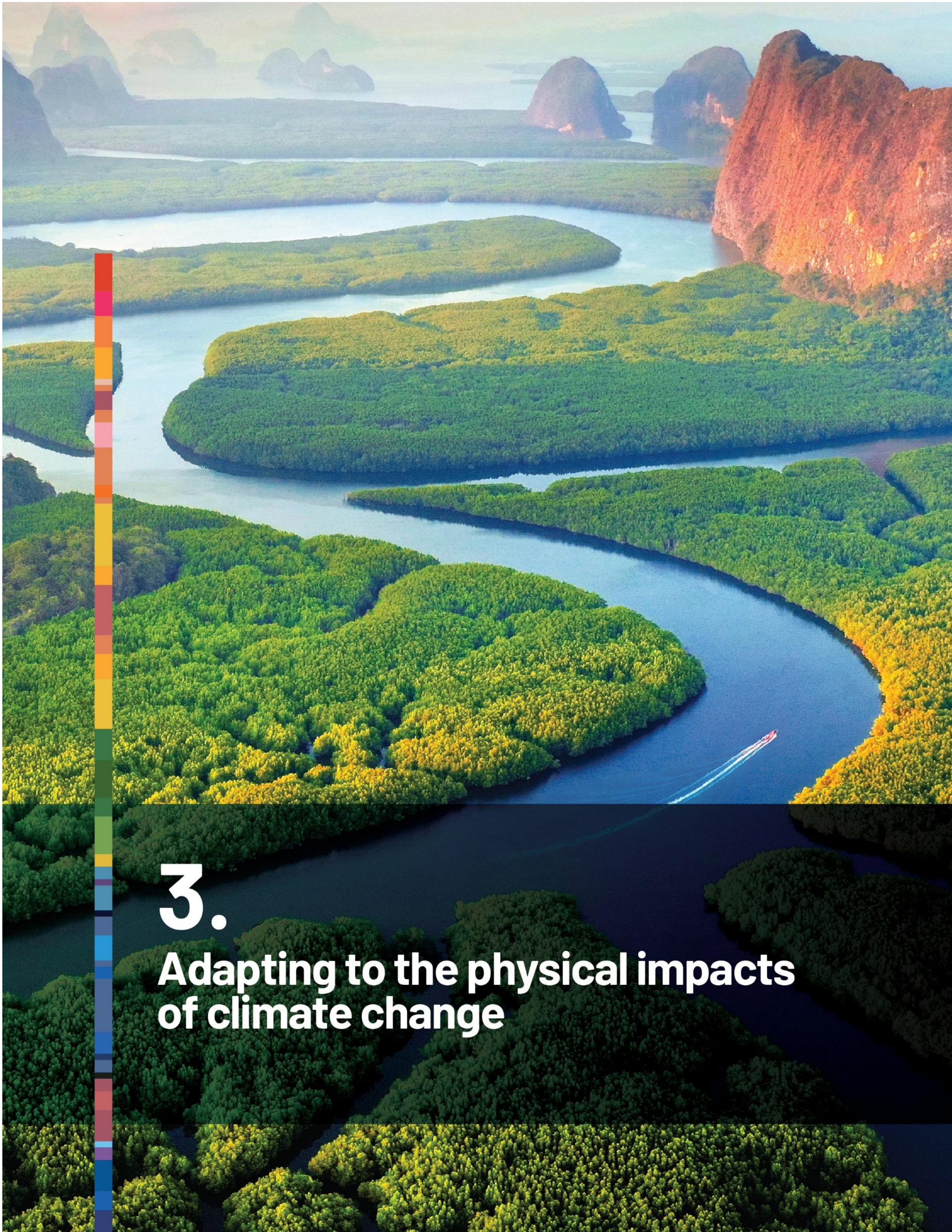
EAST ASIA
PACIFIC

Thailand

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT



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Adapting to the physical impacts of climate change

3 Adapting to the physical impacts of climate change

This chapter explores how the economic and social impacts of climate change on Thailand (as set out in Section 2.2) might be reduced by climate adaptation actions. To start with, the potential economic impacts of climate change over the next 25 years are estimated under a "business-as-usual" (BAU) scenario, which assumes no additional adaptation measures are implemented. An "adaptation" scenario is then used to assess how targeted adaptation policies and investments could reduce climate-related damages and influence broader economic outcomes. This "adaptation" scenario incorporates investments in flood mitigation, water security, coastal protection, and other measures designed to enhance Thailand's capacity to limit and adapt to the physical impacts of climate change (Annex 1 provides details on the modelling approach).

The modelling conducted for this CCDR shows that climate change could have substantial impacts on the Thai economy over the next 25 years, making it much more difficult to achieve high-income targets. The magnitudes of impact vary across the two macro-economic models used in this CCDR owing to differences in modeling assumptions, and also vary from previously published estimates.[1] But both models are consistent in showing that climate change could substantially lower aggregate output in the business-as-usual scenario (relative to a baseline scenario without climate change) by mid-century. The size of the 2050 GDP impact in the pessimistic (dry/hot) scenario is centered around -7 percent for MFMod and -14 percent in E3-Thailand. This implies that in the coming two to three decades climate change could reduce annual average growth rates by half a percentage point or more, making it much more difficult to achieve already ambitious high income targets. Despite uncertainties, both models are consistent on the compounding effect of climate change, i.e., the cost of inaction under the business-as-usual scenario grows larger with passing time. Both models are also consistent in picking up heat related labor productivity loss as the strongest mechanism of impact, impacting workers across all sectors and in all parts of the country.

The annual average impacts set out in Figure 3.1 may understate the physical threats of climate change in Thailand. First, the results only estimate the marginal impacts from additional climate change over the next 25 years, not the impacts of climate change already realized. For instance, the additional impacts from flooding attributable to future changes in climate do not capture the total estimated impacts of flooding on the Thai economy, which are estimated to average around USD 18 billion or about 3 percent of GDP per year (providing a key rationale for flood mitigation investments). Second, while the impacts of flooding are relatively modest in annual average terms, flooding shocks could have a much larger impact in years in which tail risk events (such as the 2011 floods) materialize (Box 3.1). Climate change will also increase the risk of extreme events and scenarios that, for example, could have implications for the viability of some urban areas in and around Bangkok, triggering substantial costs which are not accounted for in the modelling.

Average economy-wide effects also conceal sizeable impacts on certain demographic, social and economic sub-groups. Households with more concentrated income sources and lower savings and other forms of assets are more vulnerable to climate-induced hazards such as floods and droughts. Empirical analysis of socio-economic and geo-physical data over the 2007-2021 period shows that precipitation shortfalls have had a significant negative impact on aggregate household welfare,

