was annual losses caused by natural disasters. The accelerating pace of damage was 12.7% from 1995 to 2017. Hurricanes, floods, and flash floods primarily caused damage to humans (81%) and the economy (56%). Cyclones and

hailstones caused extensive damage to people (17%) but were less harmful to the economy (1%). Drought and saltwater intrusion were the main causes of economic damage (40%) in 2016 without damaging people. Viet Nam gave strategic directions, established interdisciplinary apparatuses, and integrated relevant regulations into the legal framework to reduce vulnerability and risk to the impacts of climate change by strengthening resilience, the adaptive capacity of communities, economic sectors, and ecosystems, and promoting the integration of climate change adaptation (CCA) into the strategic and planning system. However, Viet Nam also faces many challenges to achieving the above goals, such as a lack of resources, inadequate institutions, limited skills of people and officials, and especially a lack of information and databases in supporting policymaking, monitoring, and evaluation. The chapter illustrates Viet Nam's road map in building adaptation road maps, the current status of the information database in strengthening climate change and disaster management, and some initiative suggestions for Viet Nam.

2. Impacts of Climate Change on Viet Nam's Economic Growth and Social Development

2.1. Changes in Temperature, Rainfall, and Weather Patterns

The Ministry of Natural Resources and the Environment (MONRE) study on climate change (2021) summarised the evolution of climate change in Viet Nam in 1958–2018, as follows:

The temperature increased nationwide in 1958–2018. The average annual temperature increased by about 0.89°C during 1958–2018, 0.74°C in 1986–2018, and 0.32°C in 2001–2018 (Table 7.1). Assuming a similar rate of increase in average temperatures, by 2080–2090, temperatures could be higher by 1°C –3.4°C, relative to the 1986–2005 baseline for Viet Nam. The temperature rise will likely amplify the impacts on rainfall patterns, human health, livelihoods, and natural ecosystems.

Table 7.1. Change in Average Temperature (°C) across Climate Zones, 1958–2018

Climate Zone	Winter	Spring	Summer	Autumn
Northwest	1.1	0.8	0.9	1.3
Northeast	1.0	0.8	0.8	1.1
Northern Delta	0.9	0.9	0.7	1.2
North Central	0.8	0.9	0.8	1.3
South Central	0.6	0.4	0.6	0.9
Highlands	1.3	0.7	1.0	1.4
Southern	1.1	0.8	0.9	1.1

Source: MONRE (2021).

Annual rainfall nationwide increased by 2.1% between 1958 and 2018 mainly in the southern region. Table 7.2 illustrates the change in average rainfall across seven climate zones in Viet Nam from 1958 to 2018. According to the country's climate change scenarios, Viet Nam will face two important issues: rainfall patterns and the change in intensity of extreme weather phenomena, such as floods and droughts.

Table 7.2. Change in Average Rainfall (mm) across Climate Zones, 1958–2018

Climate Zone	Winter	Spring	Summer	Autumn
Northwest	41.4	9.9	-4.3	-17.3
Northeast	34.3	-0.7	1.4	-16.0
Northern Delta	13.8	2.7	-0.9	-27.1
North Central	16.8	13.0	8.6	-12.1
South Central	82.2	23.0	8.9	11.3
Highlands	40.3	14.6	0.5	7.4
Southern	97.4	7.5	2.5	3.8

Source: MONRE (2021).

Further, the low-lying coastal and river delta regions of Viet Nam have a very high vulnerability to sea-level rise. Water level data at the hydrographic stations tend to increase with the strongest rate of over 6 mm/year at the Cua Ong, Bach Long Vy, and Con Dao stations. The average sea level of all stations increased by about 2.7 mm/year from 1993 to 2018 (MONRE, 2022b).

The number of storms and tropical depressions tends to be less variable but more concentrated at the end of the monsoon season, which is also the period when cyclones are mainly active in the south. Strong to very strong storms tend to increase over time. On average, about 12 to 13 storms and tropical depressions operate in the East Sea yearly. Intense storms tend to increase slightly. The activity of tropical depressions affecting Viet Nam recently has many irregularities and erratic patterns. The number of hot days when the temperature is more than 35°C tends to increase almost everywhere in the country: the largest is in the North Central, South Central, and Southern regions. Drought may become more severe in some regions due to increased temperature and reduced rainfall in the dry season, such as in the South Central region in spring and summer, the South in spring, and the North in winter. The number of days of intense and harmful cold also tends to decrease. However, the number of cold spells fluctuates sharply yearly.

2.2. Consequences of Climate Change and Natural Disasters on Viet Nam's Socioeconomic Development

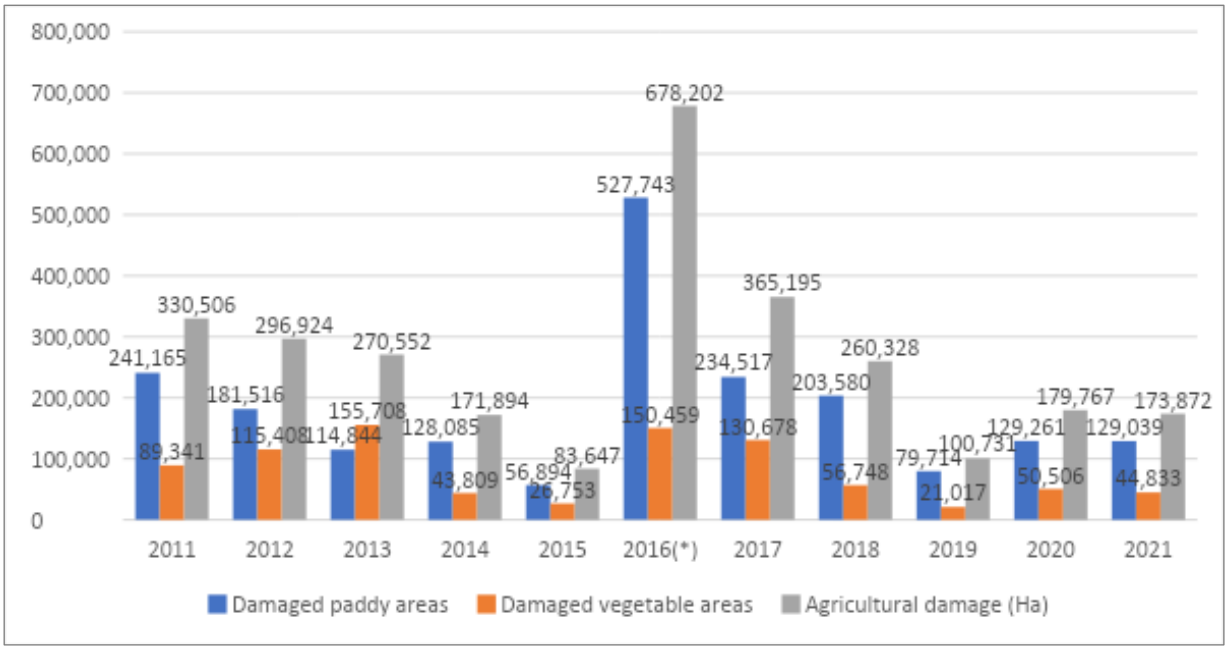
Climate change–induced natural disasters affect the basic elements of human life in all the provinces. The availability and access to water, food, energy, and health are becoming a major challenge to achieving sustainable economic growth (World Bank Group, 2022). It profoundly impacts attaining the Sustainable Development Goals for 2030 through gradual processes like temperature and sea level rise and accelerated processes through increasing extreme weathers, such as hurricanes, flash floods, heavy rains, urban flooding, drought, extremely hot and harmful cold temperature, and salinisation. According to the Viet Nam *Special Report on Disaster Risk Management and Extreme Events* (IMHEN and UNDP, 2015), increased exposure to changing weather patterns and hazards to people and property has profoundly impacted all socioeconomic development and regions. The information database from the World Bank (Table 7.3) and the General Statistics Office illustrated in Figure 7.1 describes the historical value of damages caused by natural disasters in the country in terms of crop-cultivated areas and the economic value of damages.

Table 7.3. Summary of Natural Hazards in Viet Nam, 1900–2018

Disaster Type	Disaster Subtype	Events Counts	Total Deaths	Total Affected	Total Damage (1,000 $)
Drought	Drought	6	0	7,860,000	7,399,120
Epidemic	Others	1	16	83	0
	Bacterial disease	1	598	10,848	0
	Parasitic disease	1	200	0	0
	Viral disease	8	395	97,027	0
Flood	Others	16	1,012	2,011,287	160,055
	Coastal flood	6	804	4,353,316	749,000
	Flash flood	13	481	912,607	516,700
	Riverine flood	52	3,644	25,637,158	2,896,407
Landslide	Avalanche	1	200	38,000	0
	Landslide	4	109	40	0
	Mudslide	1	21	1,034	2,300
Storm	Other	10	323	219,280	145,035
	Convective storm	8	160	4,513	10,100
	Tropical cyclone	92	18,869	53,272,568	9,967,657

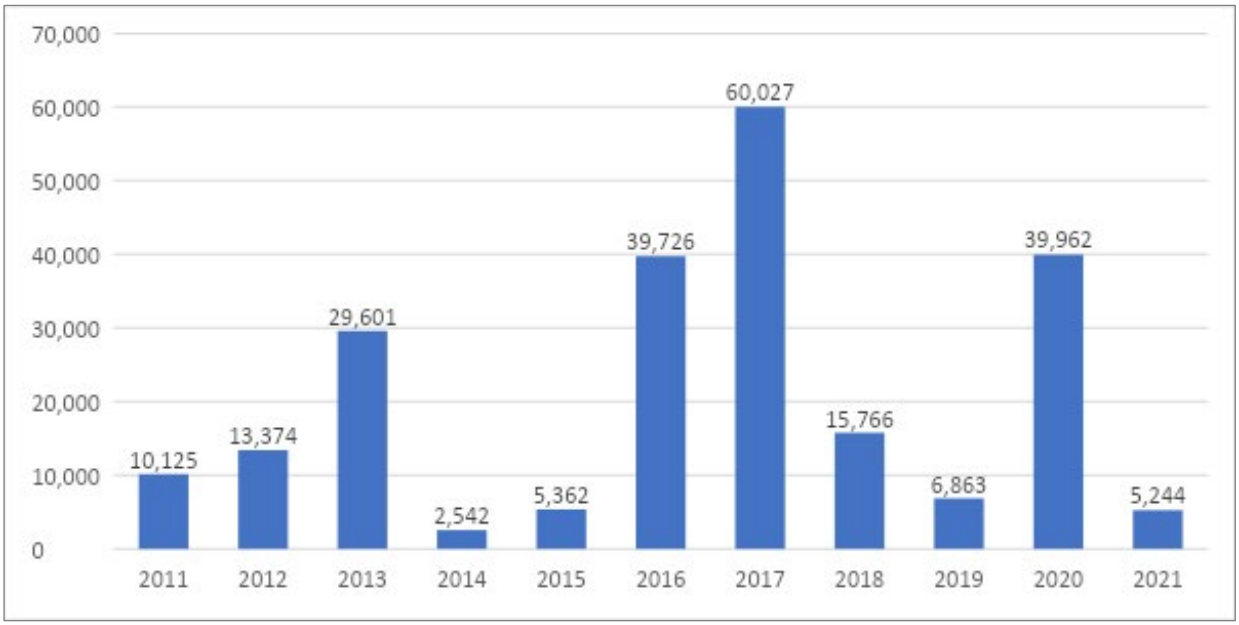
Source: World Bank Group and ADB (2020).

Figure 7.1. The Trend of Damage in Rice and Crop Areas Caused by Natural Disasters, 2011–2021



Source: General Statistics Office (2022).

Figure 7.2. Total Economic Losses Annually by Natural Disasters, 2011–2021 (billion ₫ [dong])



Source: General Statistics Office (2022).

2.3. Climate Risk Management and Resilient Economic Growth

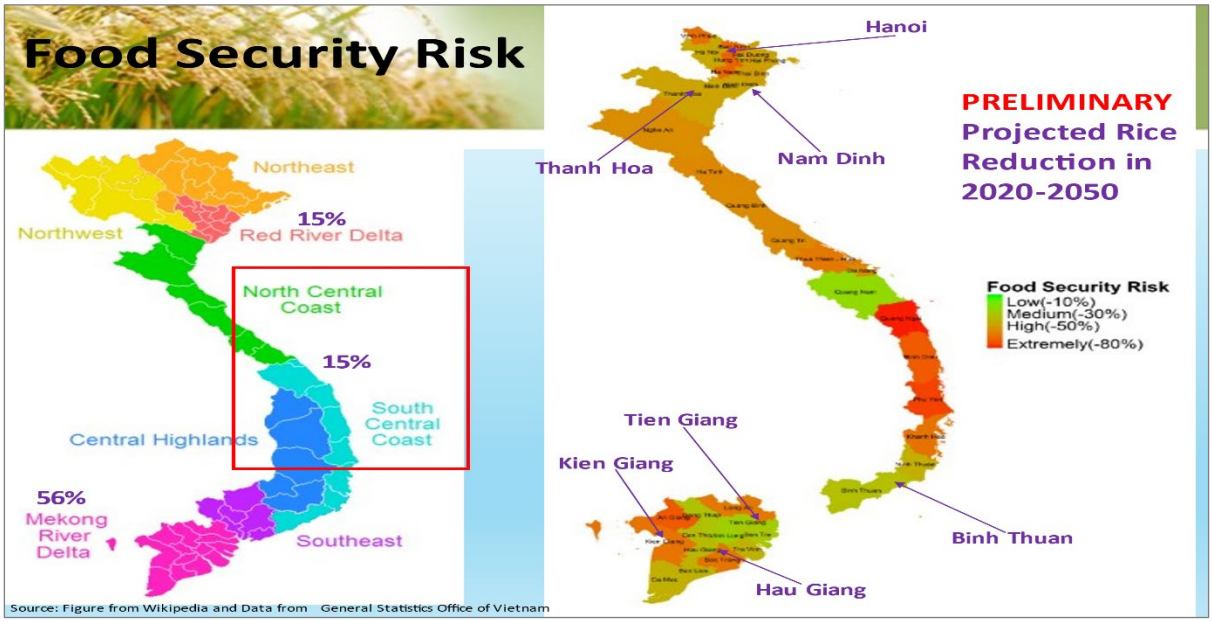
The Climate Change Vulnerability Index (MONRE, 2021) categorises Viet Nam as one of the 30 countries worldwide as extremely risky. Excerpts from the German watch report (Eckstein, Künzel, and Schäfer, 2021) on Climate Risk Index for 2000–2019 placed Viet Nam as the thirteenth most affected nation by the impact of natural disasters in the same period, and ranked fourth amongst the ASEAN member countries most affected by climate-induced natural disasters (Table 7.4).

Table 7.4. Climate Risk Index in the ASEAN Region, 2000–2019

CRI Rank Globally	CRI Rank in ASEAN	ASEAN Country	CRI Score	Average Fatalitie, 2000–2019 (Rank)	Average Fatalities per 100,000 Inhabitants, 2000–2019 (Rank)	Average Losses, 2000–2019 (million $, PPP)	Average Losses per Unit GDP, 2000–2019 (%)
176	9	Brunei Darussalam	167.50	167	151	178	178
14	5	Cambodia	36.17	38	35	53	28
72	7	Indonesia	143.17	93	155	120	168
52	6	Lao PDR	60.50	82	66	73	38
116	8	Malaysia	105.67	64	108	66	144
2	1	Myanmar	10.00	1	1	19	19
4	2	Philippines	18.17	7	16	8	31
179	10	Singapore	172.00	172	172	162	177
9	3	Thailand	29.83	22	60	3	17
13	4	Viet Nam	35.67	15	47	11	47

CRI = Climate Risk Index.
Source: Eckstein, Künzel, and Schäfer (2021).

Figure 7.3. Climate Change and Food Security Risks in Viet Nam (2020–2050)



Source: Anbumozhi, Breiling, and Reddy (2019).

Without effective adaptation measures, 6–12 million people of Viet Nam could be affected by coastal flooding by 2070–2100, exacerbating the already-substantial risks posed by river floods by 2035–2045. Several million croplands are affected by extreme floods every year. Combined with drought, almost all provinces will face severe food security challenges, with extreme risks projected in the Mekong River Delta (Figure 7.3). Climate change is increasingly disrupting Viet Nam's economy, and the costs are already undermining the current economic growth. Recent estimates suggest that Viet Nam lost $10 billion in 2020, or 3.2% of its GDP due to climate change (World Bank, 2022). The magnitude of these damages, projected to increase rapidly, emphasizes the increasing need for Viet Nam to adapt to the risks of a changing climate. Flood represents the largest risk by economic impact in Viet Nam, accounting for an estimated 97% of average annual losses from hazards (World Bank Group, 2022).

The report on the Index for Risk Management by the European Commission 2017 in Table 7.5 ranks Viet Nam 98th globally on the INFORM Climate Change Risk Index. Compared with Japan (ranked 153), Viet Nam's rank in the index is still low. This requires Viet Nam to make more efforts in natural disaster prevention and CCA.

Table 7.5. Index for Climate Change Risk Management in Viet Nam and Other ASEAN Countries and Japan

ASEAN Country	Natural	Human	Hazard & Exposure	Social Economic ulnerability	Vulnerable Groups	Vulnerability	Institutional	Infrastructure	Lack of Coping Capacity	INFORM 2017	RANK	Lack of Reliability Index
Brunei Darussalam	2.3	0.1	1.3	1.0	0.6	0.8	4.7	4.2	4.5	1.7	164	4.1
Cambodia	5.4	4.2	4.8	4.1	1.7	3.0	7.0	6.0	6.5	4.5	59	2.2
Indonesia	7.8	6.6	7.2	2.3	2.3	2.3	4.5	5.1	4.8	4.3	66	1.3
Lao PDR	4.7	2.9	3.9	4.2	2.0	3.2	6.4	6.0	6.2	4.3	66	1.7
Malaysia	4.8	3.6	4.2	2.3	3.7	3.0	3.3	2.9	3.1	3.4	100	3.1
Myanmar	8.0	7.0	7.5	5.0	6.9	6.0	7.4	5.7	6.6	6.7	12	3.4
Philippines	8.4	9.0	8.7	2.6	4.1	3.4	4.6	3.6	4.1	4.9	50	1.6
Singapore	0.1	0.1	0.1	0.6	0.3	0.5	1.2	0.9	1.1	0.4	191	3.3
Thailand	6.4	4.3	5.4	2.1	3.8	3.0	5.0	2.9	4.0	4.0	80	2.2
Viet Nam	7.2	2.8	5.4	2.6	0.9	4.1	3.5	5.2	3.4	4.3	98	1.8

Source: Marin-Ferrer, Poljanšek, and Vernaccini (2017).

Climate change negatively affects strategic sectors, such as agriculture, water, transport, and fisheries, and global supply chains and production networks, slowing labour productivity growth, increasing costs for insurance, and developing business continuity plans and health expenditures (Table 7.6). CCA seeks to reduce the risks posed by climate change and to benefit from any associated opportunities where possible. It is one of two main policy responses to climate change in Viet Nam, the other being mitigation – reducing greenhouse gas emissions to address the root causes. While Viet Nam's climate risks are substantially well captured in recent policy documents, and academic reports, national economic statistics and public and private budget outlay often fail to account for the loss of natural and physical assets.

Table 7.6. Identifying the Most Vulnerable Subjects to Climate Change in Viet Nam

Impact Factors	Sensitive and Vulnerable Subjects		
	Regions	Sectors	Communities
Rising temperature	Mountainous areas such as the Northeast, Northwest, North Central	Agriculture, security of food, fisheries, ecosystem, biodiversity, water resource, energy, community health	Farmers, ethnic minorities, older people, children, women
Sea level rise	Coastal areas such as the Cuu Long River Delta, Red River Delta, Central Coast	Agriculture, security of food, fisheries, marine and coastal ecosystems, water resources, energy, tourism, infrastructures, community health, habitat, residence	Coastal residents, older people, children, women
Floods, flash floods, and landslides	Coastal areas, including deltas, wetlands, mountainous areas	Agriculture, food security fisheries, transportation infrastructure systems, resident, trade, tourism	Coastal residents, ethnic minorities, older people, children, women
Drought	Central regions such as the South Central region, North Delta, Cưu Long Delta, Highlands	Agriculture, food security, water resources, energy, water transportation, health, and living conditions	Farmers in the South Central region and Highlands; older people, children, and women
Other extreme weather phenomena	The Central Coast, Northern mountainous and Midland regions	Agriculture, food security, community health	Farmers, older people, children, and women

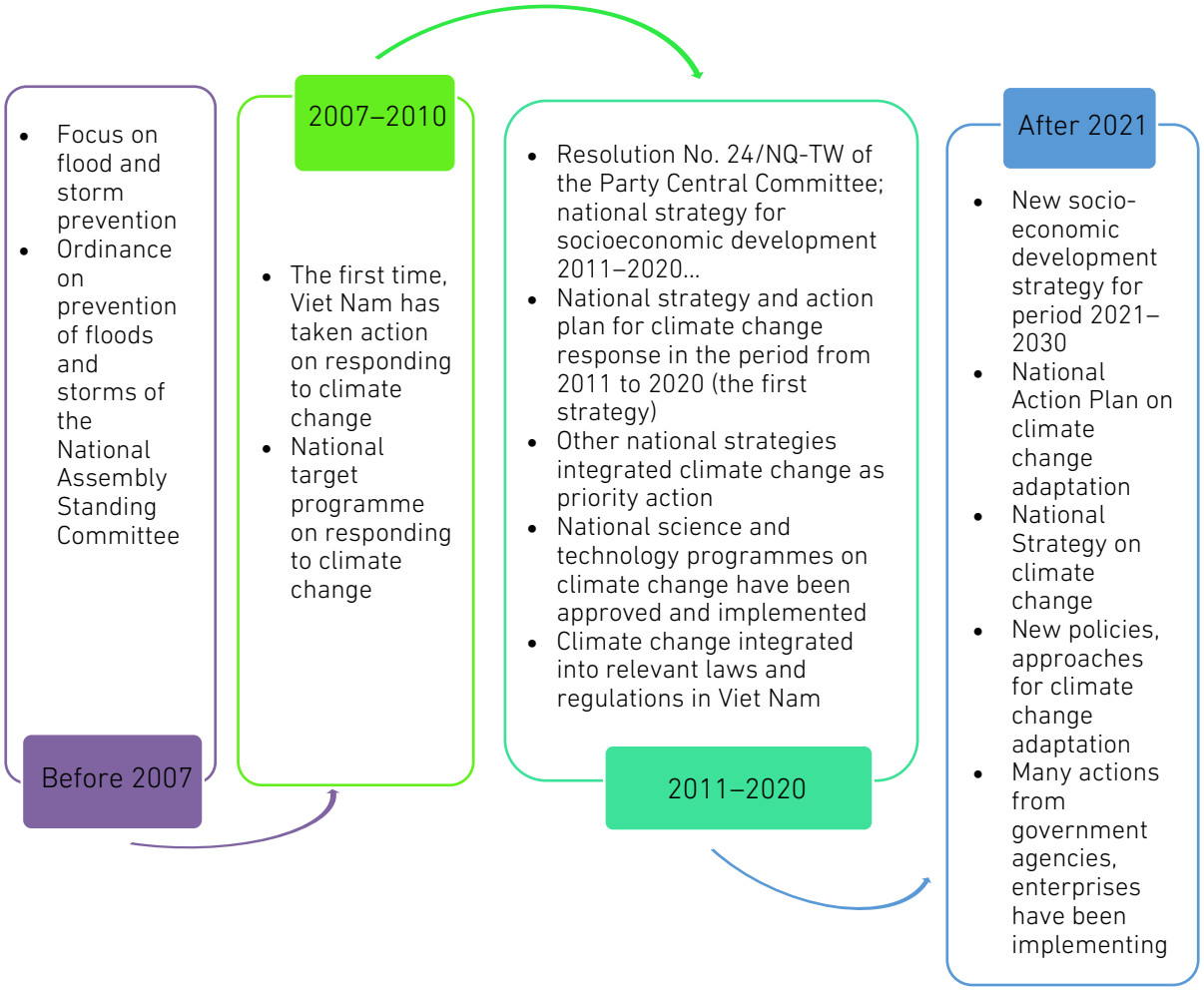
Source: Author, collected from MONRE (2008), World Bank (2022), and World Bank Group and ADB (2020).

3. Current Strategies, Policies, and Legal Frameworks in Addressing Climate Change Risks

3.1. Building Adaptation Road Maps in Viet Nam

Developing Viet Nam's adaptation road maps can be divided into four stages (Figure 7.4).

Figure 7.4. The Process of Building Adaptation Road Maps in Viet Nam

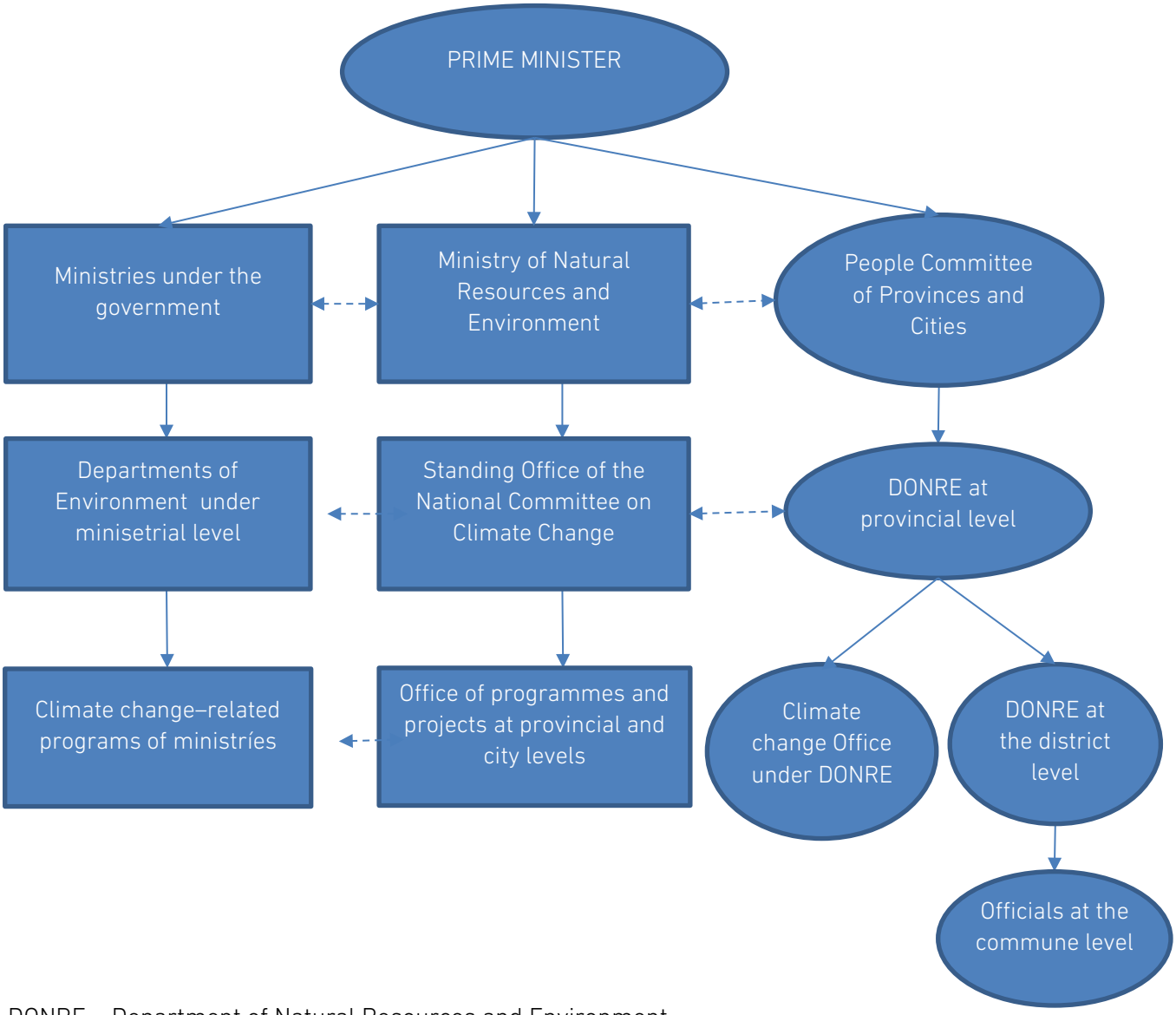


DONRE = Department of Natural Resources and Environment.
Source: Authors, compiled from different sources.

