



EAST ASIA  
PACIFIC

# THAILAND

Overview

World Bank Group

# COUNTRY CLIMATE AND DEVELOPMENT REPORT

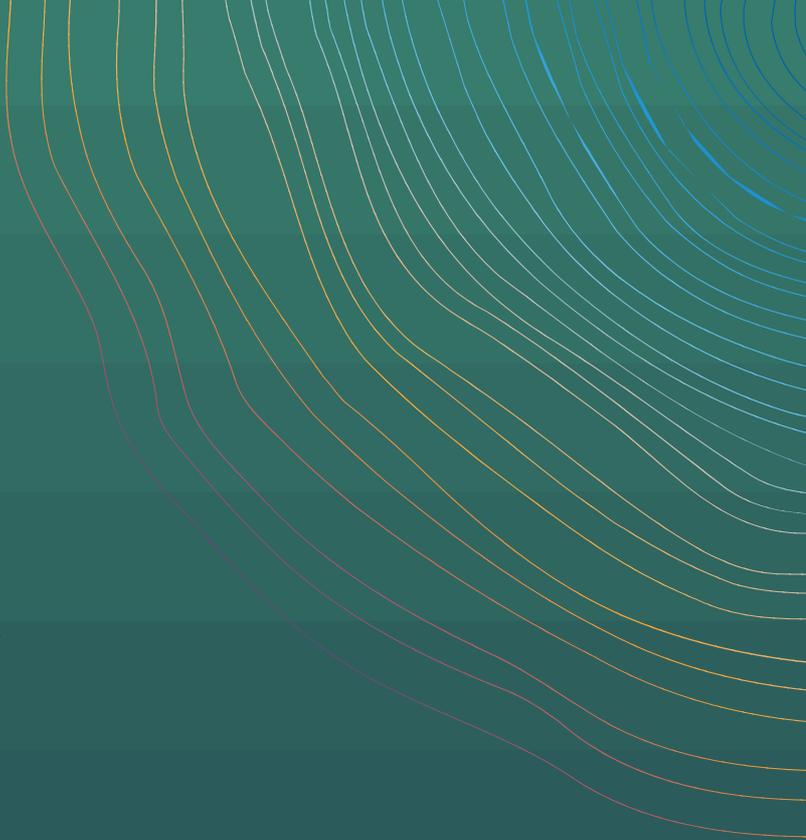
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**The Thailand Country Climate and Development Report (CCDR) identifies how Thailand can achieve economic development which is greener and more climate resilient.** Despite several decades of development success, Thailand's aspirations to become a high-income economy are facing headwinds: investment growth has slowed, structural transformation out of agriculture and into higher value-added activities has stalled, rising global protectionism poses threats to exports, and the population is aging rapidly. Incomes and wealth are concentrated in Bangkok, while other parts of the country struggle to develop. Climate change is reinforcing and exacerbating these challenges. Urban flooding risks are among the highest in the world and Bangkok – which hosts a concentration of Thailand's export-oriented industries – remains especially vulnerable. The relatively poor north and north-eastern parts of Thailand are vulnerable to drought, water shortages, and changing rainfall patterns, which will continue to impact agricultural production, exacerbating existing inequalities. Heat waves and prolonged heat exposure directly impact labor productivity and well-being, as well as increasing risks of illness.

**Although Thailand is not a major emitter, investments and reforms are needed to achieve the country's goals of reaching carbon neutrality by 2050 and net zero emissions by 2065.** Reducing emissions will involve decarbonizing the electricity and transport sectors, investing in cleaner technologies, increasing energy efficiency, and adopting more sustainable climate-smart practices in agriculture. There are compelling co-benefits associated with such measures: lower costs, greater energy security (as fossil fuel dependence declines), improved air quality, and less congestion. At the same time, the global net-zero transition means that Thailand's future comparative advantage will hinge on its ability to lower the emission intensity of its economy, and shift production toward greener goods and services. Thailand is deeply integrated into global value chains and manufactured exports are a key driver of economic activity, equivalent to around half of GDP. Meeting international standards and requirements for greener production of exports is therefore critical. Moreover, the global transition toward sustainability is generating new opportunities for countries like Thailand that have the potential to export more complex green products and offer more sustainable tourism experiences. Thailand's future growth path will depend on its ability to capitalize on these emerging opportunities.

**Thailand must move swiftly to address the physical and transition risks posed by climate change and to seize the opportunities associated with the global shift toward sustainability.** Business as usual is no longer a viable path, and while the costs of required investments are substantial, the costs and risks of inaction are much higher. This Country Climate and Development Report (CCDR) offers a strategic playbook to support climate action in Thailand, complementing existing national plans. It assesses critical risks to the economy, including the direct impacts of floods, droughts, heat stress, and other climate-related disasters, as well as the potential consequences for trade, investment, and private sector activity if progress on emissions reduction and resilience-building falls short. The report outlines concrete actions to help Thailand adapt to the impacts of climate change, reduce its greenhouse gas emissions, and take advantage of green growth opportunities, particularly in sectors where Thailand holds comparative advantages, such as electric vehicle and component manufacturing, solar technologies, and energy-efficient air conditioning. Recognizing that public resources alone will not suffice, the CCDR underscores the vital role of private finance in scaling up investments in adaptation, mitigation, and innovation. As part of its analysis, the CCDR reviews current government plans, identifying implementation challenges, and pinpointing where additional efforts will be required.