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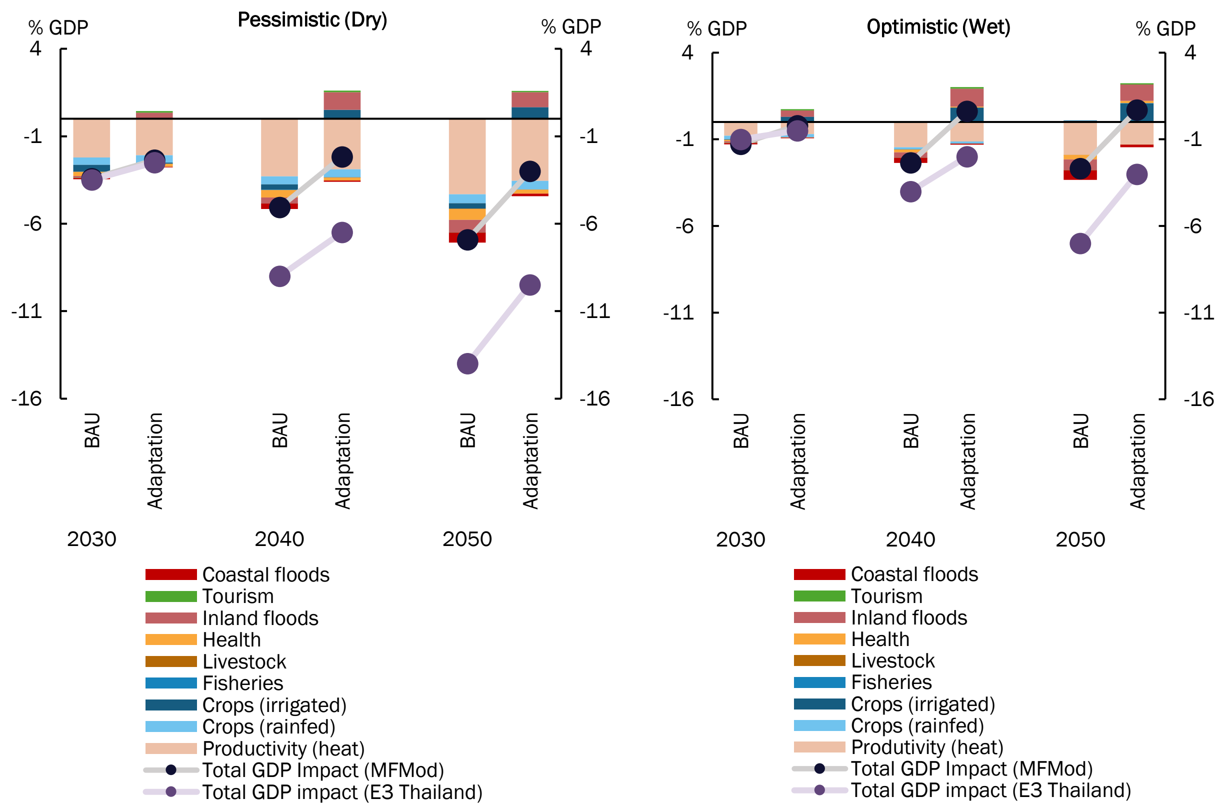
[1] Two macroeconomic models are used to estimate economy-wide impacts in this CCDR. The first is the World Bank's Macro-Fiscal Model (MFMod) which is a comprehensive macro-structural econometric tool that simulates the flow of funds throughout the entire economy. The second is E3-Thailand, another macro-econometric model that was built specifically to look at climate-economy interactions in Thailand. Previous estimates have suggested that the cost of climate change on the Thai economy could be around 10 to 20 percent of GDP by mid-century, with noticeable impacts possible even this decade (World Bank. 2023. Thailand Public Revenue and Spending Assessment: Promoting an Inclusive and Sustainable Future. World Bank, Bangkok). Another more recent estimate suggests more muted average impacts on GDP of around 2.5 percent of GDP by 2050 (Mani, M. & Pollitt, H. (2024) "Towards a Green and Resilient Thailand" (September), World Bank, Washington, DC.).

increasing poverty and inequality rates. The impact on welfare is particularly acute in rural, rice-growing parts of the country that have less irrigation infrastructure. The same work also shows that households with a more diversified income portfolio, those benefiting from existing social protection programs and those with stronger access to finance, are more resilient to these shocks (Tiwari et al 2025).[2] Similarly, households with elderly, children, pregnant and lactating mothers are typically more vulnerable. For example, there is evidence that displacement during 2011 floods adversely impacted birth outcomes among pregnant women. Climate vulnerabilities in Thailand are also compounded for specific communities such as indigenous groups in the northern province of Chiang Rai who have lost control over ethnic lands because of forest conservation and reclamation efforts while also remaining ineligible for government assistance on account of their lack of Thai ID.[3]

Figure 3.1: Physical impacts of climate change on GDP

("Business as usual (BAU)" and "Adaptation" scenarios are relative to a baseline scenario with no additional climate change from 2025-50)



Note: Climate scenarios are obtained from the World Bank's Climate Change Knowledge Portal for 30 General Circulation Models (GCMs) from the Coupled Model Intercomparison Project 6 (CMIP6) suite of model outputs. We select climate scenarios in such a way as to capture the broadest range of climate change effects across GCMs. Further, we consider climate projections for SSP2-4.5 and SSP3-7.0 as the two most likely scenarios. SSP2-4.5 represents a global mitigation scenario consistent with current climate commitments and SSP3-7.0 a scenario in which warming reaches 4°C by 2100 due to lax climate policies or a reduction in ecosystems and oceans' ability to capture carbon. Wet/warm and dry/hot scenarios are constructed by taking the 10th and 90th percentiles of mean temperature and precipitation changes across SSP2-4.5 and SSP3-7.0 GCMs.

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[2] Tiwari, Sailesh, Emmanuel Skoufias & Varun Kshirsagar (2025). "Welfare Impacts of Climate Change in Thailand" CCDR background paper.

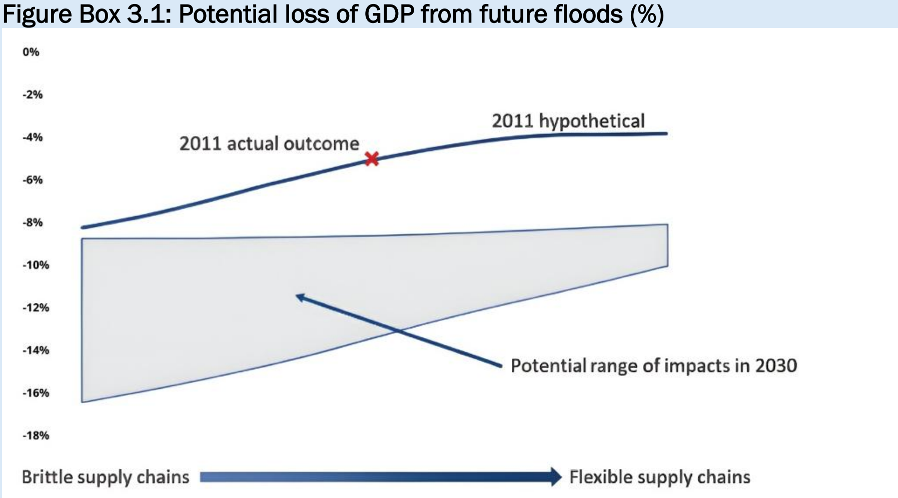
[3] While recent policy efforts have been geared towards making it easier for indigenous communities to obtain Thai ID cards, many elders still lack them, limiting their access to a variety of government services. See Tansanguanwong, Pamornrat; Geithner, Sarah; Vichitrananda, Sutthana (2025). Building Climate Resilience of Vulnerable Populations and Communities in Thailand: Synthesis Report (English). Washington, D.C: World Bank Group.

Box 3.1: The need to protect against extreme risks

Thailand faces substantial tail risks from climate change, including the risks of a severe flood or drought. From a risk mitigation perspective, adaptation responses should also account for the possibility of these tail events occurring rather than being calibrated solely on estimates of annual average impacts, which smooth over the impact of rare but severe events.

One example is the 2011 floods—classified as a 1-in-50-year event—which caused damages equivalent to 12.6 percent of GDP (THB 1.43 trillion or USD 46.5 billion) and cut production by around 5 percent of GDP.[4] Due to climate change, the intensity of similar events could increase, and there is now an estimated 50 percent chance that such a flood could occur again by 2050.[5] An equivalent flood in 2030 could reduce Thailand's GDP by nearly 10 percent in that year alone, with losses rising to 15 percent if recovery is slow or future floods hit before reconstruction is complete (Figure Box 3.1). Impacts will vary by location and adaptive capacity—but risks to GDP are magnified when supply chains are disrupted or businesses unaffected by flooding are forced to shut down.

Figure Box 3.1: Potential loss of GDP from future floods (%)



Source: World Bank Group. 2023. Thailand Economic Monitor: Coping with Droughts and Floods; Building a Sustainable Future. World Bank, Bangkok.
Notes: Supply chain flexibility is measured as length of time companies can keep production uninterrupted in the event of disruption. The range on the chart's x-axis is zero to six weeks.