During 2011–2020, CCA and disaster prevention are mainly focused on perfecting institutions and integrating them into relevant strategies, laws, and regulations. Communication and capacity-building activities on CCA are strongly focused at the national and local levels. From 2021 until now, climate change response has been focused on specific actions (especially after the Conference of the Parties 26).

3.2. Organisational Structure

Figure 7.5. Organisational System on Response to Climate Change in Viet Nam



DONRE = Department of Natural Resources and Environment.
Source: Authors, compiled from different sources.

The organisational system of Viet Nam's climate change response is shown in Figure 7.5. Viet Nam has a National Committee on Climate Change, which advises and assists the government and the Prime Minister in researching, proposing, directing, regulating, coordinating, and urging the settlement of important and related tasks, sectors, fields, programmes, and national strategies on climate change; directs and coordinates the implementation of national strategies and programmes on climate change; and directs and organises the implementation of international cooperation programmes. The Prime Minister is the chair of the committee; the permanent vice president is the Deputy Prime

Minister, and the vice president is the Minister of Natural Resources and Environment. The members are ministers of relevant ministries and branches.

In addition, Viet Nam has a National Steering Committee for Natural Disaster Prevention and Control established by the decision of the Prime Minister (the Ministry of Natural Sources and Environment of Viet Nam, personal communication, 20 March 2015). The committee oversees inter-sectoral coordination, assisting the government and the Prime Minister in natural disaster prevention and control nationwide. The committee is headed by the Prime Minister or the Deputy Prime Minister; members include ministers, heads of ministerial-level agencies, or leading representatives of several related ministries and agencies, all working part-time. The Ministry of Agriculture and Rural Development is the standing body of the committee and has a specialised agency to advise and assist it.

3.3. Strategic Approaches and Road Maps to Adapt to Climate and Disaster Risks

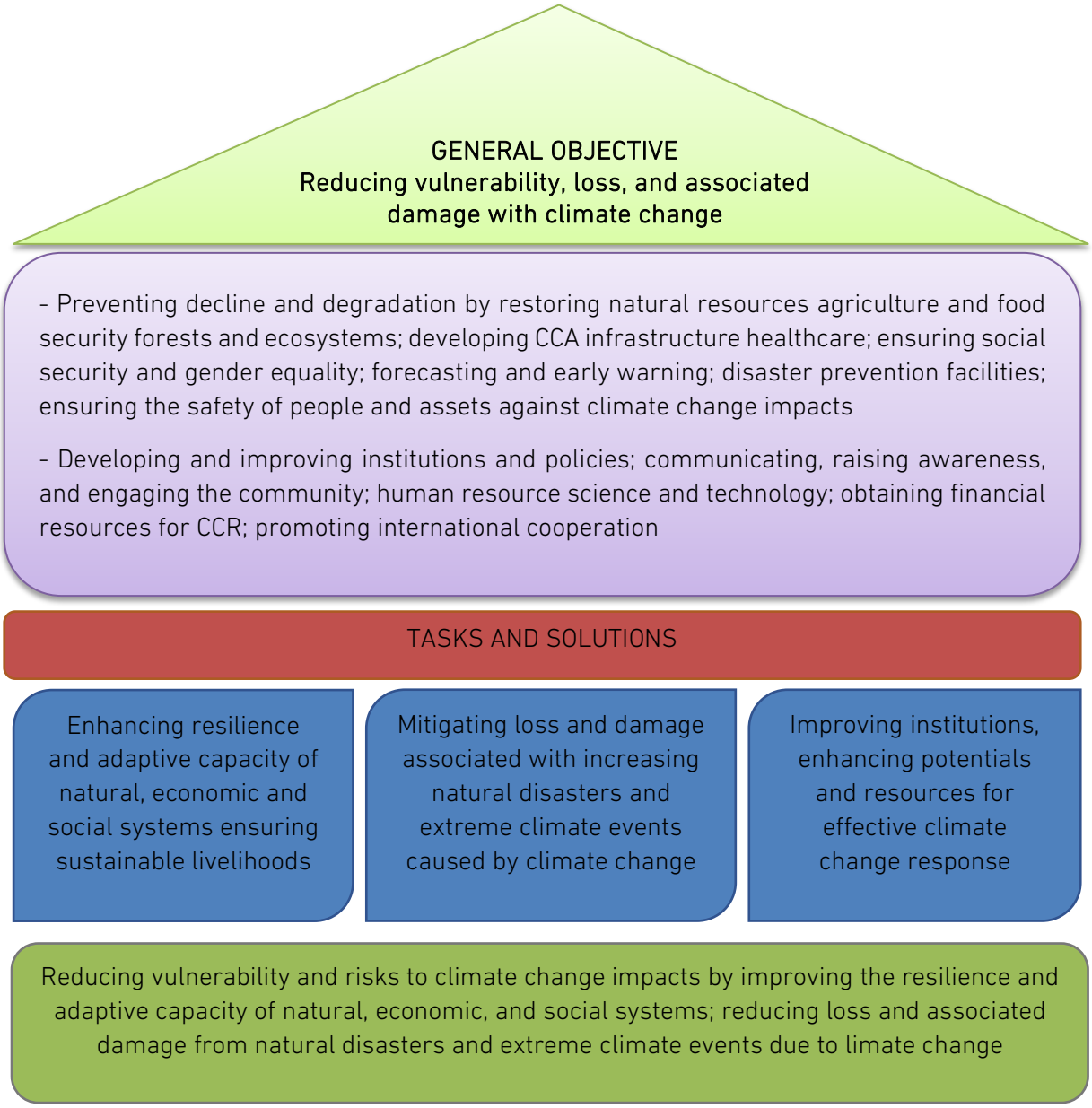
Policy orientations on CCA and disaster prevention in Viet Nam were soon clearly shown in the orientation of the Communist Party of Viet Nam, such as the resolution on proactively responding to climate change, strengthening resource management, protecting the environment (Central Committee of the Communist Party of Viet Nam, 2013); strategies and plans for socioeconomic development through the periods 2010–2020 and 2021–2030; other relevant resolutions of the Communist Party of Viet Nam and the Government of Viet Nam on the development of specific regions, industries, etc. Based on these orientations, Viet Nam issued specific orientations for CCA, natural disaster prevention and control, including the national climate change adaptation plan for the 2021–2030 period with a vision by 2050, and the national strategy for climate change until 2050 within the detailed viewpoints, goals, specific tasks, solutions, and mechanisms.

Figure 7.6 illustrates that the overall objective of a national strategy for CCA is to reduce vulnerability and risk to the impacts of climate change by strengthening the resilience and adaptive capacity of communities, economic sectors, and ecosystems, and promoting the integration of CCA into the strategic and planning system. The specific objectives are the following: (i) improve the effectiveness of CCA by strengthening the state management of climate change, including CCA activities, promoting the integration of CCA into the system of strategies and planning; (ii) strengthen resilience and enhance the adaptive capacity of communities, economic sectors, and ecosystems through investment in adaptation actions, science, and technology, raising awareness to be prepared to adjust to climate changes; (iii) reduce disaster risk and damage, increase preparedness to respond to natural disasters and climate extremes due to climate change.

Policy and legal orientation on CCA focus on the main contents, including (i) capacity building for forecasting, warning of natural disasters, and monitoring of climate change; (ii) strengthening capacity for natural disaster prevention, combat, and mitigation, and proactively responding to climate change; (iii) strengthen resilience and enhance the

adaptive capacity of communities, economic sectors, and natural systems. The national strategy for climate change to 2050 created a road map to reducing vulnerability and risks to climate change impacts by improving the resilience and adaptive capacity of natural, economic, and social systems, and reducing damage from natural disasters and extreme climate events due to climate change.

Figure 7.6. Summary of the National Strategy for Climate Change Adaptation to 2050



Source: Authors, edited from Viet Nam policies (2022): (i) Prime Minister of Viet Nam (2022a), Decision No. 896/QD-TTg by Prime Minister on approving the National Climate Change Strategy to 2050, 26 July. (ii) Prime Minister of Viet Nam (2022b), Decision No. 1055/QD-TTg by Prime Minister about the promulgation of the national plan to adapt to climate change for the period of 2021–2030, with a vision to 2050, 20 July.

3.4. The Legal Framework for CCA

Viet Nam does not have a law on climate change. However, the legal system has integrated disaster prevention and climate change response. The following summarises Viet Nam's legal system on CCA.

Article 90 of the Law on Environmental Protection 2020 provides for adaptation to climate change. Accordingly, CCA comprises activities to enhance the resilience of natural and social systems, minimising the negative impacts of climate change and taking advantage of opportunities caused by it. CCA content includes (i) assessment of impacts, vulnerabilities, risks, losses, and damages due to climate change for sectors, regions, and communities based on climate change scenarios and socioeconomic development forecasts; (ii) implementation of CCA, disaster risk reduction, community-based, and ecosystem-based CCA models; response to sea level rise and urban flooding; (iii) development and implementation of a monitoring and evaluation system for CCA. The law also stipulates the responsibilities of ministries, ministerial-level agencies, and provincial-level people's committees in implementing CCA content. Next, the circular detailing the implementation of the Law on Environmental Protection 2020 (MONRE, 2022a) stipulates the contents of assessing the impact of climate change, including subjects of climate change impact assessment (CCIA); requirements when performing CCIA, information and data for CCIA, contents of CCIA, order of CCIAs, and CCIA report.

Adaptation to climate change is also gradually mentioned in specialised laws, such as the following:

1) Legislation related to forecasting, disaster warning, and climate change monitoring (National Assembly, 2015), with regulations related to climate change and strengthening capacity for forecasting and warning of natural disasters
2) Legislation on disaster risk reduction, prevention, and control; providing regulations on disaster prevention and response to natural disasters; overcoming consequences of natural disasters; rights and obligations of organisations, households, families, and individuals in natural disaster risk reduction and prevention; international cooperation in natural disaster prevention and control and state management responsibilities in natural disaster prevention and control (National Assembly, 2013)
3) Specialised legislation such as the Law on Water Resources (National Assembly, 2012) has provided for the prevention, combating, and overcoming consequences and harms caused by water. The Law on Articles provides regulations on planning principles for flood prevention and control of river routes with dikes. Dike planning must be consistent with strategies for natural disaster prevention, control, and mitigation (National Assembly, 2006)
4) Legislation related to strengthening resilience and improving the adaptive capacity of communities, economic sectors, and natural systems are reflected in the Laws on Crop Production (National Assembly, 2018b), Law on Animal Husbandry (National Assembly, 2018a) and Law on Fisheries (National Assembly, 2017).

4. Experiences, Limitations, and Reasons for CCA Road Maps

4.1. Experiences and Progress in Enhancing Adaptive Capacity

Viet Nam's promulgated policy and legal system is generally modern, updated with much scientific evidence, and have good international experience. The dissemination of laws related to natural disaster prevention and response to climate change was organised quite effectively. Notably, the Law on Natural Disaster Prevention and Control has organised 44 classes with 1,320 commune-level officials trained.

The network of hydrometeorological monitoring stations has been gradually consolidated and renewed towards automation.[1] The assessment of climate change and sea level rise has received more and more attention. Transforming the structure of plant varieties and livestock, and adjusting seasons and agricultural production techniques to adapt to climate change have been outlined in the Action Plan of the agricultural sector and rural areas to respond to climate change. Training activities to raise public awareness of disaster prevention were promoted; the awareness of authorities and people about natural disaster prevention has gradually improved. Information and communication work has changed many times, effectively contributing to the warning of natural disasters. Science and technology research programmes on climate change response have been implemented in recent years.

The National Report on Sustainable Development Goals conducted by the government (The Central Committee of the Communist Party of Viet Nam, 2013) stated that Viet Nam would complete Sustainable Development Goal 13, including three specific goals: (i) strengthening resilience and adaptability to risks associated with climate change, disaster response, and other natural disasters; (ii) integrating climate change factors into development policies, strategies, planning, and plans; (iii) education, awareness raising, capacity building, and institutions in early warning, climate change response, and disaster risk reduction. However, to achieve this goal, Viet Nam must continue to mobilise resources (especially financial resources); perfect the system of monitoring infrastructure, natural disaster warning, and project hydrometeorological reports; and improve the system of relevant institutions, policies, and laws.

4.2. Major Limitations and Key Reasons for CCA

The policy experience with CCA contributed to an effective understanding of the risks and designing good practices to manage the risks. However, there are limitations in coping with future climate risks. Key limitation points were collected from relevant documents (

[1] Viet Nam has 187 surface meteorological stations, 242 hydrological stations, 20 hydrographic stations, 10 weather radar stations, 6 radio air-sensing stations, 8 pilot stations, and 782 independent rain gauges.

Marin-Ferrer, Poljanšek, and Vernaccini, 2017; IMHEN and UNDP, 2015; MONRE, 2022b; World Bank Group, 2022; World Bank Group and ADB, 2020). These include the following:

1) The early warning information system has not met the requirements at the local level, especially for natural disasters such as flash floods, pipe floods, landslides, thunderstorms, cyclones, hail, and fog at sea.

2) Forecasting systems, climate risk warnings, and natural disasters have not met the requirements, especially for types of natural disasters such as flash floods, pipe floods, landslides, thunderstorms, whirlwinds, hail, and fog at sea.

3) Damages caused by natural disasters, although they tend to decrease, are still large (about 1.5% of GDP/year); the construction and operation of key disaster response works lack synchronisation; in some localities, the work of natural disaster prevention and control is still passive; the system of disaster warning zoning maps is incomplete.

4) Water resource security, such as the lack of a database on the evolution of water reserves and quality in space and time, and the sharing of information on water resources with upstream countries, is a significant problem.

5) The application of technology in the fields to adapt to climate change is still limited. Infrastructure capacity to respond to natural disasters has not met the requirements; some 1,150 out of 6,648 reservoirs have not been secured; 70% of sea dikes have not received investments for upgrading; over 50% of the boat anchorage has not yet been invested.

6) The local communities to respond to climate change are still isolated, have not been deployed on a large scale, and some localities have not issued disaster prevention plans and livelihood models associated with climate change. Local people living in areas vulnerable to natural disasters and climate change do not have much knowledge and experience in disaster prevention and response to climate change.

Natural capital resources are declining, negatively impacting socioeconomic conditions and people's livelihoods. Coverage has increased, but forest quality continues to decline. Biodiversity continues to decline. Specific ecosystems such as coral reefs and seagrass beds are still in danger of being degraded due to the direct impact of socioeconomic development activities and climate change. Afforestation and protection of special use forests face many difficulties due to lack of capital and land. Meanwhile, short-term logging and exporting a lot of wood chips continue.

Some of the main causes leading to limitations in CCA and natural disaster prevention and control that Viet Nam is facing include:

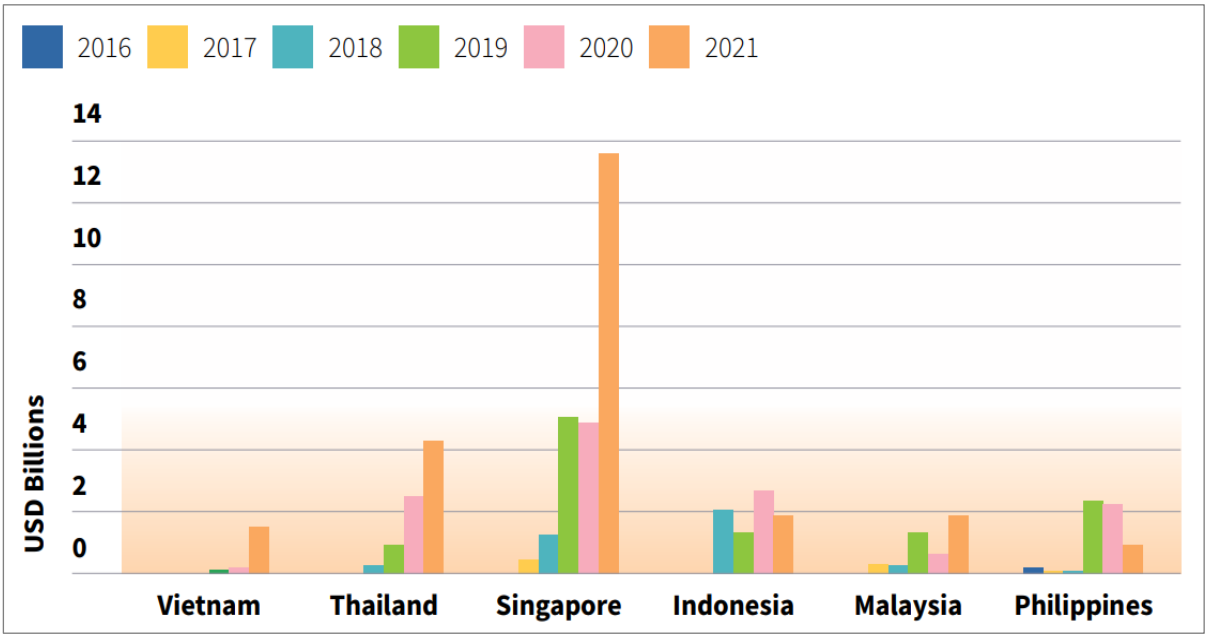
1) Limitations in interdisciplinary and inter-regional thinking. The ability to withstand and recover from natural disasters is still limited. The investment in natural disaster prevention and control is still weak, fragmented, small, lacking capital, and burning technology, techniques, and human resources.

2) Information, data, and qualifications of officials and people in analysing and using information and data effectively are still not high. The technical infrastructure system to cope with climate change and natural disasters is still limited and outdated
3) Financial resources for climate change response are lacking compared to requirements. International support tends to decrease and the mobilisation of resources from private enterprises has not been achieved as expected.
4) The application of science and technology in climate change response is generally slow, not meeting the requirements. Hydrometeorological monitoring systems, climate monitoring, and climate change databases are lacking and inconsistent (MONRE, 2022b). Monitoring and evaluation systems are lacking and the monitoring and supervision of implementation have not been paid due attention.

4.3. Capacity Building Challenges and Financial Needs for Enhanced Adaption

Five major challenges need immediate attention to advance the capacity and capability to tackle climate change risks. First, Viet Nam's climate strategies must be rebalanced to include strong policies and investments for adaptation and mitigation. The new strategies now emphasize mitigation. But as a highly vulnerable country, Viet Nam also needs to invest significantly in building resilience given the serious impact of climate change on growth. The imbalance between mitigation and adaptation is most visible in the green growth strategy, which introduces several energy intensity targets both nationwide and sectoral, but no equally specific targets in terms of adaptation – even though the strategy recognises the importance of resilient agriculture, transport, and cities.

Figure 7.7. Total Annual Value of Green Bonds and Green Credits of Six ASEAN Countries



Source: Climate Bond Initiative (CBI) (2022).

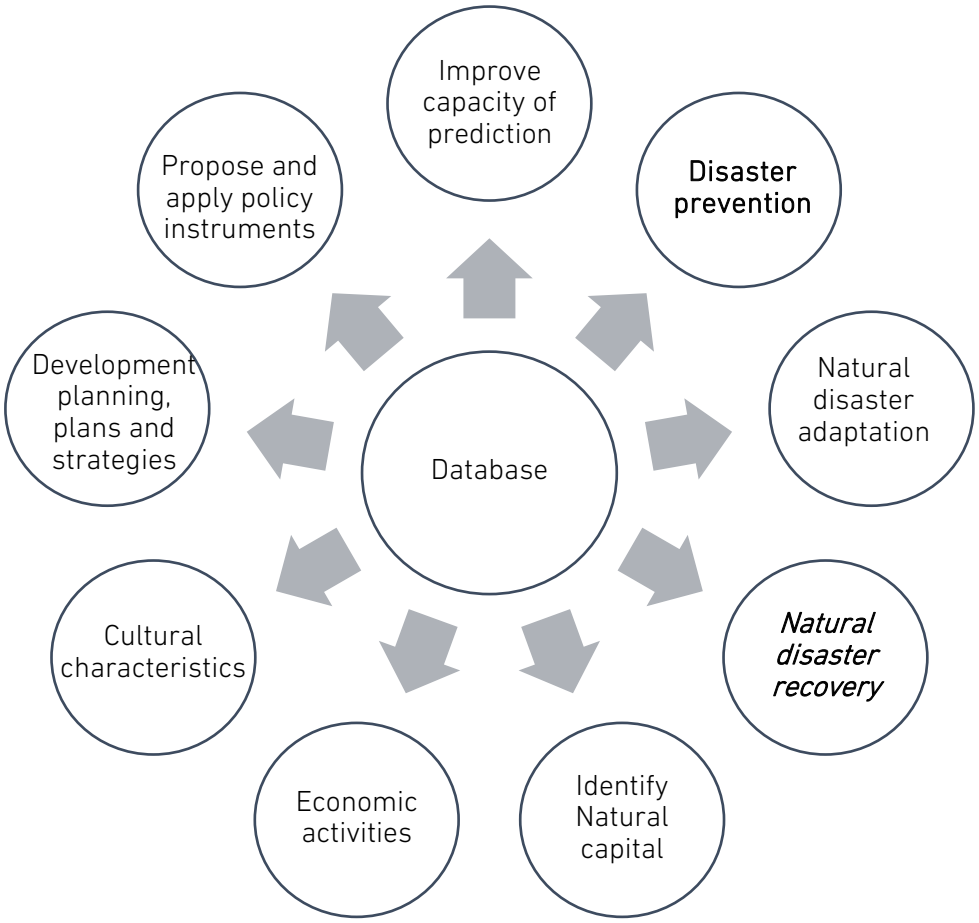
In addition, green financial flows, including green credits, green bonds, and green loans, are showing strong signs of development in Viet Nam due to the commitments of commercial banks, international financial institutions, etc. to accompany the government implement the commitments at COP26 (Figure 7.7). However, this resource is still quite small, focusing mainly on a few key areas such as renewable energy (wind and solar power) and green agriculture projects. The green finance for climate change adaptation and natural disaster prevention aspects have not been focused. Therefore, Viet Nam needs to implement the following solutions soon: build a green taxonomy, create conditions for commercial banks and businesses to access green financial capital in CCA, and work towards reducing disaster.

4.4. The Information Database for CCA in Viet Nam

The database plays an important role in setting, monitoring, and implementing Viet Nam's road map for CCA and resilience: (i) improving good governance (integrating into national strategies, development planning, trade-off analysis, using efficiency policy instruments, etc.); (ii) supporting natural disaster risk zoning and disaster warning (hurricane, storm surge, flood, flash flood, landslide, drought, saltwater intrusion, etc.); (iii) identifying the functions of the natural system, the interaction between the natural system and its economic activity, and trends; and (iv) integrating the natural system and the socioeconomic system to propose development strategies, plans, and master plans. Figure 7.8 illustrates the roles of the database in supporting objectives, targets, and solutions approved in the national strategy for climate change until 2050 in Viet Nam.

Supporting the implementation of CCA goals, tasks, and solutions requires different data types, such as socioeconomic, natural, financial, policy, cultural, and knowledge. At the same time, connecting system data and effectively using data sources to help policymaking and monitoring the results and effectiveness of CCA are extremely important. From the research results, the proposed development orientation for green economy models in the Lam River Basin in Nghe An, Viet Nam (Lai Van Manh, Ngo Dang Tri, and Do Thi Thanh Nga, 2020) and related documents show that the types of information and data for CCA are also very diverse, including satellite images, maps, natural disaster developments, natural capital (land, water, ecosystems, and biodiversity, etc.); and socioeconomic activities at all levels, culture, gender, people, policies, and legislation framework, etc. However, comparing those requirements with the reality in Viet Nam shows that the database system has many limitations: (i) information and data systems for disaster prevention should be segregated by region, gender, and age; (ii) lack of knowledge, approach, and use of data; (iii) distributed, duplicate, and asynchronous data management; (iv) lack of sharing mechanisms data between relevant agencies; and (v) some types of database products such as maps, economic, natural conditions, etc. do not have a standard format, so it is difficult to integrate them into the common management system.

Figure 7.8. Roles of the Database in Supporting the National Strategy on Climate Change in Viet Nam



Source: Authors.

5. Conclusions and Recommendations

Even if the world swiftly addresses climate change, Viet Nam faces major impacts. To respond to climate change, Viet Nam needs to focus on restructuring the economy towards promoting sustainable growth models. The models, such as green economy, circular economy, and low carbon economy is the preferred approach based on the effective and sustainable use of natural, financial, infrastructure, and human and cultural capital to perfect institutions, policies, instruments, and concentrating resources to transform the economy to achieve sustainable development. The government should enhance the adaptive capacity of the sectors to achieve its aspiration of reaching a high-income status by 2045. Priority sectors on which Viet Nam should focused include agriculture, transport, trade and industry, and the coastal cities, towards resilient infrastructure design and development, resilient industry and manufacturing sector, resilient coastal areas, and smart cities. The following are the main recommendations for

strengthening climate change and disaster management information database for risk assessment and building adaption road maps:

Firstly, green economy, circular economy, and low carbon is the preferred approach based on the effective and sustainable use of capital – natural, human and cultural, financial, and infrastructure – to perfect institutions, policies, instruments, and relevant resources to transform the economy and achieve sustainable development. Climate change response must be central to development decisions at all levels. There should be harmonious and effective combination of policy instruments such as communication and education; administrative, economic, and other measures to enhance practical effectiveness in CCA; priority in addressing the main groups of barriers to CCA, including information and data; education and training to raise awareness; financial resources for CCA to improve self-adaptation and self-healing capacity; and promotion of research, replication of good practice models on CCA, and sustainable development in accordance with the natural and socioeconomic characteristics of each region. It is necessary to improve the resistance of urban and rural areas.