## Key findings and recommendations

### 1 Climate action is needed to support Thailand's high-income aspirations.



**Thailand has achieved remarkable development progress, but the recent experience has been less rosy.** Thailand successfully transitioned from a low-income, agrarian economy in the 1970s and 80s to one that is modern, industrialized, and export-driven. But growth has decelerated to an average of 2.6 percent annually since 2010, with sluggish investment, stalling structural transformation away from lower-productivity agriculture, and deepening demographic challenges. Agriculture continues to employ roughly 30 percent of the labor force, a share that has barely shifted over the past decade, despite contributing less than 10 percent of GDP. The country is aging rapidly, with labor force participation starting to decline. Urban congestion, particularly in Bangkok, is curbing productivity, while business regulations and investment restrictions impede competition and innovation.

**Climate change compounds these development challenges, and the poorest are most vulnerable.** The physical impacts of flooding, coastal erosion, water shortages, and heat stress translate into significant economic effects on agriculture, industry and tourism. Moreover, climate change exacerbates the vulnerability of Thailand's poorest people to extreme weather events, disrupting their livelihoods, and increasing their exposure to health risks and economic insecurity. With the top 10 percent of households controlling more than half the country's wealth, Thailand is one of the most unequal economies globally, and this is already a key constraint to faster and more inclusive growth. While incomes and wealth are concentrated in Bangkok and surrounding regions, rural areas, especially in the north and northeast, are significantly poorer and more vulnerable to climate shocks.

**The risks to development are not limited to physical climate impacts.** Thailand is not a major contributor to global climate change, but its per capita emissions surpass those of several neighboring ASEAN countries. The global shift in demand toward low-carbon goods and services means that Thailand's future comparative advantage may depend on its ability to lower the emissions intensity of production. For instance, initiatives such as the EU's Carbon Border Adjustment Mechanism could have larger impacts if they are expanded to a wider set of products or services and/or if other countries implement similar measures. In pursuit of their own climate goals, multinational corporations may start avoiding countries with carbon-intensive supply chains (and especially carbon-intensive electricity generation). Without a timely and credible decarbonization strategy, Thailand may face rising production costs, stranded assets, and reduced access to key export markets.

**There is therefore a strong development imperative for action on both climate adaptation and emission reduction.** Conversely, achieving high income status is likely to be very difficult in the absence of climate action. To achieve its vision of becoming a high-income country by 2037, Thailand must grow at about 5 percent annually – achieving growth at this pace will become even harder if climate risks, which could

knock an additional half a percentage point or more off average annual growth rates over the next one to two decades, are left unaddressed. On the other hand, adaptation can limit the losses and damages associated with climate shocks, reduce the risks of extreme events, and protect the most exposed and vulnerable. Similarly, mitigation efforts are needed to limit the risks to Thailand's economic competitiveness of failing to decarbonize. Cutting emissions in key sectors will ultimately lower costs and dependence on fossil fuel imports, reduce Thailand's vulnerability to shifts in consumer preferences for greener goods and services, and position the private sector to benefit from international efforts to green global supply chains.

## 2 The risks of inaction on adaptation are large, but much can be done to bolster resilience and support the most vulnerable.



**Without additional action on adaptation, climate change will have increasingly severe impacts on the Thai economy.** Agriculture is vulnerable to the labor productivity impacts of heat stress, and the impacts of droughts and water shortages, with highly water-intensive rice production especially susceptible. Manufacturing is concentrated in and around Bangkok and is vulnerable to urban flooding; 70 per cent of the recorded damages and losses from the 2011 floods were attributed to the manufacturing sector, mainly from flooding in industrial estates in Ayutthaya and Pathum Thani. Water supply constraints faced by industry in the Eastern Economic Corridor – which accounts for approximately 15 percent of Thailand's GDP – are also likely to worsen with climate change. Tourism faces mounting risks from coastal erosion, heat stress, and flooding, while warmer water temperatures and acidification are already affecting coral reefs and marine ecosystems.

**Thailand is among the ten most flood-prone countries in the world and the impacts of climate change are expected to intensify, but cost-effective adaptations are available.** The Chao Phraya river basin, home to 40 percent of Thailand's population, 78 percent of its workforce, and 66 percent of its GDP, will suffer from an increasing intensity and frequency of floods. The 2011 floods, triggered by tropical storms, affected 13.6 million people across 65 provinces, caused 815 deaths, and inflicted damages equivalent to 12.6 percent of GDP. Projections suggest that the number of people affected by floods between 2035–2044 could be 2.5 times higher than in 2010, and over this period the return periods of major floods will shorten dramatically. While significant investments have been made, further action is needed. The Chao Phraya “Nine Plans” offer a comprehensive solution to managing flood risk through upstream dams, bypass channels, and improved drainage infrastructure. Implementing these plans, combined with complementary measures to improve land management and zoning, conserve forest areas in the upper basin, and enhance early warning systems, could together mitigate most of the expected annual damages, lowering the costs of floodproofing individual buildings and infrastructure.

**Water availability is an emerging constraint on development and climate resilience.** Changes in weather patterns are increasing the frequency of droughts and exacerbating water shortages in agriculture – which accounts for over 70 percent of national water withdrawals – especially in the north and north-eastern provinces. As one of the world's largest rice exporters, Thailand's agricultural sector demands

vast amounts of water for irrigation, with traditional rice farming methods heavily reliant on flooding fields. Industrial activity is also being affected by water supply constraints, including in the Eastern Economic Corridor. Currently only around half of water demand in the EEC is being met, and in 2037 the deficit is projected to remain high at about 40 percent, increasing to 72 percent in dry years. Competition for water between agricultural needs and other sectors is increasing. More integrated approaches to water resource management, investments in wastewater treatment and storage infrastructure, and increased efficiency in water use are needed to alleviate these water supply constraints; international experiences (including e.g. in California) suggest that such measures can feasibly be implemented to decouple water use and private sector growth.