Another tail risk is a sharp increase in susceptibility to flooding due to land subsidence in and around Bangkok, the impacts of which would be amplified by climate-induced sea level rise and the increased intensity of storm surges. While groundwater pumping restrictions have mitigated some of these risks, there remains substantial uncertainty around future outcomes.[6] Under some scenarios the coastal provinces in particular would become much more flood-prone than they are today, which in the absence of remedial action could have implications for their longer-term viability. While not accounted for in the modelling, the realization of this tail risk could have substantial economic impacts: one in four Thais could be directly affected while the capital region accounts for half of national GDP.[7]

Adaptation investments can significantly reduce but not entirely offset the adverse macroeconomic impact of climate shocks, with the costs of inaction significantly greater than the costs of action. The

[4] Thai Flood 2011: rapid assessment for resilient recovery and reconstruction planning (Vol. 2 of 2): Final report (English). Washington, DC: World Bank.
[5] World Bank Group. 2023. Thailand Public Revenue and Spending Assessment: Promoting an Inclusive and Sustainable Future. World Bank, Bangkok.
[6] See UNESCO, 2024. Catalogue of Hydrologic Analysis for Asia and the Pacific, Volume 3, Groundwater.
[7] World Bank Group. 2023. Thailand Economic Monitor: Coping with Droughts and Floods; Building a Sustainable Future. World Bank, Bangkok.

modelling indicates that investments in flood mitigation, coastal protection, water security, and cooling could raise annual GDP by 2-3 percent by 2040 and 4-5 percent by 2050 relative to a business-as-usual scenario, at an annualized cost of a little over 1 percent of GDP (see Chapter 6). These net benefits would likely be even larger to the extent that concerted action to mitigate climate risks helps to boost the attractiveness of Thailand as a destination for foreign investment. The modeled climate resilient pathway incorporates the costs and benefits of recommended adaptation investments, as well as the impacts of other policy reforms and interventions such as early warning systems and better land use planning. These include investments to protect against flooding, particularly in the Chao Phraya basin and Greater Bangkok area; to promote water security, particularly in the EEC and in the drought-affected north and north-east regions; and to protect against coastal erosion, particularly in heavily touristed areas on the Gulf of Thailand. We include the capital costs of these investments in this scenario and, given their public goods characteristics, assume that they are funded largely by the public sector, with implications for public finances and debt. The estimated benefits associated with these investments (avoided climate damage and economic losses, alongside macroeconomic gains from the investments themselves) are also incorporated.

The efficacy of adaptation investments varies across the different climate scenarios. The results suggest that adaptation investments can significantly limit the losses and damages from flooding but have a proportionally smaller impact on heat stress and associated declines in labor productivity. This reflects less scope for additional heat adaptation due to the high prevalence of air conditioning especially in urban areas, and also highlights the challenges of mitigating heat impacts on outdoor workers.[8]

The remainder of the chapter assesses key investments and actions needed to reduce the damage and losses associated with climate change and adapt to its impacts. It sets out more details on the recommended investments in adaptation and the supporting policies and reforms that would be needed to boost climate resilience.

3.1 Mitigating flood risks

Thailand's vulnerability to flooding is largely concentrated in the Chao Phraya basin. The Chao Phraya basin is the largest in Thailand, home to 40 percent of the population, 78 percent of its workforce, and 66 percent of its GDP, but suffers from an increasing intensity and frequency of floods. While the flood risk in this area stems from multiple factors in addition to rainfall and runoff (such as land use changes, subsidence, river morphology, and tidal effects), climate change is leading to a very significant increase in the flood hazard (see Table 3.1 below). For example, by the 2040s and 2050s, the current 120-year flood is expected to return every 19 years (in RCP 4.5 scenario) or every 6 years (RCP 8.5 scenario).

Table 3.1: Projected Flood Return Periods in the Chao Phraya Basin

Flood Event (Year)	Observed Chao Phraya discharge	Return Period	Return Period under RCP 4.5 scenario		Return Period under RCP 8.5 scenario	
	(m^3/s)	Present	2040- 2059	2080-2099	2040- 2059	2080-2099
2006	5,457	120	18.4	11.6	5.4	7.0
1995	4,820	43	7.1	5.1	2.8	3.5
2002	3,997	19	3.8	2.9	1.9	2.2
2010	2,826	6	1.9	1.4	1.2	1.4

Source: Singharak, P., (2015). Final Report on the Work of the National Climate Change Expert - Training for Royal Irrigation Department on Project and Budget Analysis under Climate Change. Prepared for UNDP and Chulalongkorn University.

[8] Identifying the exact mechanisms of impact of heat stress on worker productivity is a knowledge gap that future analytical work could address.

A range of interventions have been and are being considered to protect against floods in the Chao Phraya basin. The Chao Phraya River Basin Flood Mitigation Master Plan, developed by the Office of the National Water Resources (ONWR) and Royal Irrigation Department (RID) in response to the 2011 floods remains a key strategy for flood management in the Chao Phraya basin. The Master Plan is designed to achieve flood protection for a 1 in 50-year flood event and comprises of nine projects ("Nine Plans") with a combined cost of USD 12.3 billion. The Plans include provisions for new upstream water retention, the Ayutthaya bypass, Bangkok outer ring road diversion, new Pasak-Gulf of Thailand bypass canal excavation, raising of dikes, upgrade of irrigation structures and river improvement works, among others.

Full implementation of the Chao Phraya "Nine Plans" could significantly curtail future damages and losses due to floods. Given the large scale of investments and extended timeline of the program, different implementation scenarios have been simulated to assess the differential benefits of incremental investments in Chao Phraya floods management. In a "No Action" baseline scenario, the Chao Phraya River Basin is projected to incur substantial and recurring climate-related damages—estimated at USD 811 million annually in direct physical losses, alongside economic disruptions amounting to USD 488 million per year. This results in a combined annual impact of approximately USD 1.3 billion. However, comprehensively scaling up investment in flood management infrastructure and planning demonstrates clear economic benefits. Full implementation of all nine planned flood management interventions could almost entirely mitigate the damages and losses in most years, lowering the costs associated with flood-proofing individual buildings and structures.

While Thailand's focus on flood management infrastructure is well placed, global experience shows that complementary efforts are needed to provide more comprehensive protection. Investments geared towards, for example, technical and institutional improvements in hydrometeorological services, flood forecasting and early warning systems are not only critical for reducing casualties but also provide the highest rates of return across a range of investments.[9] Better land management, zoning, and management of construction in flood-prone areas are also important components of effective flood mitigation strategies.

Measures to conserve and enhance the forest areas in the upper basin can help to attenuate runoff and forestall flash floods, while providing substantial carbon reduction benefits. Forests' role as a carbon sink is a key component of Thailand's overall decarbonization pathway (see Chapter 4). At the same time, forests provide critical ecosystem services. By regulating water flows, forests help mitigate flash floods in upstream/mountainous regions, while absorbing excess water and reducing downstream flood risks. Forests can also protect water quality by reducing soil erosion and landslides, preventing sediment from entering rivers and reservoirs.

Recommendations

Given the significant projected impacts and risks associated with flooding, particularly in the Chao Phraya basin, Thailand should prioritize the implementation of comprehensive flood management strategies which reduce the vulnerability of communities and infrastructure to flooding events. Community engagement is critical to address local risks. This CCDR recommends:

- **Prioritize implementation of critical flood management plans.** Chao Phraya basin is the central focus of Thailand's flood management efforts with the Nine Plans representing the main

[9] Recent amendment to the scope of "Plan 1" attempt to address some of these issues. Specifically a new component has been added to the plan that includes efforts to: (i) upgrade hydromet networks (including communication systems) which still include many manual or non-functional stations at important locations; (ii) improve communication and coordination between the four independent flood forecast and Early Warning systems operated by different agencies in Thailand; (iii) upgrade the current flood forecasting models (from 1D to 2D or combined 1D2D models which are required to produce reliable forecasts of flood flows and water levels), and; (iv) streamline the multi-institution process for decision-making which is currently too slow for emergency scenarios.

strategy. Two of these plans (Plans 6 and 9) have been completed and Plan 7 is in an advanced construction stage. However, implementation of the most critical plans has not yet started. The government could use scenario-based planning to sequence the roll-out of remaining plans, accounting for risk exposure and the cost-effectiveness of each intervention. For example, a two-phased implementation of Plan 2 (with a first phase starting in conjunction with Plan 1) could bring very significant flood protection benefits in a relatively short period of time. Global experience on capturing land value enhancements that result from flood risk reduction could also be explored as a complementary source of finance, especially in urban areas.

- **Promote sustainable upland and watershed management** through reforestation, wetland restoration, sustainable farming and soil stabilization which would not only help reduce flash floods, erosion and landslides in upstream/mountainous regions but also absorb excess water and reduce downstream flood risks.
- **Enforce climate-smart land use planning and floodplain zoning** to steer new development away from high-risk areas and reduce downstream flood impacts would help build greater resilience.
- **Expand and modernize early warning systems and hydrometeorological services**. Enhanced forecasting and real-time alerts will allow vulnerable communities and key sectors to prepare for flood events, reducing loss of life, economic disruption, and the burden on emergency services.

3.2 Protecting against coastal erosion

Over the past three decades, up to 30 percent of the Thai coastline has suffered from coastal erosion, resulting in total land loss of around 12000 hectares, a land value loss of more than USD 1.3 billion exclusive of other economic losses and damages. Natural defenses along the Gulf of Thailand coastline, including mangroves and beaches, have been degraded due to unsustainable land use and urban development. Modelling conducted for this CCDR indicates that annual tourism revenue losses along this coastline (due to additional land loss) could reach around USD 1 billion (in constant 2025 prices) by the mid-2040s in a no-adaptation scenario. Thailand's National Adaptation Plan and Climate Change Master Plan (2015–2050) identify coastal flooding as a major risk, with coastal zone management prioritized as an adaptation strategy.