Secondly, major actions include (i) integrating the goals of natural disaster prevention and CCA into regional and local development master plans and plans; (ii) enhancing economic and financial policy instruments to promote disaster prevention and adaptation to climate change; (iii) improving the resilience capacity of economic sectors and priority areas in response to natural disasters and climate change; (iv) developing science and technology for natural disaster prevention and response to climate change; (v) investing on high-quality infrastructure to strengthen natural disaster prevention and response to climate change; (vi) mobilising private capital to leverage public financing of climate-resilient growth; and (vii) promoting communication, education, and training to disseminate knowledge to improve people's capacity to access knowledge and techniques to develop climate-resilient economic models in the river basin.

Thirdly, to strengthen the database system to support effective CCA and disaster governance, Viet Nam must consider some initiatives:

1) Improve the capacity to manage, analyse, and use information and data in a centralised manner, avoiding overlaps with detailed solutions such as developing regulations on information collection, and sharing amongst agencies and organisations to serve common purposes;
2) Build a system of information management, direction, and administration uniform natural disaster prevention from central to local level develop database, interlinked disaster monitoring system;
3) Upgrade the transmission infrastructure in collecting hydrometeorological data;
4) Develop digital forecasting technology and rain forecasting technology, including flood forecasting technology for reservoir operation;
5) Build database, disaster management software, flood and inundation simulation, and research to assess the impact of increasing disaster risk, especially floods in the

Central and Central Highlands regions, and the impact of upstream development on downstream disasters;

6) Conduct scientific research and apply high technology in hydrometeorological observation, forecasting, warning of natural disasters, and climate change monitoring;
7) Conduct assessment, disaster risk zoning, disaster warning mapping, and hydrometeorological data processing; and
8) Strengthen training in statistics, communication on statistical information, etc., develop a unified, effective, and easy-to-use statistical data collection tool that ensures comparability between production agencies and information users.
9) Develop and implement an integrated economic and environmental accounting programme (Prime Minister of Viet Nam, 2022b), prioritising natural capital accounting in the short term (MONRE, 2022a).

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Chapter 8

Optimising the Choice of Structural and Non-structural Climate Change Adaptation Measures

Jacob Kumaresan, Sadhani Rajapakse

Climate change is a global problem felt at local levels. Effective solutions to mitigate and adapt to climate change should consider many dimensions such as science, economics, society, politics, morality, and ethics. Cities and municipalities are in the frontline of adaptation measures aimed at adjusting to actual or expected future climate conditions. The scale and scope of adaptation range from short-term coping to longer-term deeper transformations. The process of adaptation requires an in-depth understanding of the problem, planning appropriate and effective actions, and managing and monitoring the implementation of the plan.

This chapter analyses the barriers to adaptation measures, defines a diagnostic framework to assess barriers, and proposes an integrated method to overcome the barriers. A study of the coffee-growing communities in Guatemala reveals how these communities achieve transformative change by engaging in structural and non-structural measures both individually and collectively. While it is prudent to invest in smart growth strategies, the cost factor is a serious consideration for national governments. Options for cost analysis are provided based on the availability of information, including a few costing tools and ideas for green budgeting. There are several effective recommendations for policymakers to consider. Climate change solutions vary from place to place, are difficult to predict, and have many trade-offs. Yet, climate change adaptation is a necessary investment that will result in a healthier population living in healthier and more sustainable environments.

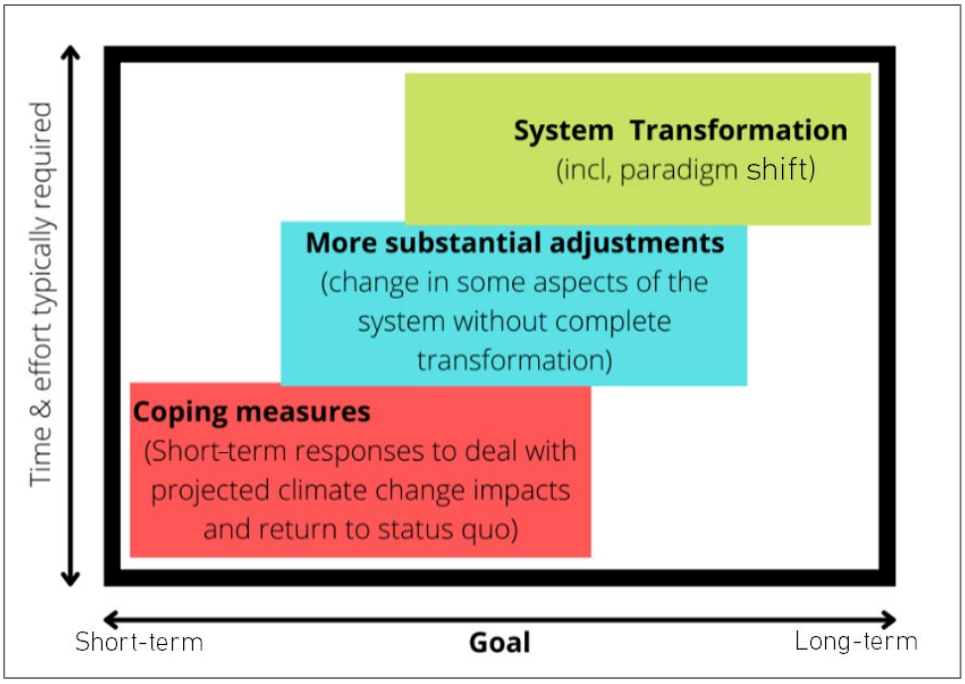
1. Introduction to Climate Adaptation

Climate change is a global problem, felt acutely at local levels. Sadly, due to its evolution, it will be with and around us for decades and centuries. Associated actions often fall into one of two main categories: mitigation efforts to lower or remove greenhouse gas emissions from the atmosphere and adaptation measures to modify systems to withstand the impacts of climate change. Responding to climate change involves many dimensions, such as scientific facts, economics, politics, and moral and ethical issues. Adaptation measures require adjusting to actual or expected future climate. The goal is to reduce vulnerability to harmful effects such as sea level encroachment, extreme weather events, food insecurity, etc., while making most of potential opportunities, such as longer growing seasons and increased yields in some regions.

There are several challenges to adaptation. Think of a person moving from a tropical country to a cold temperature region, who would need warmer clothes and to learn to drive in icy conditions to adapt to the new environment. Similarly, a warming world implies a new climate is coming to us. This will affect where we can grow food, how much water we have, and where we must build our homes. Additionally, there will be several new challenges. For instance, firefighters will have to battle more intense and longer fire seasons; public health officials will be required to manage diseases that are not a problem; and city planners will have to design and develop areas away from coastlines and riverfronts. Solutions will vary from place to place, become difficult to predict, and result in many trade-offs.

A two-pronged strategy should be applied in implementing solutions: (i) understand local risks to develop plans accordingly, and (ii) take actions to put systems in place to respond to impacts. The scope and scale of adaptation measures range from short-term coping mechanisms to longer-term, deeper transformations, including paradigm shifts (Figure 8.1).

Figure 8.1. The Scope and Scale of Climate Adaptation Measures



Source: Authors.

Consider 'smart growth strategies' contributing to climate change mitigation and adaptation (EPA, 2017). Mitigating climate change requires moving to more compact, greener infrastructure development designs that use energy efficiently. Development projects must consider these mitigation efforts while preserving the existing green spaces for a healthier planet to cater to the inevitable growing population needs (Ewing et al., 2007).

Smart growth strategies also help communities adapt to the changing climate. These measures would strengthen the capacity to face natural disasters and economic pressures. A few strategies recommended by the US Environmental Protection Agency (2017) detail the various elements of implementing these activities:

- Encourage growth in areas well connected to existing development and less vulnerable to current or projected climate change impacts.
- Preserve large areas of open spaces to protect ecosystems under pressure.
- Coordinate lands and transportation infrastructure decisions.
- Encourage water- and energy-efficient buildings.
- Upgrade stormwater systems to manage heavy storm flows.
- Promote green roofs, parks, and street trees to reduce ambient air temperatures and filter pollutants from stormwater runoff.
- Design buildings for passive survivability.

All of the above is easier said than done! The adaptation process involves three main steps: understanding the problem, planning actions, and managing implementation. Figure 8.2 captures the cyclical nature of this process, starting from detecting the problem to monitoring and evaluating the various options.

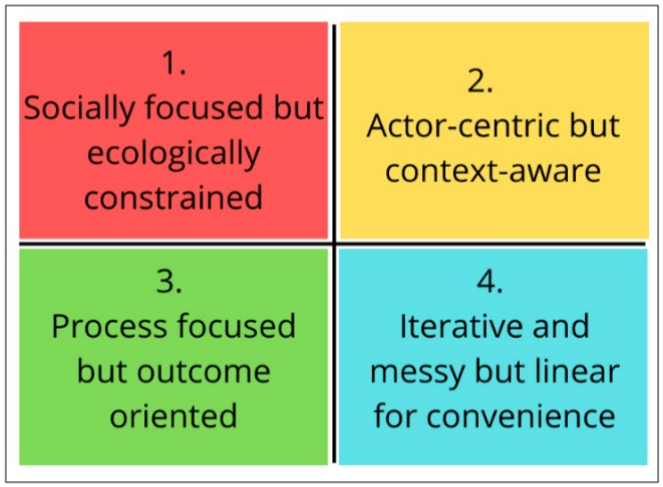
Figure 8.2. Climate Adaptation Process

Source: Authors.

2. Barriers to Adaptation Measures

Barriers are impediments that stop, delay, or divert the adaptation process. Best practices in adaption require adjustments along the process through frequent monitoring and evaluation of outcomes. Good practices involve changes to socioecological systems in response to actual and expected impacts of climate change, considering the context of interacting non-climatic changes. Figure 8.3 outlines four principles that define the framework for diagnosing barriers to adaptation. Overcoming the barriers should not be approached as a purely technical matter. One must delve into the entanglements of social, cultural, economic, political, and biophysical changes in addressing climate change. Given the issue's complexity, a deeper understanding of the human dimensions will inform us about the transformative responses required. Gail Hochachka (2021) studied the subjective non-structural factors associated with overcoming barriers in Guatemalan coffee communities and proposes 'interiority' as a concept associating culture, values, ethics, identity, and emotions playing a significant role towards transformative change.

Figure 8.3. Diagnostic Framework of Climate Adaptation Barriers

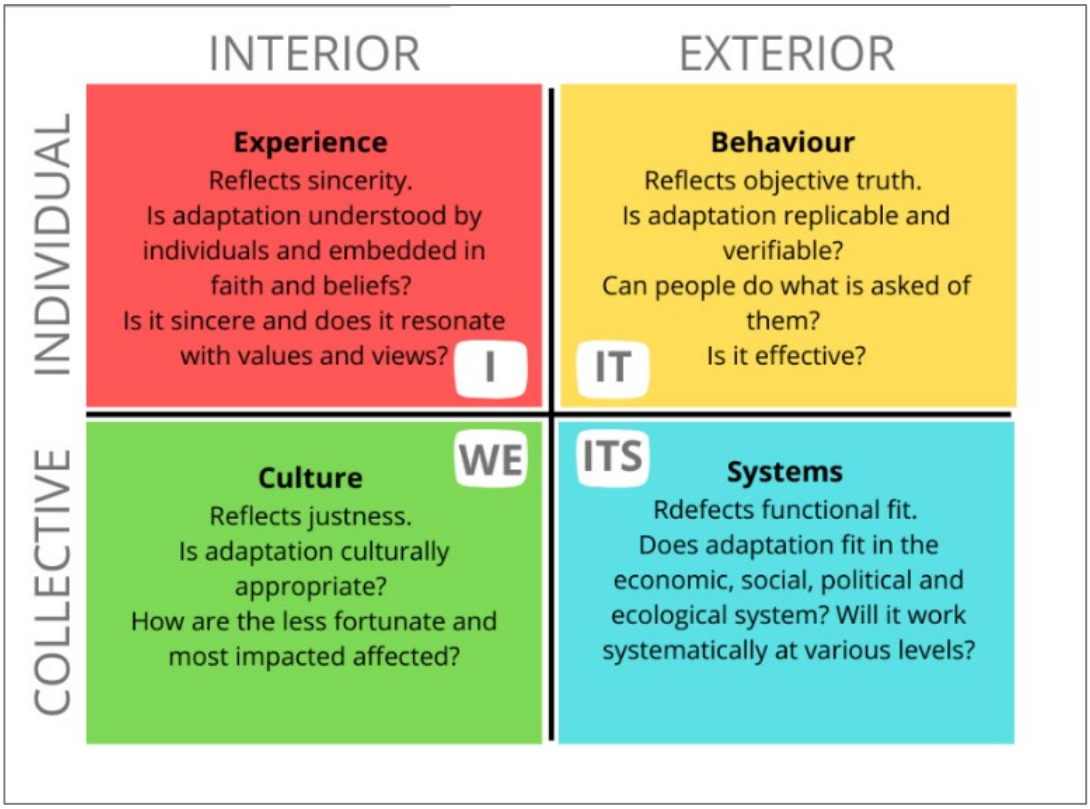


Source: Authors.

3. Case Study: Guatemalan Coffee Communities

Hochachka's work on adaptation measures in Guatemala investigated both the structural (objective) efforts, such as applying fungicides, retaining soil moisture, and using new seed varieties, as well as the non-structural (subjective) efforts, such as beliefs, values, and societal perceptions (Hochachka, 2021). Generally, funding favours technical structural science over non-structural social science, although the most powerful leverage points for systems change are non-structural elements. This research is needed to integrate technology and sociology meaningfully and rigorously. The study in the Guatemalan coffee communities was designed to understand the role of beliefs, values, and world views in transforming individual and shared behaviour. The four domains of reality – interior (non-structural), exterior (structural), individual, and collective – were integrated into a 4 X 4 table (Figure 8.4). The interior of the individual (I) reflects sincerity. The exterior of the individual (IT) reflects objective truth. The collective interior (WE) reflects justness, and the collective exterior (ITS) reflects functional fit. Relevant questions in each domain are presented in the framework. The premise is that adaptation is socially mediated as a composite of individual adaptation, such that change occurs through activities that depend on group members' participation in discourse, imitation, or shared collective and individual action. Positive outcomes are a result of collective responsibility for a shared problem.

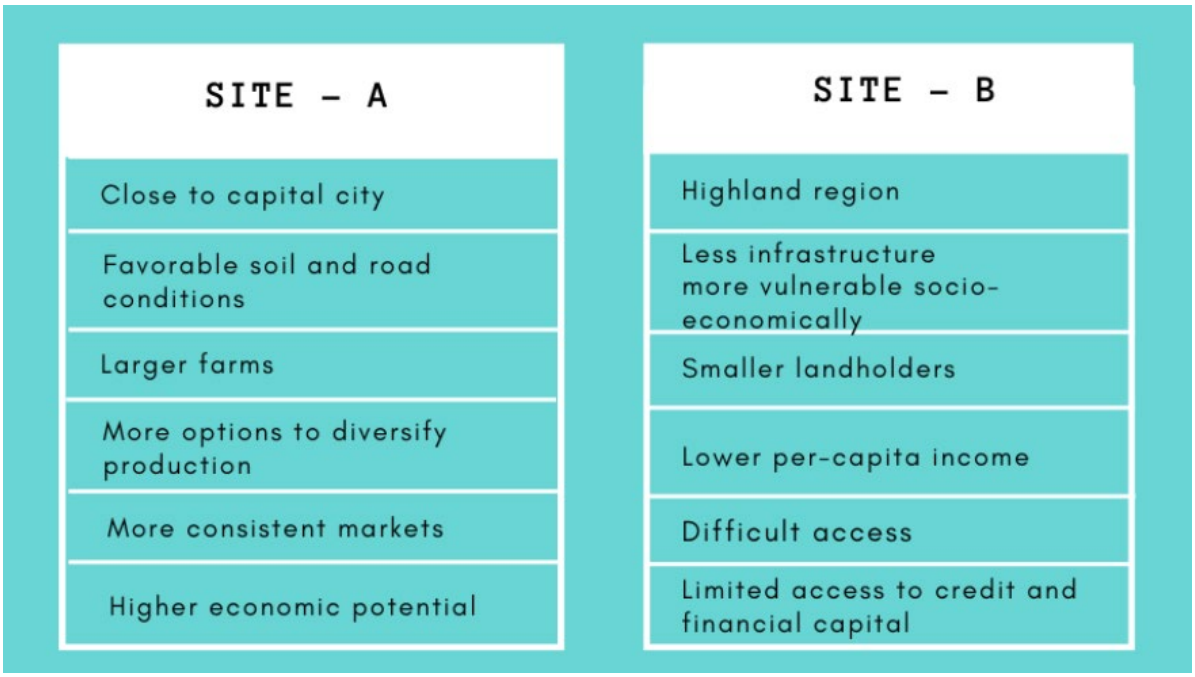
Figure 8.4. Study Domains



Source: Authors.

The research was designed as a qualitative case study to investigate how people navigate complex change processes due to climate change. Two study sites that historically produce arabica coffee as the main income-generating activity were selected – one close to the capital city with favourable soil and road conditions, larger forms, more options to diversify production, and more consistent markets with higher economic potential. The other was in the highland region with low per capita income, smaller landowners, less infrastructure with difficult access, limited credit and financial capital, and socioeconomically more vulnerable. Figure 8.5 tabulates the characteristics defining the two research sites. People living in both sites had diverse cultures and religious affiliations, creating different ways of thinking, adaptive capacities, and views of the outside world. The methodology included key informant interviews, site visits, participant observation, and focus groups conducted in Spanish in each community. Interviews were semi-structured, often accompanied by a site visit to the producer's farm, wet mill, or workplace. The themes of the interview protocol were (i) the respondent's background and current practices in coffee production; (ii) the climatic changes they had observed over time; and (iii) their past, present, and foreseen future responses to those changes. Multiple verification strategies, including triangulation of both methods and sources, ensured the validity of the data collected over time.

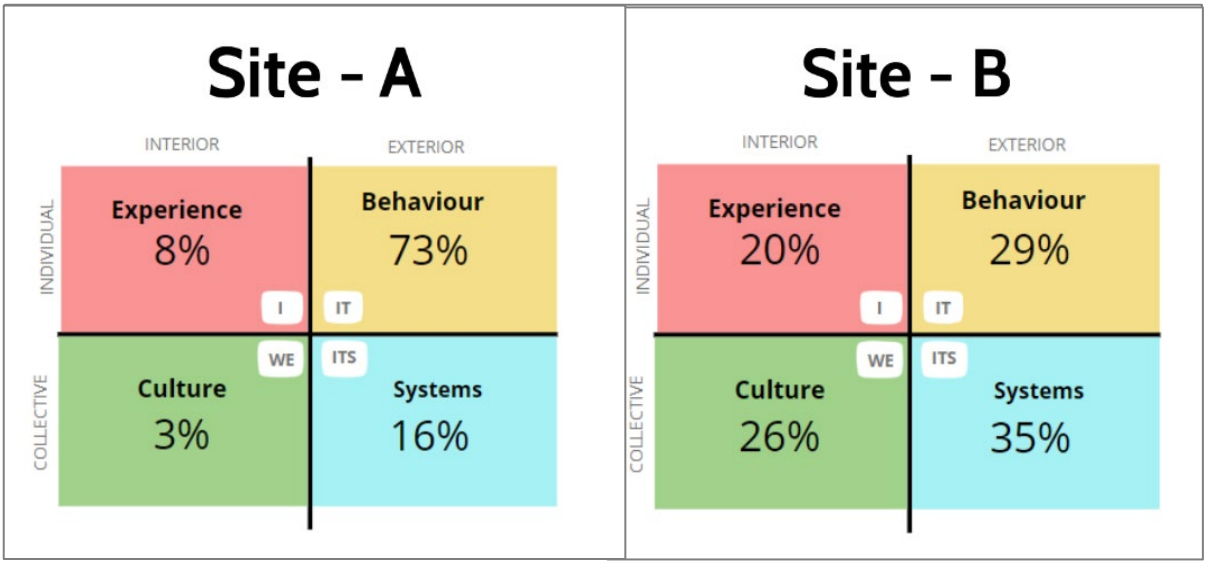
Figure 8.5. Study Site Details



Source: Authors.

The results of the qualitative analysis showed that the coffee producers in the two regions adapted to two climate changes in diverse ways (Figure 8.6). In region A, the exterior element behaviour (IT) was most important (73%), followed by systems (ITS) 16%. In comparison, the interior elements, experience (I) and culture (WE), were less predominant at 8% and 3%, respectively. Region B revealed a more balanced spread of adaptation, with behaviour (IT) and systems (ITS) accounting for 29% and 35%, respectively, with experience (I) and culture (WE) resulting in 20% and 26% share of the impact. In summary, coffee producers in Region A were largely influenced by structural elements (89%), while this aspect accounted for only 64% of the markers for climate change adaptation in Region B. On the other hand, non-structural elements were responsible for control of adaptation three times more in Region B (36%) than in Region A (11%).

Figure 8.6. Variation in Climate Change Adaptation Strategies



Source: Authors.

Behaviour (IT) was the frontline of defence in both regions consisting of the following factors: (i) adding inputs into coffee such as fertilisers, pesticides, and mulch; (ii) managing coffee farms through proper pruning, retaining soil humidity, and maintaining shady trees; (iii) planting more resistant (leaf rust) varieties of coffee; and (iv) diversifying income generation by planting new export crops, technology transfer and external training, and migration to secure livelihoods. Systems or ITS was the next prominent influencer in adaptation, including mechanisms to secure financing such as credit advances, donations, grants for coffee variants, fertiliser kits, seedlings of side tree species, organic fertilisers; linking to existing cooperatives in the communities supporting community resilience measures, including funds for education, women's empowerment, and engagement in global social movements. Culture (WE) had minimal impact in Region A but played a significant role in Region B. Collective organisation and unity provided strength and support to each other as well as collective problem-solving, capacity building, and shared learning. One respondent in Region B summed up the value of collectivism with this quote: 'It is necessary that we all unite for this cause so that together the fight against pollution is greater'. Clearly, experience (I) was a strong emotional influencer in both regions. While many respondents mentioned frustration and sadness as major factors, religion and faith played a valuable and positive role in helping coffee producers adapt to climate change. Sharing and building on personal experiences to encourage action for climate change adaptation demonstrated the need to integrate structural and non-structural measures.

The primary role of structural elements was notable in both sites; behaviour, for instance, was more predominant in A, which was privileged by technological and financial support. Though beneficial, behaviour has its boundaries which coffee producers in both sites countered with a systems approach, for example, investing in community development

and seeking innovative buyers. Non-structural elements were proportionally less represented in both sites, nevertheless, an important way for coffee growers to respond to climate change. Social capital and social organisation, civil networks, and social trust were relevant features contributing to adaptation. Particularly, cultural personal convictions, positive attitudes, and church support offered ways to metabolise difficult emotions, find refuge from hardships, and locate purpose and vision in challenging times. Despite higher vulnerability and other stressors, coffee growers in site B engaged in all four facets of adaptation, demonstrating its relevance to how people can navigate through complex change processes. Respondents from site B highlighted the need to understand the issues, what they think and what they can do about these, how they view themselves and others, and how they relate to the world around them. This group did more than conform and adjust to climate change conditions; they transformed their behaviour and practices considering the developmental trajectory of their region. One respondent aptly summarised the process in this statement: 'The most is nature, and if we do not create awareness of this, we will all suffer; sure, we may be able to adapt (technically), but animals and plants suffer from us using so many chemicals…. If human beings do not become aware of this damage, in a short time, we will destroy everything we have, pollution will increase, and living beings will die. These values of social organisation – civil networks and social trust – contribute to social capital in communities. The phenomenon of becoming stronger through adversity is vital to understanding these pathways.

Human understanding and adjustment to environmental change, although studied for over 75 years, have not resulted in wisdom, tradition, or action. With its scale, dynamism, and eventual construct, climate change is a unique challenge requiring an adaptation that can co-evolve with it. It should not be viewed as an external threat to be adjusted to or managed but as an internal aspect of our decisions, choices, and values.

4. Costing of Interventions

Climate change adaptation measures are expensive but should be considered an investment for the future and economically viable. There are two main economic approaches for costing the various interventions: economic analysis and economic modelling. A brief description is provided regarding these approaches:

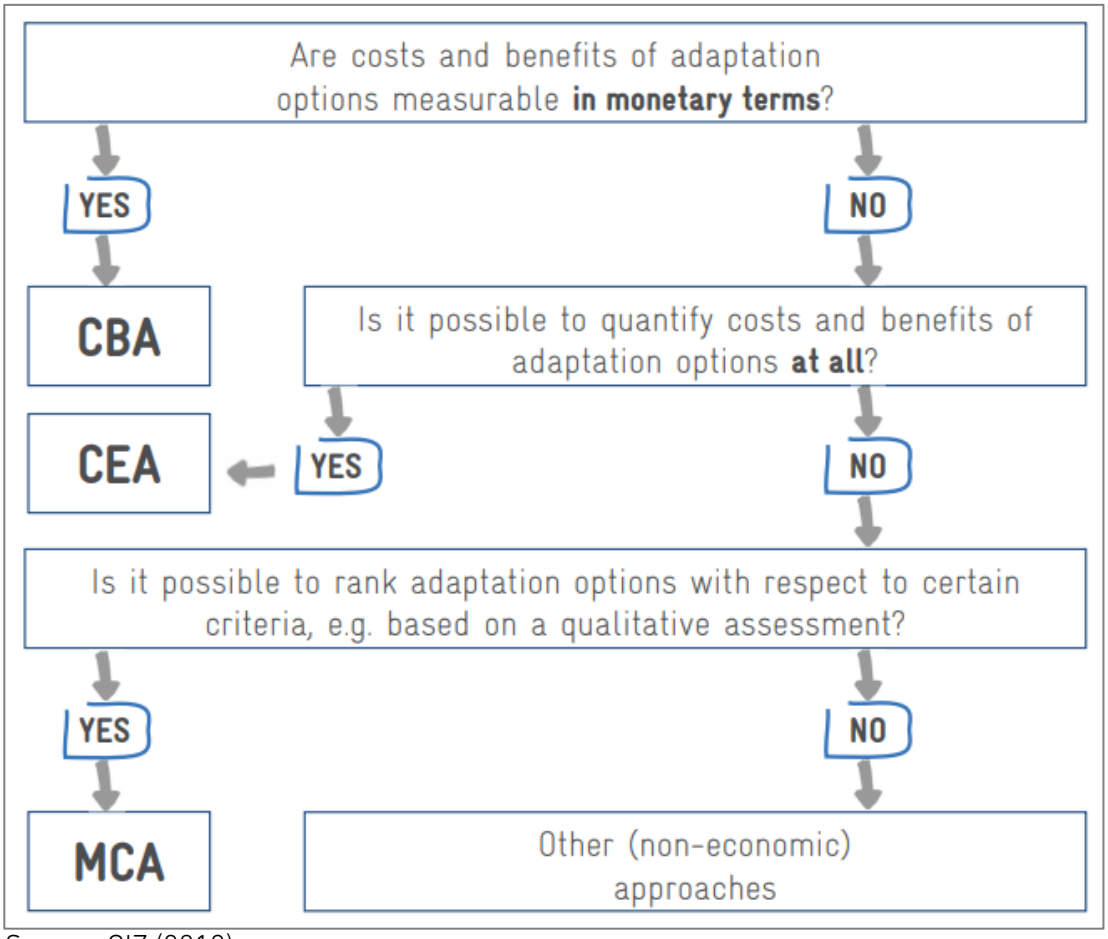
4.1. Economic Analysis

1) Cost–benefit analysis compares the costs and benefits of an intervention over time. The major limitation is that all the costs and benefits must be measurable in monetary terms.
2) Cost-effectiveness analysis (CEA) can be used if the benefits of interventions cannot be measured in monetary value. CEA determines how a well-defined initiative can be achieved most efficiently.