**Coastal erosion is accelerating along Thailand's densely populated and economically important coastlines.** Over the past three decades, up to 30 percent of the Thai coastline has suffered from erosion, resulting in total land loss of around 12000 hectares. 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 additional tourism revenue losses along this coastline could reach around USD 1 billion (in constant 2025 prices) by the mid-2040s in a no-adaptation scenario. Recent investments in hard infrastructure have provided temporary protection but can be costly to maintain and inflexible to worsening climate conditions. If poorly coordinated, these measures can also shift flood risk to neighboring areas, while seawalls can disrupt sediment flows, exacerbating erosion elsewhere. But investment in nature-based solutions, such as mangrove reforestation and beach nourishment, can buffer storm surges and reduce erosion. Such investments would unlock additional tourism revenues that far outweigh the investment costs and generate substantial co-benefits such as fisheries protection and carbon sequestration.

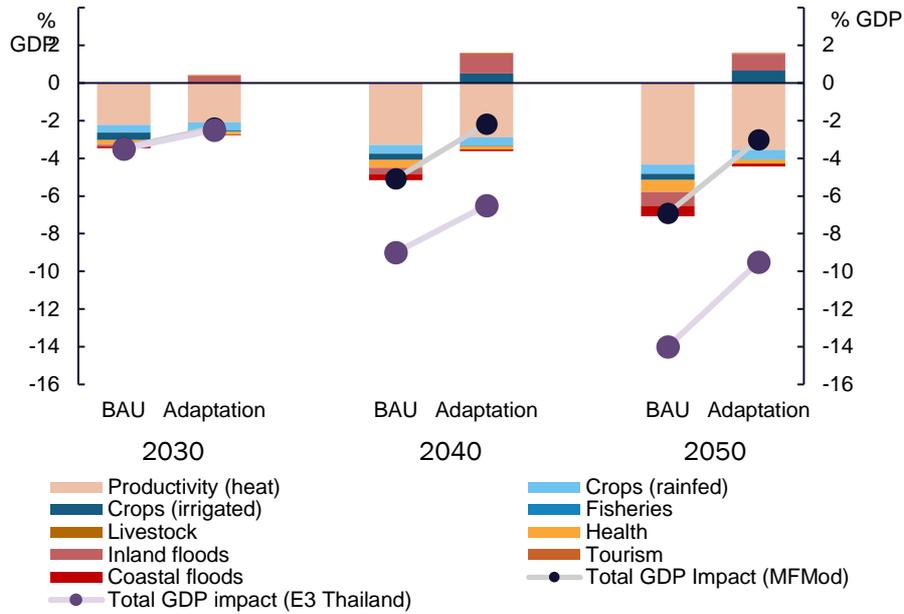
**Heat stress is projected to significantly reduce labor productivity, particularly in Bangkok and industrialized provinces.** Heat stress can affect the productivity of workers, 61.5 percent of whom work outdoors, and increases risks from heat-related illnesses. Labor productivity could decline by 14 percent in agriculture and by 5 to 7 percent in services and industry by 2050, with significant impacts on overall economic activity. Overheated classrooms can make it difficult for children to concentrate and learn. The Urban Heat Island effect causes some parts of Bangkok to experience nighttime temperatures up to 6 °C higher than rural surroundings. Urban greening, climate-sensitive zoning, and improved building codes are being implemented to help reduce local temperatures, but some heat hotspots and vulnerable populations remain underserved.

**Agricultural systems are increasingly exposed to climatic shocks, especially droughts and floods.** By 2040, climate change is projected to reduce national rainfed crop production by 12 percent and irrigated crop production by 7 percent in the hot/dry scenario, primarily due to heat stress and reduced water availability. Climate-smart agriculture practices—including improved irrigation, pest and nutrient management, and stress-tolerant seed varieties—are essential for safeguarding rural incomes and food security. But scaling adoption requires repurposing agricultural support, targeted investments, and stronger linkages with agribusinesses. Subsidies should be redirected away from price support schemes and toward incentives for established technologies such as Alternate Wetting and Drying (AWD) in rice, Site-Specific Nutrient Management (SSNM), and biogas systems in livestock production. Public investment in agricultural R&D, extension services, and risk management tools – including weather index-based insurance – can also support farmers in adapting to climate change.

**In a hot/dry climate scenario, modelling conducted for this CCDR indicates that climate change could lower GDP by between 7 and 14 percent by 2050 (Figure O.1).** This is compared to a baseline with no further climate change over the next 25 years. The models suggest that heat impacts on labor productivity and the capital losses and production disruptions associated with flooding will have the largest economic impacts. While substantial, these average annual impacts understate the physical risks of climate change: they do not incorporate the effects of already realized climate change on the Thai economy, nor do they preclude the need to prepare for a much larger shock (such as a 1 in 50 year flood) that could hit in any given year. Another risk is an 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 increased storm intensity. While not accounted for in the modelling, this could have substantial economic impacts: one in four Thais could be directly affected while the capital region accounts for half of national GDP.