Several measures have already been adopted to protect against coastal erosion, but the efforts have largely been *ad hoc* and fragmented in nature, tending to over-emphasize hard engineering-based solutions. Recent investments—such as seawalls, revetments, breakwaters, and flood barriers around urban centers like Bangkok—offer temporary protection. However, these hard infrastructure solutions are costly to maintain, inflexible to worsening climate conditions (e.g., rising seas, stronger storms), and can have unintended consequences. In particular, poorly coordinated measures may shift flood risk to neighboring areas, while seawalls can disrupt sediment flows, exacerbating erosion elsewhere.

Lessons learnt from experience in other countries and incipient efforts within Thailand suggest that nature-based solutions could provide a more effective and sustainable alternative to coastal protection. Adaptation measures should prioritize structural designs that mimic natural processes—such as planting mangrove pioneer species—to reduce wave energy, curb coastal erosion, and promote sediment accumulation. The optimal approach combines minimal structural intervention with effective water flow and wave dissipation. Beyond enhancing resilience to extreme events like storm surges and sea-level rise, these nature-based solutions support local livelihoods by revitalizing ecosystems that underpin tourism, recreation, and fisheries. Mangroves also offer significant climate co-benefits, playing a vital role in carbon sequestration. Private operators are also turning to nature-based solutions, in addition to flood-resistant designs (Box 3.2).

Modelling conducted for this CCDR indicates that the economic benefits of investments in such nature-based solutions would outweigh costs by an order of magnitude. Five areas in the Upper Gulf of Thailand—Bangkok, Samut Prakan, Samut Songkhram, Samut Sakhon, and Chachoengsao—have been identified as priority zones for coastal mud beach protection. The total investment required for designing and installing nature-based protective structures, including mangrove restoration and maintenance across three phases, is estimated at USD 1.5 billion over a 20-year period (USD 1.1 billion in NPV terms). In parallel, 35 beaches along both the Gulf of Thailand and the Andaman Sea have been identified as needing urgent investment in sustainable sand beach nourishment. The total cost for these interventions, implemented over nine phases within 20 years, is projected at USD 1.4 billion (USD 0.9 billion in NPV terms). On the other hand, the net economic gains – purely in the form of additional tourism revenues associated with avoided losses from lost land, and additional gains from reclaimed land – could reach USD 14 billion in NPV terms, or upwards of USD 2 billion per year by the mid-2040s.

Box 3.2: How the private sector is leading efforts toward sustainable tourism

Thailand's private sector has been playing a vital role in enhancing climate resilience in tourism. Developments like IconSiam in Bangkok, with elevated structures and flood barriers, demonstrate how flood-resistant designs can protect operations in urban areas. In heritage-rich locations like Ayutthaya, portable flood barriers—similar to those used in Venice—offer practical protection for cultural assets. Resorts such as Keemala in Phuket have adopted elevated villas and water diversion systems to reduce flood impacts.

Private operators are turning to nature-based solutions. Coastal resorts in Phuket and Pattaya are funding or co-financing mangrove restoration, which helps prevent erosion and storm surges while supporting eco-tourism through guided tours and education programs. Marine tourism providers are engaging in coral reef restoration; for instance, The Sarojin in Khao Lak and Banyan Tree Hotels have established coral nurseries and artificial reefs to protect biodiversity and attract divers.

Community partnerships offer further promise. In Krabi, the Nai Nang Apiculture Group, supported by Marriott Hotels, links mangrove restoration with beekeeping, creating local livelihoods and sustaining conservation. Products like Nai Nang honey are now sold in Marriott gift shops and used in restaurants, aligning community benefit with corporate sustainability goals.

The private sector is also acting to reduce tourism sector emissions, partly in response to a shift in consumer preferences towards environmentally conscious travel. A 2024 survey by Booking.com revealed that 75 percent of global travellers aim to embrace more sustainable travel practices in the coming year, and the trend is particularly strong in the Asia-Pacific region. Thailand is no exception to this global trend. Agoda's Eco Deals Survey from 2024 found that 84 percent of Thai consumers are ready to adopt greener travel options, with financial incentives like discounts being a major motivator. Emissions-reduction initiatives in Thailand include the CF-Hotels platform, launched by the Tourism Authority of Thailand (TAT), which allows participating hotels to track and reduce emissions across energy, water, waste, and carbon metrics. While over 695 hotels (as at August 2025) have joined the platform, only 160 hotels self-reported their emissions reduction efforts in 2024. The overall adoption and use of the platform still remains limited due to resource and capacity constraints.

Scaling sustainability across the sector will require more than a few flagship initiatives, and broader challenges to additional private sector investment will have to be addressed. There is a business case for investing in sustainable tourism which can lead to higher revenues and cost savings, particularly via energy and water usage efficiencies. However, the significant initial investment is a deterrent. Financial incentives can help address this gap and improve the attractiveness of investment in nature-based solutions in particular, which tend to have wider public benefits that are not fully captured by the private investor. Tailored financial tools such as concessional loans, results-based subsidies, or co-financing tied to climate resilience remain limited (see Chapter 6). Biodiversity and catastrophe bonds, and climate insurance are also viable financing instruments which need to be scaled up in Thailand. Broader uptake of sustainable and adaptive practices will also require clearer policy signals. Publicly provided financial incentives and regulations—such as tax breaks for resilient infrastructure or stricter zoning laws to avoid risky construction—can be used as a way of scaling efforts. Limited awareness and understanding of sustainability principles, and lack of standardized sustainability benchmarks, further hinders progress, particularly among smaller players. Government support will be particularly important to help SMEs access capital and technical expertise, enabling them to respond to evolving climate risks and consumer expectations alike.

Moreover, while Thailand's tourism strategies reference sustainability, they often lack concrete action plans and enforcement mechanisms, leaving implementation inconsistent across regions. For instance, while the National Tourism Development Plan (2023-2027) sets an emissions reduction target of 2 percent per year, it lacks clear mechanisms, incentives, or compliance measures to help hotels contribute to this goal.

Underpinning all of the above is the need for stronger inter-agency coordination and a robust public-private sector dialogue. For instance, in Thailand, agencies such as the Ministry of Tourism and Sports, the Ministry of Natural Resources and Environment, and the Energy Regulatory Commission have overlapping mandates but lack a cohesive strategy for sustainable tourism, leading to policy inconsistencies and gaps in enforcement. On the private sector side, tourism businesses, particularly SMEs, have limited representation in policymaking discussions.

Recommendations

A scaled-up and better coordinated approach to coastal protection is vital to avoid land loss to erosion, protect against storm surges and coastal flooding, revitalize ecosystems that underpin recreation and fisheries, and support the tourism industry which is concentrated on Thailand's coasts.

- **Nature-based solutions and ecosystem-based adaptation should be scaled up and positioned as the first line of defense against coastal erosion**, including by pursuing investments in mud beach protection in priority zones of the Upper Gulf of Thailand, and in sand beach protection and nourishment at the 35 identified beaches along the Gulf of Thailand and the Andaman Sea. This would entail rebalancing the current infrastructure-heavy approach, e.g. by blending green and grey infrastructure through a combination of mangrove buffers and low-impact barriers.
- **A more integrated approach to coastal protection could be pursued, by aligning coastal policies with land-use plans, urban planning and watershed management efforts**. Greater use of spatial planning tools and Integrated Coastal Zone Management (ICZM) would help coordinate actions across government. A more coordinated approach could also be used to discourage hard infrastructure in those cases where nature-based alternatives may be more viable.
- **Engagement of local communities in the planning and monitoring of these efforts and facilitating investments from the private sector** – including through financial incentives where possible – would foster greater ownership, acceptance and sustainability of these efforts.

3.3 Addressing water scarcity

Thailand's baseline water security challenges are being exacerbated by climate change, prompting interventions to protect farmers, industry, and households. In agricultural areas in the north and northeastern parts of the country, the development of irrigation systems and measures to climate-proof and increase the capacity of water storage infrastructure have the potential to have significant impacts on agricultural yields and farmer incomes. In the Eastern Economic Corridor (EEC), a regional hub being promoted by the government to drive innovation and growth, the challenge is to climate-proof water supply to ensure that it can adequately meet the growing demand for industrial uses.