3) **Multi-centric analysis (MCA)** is used when the benefits cannot be measured quantitatively. MCA rankings are not based on economic calculations but on a qualitative assessment of criteria, such as feasibility, co-benefits, ease of implementation, accessibility to the local population, and resources required. MCA uses qualitative expert judgement to fill the information gap.

A simple algorithm describing the process to be followed in ascribing the proper analysis is pictured in Figure 8.7.

Figure 8.7. Analytic Tool Selection Process



Source: GIZ (2013).

4.2. Economic Modelling

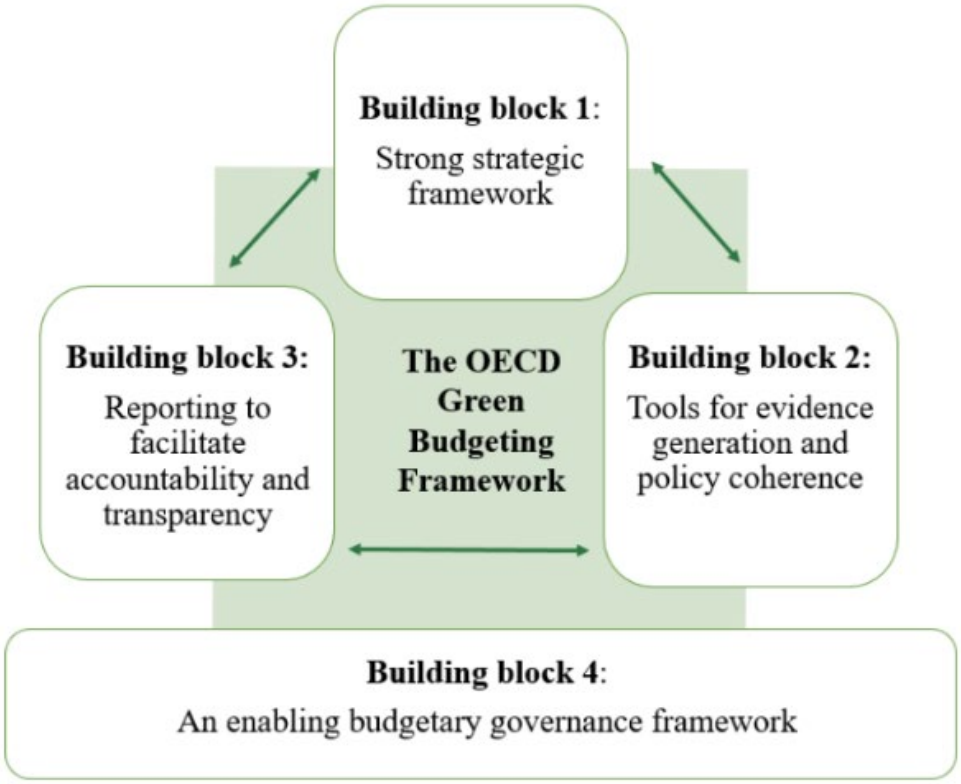
1) **Market equilibrium models:** Climate change affects many economic variables and actors. Economic theory offers a way to analyse these market variables simultaneously. This model projects future market changes based on assumptions of market mechanisms and driving forces observed in the past. The model can provide an empirical structure and framework for allowing the user to look at potential interactions between climate change adaptation options and economic structures.

2) Ricardian and physical (or crop) models: This approach employs patterns of previously observed behaviour or changes in other areas and applies that experience to the specific location being studied. A major obstacle with this methodology is that it does not consider local particularities. This model assumes that climate change impacts and adaptation outcomes observed (or expected) elsewhere can be copied and pasted from one faction to another.

The big question with the economic analysis and modelling is how well each approach described above considers the non-structural elements in adapting to climate change. Green budgeting is possible when economic analysis or modelling is not feasible. This approach uses the tools of budgetary policymaking to help achieve environmental and climate goals. This includes evaluating the environmental impacts of budgetary and fiscal policies and assessing their coherence towards the delivery of national and international commitments.

Green budgeting can also contribute to informed, evidence-based debates and discussions on sustainable growth. The Organisation for Economic Co-operation and Development (OECD) proposes a green budgeting framework based on four building blocks (Figure 8.8) (OECD, 2020).

Figure 8.8. OECD Green Budgeting Framework



Source: OECD (2020).

Block 1 focuses on a strong strategic framework, where a country's fiscal planning considers the environment and climate-related priorities and objectives. Making climate adaptation part of the national priorities can influence the government's taxing and spending decisions.

Green budgeting tools are captured in Block 2 of the framework. These tools support gathering and analysing relevant information supporting budgetary decision-making processors. The tools need to be country and context relevant, and several tools are designed to gather evidence on how budget measures impact environmental and climate objectives.

Some such tools are:

- Green budget tagging: classifying budget measures according to their environmental and/or climate impacts
- Environmental impact assessments: requiring environmental impact assessments to accompany new budget measures
- Ecosystem services, including carbon pricing: putting a price on environmental externalities such as greenhouse gas emissions, often through taxes and emissions trading systems
- Green perspective to spending review: incorporating the consideration of the impact of measures on national environmental and climate goals alongside efficiency considerations
- Green perspective on performance setting: integrating performance objectives related to national environmental and climate goals.

Block 3 of the OECD Framework focuses on accountability and transparency of the green budgeting practices to relevant stakeholders. It focuses on ensuring quality outcomes through mechanisms like Green Budgeting Statements being part of the budget practices to ensure that the green objectives are met, thus, making them effective advocacy tools.

The final step of the framework (OECD, 2020) is to enable a governance framework. This highlights the importance of strong political leadership in implementing green budgeting practices. A governance framework aims for link planning, multiyear budgeting, empirical strategies, and stakeholder engagement. Such a framework will define the responsibilities of the different stakeholders, making them accountable to the process and empowering communities to call for action.

Like the climate adaptation initiatives with the coffee farmers in Guatemala (Hochachka, 2021), the availability of strong structures and community ownership and accountability are fundamental pillars for sustainable green budgeting.

5. Conclusion and Recommendations

Adaptation solutions to climate change responses vary from place to place, are difficult to predict, and involve many trade-offs. Policymakers need to understand local risks, develop plans to manage those risks, respond quickly to current impacts, and put appropriate systems and policies in place for the future and long-term impact.

National governments may consider the following policy recommendations:

1) Build infrastructure that is safer and more sustainable to withstand extreme weather events.
2) Restore damaged ecosystems.
3) Diversify crops that can tolerate warmer and drier or wetter conditions.
4) Invest in solutions to manage resources wisely, especially food production, water resources, and conserve the natural environment.
5) Help communities reduce their risks and be prepared to handle climate emergencies such as sea level rise, floods, and droughts.

In summary, we are all in this together. No one is exempt from the impact of climate change. On a positive note, there is international support for climate change adaptation. The United Nations (UN) Framework Convention on Climate Change is the UN entity tasked with supporting the global response to the threat of climate change. The Convention has near-universal membership (198 parties) and is the parent treaty of the 2015 Paris Agreement and the 1997 Kyoto Protocol. In accordance with these agreements, many organisations are working globally, regionally, and locally to combat climate change. So are many communities. Adaptation to climate change is a collective response.

Working together in partnership, we can defeat climate change. And if we do this in a decade, we will reap many benefits and our lives will be as follows:

- Most journeys would be made by trains or shared electric cars equipped with algorithms that will select the best route to reduce consumption.
- In towns, we would walk, bike, or use public transport to save time and improve quality of life.
- We would live in houses fed by renewable energy. There would be more urban allotments, parks, and gardens.
- Our staple diet would be fruits and vegetables.
- We would reduce livestock farming, which will positively affect reforestation, freeing up land for cultivation of food for human consumption.
- We would share goods and services, purchase less, reuse more, and recycle almost everything.

Let us look forward to a healthy population living in a healthy environment that supports a safe and healthful habitat for humans, plants, and animals.

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Chapter 9

Mainstreaming Climate Change Adaptation and Enhancing Adaptive Capacity: Opportunities for Educational Innovation and Experimentation

Eiji Yamaji

1. Greenhouse Gas Emission and Global Warming

Although greenhouse gases (GHGs) have been gradually emitted in larger quantities since the Industrial Revolution, the increase in emissions in recent years has undoubtedly caused climate change. The impact has been significant, causing rising sea levels, frequent extreme weather events, and weather disasters, which have also claimed many lives.

Average temperatures have gradually increased, with annual fluctuations: the temperature increase determined from data from 1890 to 2020 is 0.73 degrees per 100 years.

As a result, the following events are taking place and are expected to proceed: continuous air temperature increase, ocean water temperature increase, decrease of ice in the North Pole, increases of wind speed, and rainfall intensity of typhoon/hurricane.

In Japan, the temperature rises higher than the world average, the number of extremely hot days increases by 0.2 days per 10 years; heavy rains increase and rainy days decrease; snowfall decreases; and heavy snow increases inland.

The United Nations Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme and the World Meteorological Organization to comprehensively assess anthropogenic climate change, impacts, adaptation, and mitigation measures from a scientific, technical, and socioeconomic perspective. The IPCC Sixth Assessment Report simulated five Shared Socioeconomic Pathway (SSP) scenarios of projected socioeconomic global changes up to 2100. The conditions are as follows: SSP1 – Sustainability (Taking the Green Road), SSP2 – Middle of the Road, SSP3 – Regional Rivalry (A Rocky Road), SSP4 – Inequality (A Road Divided), and SSP5 – Fossil-fueled Development (Taking the Highway).

The author hopes every country agrees to take SSP1, though it is very difficult.

2. Weather Disasters

Before predicting the future, global warming to date has already caused the following disasters: (i) natural hazards – volcanic eruptions, earthquakes, landslides, etc.; (ii) weather disasters – rain (heavy, long, flooding); snow (heavy, flooding caused by melting snow, avalanche); wind (strong, salty, tornado, high-tide thunder, drought, dry, cold, frost, low sunshine, etc.)

Impacts on the agricultural sector are as follows: on yield and quality of rice, on quality of fruits, on suitable grown areas of fruits and mushrooms, and delay of the southward movement of saury fish.

Influences on the natural ecosystems in Japan are changes in the migratory routes of birds, the invasion of bamboo into forests, and the decline and disappearance of seaweed beds.

Influences on the water environment are changes in river flow regime, flooding and landslides in the basin, and storm surges caused by typhoons.

Influences on health and life are increased incidence of heat stroke and various impacts on industrial and economic activities and livelihoods.

On the damage to agricultural land and facilities, the reasons for disasters in agriculture are (i) natural factors: typhoons, earthquakes, volcanic disturbance, erosion, landslide, heavy rain, and drought; (ii) social factors: water pollution, land subsidence by pumping, soil contamination, and flood by watershed development; (iii) ageing: the collapse of ponds; and (iv) recent events: global warming, extreme weather.

Agricultural sector damages have been increasing yearly, reaching around ¥500 billion on average. In addition, large earthquakes caused enormous damage: the 2011 Great East Japan Earthquake caused ¥2,284 billion.

In the 2012 rice crop season, maximum temperatures were higher than usual across the country, resulting in higher yields. However, daily minimum temperatures in some areas were much higher than normal in late August and throughout September, resulting in high-temperature injury.

High-temperature injury is a disorder in which the rice plant's water absorption cannot keep up with transpiration, causing it to wilt and die. In addition, the stomata of the leaves close to prevent transpiration. When the stomata close, photosynthesis ceases, growth stops, and the rice may eventually wither and die.

High temperatures at night increase respiration in rice plants. The starch produced during the day is consumed by respiration, and less is fed to the ear, resulting in a lower rate of maturity and the development of milky white rice (white immature grains).

Apart from rice, high temperatures also cause damage, such as (i) fruits: discoloration of grapes and apples, (ii) vegetables: bad fruiting and low quality of tomatoes, (iii) livestock: decreased volume and quality of milk.

3. Adaptation and Mitigation Measures

Measures to deal with climate change and global warming can be broadly classified into adaptation and mitigation measures. Adaptation measures accept climate change and global warming and address each activity individually. However, in some cases, acceptance may be inappropriate, and many matters cannot be fully adapted to. Therefore, control or mitigation measures are adopted, and GHG emission control must be promoted in all sectors.

The basis of mitigation measures is to reduce GHG emissions. Various measures have been devised in industry and life. In particular, people's awareness and lifestyles must change. Environmental education is important in this context.

In this chapter, Section 4 describes adaptation measures in agriculture, and Section 5 describes environmental education in Japan.

In May 2021, the Ministry of Agriculture, Forestry and Fisheries (MAFF) formulated the Green Food System Strategy as a new policy to realise both improvements in productivity and sustainability of the food, agriculture, forestry, and fisheries industries through innovation and working towards building a sustainable food system that is resilient to disasters and climate change. In October 2021, the MAFF Climate Change Adaptation Plan was revised to promote the development and dissemination of stable production technologies and varieties that can adapt to climate change as set out in this strategy, based on enhanced scientific knowledge of the effects of climate change.

The basic approach of the plan is as follows:

a) Plan formulation based on current and future impact assessments

The plan should be developed in line with the government's Second Climate Change Impact Assessment Report to ensure accurate and effective implementation of responses to the impacts of climate change. In addition to conducting impact assessments for those items for which no impact assessment has been conducted, from the viewpoint of addressing issues at production sites, the plans will be organised and promoted by sector and product, focusing on actions necessary for the next 10 years or so, while considering the impact assessment by the end of this century.

The adaptation measures to be developed and disseminated in the future should be considered so that they do not burden the environment.

b) Response to the effects of climate change, such as global warming

Research and development of adaptation technologies and varieties, conversion of varieties and products, and dissemination of adaptation technologies should be promoted to reduce the decline in production and quality of agricultural products due to rising temperatures.

c) Disaster prevention and response to disasters caused by extreme weather events

To address the increased risk of waterlogging of farmland and mountain disasters due to torrential rains and increased risk of storm surges due to rising sea levels, constant preparedness for increased risk of storm surges due to rising sea levels and systematic promotion of the construction of facilities and other measures contributing to disaster prevention are necessary. The measures includes risk assessments to identify vulnerable areas and potential hazards and develop comprehensive disaster risk reduction plans that prioritize high-risk zones.

d) Exploit opportunities presented by climate change

Opportunities provided by climate change should be utilised, such as the expansion of production areas by reducing damage from low temperatures, the introduction and conversion of subtropical and tropical crops that could not be produced in the event of global warming, the development of production areas, the extension of cultivation periods due to shorter snow cover, and increased production through the expansion of regions.

e) Cooperation, division of roles, and information sharing amongst stakeholders

Based on the Climate Change Adaptation Law, the Government of Japan, in cooperation with relevant ministries and agencies, is mainly responsible for the scientific assessment of the current situation and future impacts of climate change in Japan, taking into account adaptation efforts and positioning in the international community, basic research and development of adaptation technologies, presentation of support measures for regional efforts in terms of both software and hardware and collection and dissemination of information both at home and abroad. The primary responsibilities are the collection and dissemination of national and international information.

Local governments are mainly responsible for the independent selection and promotion of adaptation measures by local entities through the formulation of 'local climate change adaptation plans' based on the Climate Change Adaptation Law, considering the regional differences in the impact of climate change on society and the economy.

The Government of Japan and local governments will also cooperate to ensure the effective implementation of climate change adaptation in the region.

f) Continuous review of plans and promotion of measures through optimisation

To appropriately respond to the impacts of climate change with uncertainties, the current and future impact assessments should be reviewed based on the latest findings, taking the opportunity of appropriate assessments such as new reports by the IPCC. The progress and research results of this plan's adaptation measures and other initiatives should be confirmed, and the latest background circumstances considered. The plan will be continuously reviewed to ensure that it is consistent with the basic direction set out in the government's overall Climate Change Adaptation Plan, and that it considers the latest background circumstances.

In September 2015, the Sustainable Development Goals (SDGs), consisting of 17 goals and 169 targets to realise a sustainable world, were adopted at the UN General Assembly. Japan is also making efforts to realise the SDGs. Adaptation under the Paris Agreement and the SDGs share the common goal of building resilient and sustainable societies that can cope with climate change. It is important to promote international coordination between these goals.

4. Adaptation Measures in Agriculture

As a result of global warming, high-temperature damage to crops is becoming apparent. In addition to basic technologies, such as soil improvement and water management, the development of new varieties tolerant to high temperatures and the introduction and diffusion of new cultivation and management techniques are underway.

Paddy rice: White immature grains (white and cloudy due to insufficient starch filling) occur due to high temperatures during the ripening period (from ear emergence and flowering to harvest). So, high-temperature tolerant varieties with fewer white immature grains are introduced even at high temperatures (e.g. *Kinumusume, Tsuyahime, Nikomaru*[1]). The area planted with high-temperature tolerant varieties was 38,000 hectares (ha) in 2010; it grew to 153,000 ha in 2020. Varieties that can withstand high temperatures will more likely produce a better yield under challenging conditions.

Fruit trees: High temperatures and heavy rainfall have led to a 'floating peel' in *Unshu* mandarins, where the peel and fruit are separated. And high temperatures have caused 'poor coloring' of apples and grapes. So, the countermeasures are spraying plant growth regulators to reduce floating peels in mandarin oranges, and introducing reflective sheets to promote orange coloration, yellow-green varieties of grapes, and ring peeling technology to promote coloration of grapes.

Vegetables: High temperatures suppress the production of red pigment in tomatoes, resulting in 'poor coloring'. Then, shading materials and high-temperature tolerant varieties are introduced.

Livestock: Reduced and low-quality milk yield due to heat. Cooling and shadowing the roof of the milk-cow hatch are introduced.

At the village level, disaster prevention facilities were introduced. Those are landslide prevention facilities, wind and snow damage, fire prevention facilities, stormwater drainage facilities, waterway and pond safety facilities, traffic safety facilities, crime prevention facilities, and disaster prevention radio facilities.

The Agricultural Mutual Aid Scheme is a 'mutual aid insurance' system based on farmers helping each other; farmers contribute to create a common property and receive mutual

[1] Rice varieties for Japan's western area with excellent palatability, grain quality, consistent yield, and resistance to high temperatures during the ripening period

aid payments in the event of a disaster to protect their farming operations. ,The state pays about half of the premiums to reduce the burden on farmers. The types of agricultural mutual aid programmes are as follows.

a) Agricultural crop mutual aid

Mutual aid payments compensate for the loss of income due to weather disasters, pests and diseases, fire, and damage caused by birds and animals in paddy rice and wheat.

b) Livestock mutual aid

Mutual aid payments compensate for damage caused by death, disuse, disease, and injury to cattle, horses, and pigs.

c) Fruit tree mutual aid

Mutual aid payments compensate for the loss of revenue and quality of plums, pears, mandarin oranges, and yuzu fruits due to weather disasters, pests and diseases, fire, and damage by birds and animals, as well as losses caused by death, loss, or burial of the tree body.

d) Field crop insurance

Mutual aid payments compensate for the loss of revenue due to weather disasters, pests and diseases, fire, and damage by birds and animals in the case of soybeans.

e) Horticultural facility mutual insurance

Losses due to weather disasters, fire, explosion collision with vehicles, and similar disasters, pests and diseases, and bird and animal damage to crops in the facility are covered by mutual aid for the horticultural facility itself, such as greenhouses, and ancillary facilities such as heaters.

f) Voluntary mutual aid

Fire, lightning, falling or colliding objects, water damage caused by accidents involving water supply and drainage equipment, water leakage, water discharge or water run-off, damage or defacement caused by theft, and damage caused by natural disasters are covered by mutual aid for buildings and agricultural machinery.

Agricultural mutual aid schemes are not a global warming adaptation measure but can be used to keep farmers motivated to produce.

5. Mitigation Measures in Agriculture

a) GHG emission from the agricultural sector

Global GHG emissions total 52 billion tonnes (CO_2 equivalent). Agriculture, forestry, and other land use emissions account for 23% of total global emissions (2007–2016 average).

Japan's emissions amounted to 1.212 billion tonnes, the lowest value since 1990 when

emissions were calculated. The agriculture, forestry and fisheries sectors accounted for about 47.47 million tonnes, or 3.9% of total emissions (FY 2019).

The breakdown of emissions from the agricultural sector includes 11.95 million tonnes from rice cultivation, 13.58 million tonnes from livestock, 15.7 million tonnes from fuel combustion for farm machinery and heating, and 5.58 million tonnes from agricultural soil.

On the other hand, agricultural land absorbs and emits, with forests absorbing 42.9 million tonnes and agricultural land and pastures 1.8 million tonnes (FY 2019).

b) Efforts to reduce GHG emissions in Japanese agriculture

In the field of horticulture, the GHG emission reduction targets for the horticulture sector were reviewed in the Plan for Global Warming Countermeasures (approved by the Cabinet on 22 October 2021). In the revised Global Warming Prevention Plan of MAFF (decided on 27 October 2021), the direction of the promotion of measures was concretised. In other words, the goal is to reduce CO_2 emissions by 1.55 million tonnes from the FY2013 level by FY2030 through energy conservation measures, such as introducing energy-saving equipment in horticulture facilities.

The contents of these efforts are the following:

- Spreading awareness of energy-saving production management
- Efficient heating and thermal management of production based on the 'Facility Horticulture Energy-Saving Production Management Manual' and 'Facility Horticulture Energy-Saving Production Management Check Sheet'.
- Promoting the introduction of energy-saving facilities for horticulture and heating technology that does not depend on fuel oil
- Introducing heat pumps, heaters using woody biomass, and multi-layered covering facilities. In addition, heating that does not depend on fuel oil using geothermal heat, waste heat from factories, etc. will be introduced.
- Promoting efforts to form production areas using energy-saving technologies, and forming production areas with strengths utilising energy-saving measures in cooperation with actual consumers.

Another major measure is the reduction of emissions from rice cultivation. Specifically, methane emissions will be reduced by extending the drying-out period and fall plowing. Nitrous oxide will be reduced by promoting appropriate fertiliser applications through soil diagnosis.

Methane generated from paddy fields is produced from organic matter contained in the soil, and CO_2 and acetic acid are produced by decomposing organic matter fed as fertiliser, through the action of anaerobic methanogenic bacteria. It is essential to lengthen the drainage period and reduce the amount of organic matter, the source of methane, during the flooding period to reduce methane production from paddy fields.

Specifically, extending the drying-out period by about 1 week from the customary period will lengthen the drainage period and reduce methane emissions by about 30%. In addition, if the rice straw plowing period is changed from spring to fall, the decomposition of rice straw will proceed before waterlogging, and methane emissions will be reduced by approximately 50%. Furthermore, by conducting soil diagnostics and applying appropriate fertilisers, the amount of nitrogen-containing synthetic fertilisers and nitrous oxide emissions can be reduced.

6. Environmental Education in Japan

Environmental education refers to education aimed at identifying current problems in the human environment while improving the environment and sustaining its desirability for future generations to follow. The International Union for Conservation of Nature, UNESCO, and the United Nations Environment Programme strongly promoted 'environmental education'. In Japan, based on the Basic Environment Law enacted in 1993 and the Act on the Promotion of Motivation for Environmental Conservation and Environmental Education enacted in 2003, environmental education promotes the development of citizens who can make appropriate value judgments regarding the environment and act appropriately accordingly. Education and learning activities that address various human–environment problems are expected in all educational opportunities, including school and social education.

This law was amended and became the Act on the Promotion of Environmental Conservation Activities through Environmental Education, which came into full force on 1 October 2012.

The need for the law to be amended is as follows. Environmental conservation activities and collaboration between government, business, and private organisations are becoming increasingly important in promoting growth based on the environment. In light of the UN Decade of Education for Sustainable Development and the growing interest in environmental education in schools, it is necessary to enhance further environmental education that utilises the philosophy of coexistence with nature and leads to the development of people with rich human qualities.

The following is an image of the revised concept.

1) Enhancement of basic principles

The promotion of cooperative action is added to the objectives of the law. Respect for life, an integrated development with the economy and society, and the formation of a recycling-oriented society are added to the basic principles and definitions.

2) Specific promotion framework by local governments

Preparation of action plans for environmental education, promotion of cooperative action, and establishment of regional councils. Local governments are obliged to make efforts to prepare action plans for environmental education and cooperative initiatives by setting up

councils consisting of local stakeholders.

3) Enhancement of environmental education in school education

(a) Obligation to make efforts to consider the environment in educational activities

Promotion of appropriate environmental considerations when developing school facilities and environmental conservation activities through education

(b) Further promotion of environmental education in school education

The state and local governments shall provide information such as reference materials, develop teaching materials, and take other necessary measures to ensure that systematic environmental education is provided in schools through each subject and other educational activities. In addition, measures shall be taken to improve the quality of academic personnel, such as training.

4) Strengthening of the infrastructure for environmental education, etc.

(a) Designation of organisations to support environmental education

Designation of organisations to support environmental education, which supports the efforts of various entities in environmental education

(b) Addition of projects for the development of teaching materials for environmental education to the registration of projects for the recognition of human resources

Development of teaching materials for environmental education added to the registration of projects for certification of human resources

5) Introduction of a mechanism for providing opportunities to experience nature

Introduction of a system of accreditation by the governor of places of opportunity for nature experience activities

6) Promotion of the participation of private sector organisations in environmental administration and collaborative initiatives

(a) Reflection of public opinion in policy formation

Develop and utilise a mechanism for seeking the opinions of diverse actors, including the public and private sector organisations, formulating policies, and promoting policy proposals by the public and others

(b) Consideration for promoting opportunities for private sector participation in public services

The state and others consider factors other than price when contracting with private organisations to implement public services

(c) Introduction of an agreement system to promote cooperative initiatives

A registration system to promote the conclusion of cooperative agreements between relevant actors, such as administrative bodies, citizens, and private organisations, to

promote cooperative initiatives.

(d) Support for activities of business-type environmental nonprofit organization (NPOs)

The state supports the activities of NPOs so that environmental conservation activities can be financially self-sustaining.

7) Revision of legal name

The title of the law was changed to correspond to the detailed provisions for developing a wide range of practical human resources, as described above.

Objectives

(a) To establish basic principles for environmental conservation activities, promote motivation for environmental conservation and education, and collaborative initiatives.

(b) Clarify the responsibilities of citizens, private organisations, the state, and local governments

(c) Establish basic policies and other matters necessary for promoting environmental conservation activities, motivation for environmental conservation and education, and cooperative initiatives.