**Figure Error! No text of specified style in document..1: Climate change could have pronounced economic effects**

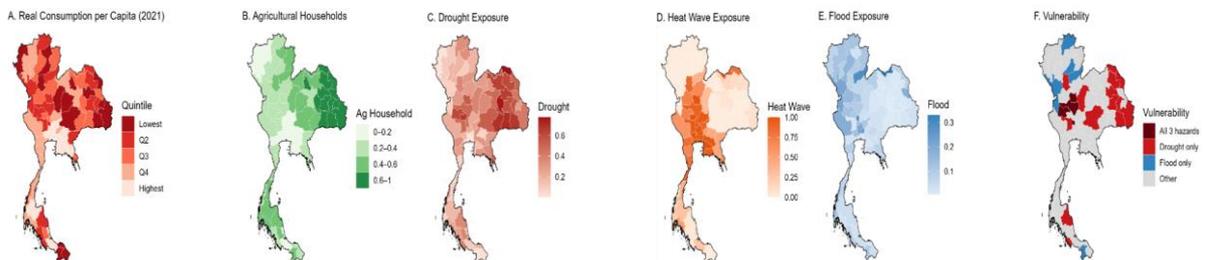
Projected impacts on GDP in a hot/dry scenario, relative to a baseline with no additional climate change



Notes: The GDP impacts from MFMMod (black dots) are also disaggregated across sectors (stacked columns), but the GDP impacts from the E3 Thailand model (purple dots) are presented only as the total aggregated effect.  
Source: World Bank analysis.

**Impacts on people could be correspondingly severe, with the poorest and the most vulnerable likely bearing the highest cost.** Thailand's water scarce and flood prone areas are also some of the poorest in the country. These places are characterized by high dependence on rice-based agriculture and fisheries, which are particularly sensitive to heat and drought conditions (Figure O.2). They also tend to have high dependency ratios, and weaker community response systems, as well as a lack of infrastructure, education, and healthcare which further compounds these challenges. While severe floods can affect all types of households, impacts are typically larger for poorer households. In the aftermath of the 2011 floods, for example, richer households primarily faced losses in business incomes and were able to build back more quickly in subsequent years. Poorer households were most affected due to losses in agricultural incomes and were slower rebuilding their homes and livelihoods. Government compensation was not only inadequate to cover the full extent of these losses but also ended up benefiting relatively richer households rather than the poor.

**Figure Error! No text of specified style in document..2: Many of Thailand's drought and flood-exposed areas are also relatively poor**



Notes: Hazard exposure is measured as the share of population likely to be affected by 20-year return period event, with separate estimates for drought, heatwave and flood risks as described in Doan et al (2024). A province is classified as vulnerable if it is in the bottom 40 percent of the average per capita consumption distribution and top 40 percent in terms of exposure to a given hazard.

Source: Doan, M.K.; Hill, R.; Hallegatte, S.; Corral Rodas, P.A.; Brunckhorst, B.J.; Nguyen, M.; Freije-Rodriguez, S.; Naikal, E.G. (2024). "Counting People Exposed to, Vulnerable to, or at High Risk From Climate Shocks – A Methodology". Policy Research Working Paper; WPS 10619, World Bank.

**While the risks of inaction are large, this report identifies several key investments and actions that can reduce the damage and losses associated with climate change.** The above results apply to a scenario in

which no adaptation reforms or investments are undertaken beyond current plans; on the other hand, 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. 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. Complementary measures such as early warning systems and better land use planning, as well as institutional reforms to drive better cross-government and central-local coordination on adaptation measures, could further add to these economic gains.

**While adaptation measures can reduce climate vulnerabilities, social protection is a key mechanism for building household-level resilience to climate shocks.** The adaptation measures outlined above will reduce some but not all climate impacts, and some of Thailand's poorest and most vulnerable populations will remain exposed to climate shocks. Scaling up social protection will therefore be a critical adaptation response. 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 very low. Assistance provided in the aftermath of climate-related disasters has fallen short of fully addressing the needs of those affected. In the aftermath of the 2023 floods, for example, the assistance provided covered only about 20 percent of the estimated loss in incomes. 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. A unified social registry – building on advances during the COVID-19 pandemic – would improve delivery efficiency and targeting, ensuring that assistance quickly reaches those affected by climate events.

## Key recommendations

1. Fully implement the “Nine Plans” to mitigate the impact of floods in the Chao Phraya basin. Complement these investments with efforts to promote sustainable watershed management through reforestation and wetland restoration; enforce climate-smart land use planning and floodplain zoning to steer new development away from high-risk areas; and expand and modernize early warning systems and hydrometeorological services.
2. Scale up nature-based solutions 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 identified beaches along the Gulf of Thailand and the Andaman Sea. Blend green and grey infrastructure through a combination of mangrove buffers and low-impact barriers. Adopt a more integrated approach to coastal protection, engaging local communities and the private sector.
3. Adopt a multi-pronged strategy to address water deficits in the EEC: pursue water conveyance projects; scale-up wastewater treatment; and reduce water demand via improvements in efficiency.
4. In drought-prone agricultural areas in the north and north-east, integrate provincial water planning and mobilize financing for small- to medium-scale retention ponds, canals, and small-river networks. Actively encourage and facilitate local participation in planning and implementation.
5. Support policies and investments to cool indoor public and residential spaces; including by subsidizing lower-income households. Expand public cooling centers by repurposing public facilities and implement targeted outreach programs to identify and protect the most vulnerable.
6. Repurpose agricultural public expenditure away from distortionary price support schemes and toward investment in R&D, extension services, and climate smart agriculture (CSA) technologies. Help scale CSA practices by embedding economic incentives for collective actions which reduce the fixed costs of investment and facilitate enforcement of sustainability standards necessary for accessing high-value export markets. Overhaul land and regulatory systems (e.g. insecure land tenure, cumbersome laws on plant variety registration) to incentivize innovation and sustainability. Support greater use of weather index-based insurance by farmers.
7. Increase the regular and post-disaster benefits provided to State Welfare Card (SWC) holders who are exposed to climate risks, building both *ex ante* and *ex post* resilience to climate shocks. Integrate programs through the establishment of a unified social registry and improve targeting via hybrid proxy means tests.