Several adaptation solutions are available, but implementation is hampered by challenges related to financing, capacity and institutional support. Key adaptation measures to address water security in the northern provinces include increasing small-scale retention ponds, enhancing retention capacities in canals and small river networks and improving groundwater and reservoir strategies. However, the implementation of these measures remains challenging due to bureaucratic budgeting scrutiny, limited authority to administer water management tasks, lack of an integrated and evidence-based provincial master plan, and in some cases, lack of capacity within local governments. A qualitative exploration of these issues in Khon Kaen Province (see Annex 1), drawing on in-depth interviews of several key stakeholders including the Governor and the provincial administrative team, revealed technical capacity to conduct integrated provincial water planning and mobilizing financing for small-scale retention ponds as two main challenges that need to be overcome.

The government is aware that the planned growth of the EEC cannot be realized without a secure water supply. The EEC is being championed as a transformative hub for investments, technology, and transportation. Covering an area of approximately 13,000 sq.km in the provinces of Rayong, Chonburi, and Chachoengsao, the EEC is already a major contributor to national economic output, accounting for approximately 15 percent of GDP in 2022. It serves as a critical production base for advanced industries including petrochemicals, smart electronics, and electric vehicles. Additionally, the region is a source of high-value agricultural exports such as durian, mangosteen, and premium seafood products, and it is also emerging as a prominent destination for tourism, particularly in Chonburi. As a part of Thailand 4.0 strategy, the EEC's goal is to become a world-class smart city and an investment destination for a range of critical sectors, including digital technology, health, smart logistics, and decarbonization. The growth plan envisions the creation of over 200 thousand jobs by 2032.

Addressing the imbalance between increasing water demand and limited available supply is a key challenge to realizing this vision for the EEC. The current water infrastructure is inadequate to cope with peak demand during the dry season, leading to critical shortages that affect not only the industrial sector but also agriculture and public utilities. Given the current situation, EEC's future development is not feasible without addressing water scarcity. Table 3.2 below presents the demand-supply gap for the three provinces comprising the EEC, for 2024, 2027 and 2037. Assuming average water supplies are similar to average actual hydrological conditions in the decade leading up to 2023, it is projected that in 2037 the EEC will face a supply shortfall of almost 40 percent. The situation in dry years will be even more precarious, with the shortfall increasing to 72 percent. These projections already account for the 32 infrastructure investments that have been planned to improve water supply in the EEC.

However, measures to promote more efficiency and circularity in water use can potentially address these constraints. Supply augmentation needs to be complemented by investments in water demand management and circularity (for example via the treatment and reuse of wastewater, only 37 percent of which is currently treated in the EEC) in order to address the water security challenge. In this context, it is instructive to look at the water management paradigm of California, with which the EEC shares many similarities in terms of geo-climatic location, hydrological conditions, and multi-sectoral asset base. California has achieved a path-breaking decoupling of water use and economic growth: over the 50 years to 2017, its Gross State Product increased by ~500 percent while water use increased by only ~10 percent. The EEC can aspire toward a similar decoupling.

Table 3.2: Projected water balance in the EEC provinces (in million cubic meters, MCM)

Area	2024		2027		2037	
	Demand	Deficit	Demand	Deficit	Demand	Deficit
Chachoengsao	1237	-897	1171	-811	1115	-379
Chonburi	794	-412	894	-464	1228	-729
Rayong	924	-170	1047	-139	1272	-292
EEC Total	2955	-1479	3112	-1414	3615	-1400

Source: Water Balance Report for the Eastern Economic Corridor, Office of the Eastern Economic Corridor, August 2024.
Note: Demand and deficit values are based on average water supply scenarios as opposed to dry or wet years and the average scenario assumes water supplies similar to the average actual hydrological situation for the period 2013-2023.

Recommendations

Thailand's development ambitions and its water-security challenges converge sharply in the EEC, an industrial area that is also vulnerable to other climate risks. At the same time, water availability remains a pressing issue for agricultural livelihoods in the drought-prone north and north-eastern provinces. This CCDR recommends:

- **Additional measures to boost water supply in the EEC, including the pursuit of water conveyance projects.** The Government can expedite the approval and implementation of key water conveyance projects like Prasae-Nongkhor-Bangphra and Phanthong-Bangphra to boost supply in the EEC.
- **Better harnessing latent sources of "new water", including by scaling wastewater treatment and doing better demand management.** More than 60 percent of EEC's wastewater currently goes untreated, and it is the single largest untapped source of new water supplies for the region, especially for industrial users. The initiatives being taken by the Wastewater Management Authority and the Industrial Estates Authority of Thailand for treatment and reuse of municipal wastewater need to be supported and scaled. Reducing demand is another important latent source of "new" water supplies, and this has significant potential given that water productivity in Thailand remains low compared with global and regional benchmarks.[10]
- **Identify, pilot and scale smart, innovative approaches to water management.**[11] Negotiation instruments to facilitate inter-sectoral water transfers (especially in emergencies), multi-stakeholder water platform to bring together public and private actors, smart metering and tariffs, dynamic and long-range water planning, PPPs for the enhancement of investment efficiency in water infrastructure projects, and promoting net-zero water use in key industrial sectors are some innovative approaches that could be adopted at a larger scale.
- **In drought-prone agricultural areas in the north and north-east, integrate provincial water planning and mobilize financing for retention ponds, reservoirs, canals, and small-river networks.**

3.4 Adapting to extreme temperatures and heat stress

Extreme temperatures have significant adverse impacts on the Thai economy and society. Heat stress can affect the productivity of workers, 61.5 percent of whom work outdoors. These impacts are likely to be felt most severely in the agricultural sector due to greater exposure to outdoor work and the higher proportion of workers performing strenuous physical activities. High temperatures also compound water scarcity issues faced by agriculture and industry. Tourism will be affected by more frequent and intense heatwaves, hurting Thailand's attractiveness as a year-round tourist destination. Coastal provinces such as Phuket, Pattaya, and Krabi, which rely heavily on beach tourism, are particularly vulnerable. Higher temperatures could reduce the appeal of outdoor activities, shorten peak travel seasons, and result in a shift in visitor preferences toward cooler destinations.

Rising heat can affect society in other less quantifiable ways. Overheated classrooms can make it difficult for children to concentrate and learn, affecting educational attainments and long run human capital. Infants and young children, elderly, and people with pre-existing health conditions such as cardiovascular disease or diabetes are also particularly vulnerable to extreme heat as their bodies are

[10] See also Chokchai S. and Koontanakulvong, S. (2019), Evaluation of water productivity of Thailand and improvement measure proposals.

[11] See also Koontanakulvong, S. (2024), Policy recommendations for water management through science, technology and innovation (STI).

not as efficient in regulating body temperature. Consequences include heat stroke, a life-threatening condition. Chronic heat can also strain infrastructure systems and erode overall urban livability.

Populous places such as the Bangkok Metropolitan Area (BMA) have already started putting in place variety of measures to adapt to extreme heat. These measures consist of policies, institutions and investments ranging from early warning systems to green infrastructure projects such as cooling centers, hydration initiatives and a variety of building regulations conducive to urban cooling (Box 3.3)

Box 3.3: Urban heat island adaptations[12]

In 2024, the BMA developed the Urban Heat Management Framework to address rising temperatures in the Bagkok. The framework consists of two main components. The Year-Round Intervention Framework includes measures that are implemented continuously, regardless of the season. The Hot Season Intervention Framework consists of targeted interventions activated specifically during the hot season, with priority actions determined based on four specific heat index levels: the monitoring phase (27°C – 32.9°C), the warning phase (33°C – 41.9°C), the critical phase (42°C – 51.9°C) and the extreme critical phase (beyond 52°C).

The Year-Round Intervention Framework focuses on two key areas: strengthening healthcare capacity and mitigating urban heat impacts. Efforts to enhance healthcare preparedness include training medical personnel on heat-related risks, and integrating heat risk management into public health protocols. To mitigate urban heat impacts, the BMA is implementing long-term strategies such as expanding green spaces through initiatives like planting two million trees and establishing 15-minute parks to enhance urban cooling. Additionally, climate-sensitive urban planning measures are being introduced, including promoting open façades in high-rise buildings to improve ventilation, increasing blue spaces such as water bodies to moderate temperatures, and encouraging the use of heat-reflective materials in newly constructed buildings. Efforts to cool the physical environment place emphasis on green infrastructure and surface improvements. Projects like planting more trees and expanding green spaces seek to enhance shade and reduce ambient temperatures, while cool pavements and permeable surfaces aim to reflect more sunlight and improve water infiltration, thereby lowering surrounding heat levels. Similarly, integrating design features like urban ventilation corridors and water-based elements—such as fountains—into open areas contributes to localized cooling. These strategies are at various stages of implementation across Bangkok.