(d) From the above, contribute to ensuring a healthy and cultural life for the present and future generations of citizens.

7. Case of Environmental Education

The need for environmental education and the legal system have been described, but what kind of education is provided?

Environmental education is provided at institutions such as kindergartens, primary schools, junior high schools, high schools, universities, and graduate schools, as well as by general corporate training, local authorities, and NPOs.

Examples of the environmental education content in the primary, secondary, and upper secondary schools is the Ministry of Education, Culture, Sports, Science and Technology's 'Towards the Promotion of Environmental Education'.

1) Primary schools

- Taking an interest in the relationship between themselves and nature, such as animals and plants around them, and care for nature
- Securing drinking water, electricity and gas, and waste disposal, and their relationship with their lives and industry
- Protecting people's health and living environment from pollution
- Preserving land and recharging water resources, as the function of forest resources

2) Secondary schools

- Developing science and technology in harmony with the environment
- Investigating the natural environment, understanding that it is based on the balance of the natural world, and recognising the importance of conserving the natural environment

3) Senior high school

- Developing attitudes towards the conservation of the natural environment
- Identifying the characteristics and finiteness of fossil fuels, nuclear and hydropower, solar energy, etc. and their use.
- Understanding water and air pollution, global warming, biodiversity, the relationship between living organisms and the environment, and the importance of conserving the global environment.

At the university and postgraduate levels, the curriculum is left to individual universities.

There are 790 universities in Japan: 82 national, 94 public, 592 private, and 22 others (Surveyed by Obunsha). Of these, 112 universities offer environmental science.

Tottori University of Environmental Studies is the first university with 'environment' in its name and has the following history.

April 2001: Opening of Tottori University of Environmental Studies via a publicly built, privately operated method, established by the Tottori Prefecture and Tottori City Establishment of Faculty of Environmental and Information Studies

April 2005: Establishment of the graduate school (Master's Course)

April 2012: Establishment of the Public University Corporation Tottori University of Environmental Studies

In 2012, the University of Tokyo started a unique Graduate Program in Sustainability Science – Global Leadership Initiative (GPSS-GLI) – to develop individuals with extensive knowledge, intensive specialisation, and ethically sound principles, the next generation of global leaders.

The history of the GPSS is as follows:

1996: Alliance for Global Sustainability established

2000: Youth Environmental Summit (YES) started at Braunwald, Switzerland

2003: YES was renamed to Youth Encounter on Sustainability (YES).

2004: Intensive Program on Sustainability (IpoS) started.

2005: Integrated Research System for Sustainability Science (IR3S) was established as a research institute at The University of Tokyo.

International Alliance for Research Universities established

2006: Transdisciplinary Initiative for Global Sustainability established.

2007: Graduate Program in Sustainability Science (GPSS) established in the Graduate School of Frontier Sciences, jointly operated by the six departments within the Division of Environmental Studies:

2008: Asian Program for Incubation of Environmental Leaders started.

2009: First International Conference on Sustainability Science (ICSS) hosted by IR3S. Since then, IR3S annually hosts ICSS and its Asian platform ICSS-Asia.

2010: Sustainability Science Consortium established.

2012: International Society for Sustainability Science (ISSS) established.
GPSS-GLI launched.

The GPSS-GLI curriculum comprises three pillars;

- Foundation and specialised courses covering key issues related to sustainability
- Diverse theoretical and practical exercises aimed at enhancing such skills as communication, systems thinking, social surveys, and data analysis through real-world training and debate experience
- Comprehensive research process spanning from the elucidation of research topic through to research framework development and leading to the compilation of Master's thesis and PhD dissertation

The GPSS-GLI is a sustainability science programme, but students from other disciplines can also study sustainability science as a minor programme. The essence of the Sustainability Science degree programme (GPSS-GLI) is offered as a minor course in Sustainability Science (Minor Program in Sustainability Science). This is the five-credit minor (certificate) programme. Students must attend one lecture, one field exercise (about Kashiwa-no-ha's sustainable development), and research seminar (every week and one presentation/semester) taught in English with GPSS-GLI students.

8. Discussion

Adaptation and mitigation measures for climate change and global warming were described. In particular, we discussed adaptation measures in agriculture, as exemplified by Japan, but these measures may not directly apply to ASEAN countries. This is because Japan is in the temperate zone, while most ASEAN countries are in the subtropical and tropical zones. Therefore, the successful adaptation methods in Japan may not be the same in ASEAN countries because of the differences in crops grown and agricultural methods.

The end of this chapter wraps up climate change adaptation and mitigation as follows;

- GHG emissions must be reduced.

- Development must not be hindered.
- A certain amount of warming and resulting weather disasters are inevitable.
- Climatic disasters must be reduced.
- In the long term, changing public awareness and behaviour is important.
- Environmental education is essential.

On the reduction of hazards, we need to be aware of the characteristics of disasters: (i) difficult to predict, (ii) predictable, and (iii) possible to stop or reduce.

Classification and examples are shown in Figure 9.1.

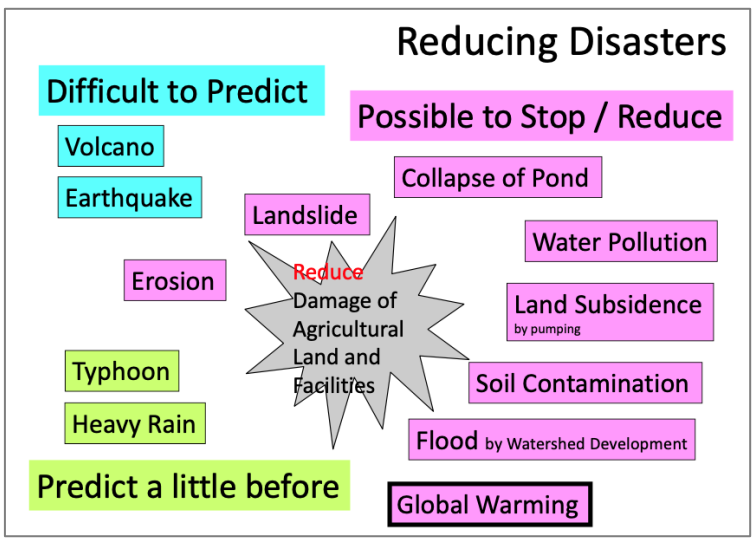
Hazards that can be predicted a little in advance, such as typhoons, can be mitigated by fleeing or taking countermeasures.

Subsidence due to groundwater pumping can be prevented by regulating pumping.

For disasters that are difficult to predict and strike suddenly, such as earthquakes and volcanic eruptions, initial damage can be mitigated by, for example, making buildings earthquake-proof. After a disaster, mutual rescue agreements can be concluded for rapid relief, recovery, and reconstruction.

In conclusion, the most important point is that we can reduce and stop 'climate change and global warming'.

Figure 9.1. Characteristics of Disasters



Source: Authors.

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Ministry of Environment (2023), 'Law of Environmental Education', https://www.env.go.jp/policy/post_61.html.

Chapter 10

Cambodia Climate Change Strategic Plan, 2014–2023

Meach Yady

The complexity and many uncertainties of climate-change risks to Cambodia's economic growth, livelihoods, and ecosystems point to the need for integrated approaches to plan climate-change policy interventions in harmony with a relevant, sustainable economic policy agenda geared towards poverty reduction and environmental sustainability. The *Cambodia Climate Change Strategic Plan 2014–2023* (CCCSP) is designed to fill the policy gap; complement ongoing efforts; and meet the emerging challenges of development, environment, and climate-change issues.

Following guidelines from the Council of Ministers, the CCCSP was prepared using an analysis of current and future national development and climate-change risks; formulation of a vision, mission, and goals; development of a strategic framework; identification of a set of actions, institutional arrangements, and implementation roadmaps; analysis of financial resources; and development of a monitoring and evaluation (M&E) framework.

The vision, mission, and goals of the CCCSP were formulated based on an analysis of institutional capacity and observed climate-change impacts and projections. The vision is that Cambodia develops towards a green, low-carbon, climate-resilient, equitable, sustainable, and knowledge-based society. The mission is to create a national framework for engaging the public, private sector, civil society organisations, non-governmental organisations, and development partners in a participatory process for responding to climate change to support sustainable development. The goals comprise reducing vulnerability to climate-change impacts, in particular on the most vulnerable populations and on critical systems (natural and societal); shifting towards a green development path by promoting low-carbon development and technologies; and promoting public awareness and participation in climate-change response actions.

To achieve the vision, mission, and goals, the government has identified eight strategic objectives:

(i) promote climate resilience by improving food, water, and energy security;

(ii) reduce sectoral, regional, and gender vulnerability and health risks from climate-change impacts;

(iii) ensure climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites;

(iv) promote low-carbon planning and technologies to support sustainable development;

(v) improve capacities, knowledge, and awareness of climate-change responses;

(vi) promote adaptive social protection and participatory approaches to reduce environmental loss and damage due to climate change;

(vii) strengthen institutions and coordination frameworks for national climate-change responses; and

(viii) strengthen collaboration and active participation in regional and global climate-change processes.

Three phases of implementation are outlined.

(i) Short term (2013–2014). This phase seeks to put in place institutional and financial arrangements for the implementation of the CCCSP, development of a national M&E framework and indicators, and development of climate-change action plans by line ministries.

(ii) Medium term (2014–2018). This phase continues to support the implementation of Phase 1 with other activities such as accreditation of the Adaptation Fund and Green Climate Fund, research and knowledge management, capacity development, mainstreaming of climate change across sectors at different levels, operation of M&E and data management systems, and launch of some high priority projects/programmes in key sectors. Initial priority is given to adaptation activities, but greenhouse gas mitigation activities will be gradually included. The government may undertake a review and revision of the CCCSP, building on lessons learned in Phases 1 and 2.

(iii) Long term (2019–2023). The focus is on research and learning, but its main objective is to scale up successful cases and to continue mainstreaming climate change into national and sub-national programmes. This involves increased budget support for national programmes, including funding climate-change responses through sub-national administrations.

1. Introduction

The Government of Cambodia is committed to pursuing national sustainable development that ensures a better quality of life and improves the living standards of the country's population. One of the main national development priorities is to reduce poverty, yet efforts to alleviate poverty cannot be separated from addressing climate change. The *National Strategic Development Plan Update 2009–2013* emphasised that to deal with the implications of climate change in Cambodia, the capacity of government institutions

needs to be strengthened.[1] This requires focussing on the following priorities:

(i) strengthening the capacity of the Secretariat of the National Climate Change Committee (NCCC);

(ii) promoting and coordinating the mainstreaming of climate change in concerned sectors;

(iii) continuing preparing the *Second National Communication under the United Nations Framework Convention on Climate Change* (UNFCCC);

(iv) preparing the *Cambodia Climate Change Strategic Plan 2014–2023* (CCCSP);

(v) promoting the establishment of a national fund for climate change;

(vi) promoting the implementation and update of the National Adaptation Programme of Action on Climate Change;

(vii) identifying and fostering implementation of the Clean Development Mechanism and greenhouse gas (GHG) reduction projects;

(viii) educating and informing the public on climate change and associated risks;

(ix) mobilising resources and support to address climate change; and

(x) decentralising the preparation of a GHG inventory, and setting up a database management system for this purpose.

Meeting these projected national development targets outlined in the NSDP update requires various measures to respond to climate change. It was envisaged that the CCCSP will provide the foundation for a structured, coherent approach to integrate climate-change mitigation and adaptation activities into national development processes.

The CCCSP has thus been developed as a national strategic document. Following guidelines from the Council of Ministers, climate-change action plans will be prepared as separate documents, which will detail the identification and prioritisation of actions for achieving the strategic objectives of the CCCSP. Alongside the CCCSP, ministries must also develop sectoral climate-change strategic plans to guide the integration of climate change into their planning, as well as sectoral climate-change action plans to operationalise their strategic plans. As good coordination of national and sub-national responses is key to effectively address climate change, guidelines for mainstreaming climate change into sub-national planning are being prepared under the Secretariat of the National Committee for Sub-National Democratic Development.

[1] Government of Cambodia (2009), *National Strategic Development Plan Update 2009–2013*, Phnom Penh, https://www.cambodianbudget.org/files-tinymce/New_Pic/Development_Policies/National_Policies_and_Decree/NSDP_Update_2009-2013_Eng.pdf

2. *Cambodia Climate Change Strategic Plan 2014–2023* Vision, Mission, Goals, and Strategic Framework

Cambodia aims to develop into a green, low-carbon, climate-resilient, equitable, sustainable, and knowledge-based society. The mission of the CCCSP, therefore, is to create a national framework for engaging the public, private sector, civil society organisations (CSOs), non-governmental organisations (NGOs), and development partners in a participatory process for responding to climate change while supporting sustainable development in Cambodia. The CCCSP aims to (i) reduce vulnerability to climate-change impacts on the population, in particular the most vulnerable segments, and on critical systems (natural and societal); (ii) shift towards a green development path by promoting low-carbon development and technologies; and (iii) promote public awareness and participation in climate-change response actions.

Cambodia is highly vulnerable to climate change, and the government recognises the need for mainstreaming climate change into national policies based on selected key guiding principles. For the CCCSP, these include:

(i) adhering to the values of sustainable development;

(ii) ensuring that national development priorities can be achieved under a changing climate;

(iii) focussing on the threats as well as opportunities of climate change, and capitalising on synergies between adaptation and mitigation;

(iv) recognising the complex and interconnected nature of climate change and the need to use interdisciplinary, cross-sectoral, and multi-scale approaches in addressing it;

(v) recognising the uncertainty of future climate change and associated impacts, building flexibility into the management of key systems to address unforeseen changes, and using risk-based and phased approaches in planning responses;

(vi) addressing both extreme events and critical changes (e.g. shifts in seasons) induced by climate change;

(vii) using a combination of science-, ecosystem-, and community-based approaches in climate-change responses;

(viii) ensuring that climate-change responses are equitable, gender-sensitive, transparent, accountable, and culturally appropriate;

(ix) leveraging knowledge, innovation, and behavioural change in developing solutions for adaptation and mitigation; and

(x) engaging actively with international and regional processes for addressing climate change.

3. *Cambodia Climate Change Strategic Plan 2014–2023* Strategic Analysis

To ensure alignment with national development goals and priorities, several key documents were considered when conducting a strategic analysis for the CCCSP, including the *Rectangular Strategy – Phase II*; draft Cambodia Vision 2030; *Cambodia Human Development Report 2011*; Cambodia Millennium Development Goals; *The Cambodian Government's Achievements and Future Direction in Sustainable Development: National Report for Rio+20*; NSDP Update; Cambodia's Initial National Communication under the UNFCCC; draft Cambodia's Second National Communication under the UNFCCC; *Cambodia National Adaptation Programme of Action to Climate Change*; draft National Environmental Policy 2012; *National Strategic Plan on Green Growth 2013–2030*; and a policy paper on the promotion of paddy production and rice export.[2]

3.1. National Development Baselines

From 1994 to 2011, Cambodia achieved long-term macroeconomic growth of 6%–7% in its gross domestic product (GDP) annually.[3] This stable, steady economic growth was attributed to the continued good performance of the agriculture, garment, construction, and tourism sectors. During these years, a project-based planning approach gave way to more programme-based planning for sustainable development. Better data collection and management contributed to improved planning systems and effective allocation of resources. However, economic diversification was still limited, and a considerable percentage of the population remained unskilled.

Forest cover, as a percentage of total land area in 2010, was 57.07%, of which more than 3 million hectares (ha) of protected areas fell under the jurisdiction of the Ministry of Environment.[4] Agriculture continued to be the dominant employment sector, accounting for 57.6% of the labour force.[5] According to the NSDP update, as of 2008, arable land area totalled about 3.31 million ha. Rice farming constituted 2.61 million ha; permanent crops, 0.59 million ha; and rubber plantations, 0.11 million ha.[6] *The Strategy for Agriculture and Water, 2006–2010* indicated that only 7%–8% of arable land area was fully irrigated, 10%

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[2] Government of Cambodia (2010), *Policy Paper on the Promotion of Paddy Production and Rice Export,* Phnom Penh, https://faolex.fao.org/docs/pdf/cam189808.pdf

[3] ADB (2014), *Cambodia: Diversifying beyond Garments and Tourism – Country Diagnostic Study,* Manila, https://www.adb.org/sites/default/files/publication/149852/cambodia-diversifying-country-diagnostic-study.pdf

[4] D. Chhun (2015), 'USAID Lowering Emissions in Asia's Forests (USAID LEAF)', *Drivers of Forest Change in the Greater Mekong Subregion: Cambodia Country Report,* Washington, DC, https://pdf.usaid.gov/pdf_docs/PA00KX4C.pdf

[5] Government of Cambodia, NCCC (2013), *Cambodia Climate Change Strategic Plan 2014–2023*, Phnom Penh, https://www.cambodiaip.gov.kh/DocResources/ab9455cf-9eea-4adc-ae93-95d149c6d78c_007729c5-60a9-47f0-83ac-7f70420b9a34-en.pdf

[6] Government of Cambodia (2009), *National Strategic Development Plan Update 2009–2013,* Phnom Penh, https://www.cambodianbudget.org/files-tinymce/New_Pic/Development_Policies/National_Policies_and_Decree/NSDP_Update_2009-2013_Eng.pdf

was supplementarily irrigated, and the remaining 80% relied on rainfall.[7]

Fish provides up to 80% of all animal protein intake in the average Cambodian diet, and fish production contributes about 10% to Cambodia's GDP, creating 6 million full- and part-time jobs nationwide.[8] The main inland fisheries are predominantly found along rivers, lakes, and wetlands, such as Tonle Sap Lake and the Mekong River. Tourism is the third-largest sector after agriculture and the garment industry. National revenue from tourism increased 17-fold, from $100 million in 1995 to $1,786 million in 2010, generating 315,000 jobs in the same year.[9]

The country has an insufficient supply of electricity, with only 17.2% of the total population – including about 6.0% of the rural population – having access in 2012.[10] In 2013, the per capita electricity consumption was 199 kilowatt-hours per year. Fossil fuel-based electricity production accounted for 95.2% of total energy production, while hydropower and other renewable resources represented only 3.3% and 1.5%, respectively. More than 80% of the population still depend on fuelwood and charcoal for household cooking.[11]

Based on statistics from the Ministry of Public Works and Transport, the total number of vehicles registered in 2009 – motorcycles, cars, vans and buses, and small and big trucks – was 307,000, with a 19% annual growth rate.[12]

3.2. National Development Projections

Cambodia wishes to progress from least-developed country status towards those of a low and a high middle-income developing country by 2018 and 2030, respectively. For 2014, Cambodia's economic growth rate was projected at 7%–8%.[13] The agriculture sector

[7] Technical Working Group on Agriculture and Water (2007), *Strategy for Agriculture and Water 2006–2010,* Phnom Penh, http://cdc-crdb.gov.kh/en/twg-jmi/sector_strategy/National_Strategy_Agriculture_Water_2006-2010.pdf

[8] Government of Cambodia, MAFF (2010), *Strategic Planning Framework 2010–2019 for Fisheries – Cambodia*, Phnom Penh, https://faolex.fao.org/docs/pdf/cam143042.pdf

[9] Government of Cambodia, MOT (2015), *Climate Change Action Plan in Tourism Sector 2015–2018,* Phnom Penh, https://ncsd.moe.gov.kh/sites/default/files/phocadownload/POLICYFRAMEWORK/mot_ccap_final.pdf

[10] Government of Cambodia (2012), *The Cambodian Government's Achievements and Future Direction in Sustainable Development: National Report for Rio+20,* Phnom Penh, https://sustainabledevelopment.un.org/content/documents/1022cambodia.pdf

[11] M. Jayakumar and S. Narayankumar (2021), *Implementation of Fast Technical Assistance – Study on Renewable Energy Grid Integration in Cambodia,* New Delhi: The Energy and Resources Institute.

[12] Government of Cambodia, MPWT (2013), *Climate Change Strategic Plan for Climate Change Adaptation and Greenhouse Gas Mitigation in Transport Sector,* Phnom Penh, https://data.opendevelopmentmekong.net/dataset/21dae100-b68b-4d52-a681-02988327330a/resource/65bd3758-5086-4ba8-9ea6-4c5542fa3eaf/download/climate-change-strategic-plan-for-transport-sector-en-final.pdf

[13] Q. Tang and M. Li (2021), 'Analysis of Cambodia's Macroeconomic Development', *E3S Web Conferences,* 235, https://doi.org/10.1051/e3sconf/202123501015

needed at least a 5% growth rate annually to meet the national economic growth target.[14] It contributed 32.1% to GDP in 2011 and was considered an important engine of growth in the NSDP update.[15] The targets for the tourism sector (i.e. in numbers of tourist arrivals) were 4.5 million and 6.1 million international tourists by 2015 and 2018, respectively, while the target for domestic tourists was 10.5 million.[16] If reached, 700,000 jobs would be created.[17] Moreover, with a 5.72% annual growth rate in rice production, Cambodia was expected to export 1 million tonnes of milled rice per year by 2015.[18]

The Ministry of Environment projected GHG emissions from the transport sector to increase from 785 gigagrams of carbon dioxide equivalent in 2000 to 11,376 by 2050, representing a 27% increase annually.[19] With over half of its of its land area under forest cover in 2010, Cambodia can benefit from carbon market mechanisms such as REDD+.[20]

3.3. Climate-Change Implications

The NSDP update outlined the importance of addressing climate change in national development planning and identified response measures as follows.

(i) Roads need strengthening, especially rural roads, so that floods do not affect the movement of people and transport of goods.

(ii) Additional dikes and drainage systems must be constructed in vulnerable areas to control excessive overflow of water from swollen rivers and creeks. As more than 80% of the population depends on subsistence agriculture, floods and droughts – destroying crops and thus livelihoods – could push large numbers of people below the poverty line. The management of water and fisheries is the lifeline of the Cambodian people.

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[14] *Ibid.*

[15] Government of Cambodia (2009), *National Strategic Development Plan Update 2009–2013,* Phnom Penh, https://www.cambodianbudget.org/files-tinymce/New_Pic/Development_Policies/National_Policies_and_Decree/NSDP_Update_2009-2013_Eng.pdf

[16] Government of Cambodia, NCCC (2013), *Cambodia Climate Change Strategic Plan 2014–2023*, Phnom Penh, https://www.cambodiaip.gov.kh/DocResources/ab9455cf-9eea-4adc-ae93-95d149c6d78c_007729c5-60a9-47f0-83ac-7f70420b9a34-en.pdf

[17] *Ibid.*

[18] Government of Cambodia, MOC (2011), 'The Expansion and Diversification of Cambodia's Exports of Milled Rice', *Aid-for-Trade Case Stories*, Paris: OECD, https://www.oecd.org/aidfortrade/48413491.pdf

[19] Government of Cambodia, MPWT (2013), *Climate Change Strategic Plan for Climate Change Adaptation and Greenhouse Gas Mitigation in Transport Sector*, Phnom Penh, https://data.opendevelopmentmekong.net/dataset/21dae100-b68b-4d52-a681-02988327330a/resource/65bd3758-5086-4ba8-9ea6-4c5542fa3eaf/download/climate-change-strategic-plan-for-transport-sector-en-final.pdf

[20] 'REDD' denotes 'reducing emissions from deforestation and forest degradation in developing countries'. The '+' adds forest-related activities that protect the climate (i.e. sustainable management of forests and the conservation and enhancement of forest carbon stocks).

(iii) Provision of water and sanitation services, particularly to rural areas, must be expanded.

(iv) Cambodia has a shortage of energy and low level of industrial development; consideration should be given to building up more eco-friendly energy sources such as hydropower.

(v) Cambodia's rich and diverse flora and fauna must be preserved. Besides protection of water and forest resources, the government must continue promoting tree planting, rehabilitation of degraded forests, and investment in the production of biofuels.

3.4. Climate-Change Projections

Temperatures in Cambodia have increased, and this trend is projected to continue with mean monthly temperatures rising between 0.013°C and 0.036°C per year by 2099 – depending on location – with higher rates at lower latitudes.[21] An increase in temperature is likely to affect agriculture productivity. According to one study, rice grain yield will decline by 10% for each 1°C increase in the growing-season minimum (i.e. night) temperature in the dry season.[22]

Projections of mean annual rainfall have indicated more rainfall for Cambodia.[23] There is a rising trend in seasonal rainfall between June and August in the north-west and a decreasing trend in the north-east of the country. Rainfall will increase in provinces at higher elevations during the wet season, but the dry season will become drier, which could hamper the production of coffee and rubber in Cambodia.[24]

Sea levels in the region are projected to rise under various scenarios. By 2090 relative to 1980–1999, the sea level will rise 0.18–0.43 metre under a low emissions scenario, 0.21–0.52 metre under a medium emissions scenario, and 0.23–0.56 metre under a high emissions scenario. A 0.56-metre rise would cause permanent inundation of about 25,000 ha of coastal Cambodia within 90 years.[25]

Indeed, the 435-kilometre coastline is vulnerable to sea-level rise and impacts of more frequent typhoons under future climate projections. This could affect tourism potential

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[21] Government of Cambodia, MLMUPC (2015), *Climate Change Action Plan 2015–2018,* Phnom Penh, https://faolex.fao.org/docs/pdf/cam207786.pdf

[22] J. Huang et al. (2004), 'Rice Yields Decline with Higher Night Temperature from Global Warming', *Proceedings of the National Academy of Sciences,* 101(27), pp.9971–5.

[23] USAID (2019), *Climate Risk in Cambodia: Profile,* Washington, DC, https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID_Cambodia%20CRP.pdf

[24] USAID (2015), *Mekong Adaptation and Resilience to Climate Change*, Bangkok: USAID Regional Development Mission for Asia, https://2017-2020.usaid.gov/sites/default/files/documents/1861/FS_Mekong%20ARCC_July%202015_0.pdf

[25] IPCC (2007), *Fourth Assessment Report,* Geneva, https://www.ipcc.ch/assessment-report/ar4/

and cause coastal erosion, while strong winds could damage settlements in coastal areas. Given that only 7%–8% of total production land area is under full irrigation, it is difficult for Cambodia to achieve 5% annual agriculture growth needed to meet the target of agriculture production export by 2030 under climate-change impacts (e.g. droughts) – especially for some cash crops such as rice – without further investment in the expansion of irrigation schemes.[26]

According to the International Disaster Database, disasters in 2011 resulted in economic losses to Cambodia of about 4.3% of its GDP.[27] Climate-related flooding is projected to increase in its frequency and intensity – especially in the central plains. While the coastal zones are affected by tropical cyclones from the Pacific, the central plains experience seasonal flooding caused by increased rainfall. Both regions are of significant economic importance due to their fiscal revenue contributions generated from tourism, services, navigation, fisheries, and agriculture production. Therefore, it is crucial that measures are put in place to minimise the impacts of climate-change risks and disasters for Cambodia to achieve the economic growth and development expected in the national development programmes.