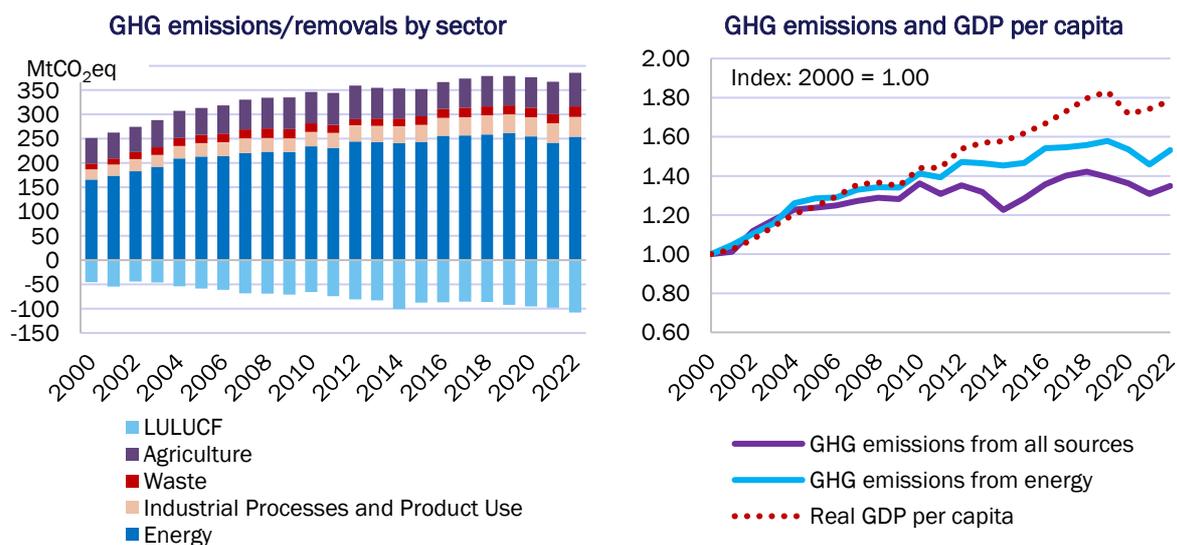


### 3 Decarbonization makes economic sense for Thailand: to achieve net zero a range of investments and reforms including carbon pricing will be needed.



Thailand’s economic growth is decoupling from GHG emissions, but achieving Thailand’s goals of carbon neutrality and net zero emissions will require substantial investments and policy effort. While Thailand is not a large emitter of GHG emissions in global terms, substantial work remains to be done to achieve carbon neutrality and net zero objectives, with emissions not yet showing signs of declining as they have in many high-income countries. Between 2010 and 2022, real GDP per capita increased by 1.8 percent per year on average, while GHG emissions from all sources were flat and GHG emissions from energy (which accounts for around two-thirds of total emissions) increased by an average of 0.7 percent (Figure O.3). Projections indicate that international commitments to achieve carbon neutrality by 2050 and net zero GHG emissions by 2065 will not be met in the absence of further action.

**Figure O.3: Greenhouse gas emissions have stabilized but are not yet declining**



Source: Thailand 2024 Biennial Transparency Report and World Development Indicators

While effective carbon pricing mechanisms will be a key driver of this transition, they will not be sufficient to deliver transformational change. A well-designed carbon price can help market actors internalize the environmental costs of emissions, shift investment and consumption patterns, and generate revenue to support green innovation and a just transition, while minimizing adverse distributional impacts. But while a carbon price would support efficiency improvements and the adoption of cleaner technologies, it would not on its own lead to transformational change. For instance, carbon pricing would only have a limited impact on fuel prices and EV adoption. In the power sector, carbon price signals will not work if the sector is not liberalized to allow more market-based competition.

**A suite of investments and reforms beyond carbon pricing will be needed to achieve Thailand's longer-term decarbonization objectives.** Modelling undertaken for this CCDR indicates that a more concerted effort to reduce emissions could help Thailand meet its carbon neutrality and net zero targets. This “accelerated decarbonization” scenario includes reforms to remove preferential treatment for fossil fuel generators and to streamline interconnection processes for utility-scale and distributed renewable energy projects in the power sector, both of which would incentivize the inclusion of lower-cost renewable generation, particularly solar. Carbon pricing becomes much more effective in such a system. Investments in battery storage, grid modernization, and regional interconnectivity would all help to offset renewable intermittency. Energy efficiency mandates and subsidies would prompt manufacturers to improve efficiency, over and above the impact from carbon pricing. Investments in charging infrastructure, electrification of public vehicles, and incentives and mandates to shift heavy vehicles to biofuels could together reduce road transport emissions sharply. Low-carbon farming technologies would be adopted at scale, and investment in reforestation scaled up significantly, alongside strengthened land management practices and legal frameworks. As a result, forest coverage would increase to 40 percent of Thailand's land area (from 31.6 percent in 2020) and annual carbon removals from land use and forestry would rise. This package of measures could allow Thailand to meet its carbon neutrality target without undue reliance on carbon capture and storage, which faces significant challenges such as high costs, limited infrastructure, and regulatory gaps.