Complementary measures highlight the importance of consistent hydration and workplace adjustments. For hydration, the city has introduced initiatives such as installing additional water refill stations and fountains, aiming to make clean drinking water more readily accessible in public spaces. These efforts also include educational outreach to underscore the significance of adequate fluid intake in hot weather. Additionally, the BMA has encouraged modifying work schedules, especially for outdoor laborers, to reduce exposure during the hottest times of day.

More can be done to systematically scale similar efforts across the country. Several solutions being piloted by BMA have the potential to be replicated at provincial and local levels. The gaps and shortcomings in BMA experience also provide important lessons for broader nationwide efforts. For example, a recent review identifies several opportunities to do better on protecting vulnerable populations, targeting high-risk areas, and aligning citywide efforts. The review finds that several green infrastructure efforts currently underway are not always spatially targeted with many high risk “heat hotspots” remaining underserved due to limited integration of micro-climate data and urban heat mapping into the planning process. Relatedly, the needs of vulnerable groups – including the elderly, children, outdoor workers, and low-income communities – could be better integrated into the design and implementation of these solutions.

[12] Based on Rubinyi, Steven, Putu Sanjiwacika Wibisana, Jane Park, Nicholas K.W. Jones, Juan A. Acero, and Pichaya Moeller. 2025. *Shaping a Cooler Bangkok: Tackling Urban Heat for a More Livable City.* Washington, DC: The World Bank.

Recommendations

Labor productivity loss due to heat stress is one of the main channels by which climate change could impact the economy; heat also has a range of impacts on health and education. The following recommended actions could help Thailand better adapt to high temperatures:

- **Support policies and investments to cool indoor public and residential spaces.** Availability and use of air conditioning has been growing in Thailand but only around 40 percent of the population has AC units at home. AC ownership is substantially higher among richer households. Financing instruments to help qualifying lower-income households afford the up-front capital investments needed to procure low cost but energy-efficient air conditioning units (e.g., window-fitted) could help boost access among the most vulnerable. To avoid exacerbating emissions from excessive air conditioning use, incentives could be provided to promote smart cooling technologies and zonal temperature controls. In the medium to long term, heat resilience considerations could be embedded in building codes and planning, mandating green roofs, reflective surfaces, minimum green cover and design that enhances natural ventilation.
- **Expand cooling centres by repurposing public facilities.** Schools are particularly well suited to double as cooling centres because of their widespread presence in communities. In addition to serving as accessible refuges for the local population during heatwaves, they can provide a relief to students for a longer period, potentially helping contain heat-related learning loss.[13]
- **Implement targeted outreach programs to identify and protect the most vulnerable.** Tailored programs and specialized outreach could be used to ensure that those without air conditioning or safe cooling options receive targeted support. For outdoor labourers, this could include heat safety measures such as mandated rest breaks, shaded workspaces, and adjusted schedules. Priority interventions could also include home visits for elderly residents, school-based heat safety education, and mobile cooling units—to protect vulnerable populations without access to safe cooling in high risks areas. Collaboration with community leaders and health agencies could be used identify at-risk populations and provide them with practical guidance.

3.5 Making agriculture more climate resilient

Thailand's agriculture and food sector is already being affected by climate change and other environmental concerns. Thailand is a major agri-business hub in the region, with agriculture employing about a third of the country's labor force and accounting for 15-20 percent of Thailand's exports and around 8 percent of GDP. Yet, most farm households in Thailand are smallholders, with around half owning less than 10 rai (1.6 ha) of land. Declining farm productivity has significantly stalled living standards improvements in recent years.[14] Rising temperatures, unpredictable rainfall patterns, and extreme weather events such as droughts and floods are compounding these challenges. By 2040, climate change is projected to reduce national rainfed crop production by up to 12.4 percent under Dry/Hot scenarios, primarily due to heat stress and reduced water availability. While wetter conditions in the Wet/Warm scenario may slightly benefit rice and vegetables, most other rainfed crops will still face production declines. Irrigated crops are also expected to suffer, with production losses reaching 7.0 percent under Dry/Hot conditions, though sugarcane may be an exception due to its lower sensitivity to water stress.

[13] Park, R.J et al (2020) show that without air conditioning, a 1-degree F hotter school year reduces that year's learning by 1 percent among secondary students in the United States. See Park, R. Jisung, Joshua Goodman, Michael Hurwitz, and Jonathan Smith. 2020. "Heat and Learning." *American Economic Journal*: Economic Policy 12 (2): 306–39.

[14] World Bank Group. 2022. *Thailand Rural Income Diagnostic: Challenges and opportunities for rural farmers.* World Bank, Bangkok.

Several climate-smart agricultural practices have begun to emerge as farmers adapt to climate change. Farmers have been adjusting crop calendars with delayed sowing of short duration crops, diversifying crops to heat, flood and disease resistant seed varieties and adopting mixed farming practices. One approach that has some policy support involves crop rotation, particularly the practice of growing maize on residual soil moisture or with limited irrigation following wet-season rice harvests. Additionally, farmers are diversifying their production by introducing alternative crops such as mung beans and sun hemp. In highland areas, agricultural adaptation has taken different forms, with some farmers shifting towards vegetable cultivation or incorporating tourism activities alongside their farming operations. In animal husbandry and livestock, farmers have invested in sophisticated housing infrastructure, incorporating modern design elements and evaporative cooling technology to combat heat stress.

Location specific solutions are also being deployed to address water security challenges. Small-scale farmers in Phetchabun's flat plains have implemented drip irrigation systems on their modest maize holdings of 2-4 rai, leveraging available groundwater resources to improve crop yields. This adoption mirrors a broader trend where farmers in drought-susceptible areas are turning to drip irrigation technology. While the initial investment is considerable, some evidence suggests that the benefits of improved water efficiency and increased crop production make drip irrigation a worthwhile adaptation strategy.[15] Similarly, livestock farms have begun installing rainwater harvesting systems to enhance water security. These installations enable farms to capture and store precipitation, providing a reliable water source during periods of drought.

Several scientifically proven solutions are available for adoption at larger scale and some of these solutions can deliver dual benefits of reduced emissions and greater climate resilience. In coastal areas affected by salinization and sea level rise, current rice systems are becoming untenable. Transitioning from rice to shrimp farming—which already accounts for more than half of Thailand's total production—could improve farm incomes and climate resilience. However, the transition must be carefully managed and regulated to have a low impact. Fluctuations in water temperature leading to reduced oxygen levels, salinity changes and declining water quality, can increase the risk of disease and early mortality for shrimp and prawns. Recirculating Aquaculture Systems (RAS), which filter and reuse water, can enhance biosecurity while simultaneously reducing emissions and water demand. Smart water quality monitoring systems—integrating AI, IoT sensors, and real-time analytics—allow for early detection of disease risks and enable farmers to proactively adjust water conditions. Additionally, incorporating mangrove forests into shrimp farms not only improves yields but also provides natural protection against storm surges and coastal erosion, while leveraging the carbon sequestration benefits of mangroves to offset emissions.

At the farm level, key barriers to adopting climate-smart agriculture (CSA) in Thailand stem from financial, operational, and behavioral constraints. The financial challenge is primarily one of scale: many CSA technologies require significant upfront investment that is not viable for smallholders operating on limited land and income. While credit is generally accessible through institutions like the Bank of Agriculture and Agricultural Cooperatives (BAAC), the high marginal costs relative to farm size often deter investment. Collective action through cooperatives could offer a pathway to shared investment and risk reduction. Agribusinesses with links to farmers could also play a key role in providing services and enforcing standards that encourage farm-level adoption. Additionally, widespread knowledge gaps and entrenched behavioral biases also hinder uptake. Tailored, region-specific interventions that combine technical support, infrastructure, and behavior change strategies are therefore essential to enable widespread CSA adoption.

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[15] Chuchird, R.; Sasaki, N.; Abe, I. 2017, Influencing Factors of the Adoption of Agricultural Irrigation Technologies and the Economic Returns: A Case Study in Chaiyaphum Province, Thailand. *Sustainability*, 9, 1524.