GHG emissions in Cambodia are currently extremely low compared to regional and global averages. In 2000, Cambodia emitted 47.6 million tonnes of carbon dioxide equivalent, but the forestry sector absorbed 48.0 million tonnes of carbon dioxide equivalent.[28] Over the same period, energy consumption by sector was highest in transport, followed by the electricity production, residential, and industrial sectors. Cambodia needs to increase energy production to boost industrial activities while improving energy efficiency in the transport and residential sectors to reduce GHG emissions. During this stage of increasing energy supply, it is important that integration of renewable energy sources be considered in future energy production.

3.5. Cambodia's Climate-Change Response Capacity

According to *Climate Change Vulnerability Mapping for Southeast Asia*, carried out by the Economy and Environment Program for Southeast Asia, Cambodia is amongst the most vulnerable countries to climate-change impacts because of its low adaptive capacity.[29] A SWOT analysis of Cambodia's response to climate change was conducted with many stakeholders, including government agencies, CSOs, NGOs, development partners, and

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[26] Government of Cambodia, NCCC (2013), *Cambodia Climate Change Strategic Plan 2014–2023*, Phnom Penh, https://www.cambodiaip.gov.kh/DocResources/ab9455cf-9eea-4adc-ae93-95d149c6d78c_007729c5-60a9-47f0-83ac-7f70420b9a34-en.pdf

[27] *Ibid.*

[28] Government of Cambodia, National Council for Sustainable Development (2015), *Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change,* Phnom Penh, https://unfccc.int/resource/docs/natc/khmnc2.pdf

[29] A.A. Yusuf and H.A. Francisco (2009), *Climate Change Vulnerability Mapping for Southeast Asia,* Singapore: EEPSEA, https://www.preventionweb.net/files/7865_12324196651MappingReport1.pdf

the private sector. The results were considered in the development of the CCCSP.

Table 10.1. Strengths, Weakness, Opportunities, and Threat Analysis of Cambodia's Response to Climate Change

Strengths	Weaknesses
• High economic growth • Interest in knowledge and information related to climate change • High interest in sustainable development • Rich natural resources base • Government policies on economic development • Sectoral climate change strategic plans developed by relevant ministries • Stakeholder support to climate-change response, including by government agencies, international community, and civil society • Increased awareness of climate change • Policy on environment and health • Gradual improvement of infrastructure	• Weak knowledge and science-based decision making • Lack of clear procedure for integration of climate change in national development plans • Limited capacity of national institutions responsible for climate change and limited participation of stakeholders • Outdated information to address climate-change impacts • Limited human resources • Climate-change planning not a common practice • Limited knowledge, research, and technology • Limited financial resources • Low adaptive capacity amongst citizens
Opportunities	**Threats**
• Increasing global climate-change funds • Establishment of national knowledge and information structure • Development of national sustainable development plan • Political commitment and support to climate change • Improved livelihoods • Global efforts in addressing climate change • Existing programmes such as Cambodia Climate Change Alliance and Strategic	• 43% of total communes highly vulnerable • Low understanding of climate change and response options • Other policies and priorities competing with climate-change policy • Key economic sectors face risks of climate-change impacts. • Limited capacity for climate-change responses • More frequent climate extreme

Strengths	Weaknesses
Programme for Climate Resilience • Development partners' support in addressing climate change • Skills and vocational development programmes	events • Lack of resilience to disasters

Source: Author.

3.6. Institutional Arrangements Regarding Climate Change in Cambodia

The NCCC was established in 2006 with the mandate to coordinate and to monitor implementation of government policies, strategies, regulations, plans, and programmes in response to climate-change issues. The Prime Minister is the honorary chair, while the Minister of Environment serves as its chair. A climate-change technical team (CCTT) was established as an inter-ministerial body to provide technical support to the NCCC in fulfilling its mandate. The Climate Change Department within the Ministry of Environment serves as the secretariat for the NCCC and coordinates the activities of the CCTT. There are climate-change focal points and working groups appointed by key ministries to oversee climate-change-related activities, such as the development of the sectoral climate-change strategic plans, action plans, and projects.

Going forwards, the climate-change institutional structure must be reviewed to help promote inter-ministerial coordination and implementation of the CCCSP as well as other climate-change response measures.

3.7. Gender and Climate Change

The government recognises that the rural poor of Cambodia – the majority of whom are women – are most vulnerable to climate-change impacts because of their high dependence on agriculture and natural resources. This vulnerable group is also very susceptible to diseases because of their limited resources and capacity to adapt to climate-change impacts, including the lack of preparedness to cope with climate risks and hazards. Therefore, gender must be mainstreamed into all climate-change response measures at all levels and involving development partners, NGOs, CSOs, research and academia, and the private sector.

3.8. Education, Awareness, and Communication on Climate Change

Mainstreaming climate-change knowledge and information into formal and non-formal education is key to sustaining climate-change awareness for a green, equitable, and climate-resilient society. It is important to create an enabling environment for climate-change education and awareness by developing and enhancing communication

structures, systems, and tools.

4. *Cambodia Climate Change Strategic Plan 2014–2023* Strategic Objectives

Strategic Objective 1. Promote climate resilience by improving food, water, and energy security by

(i) mapping sectoral contributions to the security of key systems;

(ii) engaging relevant sectors and stakeholders in identifying response measures;

(iii) enhancing institutional coordination mechanisms for coherent policy responses to climate change;

(iv) increasing capacity to identify climate-induced opportunities in agriculture production systems, ecosystems, and protected areas, including those related to agriculture diversification (e.g. crops and livestock), increased productivity (e.g. crops, fisheries, livestock, and forestry), new crop varieties, and watershed and ecosystem management;

(v) facilitating business and industry responses to carbon market opportunities for green trade and investment;

(vi) promoting renewable energy and energy efficiency to reduce GHG emissions and impacts on health, including appropriate technology transfer and solid waste and wastewater management through integrated measures in the capital, towns, and populated areas, and animal waste management;

(vii) developing decentralised energy production systems, integrating the application of renewable energy, especially solar energy;

(viii) rehabilitating and/or building water infrastructure, including small-, medium- and large-scale irrigation schemes;

(ix) rehabilitating and/or building climate-resilient rural road infrastructure, and connecting production areas to the market; and

(x) integrating climate change into the environmental impact assessment processes.

Strategic Objective 2. Reduce sectoral, regional, and gender vulnerability and health risks to climate-change impacts by

(i) using existing vulnerability and risk assessments, and conducting new ones where necessary, to prioritise climate-change adaptation measures for key regions, such as coastal zones, highlands, and rural and urban areas;

(ii) implementing key actions identified in the sectoral climate-change strategic plans of ministries for addressing climate-change impacts;

(iii) promoting the integration of the CCCSP into other national strategies such as the

NSDP and the National Social Protection Strategy;

(iv) promoting community-based adaptation approaches, and strengthening partnerships amongst development partners, CSOs, NGOs, the private sector, and government;

(v) promoting the use of appropriate technologies in livestock and crop production for vulnerable farmers;

(vi) improving fisheries sector management;

(vii) conserving water and forest ecology, mangrove ecosystems, coastal zones, and protected areas;

(viii) promoting sustainable natural rubber production by focussing on both climate-change adaptation and mitigation measures;

(ix) promoting sustainable livestock production and protection of animal health;

(x) improving health care infrastructure and the capacity of health personnel to cope with vector-borne and water-borne diseases amplified by climate change;

(xi) introducing technologies in waterworks development and rehabilitation in response to climate-change impacts;

(xii) promoting capital-intensive urban transport infrastructure planning and development;

(xiii) enhancing the ability of rural infrastructure (i.e. roads, irrigation, wells, and culverts) to be resilient to floods and droughts;

(xiv) promoting early-warning systems for disasters; and

(xv) prioritising women's needs in climate-change adaptation and mitigation actions.

Strategic Objective 3. Ensure the climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites by

(i) strengthening biodiversity conservation, and restoring ecosystems threatened by climate change;

(ii) promoting community- and ecosystem-based approaches and eco-tourism as cost-effective ways of addressing climate change;

(iii) promoting financing of ecosystem services including REDD+; and

(iv) promoting participatory land-use planning.

Strategic Objective 4. Promote low-carbon planning and technologies to support sustainable development by

(i) conducting sectoral analyses on low-emissions options and sources of emissions in the agriculture, energy, transport, industrial, land-use and forest management, and waste management sectors;

(ii) preparing low-carbon development policies, legal frameworks, and action plans in

conformity with national development priorities;

(iii) promoting appropriate technology transfer for low-carbon development (e.g. improving energy efficiency and renewable energy); and facilitating their diffusion through guidelines, technical assistance, and partnerships; financial and fiscal incentives; carbon market mechanisms; and public–private partnerships;

(iv) promoting low-carbon, climate-resilient city development planning, and developing city-level coordination mechanisms (e.g. capital and provincial effective mass transport and modernisation of wastewater treatment facilities and landfills);

(v) establishing a system of registration for GHG mitigation projects and programmes; and

(vi) establishing a high-quality national system for the GHG inventory.

Strategic Objective 5. Improve capacities, knowledge, and awareness for climate-change responses by

(i) enhancing the implementation of Article 6 of the UNFCCC on education, training, awareness, participation, and access to information by the population, and international cooperation for climate-change responses;

(ii) strengthening existing channels for promoting awareness on climate change through government service providers, teachers, journalists, extension services, religious leaders, and community elders;

(iii) developing targeted awareness programmes aimed at key audiences such as vulnerable groups, women, children, youth, and ethnic minorities;

(iv) facilitating public access to information on climate change through the radio, television, newspapers, mobile and web technologies, and targeted outreach materials;

(v) sensitising the private sector to threats and opportunities of climate change (i.e. technical support, financing, and technology transfer), and developing public–private partnerships for communication;

(vi) integrating climate-change information into curricula at all levels of education;

(vii) strengthening the quality of teachers, and building the capacity of educational planning officers on teaching and learning methodologies on climate change;

(viii) strengthening the capacity for collection, analysis, modelling, and interpretation of climate data and information dissemination to various end-users, including seasonal forecasting for adaptation and community early-warning facilities for disaster risk management;

(ix) improving national weather monitoring and forecasting systems, and developing partnerships for creating downscaled models of future climate change;

(x) developing early-warning systems and programmes for climate-related disaster

management and recovery;

(xi) strengthening the role of universities in training, research, and technology development by building international partnerships for climate research;

(xii) capitalising on lessons learned, local knowledge, and good practices for development of policies and actions for climate-change adaptation and mitigation; and

(xiii) developing a knowledge management centre for facilitating access to up-to-date information for climate-change responses.

Strategic Objective 6. Promote adaptive social protection and participatory approaches in reducing losses and damages due to climate change by

(i) encouraging microfinance to improve access to credit for local communities for climate-change responses;

(ii) encouraging insurance schemes to reduce climate-change risk and disaster burdens on society;

(iii) integrating gender into climate-change response planning;

(iv) leveraging the decentralisation process to strengthen financial and institutional processes for local adaptation measures;

(v) instituting public engagement, participation, and consultations as primary entry points for adaptation planning, and promoting the involvement of multiple stakeholders including NGOs, youth, indigenous communities, and the private sector; and

(vi) promoting public–private partnerships, including corporate social responsibility.

Strategic Objective 7. Strengthen institutions and coordination frameworks for national climate-change responses by

(i) mainstreaming climate change into national and sub-national development plans and the National Social Protection Strategy;

(ii) reinforcing the national institutional framework and inter-ministerial coordination in policy development;

(iii) strengthening the role and capacity of the NCCC Secretariat to coordinate climate financing and as a national implementing entity for global climate funds;

(iv) developing a national monitoring and evaluation (M&E) framework for climate-change responses, and integrating it into the NSDP and the National Social Protection Strategy; and

(v) encouraging all ministries to develop sectoral climate-change strategic plans and action plans and to engage in the CCCSP process.

Strategic Objective 8. Strengthen collaboration and active participation in regional and global climate-change processes by

(i) promoting regional cooperation on climate change within inter-governmental and non-governmental mechanisms through implementation of commitments under the UNFCCC, cooperation under the Association of Southeast Asian Nations (ASEAN) framework, South–South and North–South collaboration, trans-boundary initiatives (e.g. *Mekong River Basin Indicator Framework*), Clean Development Mechanism, carbon market mechanisms, and other relevant carbon credit schemes;

(ii) strengthening the national institutional platform for coordinating consultations and responses to current and future issues for international negotiations on climate change;

(iii) reinforcing negotiation skills to represent Cambodia in international climate-change processes, and improving the capacity for implementation of international obligations;

(iv) actively engaging with regional and global initiatives and programmes for cross-learning, and sharing Cambodia's experiences on climate change with the international community; and

(v) securing climate funds from international funding mechanisms.

5. *Cambodia Climate Change Strategic Plan 2014–2023* Activities

The CCCSP provides a broad framework for the implementation of climate-change responses in Cambodia. Action plans and relevant mechanisms, such as financing mechanisms, M&E frameworks, and legal frameworks, must be developed to implement the CCCSP and to provide a solid foundation for mobilising resources.

5.1. Implementation

Short term (2013–2014). In this phase, institutional and financial arrangements for the implementation of the CCCSP are put in place, together with the establishment of a national M&E framework. During this phase, detailed and prioritised action plans (2014–2018) are developed by concerned ministries and agencies, including a specific action plan for strategic knowledge management and coordination functions.

Medium term (2014–2018). This phase continues to support planned actions in Phase 1 but also includes activities such as the establishment of a nationally accredited mechanism for the Adaptation Fund and Green Climate Fund, research and knowledge management activities, capacity development and climate-change mainstreaming at various sectoral levels, operationalisation of the M&E and data management systems, and launch of a few high-priority projects/programmes in each key sector as specified in their climate-change action plans. Initially, adaptation activities are emphasised, but preparatory assistance will be provided to gradually scale up the mitigation component.

During this phase, climate-change finance for national and sub-national planning, budgeting, and implementation modalities begins and will gradually increase. In addition, in this phase, Cambodia establishes appropriate institutions with the sufficient capacity and full credibility for direct access to the Adaptation Fund and Green Climate Fund.

Long term (2019–2023). This phase continues to focus on research. The main objectives are to scale up successful pilots and to continue the mainstreaming of climate change activities at the national and sub-national levels. This involves more budget support for national programmes, including implementation of climate-change response measures through sub-national administrations.

5.2. Institutional Arrangements for the *Cambodia Climate Change Strategic Plan 2014–2023*

At the national level, the NCCC has overall responsibility for the management and monitoring of CCCSP implementation, with technical support from the CCTT and administrative support from the NCCC Secretariat. The mandate, roles and functions of the climate-change institutions must be refined to reflect their specific responsibilities in the management and monitoring of the CCCSP. The NCCC Secretariat, however, legally functions as an inter-ministerial body, which has a full mandate and authority to play its cross-cutting coordination role, and it must also have the capacity and full accreditation for global climate funds. The required legal processes are detailed in the action plan for strategic, knowledge management, and coordination functions.

At the ministry level, climate-change focal points and/or working groups have already been established. Their responsibilities will be clarified in the future, in particular their relationships with other ministry departments, to ensure that the planning of sectoral policies, programmes, and investments considers climate-change risks and opportunities.

At the sub-national administration level, guidelines on development planning in the context of climate change were in place by June 2014 under the leadership of the NCCC Secretariat. These guidelines build on the wealth of experience generated in recent years through pilot projects, mostly at the commune level. They include recommendations on collaboration between the various levels of sub-national administration and, in particular, the modalities for communes to access climate-change technical expertise from line departments located at the district or provincial level.

5.3. Associated Action Plans and Frameworks

Action plans. All relevant ministries will develop prioritised action plans and estimate the costs to implement their sectoral climate-change strategic plans with technical and financial support from the NCCC Secretariat. These action plans will be closely aligned with relevant sector strategies. A specific action plan will also be developed for coordination functions, including the roles of NCCC, CCTT, and NCCC Secretariat. Guiding

principles for the development of these action plans are below.

Financing framework. The financing of the CCCSP involves various modalities, with a mix of traditional instruments and new instruments related to climate finance. These various modalities must be properly coordinated, and potential funding partners must have a clear overview of the costs and prioritisation of activities under the CCCSP. The NCCC and CCTT are responsible for the formulation of a climate-change financing framework, which supports a programme-based approach for climate-change responses in Cambodia.

Monitoring and evaluation framework. A national M&E framework for the CCCSP was finalised by mid-2014. It is compatible and integrated with the national M&E system. Further details on this M&E framework are below.

Legal framework. A climate-change legal framework is crucial to support the implementation of the CCCSP by mainstreaming climate-change issues into related policies and core legislation. It allows for enforcement and compliance with key policy recommendations related to climate-change responses.

5.4. Principles of the *Cambodia Climate Change Strategic Plan 2014–2023*

The implementation of the CCCSP will require a programme-based approach to ensure strategic coordination and prioritisation of activities. Besides using risk-based programming, activities that promote or support capitalising on opportunities and expanded benefits and co-benefits to society and systems are encouraged. Details of the action plans are provided in a separate document as required by the Council of Ministers. The following principles must be followed when developing the programmes, which will be based on sectoral action plans.

Time frame. The CCCSP has a 10-year time frame (2014–2023), with a mid-term review scheduled for 2018. The sectoral action plans and corresponding overall programme were developed for an initial phase of 5 years (2014–2018), in line with the national planning and M&E time frame. Action plans use appropriate methods for prioritisation and phasing, including vulnerability analyses and mapping and cost–benefit analyses.

Ministry strategies. The action plans for the CCCSP cannot be developed as stand-alone 'silos' within their respective ministries. Some discrete climate-change actions are required, but most actions are related to existing public investment portfolios within the ministries. The action plans are closely integrated within the standard planning and management arrangements of concerned ministries, including reflection of climate-change-related actions in the budget process and development of climate-sensitive indicators in sectoral M&E frameworks.

Cross-cutting issues. Programming under the CCCSP also targets common issues shared by all sectors such as gender, social protection, research, education, awareness and communication, M&E, climate financing. and knowledge management.

Integrated programming. Due to the cross-cutting nature of climate change, integrated

programming is critical to capitalise on interdisciplinary, multi-sectoral, multi-stakeholder, and multi-dimensional approaches in programming response actions. All concerned ministries and agencies consider links with other sectors when developing their action plans, and the NCCC Secretariat provides dedicated support to review these links.

Partnerships. Development partners, CSOs, NGOs (both national and international), the private sector, and local communities are important actors in the downstream implementation of climate-change activities as well as in research and development associated with climate change. While the CCCSP is a government document focussing on the use of public resources, it is essential that these resources are used to catalyse broader action and responses to climate change by other actors. Government agencies are encouraged to engage all relevant partners in the development of their action plans and to identify partnerships in their action plans.

5.5. Financing

The CCCSP, together with the related action plans, provides a strategic framework for the programming of climate-change interventions in Cambodia. National climate-change financing mechanisms must support this strategic approach through the application of the following principles:

(i) Alignment with national priorities. The use of financial resources will respond to national priorities through funding programmes and projects identified in action plans under the CCCSP. All proposed climate-change financing is subject to NCCC review and approval.

(ii) Pooling resources. To minimise transaction costs, climate-change finance will be provided whenever possible through pooled funding mechanisms. These include any existing pooled funding mechanisms in relevant sectors and the possibility of a dedicated climate change fund.

(iii) Use of national systems and procedures. The government's preferred modality for climate-change financing over the medium to long term is direct budget support. However, as climate change is a relatively new field, a transitional period is required to put in place adequate M&E and financial tracking systems to assess the impact and efficiency of climate-change budget support. A national climate fund may be set up to receive domestic and external financial support and to allocate it to high-priority climate-change projects.

(iv) Subsidiarity. While climate-change financing must be coordinated by the NCCC to ensure alignment with national priorities, financing mechanisms must also ensure that the resources are managed by the most qualified ministries or local governments. The NCCC Secretariat will act as an implementer only for strategic or cross-cutting projects that do not fit within the mandate of another ministry or sub-national administrations.

The development of a climate-change financing framework for Cambodia requires several steps. A Climate Public Expenditure and Institutional Review was conducted in 2012 and provided initial information on the status of climate-change expenditures in Cambodia and associated capacity challenges.[30]). It estimated that from 2009 to 2011, about 15.8% of Cambodia's public expenditures were relevant to climate change – a high level compared to other countries in the region.

Climate financing should aim to attract new resources as well as to improve the efficiency and effectiveness of already significant climate-related expenditures. These existing funds are not always well coordinated, as they come mostly through sector-specific projects (60%), and their interventions are not systematically assessed from a climate-change perspective.

Within the coming years, it is expected that the share of dedicated climate-change financing will grow. This is an opportunity for Cambodia, as these funds can be allocated to priority sectors and programmes as defined under the CCCSP. Some projects will be funded through traditional channels, but pooling mechanisms can be put in place to fund highly relevant projects including institutional capacity development on climate change, top up existing projects that require climate-proofing, and continue to pilot innovative approaches to climate-change adaptation and mitigation.

Public expenditure through sub-national administrations is still relatively small – 5%–6% of total state expenditure – but vital for climate-change adaptation initiatives, which need to provide support for better climate resilience at the community level. Future financing mechanisms should include appropriate procedures and instruments to mainstream climate change in sub-national planning and budgets.

It is important to regularly monitor the evolution of climate-change expenditures, their alignment with CCCSP and NSDP priorities, as well as their efficiency and effectiveness. Regular reviews will be conducted to update information obtained from the initial Climate Public Expenditure and Institutional Review, and mechanisms to mainstream climate change in the national budget process must be established.

In 2014, the following actions were undertaken to put in place a credible, attractive, and effective climate-change financing framework for Cambodia:

(i) analysis of resource mobilisation opportunities (domestic and external), both at the national level and in prioritised sectors;

(ii) costing of the CCCSP and sectoral climate-change action plans, with prioritisation of highly relevant projects;

(iii) costing of the socio-economic impacts of non-action and net benefits of various

[30] N. Bird et al. (2012), 'The Climate Public Expenditure and Institutional Review (CPEIR): A Methodology to Review Climate Policy, Institutions and Expenditure', *UNDP–ODI Working Papers*, New York: UNDP and ODI, https://www.cbd.int/financial/climatechange/g-cpeirmethodology-undp.pdf

response scenarios to provide a basis for prioritisation of expenditures per sector/sub-sector;

(iv) analysis of best national practices and relevant international practices for the management of pooled funding arrangements, and recommendations for proposed arrangements for national and sub-national climate-financing mechanisms; and

(v) analysis of capacity gaps and recommendations to develop national and sub-national capacities to manage the proposed climate-change finance mechanisms, including recommendations to mobilise private finance for adaptation and mitigation activities.

This will lead to the establishment of a programmatic framework, based on action plans in priority sectors and aligned with the NSDP update.

The Climate Finance Sub-Group of the CCTT is composed of representatives from the Council for the Development of Cambodia/Cambodia Rehabilitation and Development Board, Ministry of Economy and Finance, Ministry of Environment, Ministry of Planning, and National Committee for Sub-National Democratic Development Secretariat. This group helped develop a national climate-change financing framework submitted to the NCCC in 2014.

While the exact financing mechanisms are to be determined, it is clear that domestic finance and the three main external sources of climate finance (i.e. global climate funds, bilateral climate funds, and climate-change-related activities integrated in traditional sector projects) must be coordinated and aligned with the CCCSP. Coordination between vertical projects and pooled funding mechanisms is also required.

As per Council for the Development of Cambodia/Cambodia Rehabilitation and Development Board policy, a programme-based approach is being undertaken. The NCCC created appropriate structures for the management of a climate-change programme-based approach, including one for dialogue and coordination with donors. It can accommodate various modalities of financing but provide a single engagement point and framework for coordinated planning and M&E of climate-change-related interventions in Cambodia. The NCCC Secretariat is the secretariat for this programme-based approach. Coordinated capacity development support is required to establish these mechanisms.

5.6. Monitoring and Evaluation

The impacts of climate change on ecosystems and society are complex; addressing them through adaptation requires a coordinated response across multiple sectors and scales. Establishing a low-carbon development path and contributing to mitigation efforts requires new technologies and cross-cutting policies. Given the complexity of these actions and the technical issues associated with evaluating their effectiveness and impacts, M&E of mitigation and adaptation responses poses a new set of challenges. The CCCSP recognises the importance of addressing these challenges by establishing a national framework for the M&E of climate-change actions, with a vision towards

integrating the framework into the national and sub-national development planning processes. Developing and mainstreaming the M&E framework is a long-term effort of strategic relevance, as it seeks to create an enabling environment based on accountability and learning. Improved accountability facilitates access to new international climate finance, and investments generate new knowledge critical for future policy development. The aim of the national framework for M&E of climate change is to

(i) measure to what extent adaptation efforts have been effective in keeping development on track in a changing climate,

(ii) monitor climate-change mitigation actions and low-carbon development policies,

(iii) generate evidence and lessons as a basis for future policy development,

(iv) facilitate the coherent integration of M&E of climate change in national development planning and key sectors, and

(v) provide the information required to fulfil the reporting obligations to UNFCCC, CSOs, and development partners.

The criteria that underpin the framework are as follows.

Use national systems and procedures. The M&E framework is integrated with the national M&E system. Indicators and monitoring procedures rely as much as possible on data currently monitored by relevant ministries. They are also compatible with the guidelines of the Ministry of Planning for the national M&E system. The framework systematises and builds on ongoing initiatives for monitoring and reporting of GHG emissions.

Mainstream M&E of climate change activities into national, sectoral, and sub-national development planning. Climate change can undermine achievement of the development targets set in the NSDP and sectoral development strategies. Procedures and indicators for tracking climate-change responses are integrated in the national M&E system and constitute the reference for tracking the effectiveness of climate-change sectoral strategic and action plans at national and sub-national levels.

Strengthen accountability, equity, and transparency. The framework provides a way for measuring to what extent resources have been efficiently and effectively used to achieve the targets set in policies and action plans, thus improving accountability towards the public, government institutions, CSOs, and development partners.

Promote participatory learning. Developing climate-change response policies and measures is a relatively new endeavour in Cambodia and globally. Generating a solid evidence base of what policies and measures have proven to be effective is therefore essential to informing future policymaking. The framework focusses on generating knowledge through participatory approaches and supports identification and sharing of lessons learned.

Address gender issues. Women and disadvantaged groups are often amongst those more affected by climate-change impacts. The framework addresses gender equality,

gender-sensitive performance in climate-change responses, and gender mainstreaming in climate-change responses.

The national framework for M&E of climate-change responses was developed referring to international best practices. A concept note was prepared to quantify and to mobilise the resources required for jumpstarting the development of the framework in 2014. It includes a theory of change, an indicator framework with baseline and targets for tracking the CCCSP and related action plans, procedures for data collection, guidelines for analysis and reporting, guidelines for integration of knowledge management, learning and sharing of results, guidelines for integration within M&E systems of line ministries and agencies, and detailed institutional arrangements and coordination mechanisms.