**Accelerated efforts to reduce emissions have the potential to raise economic activity.** Thailand's GDP in 2050 is projected to be 2.5 percent higher under the accelerated decarbonization scenario compared to a baseline with no mitigation action. In the short-term GDP growth is mainly driven by increased investment spending, particularly in renewable energy. In the long term, most GDP gains stem from higher household consumption, supported by more affordable renewable energy, as well as reduced fuel imports, as consumers and businesses shift more of their spending toward domestic production.

**Emissions reduction will also help Thai exporters to remain competitive in the context of stricter climate policies in key export markets and private sector efforts to make value chains greener.** International decarbonization efforts could negatively affect exporters of Thai goods and services if Thailand's emission reduction efforts lag behind. Currently, the impact on Thailand's export competitiveness is limited: the EU's Carbon Border Adjustment Mechanism (CBAM) is expected to have only a marginal effect given the structure of Thailand's exports. However, these risks could grow if CBAM's scope expands or if other countries implement similar measures. Furthermore, more than three quarters of multinational companies reportedly have plans to exclude high-carbon producers from their supply chains starting in 2025. Proactive emissions reduction measures will help mitigate these risks to Thai companies.

**Under the accelerated decarbonization scenario, Thailand also stands to gain substantial air quality and public health benefits.** By 2050, energy-related CO<sub>2</sub> emissions are projected to fall to just a third of business-as-usual levels, driven by a rapid transition to renewable energy, widespread adoption of electric vehicles, and deployment of energy-efficient technologies. These shifts result in a sharp decline in harmful air pollutants such as PM<sub>2.5</sub>, NO<sub>x</sub>, and SO<sub>2</sub>, particularly from fossil fuel combustion in the power and transport sectors, potentially avoiding over 15,000 premature deaths annually by 2050. This translates into major health gains for the population, including fewer cases of respiratory and cardiovascular illness, lower public health expenditures, and improved labor productivity.

## Key recommendations

1. Pursue power market reform to promote competition in the power sector and accelerate the adoption of renewable energy (RE). Reform the Enhanced Single Buyer Model to incentivize private renewable investments and expand grid access for decentralized renewables. This includes liberalizing grid access by removing preferential treatment for fossil fuel generators and streamlining interconnection processes for both utility-scale and distributed RE projects. Such reforms will also ensure that carbon price signals help to incentivize renewable investments. Competitive procurement mechanisms—such as auctions or capacity markets backed by long-term power purchase agreements—would offer investor certainty and ensure cost-effective deployment. Introducing PPAs for direct access to renewable energy sources would be an important step to facilitate private sector use of sustainable energy.
2. Invest in grid modernization and regional integration to enhance energy security and enable a renewables-led transition. To ensure that a growing share of intermittent RE can be effectively integrated while maintaining system stability, Thailand must deploy advanced grid management technologies, and demand

response and storage solutions. In addition, it should invest in high-voltage direct current (HVDC) systems and cross-border transmission infrastructure to facilitate energy trading and manage intermittent supply.

3. Approve the Climate Change Act to reduce private sector uncertainty and set a transparent framework for carbon pricing in Thailand. In the manufacturing sector, the implementation of a carbon price mechanism that targets top emitters should be considered. Since manufacturing sector emissions are concentrated among a few large firms, applying carbon pricing only to major emitters can deliver substantial reductions while lowering administrative and compliance costs for SMEs, which dominate employment but contribute much less to total emissions.
4. Strengthen energy efficiency standards across buildings, appliances, and industrial equipment, and provide targeted financial incentives—such as subsidies and low-interest loans—to support households and businesses in adopting energy-efficient technologies, retrofitting existing systems, and conducting energy audits. This CCDR estimates that an average of US\$2 billion in additional annual investment—equivalent to around 0.2 percent of GDP—will be needed over the next 25 years to scale up energy efficiency and deliver additional energy savings of around 18 percent (beyond what carbon pricing alone would achieve).
5. Enforce standards for low-carbon cement, mandate Environmental Product Declarations (EPDs), and incentivize clinker substitution. Investment in alternative binders and co-processing frameworks for alternative fuels is critical. Carbon capture, utilization, and storage (CCUS) may be deployed in cases where it is technically and financially feasible.
6. Invest in public charging infrastructure to accelerate EV adoption, especially for users without home chargers or concerned about range. EV purchase subsidies should be phased out as the market matures and as the upfront price of EVs becomes cost-competitive. For heavy-duty vehicles that are hard to electrify, implement biofuel incentives or mandates as a low-carbon alternative. As passenger cars transition away from consuming liquid fuels, additional biofuel capacity should become available for heavy vehicles.
7. Reform agricultural subsidies e.g. to support investment in biogas digesters and precision agriculture tools, implement anti-burning regulations, and strengthen farmer education to providing training on emissions reducing techniques such as alternate wetting and drying and site-specific nutrient management.
8. Invest in forest coverage, prioritizing the restoration of critical ecosystems like mangroves in coastal provinces and degraded upland watersheds with native species. Scale up community forestry programs granting legal management rights to locals to reduce illegal logging.