Farmers also face several structural barriers to using weather index-based insurance instruments. In collaboration with the BAAC and through public-private partnerships, Thailand has implemented several insurance programs, including beef cattle farming, fisheries, in-season rice farming, animal-feed maize, and longan insurance. Structural challenges associated with inaccurate damage assessment, lack of partial compensation, and slow payouts have hindered greater adoption and use of weather index-based insurance in Thailand. Traditional indices, such as regional rainfall data, often fail to reflect localized impacts, creating basis risk. In 2019, more than 45 percent of claims were denied because official thresholds were unmet despite visible crop damage.

Recommendations

There are several actions that could help encourage the adoption of CSA practices by farmers, increasing their resilience to climate shocks:

- **Repurpose agricultural public expenditure away from distortionary price support schemes toward long-term productivity and resilience.** Thailand could significantly increase investment in public agricultural R&D and extension services to drive innovation in climate-resilient crops, sustainable practices, and farm management. Providing financial support for science- and information-based technologies—such as digital advisory tools, satellite data, and precision agriculture—will empower smallholders with real-time decision-making capabilities. Public funds should prioritize infrastructure upgrades—including irrigation systems that improve water-use efficiency and drought resilience, alongside rural roads, storage, and local market hubs—to reduce post-harvest losses and improve input-output efficiency. Finally, financial support for farmers should shift to non-distortionary instruments like targeted, decoupled cash transfers, crop insurance, and smart subsidies, delivered through an expanded and digitized farmer registry.
- **Help scale CSA practices by embedding economic incentives for collective actions and linking with the private sector.** Farmer aggregation is a critical first step in the value chain approach to climate adaptation, as it empowers smallholder farmers in Thailand to overcome diseconomies of scale, limited market access, and labor shortages through collective action and enabling access to climate-smart technologies, finance, and private sector markets. Clear legal recognition, support for land block aggregation, improved water governance, and targeted policies for input services and extension delivery can enhance productivity and resilience. Formalizing and professionalizing cooperatives will unlock investment in adaptation and mitigation strategies while fostering equitable, climate-resilient growth.
- **Overhaul land and regulatory systems to incentivize innovation and sustainability.** Outdated regulations, insecure land tenure, and fragmented coordination among public, private, academic, and farmer institutions hinder the flow of innovation from lab to farm. Without legal land rights, especially in highland areas, farmers lack incentives to adopt long-term sustainable practices. Cumbersome laws on plant variety registration block access to improved germplasm. A policy reset is needed to remove such regulatory and legal distortions and allow climate-smart solutions that work on the ground.
- **Address structural challenges that inhibit greater use of weather index-based insurance instruments by farmers.** Solutions include deploying AI-enhanced satellite assessments, adopting tiered payout structures, and investing in hyperlocal weather infrastructure to improve index precision. Compensation delays can be reduced through digital claims automation and regulatory streamlining. Most critically, the government should externalize systemic weather risks by accessing international reinsurance or catastrophe bond markets, as done in countries like Mexico and the Philippines, allowing the state to transfer extreme event risks and stabilize domestic insurance schemes.

3.6 Protecting people

Even with the best efforts to adapt, protecting people from the adverse impacts of extreme climatic events will require a greater role for social protection. Empirical work conducted for the CCDR shows that while social assistance beneficiary households are better able to protect themselves from climate shocks, the protection is only partial. Existing schemes such as the State Welfare Card (SWC) and the Old Age Allowance provide broad coverage across the population but the benefits provided are low; for instance, the SWC covers around 14 million people (including those most exposed and vulnerable to climate impacts), but the spending allowance for essential goods is only around 300 baht per month (USD 9), though other allowances and discounts are also included. The strong and robust association between climate shocks and a buildup of household debt points to the possibility of there being significant uninsured risk that the social protection system could help manage (Tiwari et al 2025).

Assistance provided in the aftermath of climate-related disasters has tended to skew towards floods and fallen short of fully addressing the needs of those affected. The "contingency fund for the emergency assistance to disaster victims" is a designated budget line that is intended to ensure that victims of disasters receive timely assistance. It is intended to cover urgent and localized needs arising from sudden onset disasters and is activated when it is determined that existing budget allocations within agencies cannot be mobilized with requisite speed. This fund has disbursed an average of 4.7 billion baht per year over the last decade with a significant share of it being allocated to flood-related disasters with very little going to slower onset disasters like drought, whose impacts are less visible but accumulate over a longer time. Estimates suggest that even for floods, assistance provided often falls short of needs. For example, assistance provided in the aftermath of the 2023 floods, on average, covered only about 20 percent of the estimated loss to lives and livelihoods.[16] Noy, Nguyen and Patel (2019) report that government compensation in the aftermath of the 2011 floods was not only inadequate to cover the full extent of the losses but also regressive.

Fragmentation of social programs limits effectiveness and hinders a transition toward adaptive social protection. Social assistance programs in Thailand are numerous, fragmented and operate in silos with separate processes for outreach, intake, eligibility and payment. This limits their overall effectiveness in boosting ex ante resilience. The lack of a common unified social registry also makes it difficult to identify newly vulnerable households, which is crucial for increasing coverage of existing programs or establishing new ones.

Thailand's response to the pandemic provides an illustrative example of the strengths and weaknesses of the system as the country makes its overall program more adaptive to climate change. Thailand leveraged its digital ID, interoperable platforms, and administrative databases to rapidly scale cash transfers and create an instant social registry, reaching over 30 million people. The response included new emergency support for informal workers and farmers, plus expanded aid for vulnerable groups through the State Welfare Card program. However, given high workforce informality and limited social security coverage among informal workers, many of the intended beneficiaries remained unidentified by the instant social registry. Challenges with temporarily linking databases showed the need for permanent, dynamic data integration. Coordination costs and concerns about data privacy and security caused delays in accessing and linking various beneficiary databases, highlighting the importance of interoperable data platforms and robust data protection legislation. The Personal Data Protection Law became effective in 2022 but many of the other challenges around data integration

[16] 400,000 households were provided housing assistance of around 9000 baht per month with total outlay of 3.5 billion THB. An additional 0.5 billion THB was provided in the form of increased welfare. The total assistance provided (4 billion THB) however was only a fifth of the estimated 20 billion in forgone income losses from the death, job dislocations and loss of agricultural production. See Building Climate Resilience of Vulnerable Populations and Communities in Thailand: Synthesis Report (English). World Bank Group.

that Thailand experienced during COVID will need to be addressed to establish a social protection system that is adaptive to climate related disasters.

Recommendations

Thailand's social protection system has an important role in protecting the country's poorest and the most vulnerable from climate shocks, which will continue to have substantial impacts on lives and livelihoods despite the other adaptation measures outlined above. This CCDR recommends:

- **Increase the regular and post-disaster benefits provided to State Welfare Card (SWC) holders who are exposed to climate risks.** Additional annual spending of around 0.6 percent of GDP on social protection would allow a significant increase in SWC payments, as well as increased payments to affected individuals in the aftermath of disasters, thereby building both *ex ante* and *ex post* resilience to climate shocks. This additional spending would effectively double the average annual level of assistance provided to the 14.5 million holders of the SWC.[17] With other sectoral efficiencies likely to be achieved with improvements in targeting and greater use of integrated social registries, increased benefits for the most vulnerable could be achieved at a lower cost.
- **Improve targeting via hybrid proxy means tests (PMT) and integrate programs through unified social registries.** Developing integrated social registries will streamline beneficiary identification, reduce duplication, and improve the efficiency and effectiveness of social protection delivery, potentially lowering overall costs.[18] Well-functioning social registries with enhanced interoperability as well as robust targeting instruments such as hybrid PMTs that integrate administrative data will also facilitate the onboarding of newly vulnerable households or the introduction of new programs.
- **Strengthen the data underpinnings of the delivery system.** Thailand could establish a social protection data governance cluster made up of the relevant ministries and agencies that administer SP programs to establish data sharing protocols and systematize data collection and sharing when dealing with natural disasters and other shocks.[19] Geo-coding social protection beneficiary households would facilitate rapid response in the case of floods or other natural disasters that affect specific geographic regions.
- **Develop a high-level social protection strategy that incorporates responses to climate related events.** There are several agencies that are currently tasked with the delivery of assistance in the aftermath of disasters. Thailand's Disaster Risk Management (DRM) plan sets out the roles of the Ministry of Social Development and Human Services (MSDHS) and the Ministry of Labor (MOL) to provide assistance to disaster-affected people and workers, as well as contingency funds for disaster response. An inter-agency coordination entity tasked with developing and executing a framework for such a high-level social protection strategy would enhance effectiveness.

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[17] World Bank estimates based on 2021 SES survey data.