The indicator framework includes two categories measuring the institutional response towards climate-change management and development performance in a changing climate: (i) upstream indicators, tracking the effectiveness of climate risk management, including those related to the institutional framework, mainstreaming of climate change in policies and planning processes, climate financing, capacities of institutions, equity and transparency, and engagement of stakeholders and the private sector; and (ii) downstream indicators, which track changes in the development situation, emissions, and climate vulnerability of communities and ecosystems, including national development statistics and indicators aggregated from sectors and individual adaptation and mitigation projects. Results must be assessed alongside climate trends and incidence of climate extremes.

A set of indicators for inclusion in the NSDP was also identified. A plan outlining activity, capacity development, and costing for long-term implementation and mainstreaming of the framework within line ministries was prepared.

In the medium term, the framework is being operationalised at the sectoral level by priority ministries and projects, selected depending on capacities and resources available. Integration of M&E into local planning is being pilot tested. Adequate resources have been front-loaded into the selected projects to cover additional costs for specialised technical capacities in M&E of climate change; collection of baselines; and development of theories of change, learning, and knowledge management. A network of sites for long-term monitoring were established for assessing the effectiveness and sustainability of adaptation and mitigation measures tested through pilot projects. They were identified in vulnerability hotspots, such as critical ecosystems, and in areas where pilot interventions have shown promising results. This system is generating evidence stored in a national database of approaches and technologies, managed by the NCCC Secretariat in coordination with line ministries and development partners.

In the long term, the framework will be revised based on the lessons emerging during the pilot phase and mainstreamed in the remaining ministries and in sub-national and local planning.

The NCCC Secretariat is the secretariat for coordinating the development and

implementation of the framework. It is also responsible for producing the CCCSP annual progress report, in coordination with the NSDP annual progress review. A unit in charge of M&E was established within the Secretariat. A coordination mechanism within the Ministry of Planning was also established for the integration of the framework within the M&E system of the NSDP.

An M&E sub-group of the CCTT was established to coordinate data exchange and mainstreaming of the framework within ministries. Indicators, procedures, and responsibilities for data collection will be agreed with the ministries, National Institute of Statistics, and other parties interested in actively engaging in the process.

A partnership with research institutions and academia for managing the network of sites for long-term monitoring is being explored. This arrangement can also be used for organising ad-hoc evaluation studies of adaptation and mitigation effectiveness based on the data generated by the network.

6. Conclusion

The government has launched the CCCSP as a continuation of the national policy response to climate change, guiding Cambodia's transition to low-carbon and climate-resilient development. The CCCSP supports national preparedness in responding to climate risks and disaster management, capitalising on emerging opportunities such as green growth, mobilising climate funds from bilateral and multilateral sources, and enhancing effective participation in international dialogue and negotiations on climate change.

The CCCSP seeks to enhance the capacity to address climate-change impacts on national development processes through a coordination of efforts to reduce the vulnerability of the population and natural systems that support livelihoods and drive national economic growth and prosperity. The implementation of the CCCSP is strengthening national capacity, raising awareness, and informing decision-making processes using actionable knowledge developed through the implementation of priority actions, in providing evidence-based information and learning pathways for sustainable solutions. Partnership building and public–private sector engagement constitute the platform for active participation and mobilisation of resources for the implementation of the strategy.

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Chapter 11

Integrated Assessment of the Distributional Social Impacts: Climate Change amongst the Most Vulnerable

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We have two possibilities of variations of climate impacts: geographic deviation and society or social group deviation. Both relate to uneven distributional impacts for societal groups and individuals. We explain why the poorest people are hit proportionally and why many rural and peripheral areas in ASEAN and other world regions will gradually become depopulated due to the combined effect of accelerated climate change and economic growth. The future damage and loss due to climate change is still unknown, despite previous events indicating the magnitude. Perceivable and total climate change costs will likely be within 1% and 2% of the global economic product or up to half of the current global economic growth. So far, the combined effect is positive, and the adaptation capacity to counter climate change impacts increased. While the poorest and most vulnerable give up their homes in vulnerable countries and provinces, new and more radical groups in rich and more resilient countries demand accelerated climate actions as current measures to halt climate change are considered too slow. Food security is a major issue as 70% of the earth´s ice-free land is destroyed and needs to be restored. The fear that currently resilient groups in global centres become vulnerable again does exist. Further means to overcome vulnerability, like climate finance, participation in international trade, urbanisation, health, protection of ecosystems, and access to renewable energy, is discussed.

1. Climate Change Hits Unfairly

Even if climate change were the same worldwide or in the ASEAN region, it would lead to dissimilar impacts. We find diverse landscapes ranging from islands and coastlines to mountains with distinct zones of altitudes. The established land uses are fitted to the natural environment. There are zones especially wedged by more severe events of hurricanes, areas suffering more from frequent drought episodes, and yet other sites increasingly surprised by erratic climate and weather events. There is a difference between gradual climate change modifying the baselines of weather patterns and extreme events appearing randomly and often hitting in the form of catastrophic disasters. Gradual climate change and extreme climate events are highly interconnected. Meanwhile, we find the Sixth Assessment Report (AR6) of the IPCC (2023), which consists of three in-depth reports regarding the physical basis of climate change, the vulnerabilities and

adaptations, and mitigation options. Concerning the vulnerability of the poorest people, we refer to the report of Working Group II (IPCC, 2022).

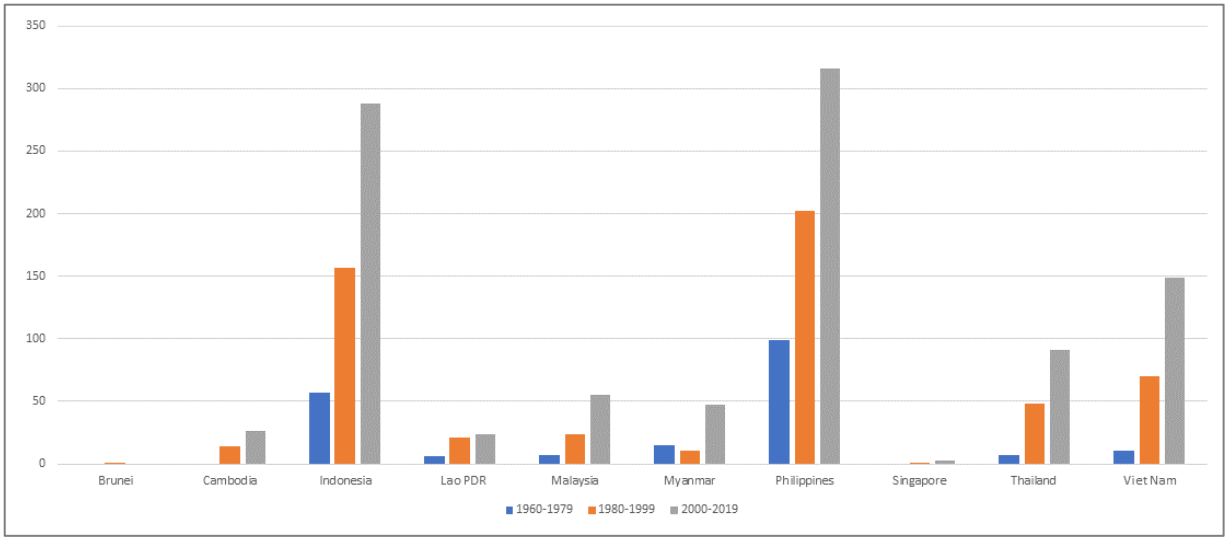
Hostile impacts of climate change, development deficits, and inequality aggravate each other. Identified vulnerabilities and inequalities intensify due to climate change. Impacts disproportionately affect marginalised groups, augmenting inequalities and undermining sustainable development across all regions. Due to their socioeconomic conditions and the broader development context, many poor communities, especially in countries and regions with high levels of vulnerability and inequality, are less resilient to diverse climate impacts (Birkmann et al., 2022).

1.1. Increased Disasters, particularly in ASEAN Countries

Observed societal impacts of climate change, such as mortality due to floods, droughts, and storms, are much greater for regions with high vulnerability than those with low vulnerability, revealing the different starting points that regions have in their move towards climate-resilient development (Birkmann et al., 2022). Climate change has global, regional, and local causes and effects. We are sure that temperature and climate extreme events are rising globally. The latest IPCC report (2022) provides abundant information about global and world regions. On a regional scale, we are less certain about the change in weather phenomena and may consider surprises to what we already expect. For example, extreme humid heat events increased globally in recent decades, while regional changes and higher-order temporal characteristics have not been widely explored (Speizer et al., 2022). Despite improved knowledge on the larger scale and roughly knowing the speed of change in average, we can only anticipate how far the variations of smaller scales generate the mean value ample from this average.

Then, let us only consider just one region, the ASEAN region. We will recognise that further oscillations from the regional average are possible due to the mosaic of many local areas that make up the region. The local deviation from the global average can be much higher than the regional deviation from the global average. Extreme climate events are seldom recognised in the whole region, but manifest in hotspots, while temperature rise is more equally distributed throughout a region. Disasters hit particular spots unevenly. The University Leuven in Belgium, in cooperation with the World Health Organization and the World Meteorological Organization, has been collecting disaster events worldwide for over a hundred years. The Centre for Research on the Epidemiology of Disasters in Leuven maintains the global emergency events database, used here as a reference (EM-DAT 2023). Additionally, we find more disaster damage databases like DesInventar, which refers to small-scale disasters, usually ignored (Moriyama, Sasaki, and Ono, 2018).

Figure 11.1. Number of Reported Natural Disasters in ASEAN, 1960–2019

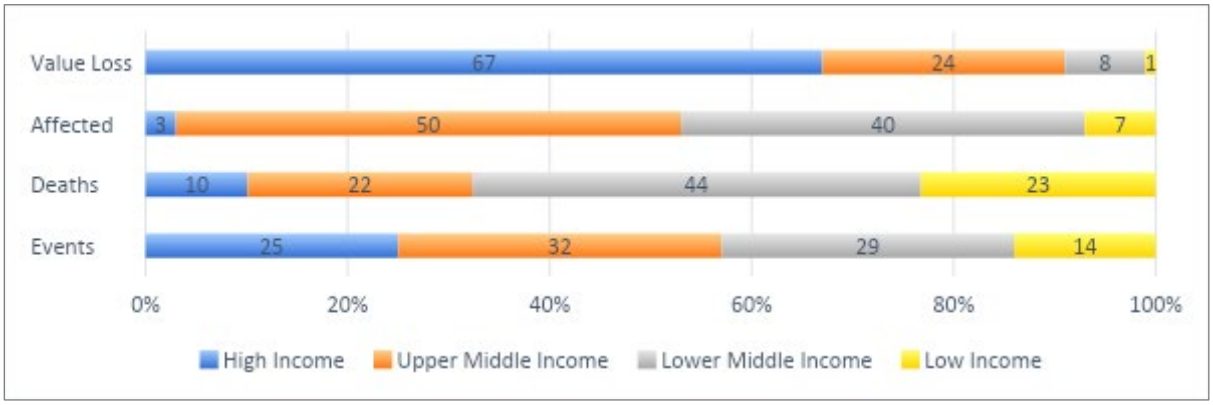


Source: EM-DAT (2023).
EM-DAT (2023), Emergency Data Base of the Centre for Research on the Epidemiology of Disasters – CRED. https://www.emdat.be/ (accessed 19 September 2023).

Figure 11.1 shows the number of climate-related disaster events in ASEAN in 1960–2019. One can observe that every 20 years, disaster events become more severe than the previous period. The number also includes non-climate-related natural disasters like earthquakes and tsunamis. While the number of non-climate-related disasters remained stable, climate-induced disasters increased. In addition, more climate-related disasters were reported to officials than previously.

Examples of climate-related disasters in ASEAN countries are the sea level rise in Indonesia (Lisan and Putri, 2020), the increase in the number of hurricanes in the Philippines (dela Cruz Santos, 2021), unexpected snowfall in the Lao PDR (Phosalath, 2018), and Cyclone Nargis in Myanmar in May 2008 as the worst single disaster event in ASEAN with 140,000 fatalities (Lwin and Tun Lwin, 2022). More climate impacts can be borne due to vector disease and temperature rise (Caminade, McIntyre, and Jones, 2019) or an accelerated life cycle of mosquitos, the primary source of vector-borne diseases (Franklinos et al., 2019). Social vulnerability due to climate change in the Lao PDR, Cambodia, Viet Nam (Ninh et al., 2022) relates to physical and social vulnerability, a function of the social conditions and historical circumstances that put people at risk. Authors comprehend vulnerability as a dynamic condition, dependent on processes and trends shaping current patterns of vulnerability and resilience. Poverty is the largest barrier to developing the capacity to cope and adapt effectively to change.

Figure 11.2. Percentage of Events, Deaths, Affected and Value Losses in High, Upper-middle, Lower-middle, and Low-Income Countries, 2000–2019



Source: EM-DAT (2020).

Figure 11.2 depicts the difference between the four disaster indicators generally used. The number of catastrophic events is one of four indicators we use to comprehend the magnitude of climate impacts. The severity is particularly indicated by the number of deaths and the number of affected people who either get injured, lose property, or experience more adverse effects by the disaster. Finally, we have an indicator of the value loss included. Climate change causes damage in case of more localised disasters, which are easier to quantify, and losses due to a general temperature rise. Most disaster events – 32% of all registered events – with the highest number of people involved accounting for half of the global disaster victims, happen in upper-middle-income countries. The highest death toll is paid by lower-middle-income countries and low-income countries, which account for two-thirds of fatalities. The largest financial loss is borne in high-income countries, with two-thirds of all financial damage. In 2022, the damage was $270 billion, of which $120 billion was insured, which was less than in 2021 (Munich, 2023). Some 40% of the global damage was also insured.

1.2. Early Warning Systems for the Poorest

The United Nations (UN) Secretary-General announced a $3.1 billion plan to ensure everyone is protected by early warning systems within the next 5 years (UNDESA, 2022). The G7 and the V20, the 'Vulnerable Twenty' (www.v-20.org), founded the Climate Vulnerable Forum, a dedicated cooperation initiative of economies systemically vulnerable to climate change. The V20 works through dialogue and action to tackle global climate change. It launched the Global Shield against Climate Risks, with new commitments of over $200 million as initial funding. Implementation is to start immediately. Announcing a total of $105.6 million in new funding, Denmark, Finland, Germany, Ireland, Slovenia, Sweden, Switzerland, and the Walloon Region of Belgium stressed the need for even more support for Global Environment Facility funds targeting the immediate climate adaptation needs of low-lying and low-income states.

Since 2020, several frameworks and documents have been produced to strengthen and improve disaster governance in the ASEAN region. These include the ASEAN Framework on Anticipatory Action in Disaster Management; the ASEAN Regional Framework on Protection, Gender, and Inclusion in Disaster Management 2021–2025; the ASEAN Regional Plan of Action for Adaptation to Drought 2021–2025; and the ASEAN Disaster Resilience Outlook in 2021 (Cook and Chen, 2022). However, contextual management is required despite new frameworks. At the end of 2021, the impact of Typhoon Odette in the Philippines during the prevailing COVID-19 social distancing measures saw limits imposed on evacuation centres. This calls for strengthening capabilities and capacities to be fit-for-purpose.

1.3. Climate Change–related Damage

As an average for the decade 2010–2019, the disaster damage was almost $0.3 trillion, contributing to over 20% of the annual climate-related damage in 2010–2019, summing up to $1.4 trillion of total climate- and water-related damage (WMO, 2021; Jaganmohan, 2022), which is approximately 1.5% of the global gross domestic product (GDP). IMF (2023) calculated the average global economic growth from 2010 to 2019 at 3.7%. As economic growth is considerably higher than climate-related economic damage, the worry about mitigating climate change with appropriate measures remained globally at a low level. From 1990 to 2010, the global increase in greenhouse gases (GHGs) was, on average, 2%, and the total increase, from 24 Gt to 35 Gt. In 2011 and 2019, the average annual increase was reduced to 1.2% to end up with 39 Gt in 2019. During COVID-19, GHG emissions reduced to 36 Gt in 2020 and slightly under 39 Gt in 2021 (BP, 2022).

In case of gradual temperature rise, the losses are more pronounced in countries with climate-sensitive economic sectors like agriculture, tourism, water, energy, and natural resources. This widely points to the economy of rural regions of the world. The total climate change damage, including disaster damage, is estimated to exceed 1% of global economic product or around $1 trillion if we take current numbers. Tol (2021) revisited earlier estimates of the total economic impact of climate change and extended the earlier analysis to attribute the distribution of impacts on a global scale. As the best estimate for 2075, he considered the climate-induced global loss in welfare as 1.3% compared to a world in a stable climate. This value is the mean of a set of calculations undertaken by the climate change unit of the University of Surrey anticipating a temperature rise of 2.5^0 Celsius combined with various economic scenarios, some of them deviating even positively due to climate change.

The best guess of welfare loss is further split into countries. It reconfirms earlier country analysis that countries located at lower latitudes, which are already hot and have high shares in primary production are worst affected by climate change and consequently suffer disproportionately. In Tol´s calculation, the deviation of economic loss due to climate change exceeds 10% for many countries or up to 10 times the loss in global welfare. Tol proceeded to analyse inside-country variations, which was not undertaken

previously. He found that three-quarters of subregions within countries lose more than average in their economic activity. A problem with slow reaction and initial neglect of distributional impacts was also that, in particular, rich and cold countries in northern latitudes are initially gaining from higher temperatures, particularly in the climate-sensitive agriculture sector (Mendelsohn, Dinar, and Williams, 2006; Mendelsohn and Dinar, 2009), and only gradually are confronted with a change from economically sound to bad.

2. The Long Way Towards Climate Change Action

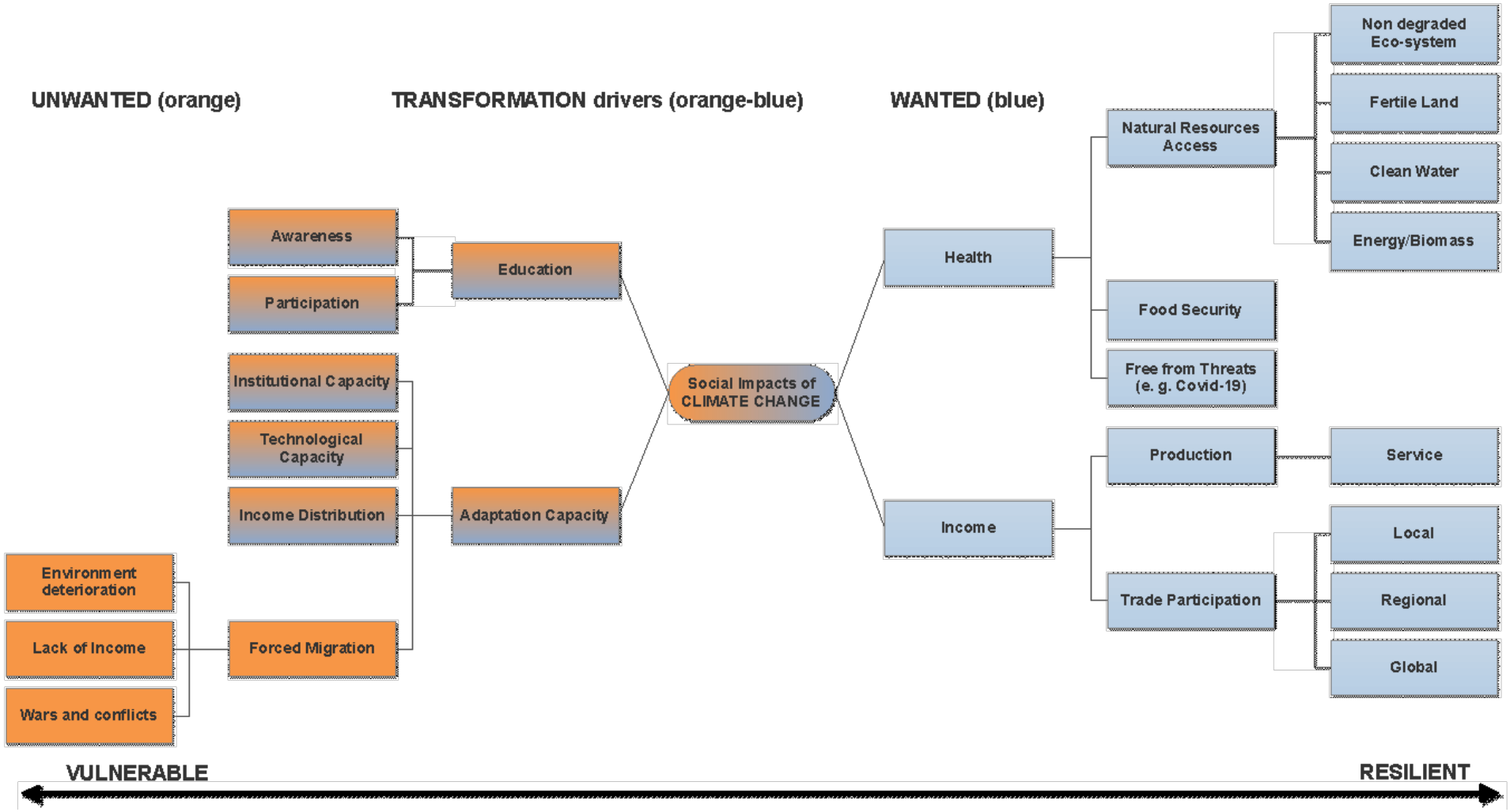
Starting with the first Global Summit on Environment and Development, the Stockholm Conference in 1972 (United Nations, 2023a), climate change has been on the international agenda for more than half a century and already for two generations. Environment and climate were not considered international or global priorities (Jackson, 2007). The report of the Club of Rome, 'The Limits to Growth' (Meadows et al., 1972), appeared in the same year. The primary concern was that many, if not most, resources would be depleted around 2000. This did not happen; instead, the key concern became the level of pollution that the world could uptake. In 1987, the World Commission on Environment and Development published its report 'Our Common Future, commonly known as 'the Brundtland report (Jarvie, 2016), leading to Agenda 21 for sustainable development (United Nations, 1992), where climate protection got for the first time a management task, which was formerly agreed at the Rio Conference in 1992 (United Nations, 2023b). This led to the formulation of the Kyoto Protocol in 1997 as a result of COP 3 (UNFCCC, 1997), where many countries planned to reduce their GHG emissions to the levels of 1990 by 2012. This did not work out as even countries that obliged themselves to a reduction – like Austria and most other European Union countries – increased their GHG emissions.

The new deal was the Paris Agreement of 2015 (UNFCCC, 2015), which, contrary to the Kyoto Protocol, is legally binding. The Paris Agreement includes the Climate Accords aimed to reduce global GHG emissions to limit the global temperature increase in this century to a maximum of 2^0C while pursuing further efforts to limit the increase to 1.5^0C. For this purpose, countries select nationally determined contributions to reduce GHGs. The states have to review the efficiency of their measures every 5 years. In addition, the Paris Climate Accords provide financing to developing countries to mitigate climate change, strengthen resilience, and enhance their abilities to adapt to climate impacts. Following the new Sustainable Development Goals, particularly Goal 13 (UNDESA, 2023), COP27 in Sharm El Sheik reaffirmed that fundamental change is necessary by 2030 (UNFCCC, 2022). If appropriate measures are not in place, climate change is irreversible. The impacts, however, do not hit countries, groups of stakeholders, or individuals equally but disfavour the low-income nations. The principle of a loss and damage facility for the most vulnerable countries was agreed upon, but implementation details will only follow at the next conference in Qatar at the end of 2023 (Krishnamurthy, 2022).

2.1. Vulnerable and Resilient Actors

We can categorise states into vulnerable and resilient actors. Many intermediate states with different degrees of resilience and vulnerability aspects determine how severe climate change hits individuals. In Figure 11.3, on the left side, some groups and people already lost the basis of their lives (orange topics including forced migration due to environmental deterioration, lack of income, and wars and conflicts), while the right-side groups and people live in the opposite direction. Some people enjoy undisturbed economic growth and separation from adverse climate change influences (blue topics, including health, sufficient income, a healthy environment providing the basis of food security, and trade participation). Between these extremes lie various situations (mixed orange-blue topics relating to education and adaptation capacity) that separate groups and individuals, ranging from those predominantly affected by climate change to those principally enjoying the fruits of development. While all people want to be on the right side, they often cannot cope with the stress imposed by the combined effect of climate change and growing economic disparities. If several adverse factors coincide, they end up in a miserable unwanted situation. There are the drivers of transformation. First, education can create an appropriate awareness of possible climate change impacts. However, awareness is not enough; participation in countermeasures is required. This leads to the climate adaptation capacity of countries, groups, and individuals: strong institutions, enough income with a fair distribution at all scales, and appropriate technological capacity are the requirements for a successful climate adaptation.

Figure 11.3. Division and Drivers of Vulnerable and Resilient Groups in Human Societies



Source: Authors.

2.2. More Radical Climate Actions

While there is accumulated knowledge from over 50 years, appropriate action to reverse adverse impacts is not in place. There is a dispute between the rich and poor countries over who should bear the cost of climate action. Developing countries want to get more resilient through higher incomes and not necessarily by securing their status as countries primarily dependent on climate-sensitive economic sectors like agriculture or tourism, which seldom give large groups of the population the desired income. Rich countries, on the contrary, often avoid accepting climate change responsibility. Only now, most countries appreciate the urgency to counter warming and follow the Paris Accords of 2015, or better, pretend to follow the Paris Accords, which should yield results by 2030, a date closely ahead of us and already in need of updating.. Like the Kyoto Protocol, even the Paris Accords are likely to fail if one regards the slow action of most countries that committed themselves to the 2030 deadline. Within the different groups of stakeholders, climate change action has different weights; in the worst case, it is still not present despite the urgency it deserves.

While scientists have been active over the last half-century in generating knowledge, nongovernmental organisations have long struggled to reach a broad audience to convey the importance of climate change measures. Eventually, this changed during the last 5 years. Greta Thunberg, a 15-year old Swedish schoolgirl, founded 'Fridays for Future' in 2018 by organising a school strike for the first time. This grew into a global movement of schoolchildren. Being familiar with the attitude of Greta Thunberg increased climate activism not only in the young generation but in general (Sabherwal et al., 2021). Greta was also named an *Überkind* that has to solve problems humans could not solve so far (Verharen, 2021). From 2020 onwards, many schools were temporarily closed due to COVID-19 measures, larger strikes did not happen, and the movement lost momentum.

Meanwhile, students formed groups like the Extinction Rebellion of British climate activists or the Last Generation of German climate activists. They started purposefully breaking the law, blocking roads, and glueing themselves to government buildings to cut carbon emissions. Climate activists gained international notoriety, thanks to those radical stunts (de la Garza, 2023). In 2022, fine arts became the target of numerous disreputable maneuvers, including throwing tomato soup on Vincent van Gogh's 'Sunflowers' in London or coloring in black Gustav Klimt´s 'Death and Life' in Vienna. Climate actions were undertaken by newer and more radical climate groups, like Britain's Just Stop Oil and Germany's Last Generation, a nongovernmental organisation that appeared first in America. Usually, the climate groups replicate in other countries to receive even more attention under the same branding and spread methods of 'civil resistance' primarily in rich and the most resilient countries concerning climate change impacts where earnestness is less exposed to the majority of people. Usually, climate groups expand into other countries, seeking greater attention using the same branding and civil resistance methods, particularly in wealthy and resilient nations facing significant climate change impacts. However, this earnestness is less evident to the majority of people.