## 4 Thailand should move swiftly to seize the economic opportunities associated with global transition.



**Thailand's export-driven growth model faces mounting pressures, with decisive steps needed to mitigate emerging risks and seize new opportunities.** Thailand's impressive growth and poverty reduction record has been closely linked to its success in expanding manufactured goods and tourism exports. However, export growth has slowed in recent years, and the global trade landscape has become increasingly uncertain, marked by rising protectionism, fragmented trade rules, and the restructuring of global supply chains—all of which threaten Thailand's market access and competitiveness. Compounding these challenges, the post-pandemic acceleration of disruptive technologies—including green technologies—is

reshaping global production and trade dynamics. Thailand's traditional export model faces challenges in this shifting context.

**One key opportunity for Thailand is the rising global demand for green, low-emission technology: while Thailand's green exports are growing, they lag structural peers and major exporters.** Thailand's exports of green products as a share of total exports have been rising steadily, following a similar trend to its East Asia and Pacific (EAP) peers. Thailand has already made strides in some green sectors. It is the world's leading exporter of eco-friendly air conditioners and accounts for 4.2 percent of global solar photovoltaic (PV) exports. The country is also rapidly emerging as a hub for electric vehicle (EV) production, attracting significant foreign direct investment (FDI). However, as a proportion of its total exports, Thailand's green exports share remains below structural peers and far behind high income exporters of green products, as well as several countries in EAP.

**Thailand has substantial potential to export more complex green products.** Based on the Green Complexity Index, a measure of a country's *current* ability to export green complex products competitively, Thailand's ranks higher than most regional peers but below structural peers and the major exporters of green complex products. However, among regional peers, Thailand has the highest untapped *potential* (as measured by the Green Complexity Potential index); indeed, on this measure Thailand ranks among the highest of all middle-income countries. Thailand exhibits strong export competitiveness across various sophisticated green and renewable energy products and has particularly high potential to increase its participation in the value chains for energy efficient air conditioners and appliances, solar PV components, and carbon capture storage technology. Thailand also has the potential to expand exports of green agricultural and food products to high-value markets, though investments are needed to meet sustainability requirements.

**Thailand's automotive exports are currently carbon intensive but offer strong potential for a green transition towards EVs; this shift has implications for labor demand.** Thailand has potential to expand EV production and increase exports, leveraging its well-established capabilities in electrical and electronics, body, and chassis manufacturing. While some components will need to be adapted for EVs, many existing parts can continue to be produced with minimal modifications. Nevertheless, the transition to electric vehicles will shift the demand for workers' skills. Job postings data reveal that 21 percent of job postings related to low carbon technologies in Thailand were in the electric vehicles sector, and over 90 percent of these roles require high-level skills. To meet these demands, existing automotive suppliers may need to upskill their workforce or recruit international expertise.

**Capitalizing on these green export opportunities could see Thailand's overall exports rise by 2030, but this will require policy action on several fronts.** Strengthening participation in Green Global Value Chains (GVCs) will require capacity-building initiatives for SMEs, fostering public-private collaboration, and ensuring research and innovation efforts align with industry needs. Improving Thailand's investment climate will be essential to continue attract foreign direct investment (FDI) and facilitate technology diffusion. And developing a skilled workforce will be crucial to sustaining Thailand's green industrial transition. With such shifts, Thailand's exports of electric vehicles and parts, solar PV components and modules, and energy-efficient air conditioners could rise by an additional 2-3 percent of GDP by 2030, and expand further in subsequent decades.

## Key recommendations

1. Improve Thailand's investment climate to attract foreign direct investment (FDI) and facilitate technology diffusion. By removing market-entry barriers, ensuring fair competition, and fostering a business-friendly regulatory environment, Thailand can provide firms with more incentive to upgrade their production processes and adopt new green technologies.
2. Ensure that foreign investment in the EV industry builds local capacity. The EV industry has benefited from various incentives, including most recently (as part of the EV 3.5 package) import duty and tax cuts, subsidies, and non-tax benefits related to visas, work permits, and land ownership. While these incentives have helped to attract foreign investment, investors should also be encouraged to facilitate an infusion of international expertise to Thailand in the form of technological transfer, skills development, and employment of local workers.
3. Prioritize high-tech skill development in digital technologies, engineering, and sustainable manufacturing, while implementing targeted talent attraction policies to address immediate skill gaps. These efforts should

be closely coordinated with the private sector to ensure that educational and training curricula remain aligned with rapidly evolving technological needs. There is also a need to raise standards of basic education so that Thailand's children are better equipped to think critically, learn new skills, and fully benefit from higher education and technical training, in line with industry needs. Government-supported training and certification programs—particularly for technicians such as EV mechanics and solar panel installers—are essential to building a skilled workforce and mitigating job displacement from the legacy auto sector.

4. Review public support for green innovation. Government support for green innovation and climate technologies in Thailand remains largely concentrated within public institutions, with relatively limited engagement of the private sector as direct beneficiaries. To strengthen the green innovation ecosystem, greater use could be made of policy instruments that support non-R&D-based innovation. These include innovation vouchers, de-risking facilities such as partial credit guarantees for green investments, and early-stage support programs targeting startups developing new green technologies.

## 5 Substantial climate financing needs can be met with carbon pricing, revenue reforms, and efforts to mobilize private capital.