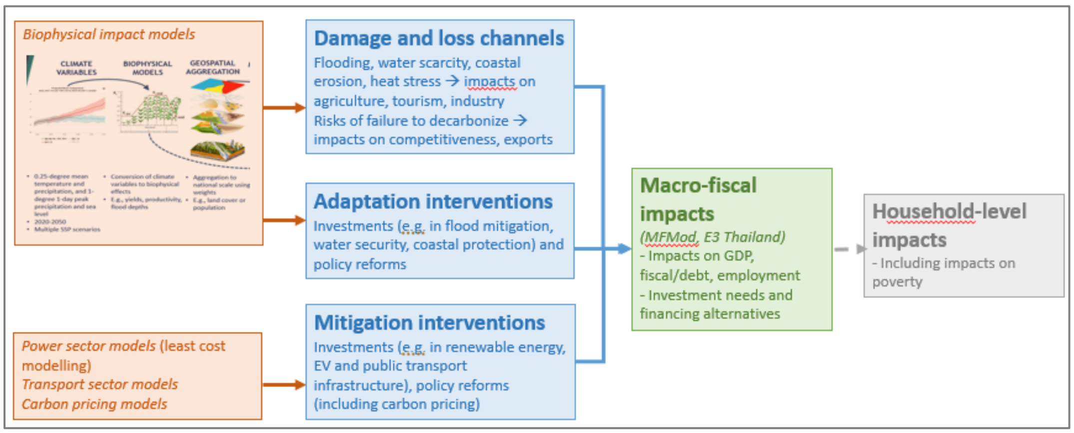
[18] A hybrid PMT to identify vulnerable households could retain the exclusion filters currently used for SWC eligibility while introducing additional eligibility criteria. These criteria would be based on other observed household characteristics that predict welfare, helping to reduce inclusion errors. Additionally combining the proxy means test with community-based targeting methods and ensuring there is a robust outreach and grievance redressal system in place can help minimize exclusion errors.

[19] See "Thailand: Data Analytics Strategy for Social Protection Sector to Enhance Service Delivery and Policymaking", World Bank 2025.

Annex 1: The modelling approach in this CCDR

The economic and social impacts of climate change and climate actions are modelled in several steps (Figure A1.1). First, separate biophysical impact models are used to assess the sectoral impacts of various climate scenarios specific to Thailand that are likely to become more frequent and severe over the coming decades. Second, we use the results from these models to quantitatively assess the economic damages and losses that Thailand faces from climate change. We then estimate the potential impacts of policy responses and priority investments to boost climate resilience and reduce emissions using two complementary macroeconomic models. Finally, we use spatial analysis, microsimulations, and other techniques to assess the distributional impacts of climate change and actions.

Figure A1.1: Structure of the modelling approach



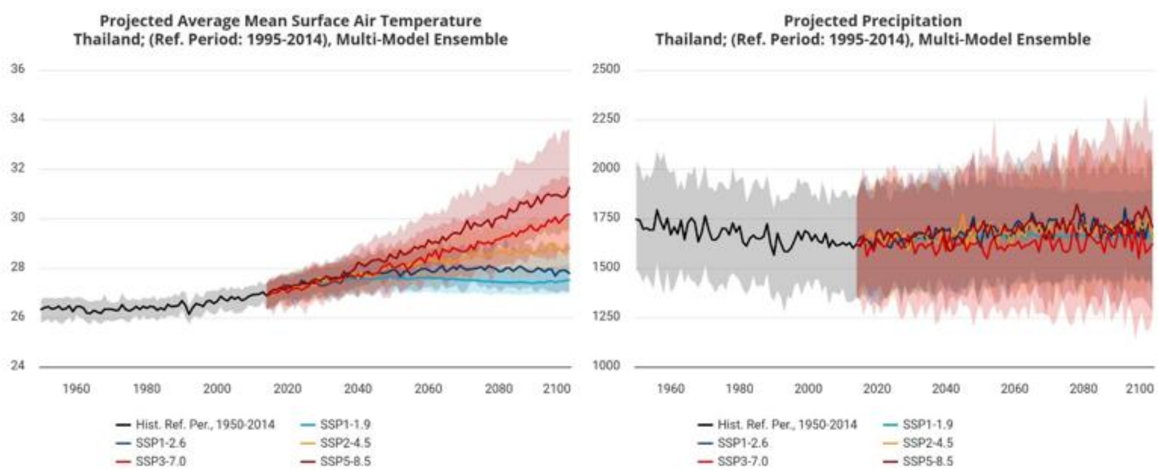
Within this framework we consider the differing physical impacts of "wet/warm" and "dry/hot" climate scenarios, compared to a benchmark (BAU) where there is no additional climate change over the 2025 to 2050 period. Climate scenarios are obtained from the World Bank's Climate Change Knowledge Portal for 30 General Circulation Models (GCMs) from the Coupled Model Intercomparison Project 6 (CMIP6) suite of model outputs. Each GCM has up to five combinations of Shared Socioeconomic Pathway (SSP) and Representative Concentration Pathway (RCP) emissions scenario runs available. We select climate scenarios in such a way as to capture the broadest range of climate change effects across GCMs within relevant SSP-RCP projections. For this study, we consider climate projections for SSP2-4.5 and SSP3-7.0 as the two most likely scenarios. SSP2-4.5 represents a global mitigation scenario consistent with current climate commitments and 2030 targets and SSP3-7.0 a scenario in which warming reaches 4°C by 2100 due to lax climate policies or a reduction in ecosystems and oceans' ability to capture carbon. Wet/warm and dry/hot scenarios are constructed by taking the 10th and 90th percentiles of mean precipitation and temperature changes across SSP2-4.5 and SSP3-7.0 GCMs.

Two macroeconomic models are used to estimate economy-wide impacts. The combination of models allows for a comparison of a range of impacts and will also provide different insights based on respective model capabilities and assumptions:

- **The World Bank's Macro-Fiscal Model (MFMod) is a comprehensive macro-structural econometric tool that simulates the flow of funds throughout the entire economy.** It maps out the core identities of national accounts, balance of payments, labor markets, and financial sectors. Macrostructural models are designed to quantify the economic and behavioral underpinnings of economic variables. These models establish structural relationships that align with economic theory and generate equilibrium outcomes over the long term while also reflecting the short-term dynamics observed in real-world economies (Burns et al. 2019).[20] The enhanced climate-aware version, CC-MFMod (Burns, Jooste and Schwerhoff, 2021), incorporates the economy-wide effects of climate-related natural disasters.[21] By integrating the MFMod with a technology diffusion model, it becomes possible to evaluate the effectiveness and macro impacts of mitigation policies. MFMod has the added benefit of providing detailed insights into fiscal and balance of payments impacts.

- **E3-Thailand is a macro-econometric model that was built specifically to look at climate-economy interactions in Thailand.** The model is highly empirical and represents the national accounting system, linked to energy consumption and emissions. Using econometric equations for 43 economic sectors, it does not assume equilibrium outcomes in either the short or long runs. It relaxes common modelling assumptions of perfect knowledge, fully rational optimizing behavior, fully flexible markets and a fixed money supply. Prices do not necessarily move to market-clearing rates and there are resources (e.g. labor) that are unused. The level of production is determined by the level of aggregate demand, unless supply constraints (e.g. full employment) are breached. There is an output gap between what the economy could produce (potential output) and what the economy is actually producing. These features of E3-Thailand mean that the impact of a policy depends on both its efficiency of the allocation of scarce resources and how the policy impacts on aggregate demand (i.e. stimulus or austerity effects).

Figure A1.2: Projected climate variables across a range of SSP-RCPs



The modeling is based on specific assumptions which imply the need for caution in interpreting the results. There is substantial uncertainty at every stage of modelling. The physical estimates of climate damages are partial and include only direct effects for the specified channels. How the direct effects spread throughout the economy is also not well known; the E3-Thailand simulations assume that impacts on labor affect capital productivity, and vice versa, while the MFMod simulations assume that labor there are no knock-on effects between labor and capital. Finally, rates of build-back and how the effects accumulate over time are not yet well known; the E3-Thailand simulations assume that useful capital is rebuilt while the MFMod simulations constrain how much is built back.

[20] Burns, Andrew; Campagne, B., Jooste, C., Stephan, D., Thanh Bui, T., (2019), The World Bank Macro-Fiscal Model: Technical Description, World Bank Policy Research Working Paper 8965.
[21] Burns, Andrew; Jooste, C., and Schwerhoff, G., (2021), Climate Modeling for Macroeconomic Policy: A Case Study for Pakistan, World Bank Policy Research Working Paper 9780.

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