3. Less Vulnerability of the Poorest People and Increased Risk for Richer People

Vulnerability thresholds are changing, and fewer people are considered vulnerable if former thresholds are applied to today´s situation. At the end of a half a century, the number of vulnerable people measured according to the standards of the beginning of the period (or in the 1970s) has diminished tremendously. In a situation of continued economic growth, the economic damage and losses as, for example, calculated by Tol, can be the reason that we will not have vulnerable people as they have all migrated to better-off places (at the right side of Figure 11.3) and have all acquired certain degrees of resilience. The possibility of trade and distribution of goods and services – widely dependent on appropriate infrastructure – is highly important for inhabitants' entirely economy-based climate adaptation coping capacity.

But the more vulnerable, poorer countries have not yet developed major resistance or climate action. The necessities of daily life press much harder here. Fighting climate change with local adaptation is more practical, direct, and relatively silent. The most hardly hit places have become depopulated, and more places are at risk of becoming depopulated. Concerning income, health, food security, and access to technology, many countries, particularly ASEAN countries, improved their situation over the last half century, during the last 2 or 3 decades.

3.1. Undernourishment and Hunger

Food-insecure persons became secure in absolute and relative numbers (Von Grebmer et al., 2022). The number of populations grew substantially, much more food is consumed today and less people are vulnerable due to gained access in global food supply chains. It is a declared sustainable development goal to eliminate hunger until 2030, and all persons should have access to food.

Table 11.1. Undernourishment in ASEAN and Selected Countries as an Indicator of Vulnerability and Change over Time (0.0% indicates a value smaller than 2.5%)

ASEAN Undernourishment	2000	2007	2014	2022
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	23.6	14.8	9.2	6.3
Indonesia	19.2	18.5	7.9	6.5
Lao PDR	31.2	20.1	8.0	5.1
Malaysia	2.5	3.6	3.6	0.0
Myanmar	37.6	20.5	5.1	3.1
Philippines	18.7	12.1	11.1	5.2

Singapore	0.0	0.0	0.0	0.0
Thailand	17.3	10.2	7.8	8.8
Viet Nam	19.7	14.1	8.6	5.7
Drastic Examples of Undernourishment	**2000**	**2007**	**2014**	**2022**
Central African Republic	39.2	35.7	47.9	55.2
Haiti	50.7	50.1	42.6	47.2
Korea DPR	35.7	38.2	39.6	41.6
European Union (EU) Members and EU Candidates Undernourishment	**2000**	**2007**	**2014**	**2022**
Bulgaria	4	4.6	3.3	3.0
Slovakia	6	5.4	5.8	3.8
Moldova (Republic of)	25	30.7	6.4	6.7
Ukraine	3	0.0	0.0	2.8%

Source: von Grebmer et al. (2022).

Table 11.1 confirms that undernourishment and starvation were on retreat for decades. What the data does not say is under what conditions this has happened. We do not know how many people started to move from their livelihoods to better-off places either in search of more income or forced by climate change. The search for infrastructure, health services, schooling, access to global supply chains, and more caused the shrinking of populated areas within countries and regions. More people move to cities with better possibilities for adaptation, and fewer people observe further damaging impacts or counteract climate change in remote places. Both contribute that vulnerability of the poorest people decreases, while adverse climate change impacts on ecosystems can grow and accumulate to larger threats. The sole reliance on the economy without caring for a good ecological status in degraded landscapes and abandoned territories is full of risks of scaling up minor damage to gigantic damage later on and a period where people can no longer act. A special case for hunger and undernourishment is war, as in Ukraine. Due to broken food supply chains, food exports are impaired, and undernourishment increases. The figure for undernourishment in Ukraine in 2022 is based on a survey from 2019 to 2021 and could be much higher. The worst undernourishment in ASEAN was recorded in Myanmar for 2000, with 37.6%, followed by the Lao PDR and Cambodia, all countries with well over 20% of undernourished inhabitants in 2000. From there, a great improvement was seen over 20 years. Currently, Thailand has the highest number of undernourishment, with 8.8%. This is not very different from the situation in poorer EU countries or the new candidate countries of Moldova, with the highest value in Europe, and Ukraine suffering from war since 2014.

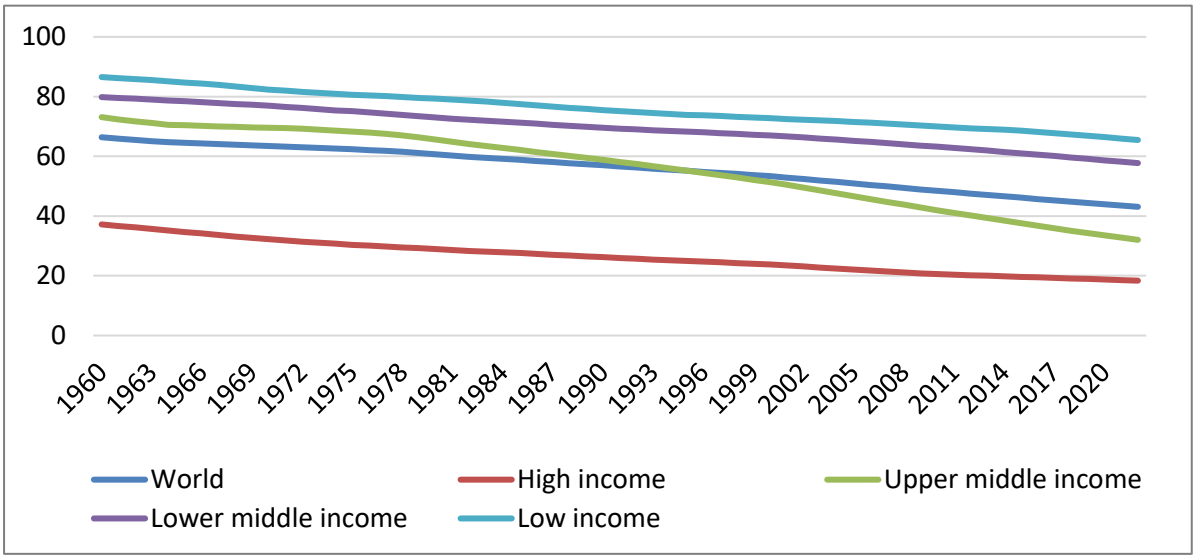
3.2. Urbanisation Leads to [Initial] Resilience

Economic growth, primarily in urban centres, serves as a pull factor for the young generation. However, adverse climate change impacts are deteriorating the local environment and income base, acting as push factors., These factors often work together to hinder the poorest societies from building local coping capacity for climate adaptation and accelerating depopulation.

Urbanisation is, therefore, strongly correlated to the decline of the functionality of rural landscapes. In Asia, between 1975 and 2015, the population doubled from 2 billion to 4 billion people, while the built-up or sealed soil area tripled in the same period (Melchiori et al., 2018). During the same period, Europe's sealed landscape doubled while the population was kept stable. Living and working in urban areas away from climate-sensitive economic sectors like agriculture led to higher personal resilience against climate change. Figure 11.4 shows that between 1960 and 2022, the global rural population decreased from 65% to 43%, which directly relates to decreased vulnerability. During the millennium shift, the world population was distributed equally over urban and rural areas, while 7 billion urban people out of 9 billion, an over 75% share global urban population, are expected by 2050 (Ritchie and Rosner, 2018), corresponding to the situation in high-income countries.

As the rural population declines, the burden of climate adaptation will hit much harder for inhabitants in rural areas, who now produce most of our food. Desertification, soil erosion, water scarcity, and water quality will become more pronounced in the coming decades, and our path as humanity is at risk. Rural development must become a stronger concern (UNDESA, 2021) for all.

Figure 11.4. Decline of Global Rural Population according to Income Classes, 1960–2022



Source: World Bank, 2023, Global Indicators Database.

Due to rural decline, we will have ever-larger degraded land areas with fewer people to shoulder the costs of climate impacts (UNDESA, 2023) and resulting environmental deterioration, particularly in remote, densely populated zones. Land degradation results from human-induced actions that exploit land, causing its utility, biodiversity, soil fertility, and overall health to decline. Ensuring food security for a growing global population requires healthy land resources and prosperous ecosystems. Kusch-Brandt (2020) identified food security amongst the local population, potential impacts of changing environments on food production and already-observed manifestations of changes, specific measures for reducing adverse environmental impacts related to food consumption, and understanding how to support desirable changes in the food supply systems effectively.

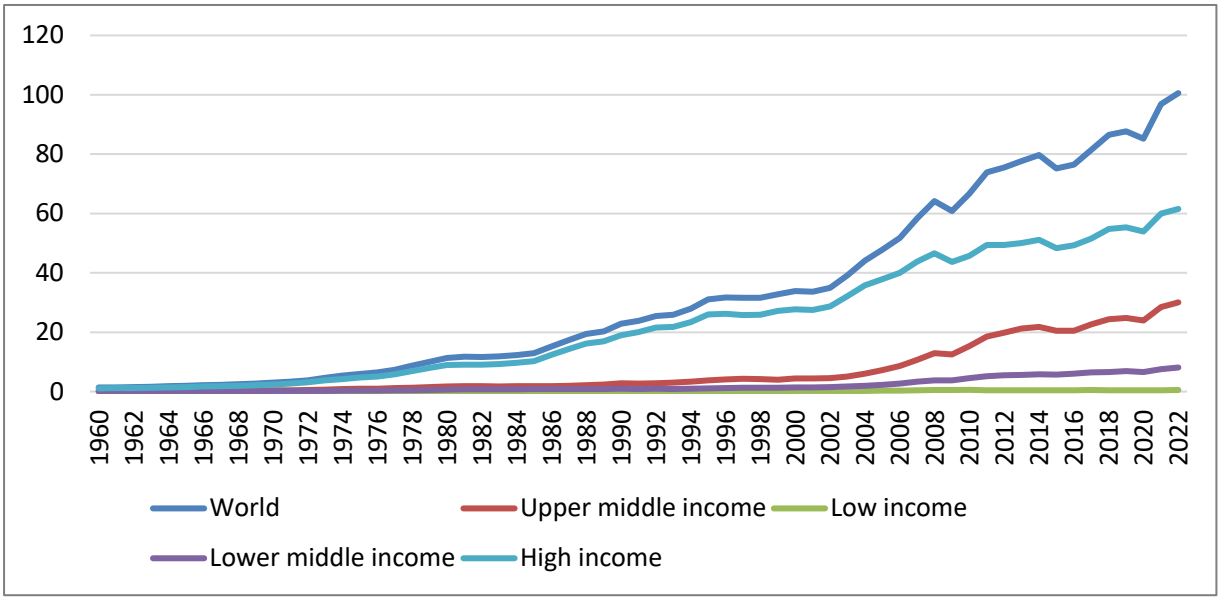
Current agricultural practices are causing soils worldwide to be eroded up to 100 times faster than natural processes replenish them. Human activity has altered 70% of all ice-free land, impacting over 3.2 billion rural people (UNCCD, 2022). The UNCCD's goal of land degradation neutrality can halt and then reverse this alarming picture of the future. The amount and quality of land resources necessary to support ecosystem functions and services to enhance food security must remain stable or increase. New occupations in environmental restoration and ecosystem services will be required.

4. ASEAN Vulnerability Highest in Periphery

Amongst the 10 countries in ASEAN, we find Singapore and Brunei Darussalam as two high-income countries modestly hit by disasters, Thailand and Malaysia as two higher-middle-income nations, six lower-middle-income nations, and no low-income countries. An approximate measure to assess the distributional impacts of climate change across different spatial scales in countries or provinces is the countries' national and per capita income. In 2019, each of the 650 million ASEAN inhabitants, roughly 8% of the world population, earned $4,747, summing up to $3.1 trillion, approximately 4% of the global gross income.

In countries, the coping capacity largely relates to the national gross domestic income that can stretch by two orders of magnitude or up to 100 times between the richest and poorest countries. The World Bank classified the world countries into four categories: 81 high-income countries earning an average of more than $13,204 per inhabitant; 54 higher-middle-income countries making $4,256–$13,204; another 54 lower-middle-income countries earning $1,086–$4,255; and 28 low-income countries earning less than $1,086 per person (World Bank, 2023). From the analysis of global income since 1960, we can understand why the damage due to disasters has to be uppermost in high-income countries. In contrast, adequate disaster protection cannot be provided in low-income countries due to lacking financial resources.

Figure 11.5. Global Gross Domestic Product and Economic Growth according to Income Groups of Countries, 1960–2022 (in trillion $)

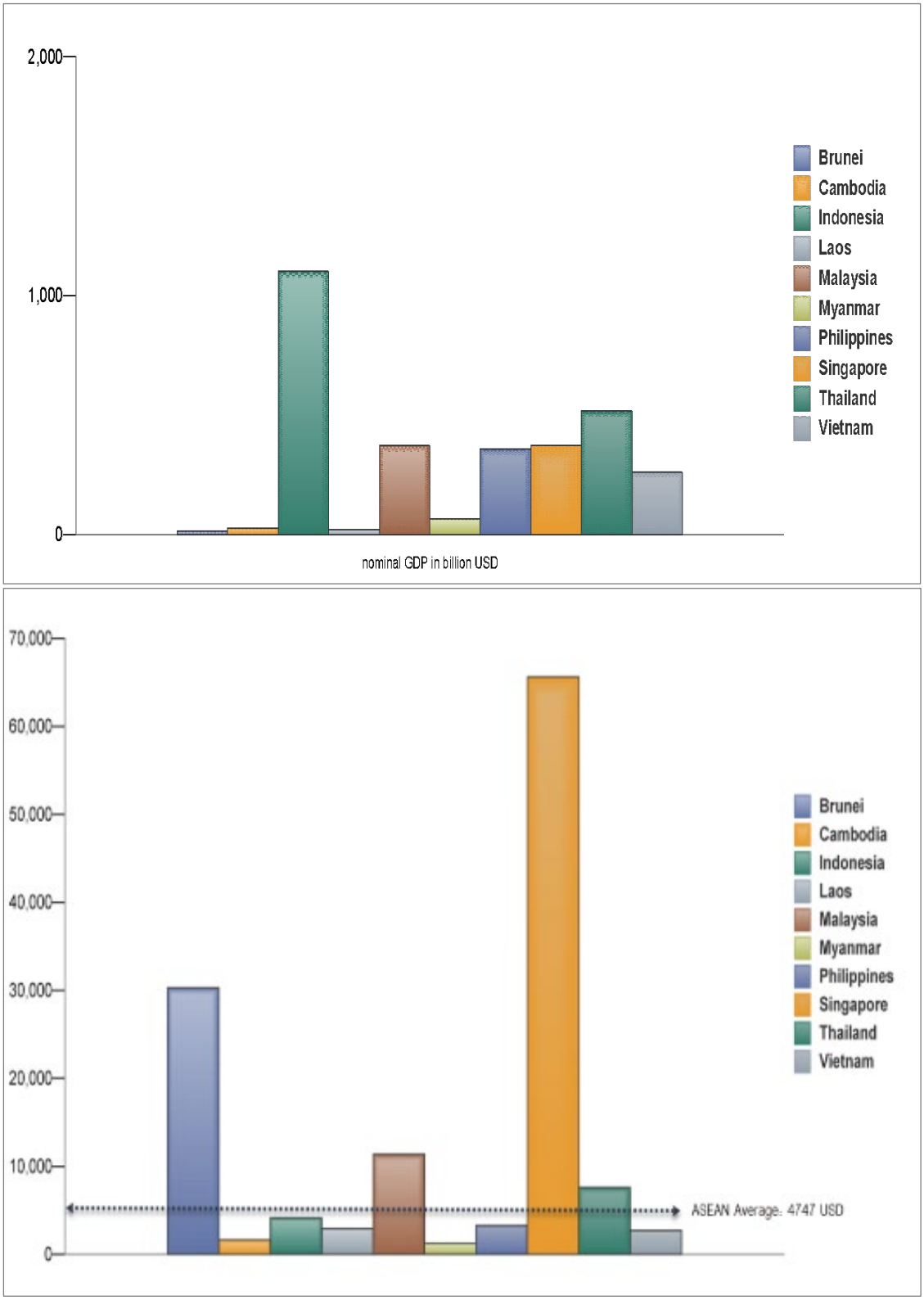


Source: World Bank (2019).

In general, the coping capacity is weaker in a poorer and hot country at lower latitudes with limited access to technological innovations to mitigate climate impacts and a lack of strong governments and institutions (Ruth and Ibarrarán, 2009). A country's average per capita income is not always a good indicator. Further variations in climate change relate to subregions or groups of people within one country. Some people are more vulnerable as they are more exposed to extreme events, or groups suffer high-income disparities within the same region or place. They have regionally and locally different coping or adaptation capacity to master an adverse situation imposed by climate change, and the poorest are the first victims of climate change. Sufficient income, appropriate technology, and good social networks are the main assets to cope with climate change on an individual scale.

The share of local and regional climate impacts is not proportional to the losses suffered or benefits gained by individuals. In individuals, the difference in coping capacity can vary much wider and relates to income between a few hundred dollars in the case of the poorest or even millions in annual income in the richest. This is perhaps four orders of magnitude between the richest individuals and poorest groups.

Figure 11.6. Distribution on ASEAN GDP $3.1 Trillion and GDP per Capita in 2019



Source: World Bank (2019).

Within ASEAN, Singapore has the highest adaptation capacity, followed by Brunei, both countries several times higher than the poorer ASEAN countries and almost free from

experience with climate-related disasters. Malaysia and Thailand are over the ASEAN average per capita income and enjoy a higher climate adaptation capacity that is also reflected in a lower number of climate incidents. Additionally, the economic disparity can be much more severe in a country than in the disparity of country average per capita incomes. This further leads to a difference in coping capacity. While the wealthiest groups or persons in a low-income country can develop individual adaptation strategies similarly to rich countries, the poorest groups or individuals already victims of adverse climate impacts cannot handle any further environmental deterioration. The pressure to give up climate-sensitive land uses like agriculture and to start migrating becomes more severe.

5. More Steps to Further Overcome Vulnerability to Climate Impacts

Access to information is a critical issue in preventing and adapting to the current and expected impacts of climate change. There is wide variation in the actual availability of such information to different groups. Digitalisation is a crucial issue in access to information. Availability and non-availability often relate to access to high-speed internet, primarily in rural areas. Other key issues concern how stakeholders act on that information. Influences like the kind and level of education received, and the local knowledge gained and transferred in generations can temper or alter the adverse impacts of climate change. A lack of knowledge and planning increases the damage of weather-related natural disasters.

5.1. Health and Equity Concern

Health equity has risen to prominence on policy agendas after the universal health coverage movement and landmark international reports on inequality in health and health care (Cookson et al., 2017). Improving total health may clash with reducing social disparities in health, for example, when effective delivery of services to disadvantaged communities requires additional costs. Who gains and loses from a cost-increasing health programme depends on differences amongst people in health risks, uptake, quality, adherence, capacity to benefit, and, crucially who bears the opportunity costs of diverting scarce resources from other uses. Many rural places lack sufficient health care; in some cases, health care in place is no longer profitable due to a shrinking number of people. Cost–benefit analysis (CBA) rarely provides information about who gains and who loses from health programmes or about trade-offs between cost-effectiveness and equity in the distribution of health-related outcomes.

5.2. Climate Finance and Distributional Equity

Negotiations continued in Sharm El Sheik and COP27 on setting a 'new collective quantified goal on climate finance' in 2024, considering the needs and priorities of developing countries. The goal of high-income and upper-middle-income countries to mobilise jointly $100 billion annually by 2020 has not yet been met. Developed countries

are reminded to meet the previously agreed goal, and multilateral development banks and international financial institutions must mobilise climate finance (UNDESA, 2022).

Bonner (2022) also considered equity–efficiency trade-off when utilising CBA as a decision-making tool. The goal of evaluating the distribution of benefits and costs is to provide information regarding the project's attractiveness to the stakeholders involved. Evaluating distributional effects allows for identifying equity issues in the CBA (OECD, 2018). Usually, when evaluating a policy or project based on the market prices, decision-makers fail to capture many benefits of interest to stakeholders, like employment, government surpluses from taxes and/or subsidies, and external impacts. Implementing social CBA using appropriate shadow prices for benefits allows for capturing these impacts indirectly.

The EU aims to reach carbon neutrality. Fragkos et al. (2021) considered implementing ambitious environmental policies eventually leading to regressive distributional impacts, disproportionately affecting low-income population groups in 10 income classes in all EU member states. Each income class is differentiated by income sources, savings, and consumption patterns. It quantifies the distributional impacts of EU's ambitious emission reduction targets, particularly exploring their effects on income by skill and energy-related expenditure by income class. The analysis shows that the transition to climate neutrality may modestly increase inequality across income classes, with low-income households facing the most negative effects. However, using carbon tax revenues as a lump-sum transfer to support household income and as reduced social security contributions will increase employment and reduce income inequality across households in EU countries.

5.3. Energy Issues

Energy and the lack of energy is closely connected to sustainable development and poverty. Within Sustainable Development Goal 30, energy, as in aim seven, is to connect more than 750 million people that do not have access to the electricity network and to give 2.6 billion access to clean cooking facilities. Introducing clean energy solutions can bring vital services such as improved healthcare, better education, and affordable broadband, creating new jobs, livelihoods, and sustainable economic value to reduce poverty.

Net-zero commitments were negotiated at COP27, serving as a how-to guide to ensure credible, accountable net-zero pledges by industry, financial institutions, cities, and regions. The UN-Energy Plan of Action Towards 2025 emphasises the role of joint programmes supported by UN-Energy in scaling up collective action by the UN system in collaboration with member states and other stakeholders. In particular, the following results should be realised by 2025: 100% renewables-based power targets established in 100 countries; 3% annual efficiency improvement in at least 50 countries across the world; global yearly GHG emissions to be reduced by at least one-third in 2025; and

provision of $40 billion for energy access investment, of which 50% is directed to low-income countries (UN-Energy, 2022).

The livelihood of indigenous people residing in the forest fringe area of developing countries like India primarily depends on the forest. A high dependency on natural resources, lack of energy, unemployment, poor quality of life, and poor socioeconomic conditions coincide with energy poverty. Climate change and lesser adaptive capacity have exacerbated their struggle to meet their livelihoods (Yadava and Sinha, 2022).

The new Indonesia Just Energy Transition Partnership, announced at the G20 Summit held in parallel with COP27, will mobilise $20 billion over the next 3 to 5 years to accelerate a just energy transition. It calls for renewable energy to comprise 34% of Indonesia's power generation by 2030 (Chipman-Koty, 2023).

5.4. Nature, Forest, and Ecosystem Protection

Several ways are discussed to save the remaining forests and landscapes by putting a value on land resources. The role of ecosystem services must be highlighted; for example, what is the importance of a mangrove forest in abating adverse climate change impacts, and what can we do to hold the environmentally benign functions upright (Bimrah et al., 2022). Suppose landscapes are destroyed or impaired, as with 70% of the world´s ice-free land. We need to reconnect to the wasteland and examine if we can enhance destructed or overused ecosystems to novel ecosystems in rural (Starzomski, 2013) and urban areas (Ahern, 2016). Bringing back lost functions or inventing new functions will help cope with climate change at a lower price.

Important progress on forest protection was made with the launch of the Forest and Climate Leaders' Partnership, which aims to unite action by governments, businesses, and community leaders to halt forest loss and land degradation by 2030 (UNDESA, 2022). However, in recent articles, the *Guardian, die Zeit,* and *Source Material* jointly published the result of a 9-month work of investigative journalism. They found that 90% of rainforest carbon offsets by Verra, the biggest provider of certificates, are worthless (Greenfield, 2023). Carbon neutrality until 2030 eventually builds up on wrong assumptions.

Similar flaws happened before. The EU Renewable Energy Directive (RED) 2009 classified palm oil–based biodiesel as a renewable energy source, disregarding indirect land use changes, and widely promoted further exploitation of tropical rain forests. Later, indirect land use change as global warming factor was classified as three times more effective than fossil energy use (Valin et al., 2015). In particular, the transport sector is blamed, and palm oil–based biodiesel use drives deforestation (Sihvonen, 2019). Two amendments to RED did not allow to count biodiesel as carbon neutral (2018) and later obliged to phase it out by 2030 (2021). While the EU Parliament accepted the decision, it did not consider the position of ASEAN producers, many of whom are small producers who succeeded in escaping their previous vulnerability as subsistence farmers. Now, these stakeholders

take part in international trade and can import goods that make them more climate resilient than before.

6. Conclusion

While acquiring a higher resilience towards increasing climate change impacts, poorer local communities – particularly in rural places – have two principal strategies. They are forced to maximise their possible income at a place, even at the expense of excessive resource utilisation, or to get transfer payments from institutions or relatives in more prosperous areas. In the first case, many can end up in a more degraded environment, and the opposite of the wanted improvement leads to a deteriorated economic standing. In the second case, the institutions of low-income countries are weak and cannot support particular groups that have to manage their situation without government support. Some family members have to separate to get a good income and support other family members. The elder generation, often looking for the kids of the younger generation, stays at a place and works primarily in agriculture, while the younger generation moves to urban centres or foreign countries to supply the larger family with considerably higher incomes. While the economic standing is perhaps better in such a situation, and the family can better participate in trade flows, this supports the tendency to social disruption of larger families or villages.

Depending on where people live, the attempt for higher incomes puts many inhabitants at risk concerning access to water, coastal flooding, diseases, and hunger. They will depend much more on trade to substitute their daily needs and the provision of environmental safety. Participation in trade needs economic power and a multifaceted agricultural, industrial, and service structure in place. Wherever we find poverty often combined with subsistence agriculture is in place, trade is reduced to a minimum. Climate change impacts can, therefore, not be moderated. On the contrary, it might trigger further environmental degradation by overuse of land to compensate for the losses experienced by climate disasters and environmental deterioration. Emergency relief like the clearing of forests might bring temporary relief and income from timber sales but it can make the land more vulnerable to future climate events.

Sooner or later, any poor place either succeeds in getting more prosperous due to higher income and participation in trade or will, consequently, vanish as a human habitat due to an impossibility of participating adequately in trade processes leading to wealth. Disfavoured places require adequate infrastructures to distribute goods and services even to the remotest zones. If this is not feasible, other plans for caring for the disfavoured population are needed. They can include the restoration of the natural resource base or a retreat from increasingly dangerous places. Governments and local authorities must act accordingly.

While the vulnerability of the poorest is shrinking – due to abandoned marginal agricultural land leading to contracting peripheral rural land to more central zones –

resilient and prosperous locations, primarily in urban centres, are at risk of losing parts of their resilience and again become more vulnerable but at an increased larger scale, which will affect many more people. Reducing the view to one´s backyard was possible for a long time but will not suffice in the future. The increased care for vulnerable rural regions is, therefore, also a responsibility for the inhabitants of prospering centres. Connecting with individuals within or distant from one´s region will help understand how to escape from further climate impacts.

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