The total additional investment needs estimated by this CCDR for responding to climate change are USD219 billion in discounted (NPV) terms over the next 25 years (USD 406 billion undiscounted). This is equivalent to 2.4 percent of cumulative GDP over this period. It includes USD 105 billion for climate adaptation, USD 96 billion for mitigation, and USD 19 billion for investments in climate smart agriculture and forests, which have both adaptation and mitigation benefits (**Error! Reference source not found.**). This is the incremental investment needed for key adaptation measures prioritized in this report and to achieve carbon neutrality by 2050, relative to a BAU scenario of no additional action or investment. It excludes O&M savings, most of which would accrue to the private sector.

**The bulk of adaptation spending is expected to be done by the public sector, while the private sector will take on more than half the investments in mitigation.** In the energy sector, for example, clean energy investments are expected to be made primarily by private producers, who will benefit from reforms to liberalize the power market and establish a carbon price signal, as well as public investments in grid modernization. In the transport sector, the shift to e-mobility and biofuels is expected to be financed primarily by vehicle owners. On the other hand, when it comes to adaptation, the public sector will be primarily responsible for spending on adaptive social protection, flood prevention, and water security, given the public goods aspects of many of the required interventions. Indeed when it comes to reducing the impact of flooding in the Chao Phraya basin, the proposed “Nine Plans” (which would be publicly financed) would cost-effectively reduce the need for flood-proofing of individual buildings and structures. The additional public adaptation spending needs would average around 1 percent of GDP per year over the next 25 years, equivalent to around USD 7.5 billion per year, a substantial addition to the estimated 117-137 billion THB (3.4-4 billion USD) of current annual climate-related spending.

**The revenue generated by carbon taxes will help to finance mitigation and adaptation investments, as well as increased social protection spending.** Public investment needs are largest over the next decade,

and then – with the exception of social protection spending – taper over time. After accounting for carbon price revenues, the marginal impact on public debt (relative to the BAU scenario) is projected to peak in 2036 before declining due to the reduction in spending needs and the increase in GDP associated with making the recommended adaptation and mitigation investments. Additional tax and social protection reforms could further reduce the impact on public debt and improve the welfare of the poorest.

**Improved planning and budgetary processes would promote more efficient spending on climate investments.** Fragmentation among fiscal authorities means that no single entity oversees the achievement of economic, fiscal, or climate change targets from an integrated perspective, diluting accountability for results. It also disconnects the planning system from the budgeting system, which means that many climate plans are essentially unfunded. The government has multiple, overlapping multi-year plans related to climate adaptation and mitigation, but these plans are not effectively linked or informed by the medium-term resource envelope, and proposed investments are not costed, appraised, and prioritized. Institutional reforms are needed to strengthen the role of the Budget Bureau, Ministry of Finance, and National Economic and Social Development Council (NESDC) in mainstreaming climate considerations into fiscal policy.

**Table O.1: Additional climate investment needs (2025-2050), USD million**

|  | Undiscounted, nominal |                |                | Total          | Net present value @ 6% | As % of GDP |
|--|-----------------------|----------------|----------------|----------------|------------------------|-------------|
|  | 2025-30               | 2031-40        | 2041-50        |                |                        |             |
| <b>Adaptation</b>                                  |                       |                |                |                |                        |             |
| Flood protection (Chao Phraya basin)               | 4,700                 | 9,400          | 0              | 14,100         | 8,613                  | 0.09        |
| Flood proofing of buildings and infrastructure     | 11,950                | 23,900         | 11,950         | 47,800         | 25,861                 | 0.28        |
| Coastal protection (Gulf of Thailand)              | 1,892                 | 781            | 173            | 2,846          | 2,058                  | 0.02        |
| Water availability (agriculture and EEC)           | 7,265                 | 12,092         | 10,955         | 30,311         | 15,451                 | 0.15        |
| Social protection                                  | 17,805                | 43,784         | 55,369         | 116,958        | 52,418                 | 0.57        |
| Energy efficient air conditioning                  | 240                   | 400            | 400            | 1,040          | 520                    | 0.01        |
| <b>Total adaptation</b>                            | <b>48,390</b>         | <b>98,784</b>  | <b>87,274</b>  | <b>234,449</b> | <b>115,427</b>         | <b>1.1</b>  |
| <b>Mitigation</b>                                  |                       |                |                |                |                        |             |
| Power – renewable energy and grid modernization    | 32,718                | 6,501          | (15,030)       | 24,189         | 26,864                 | 0.29        |
| Energy efficiency                                  | 7,127                 | 18,332         | 25,952         | 51,411         | 22,394                 | 0.24        |
| EV charging infrastructure                         | 26,718                | 20,745         | 10,377         | 57,840         | 35,755                 | 0.39        |
| Investment in hard-to-abate industries (inc. CCUS) | 2,228                 | 7,425          | 17,325         | 26,978         | 10,594                 | 0.11        |
| <b>Total mitigation</b>                            | <b>68,791</b>         | <b>53,002</b>  | <b>38,625</b>  | <b>160,418</b> | <b>95,607</b>          | <b>1.0</b>  |
| <b>Agriculture and forests</b>                     |                       |                |                |                |                        |             |
| Reforestation                                      | 7,500                 | 7,500          | 0              | 15,000         | 10,415                 | 0.11        |
| Climate-smart agriculture                          | 3,455                 | 6,589          | 7,412          | 17,455         | 8,355                  | 0.09        |
| <b>Total agriculture and forests</b>               | <b>10,955</b>         | <b>14,089</b>  | <b>7,412</b>   | <b>32,455</b>  | <b>18,770</b>          | <b>0.2</b>  |
| <b>Total investment needs</b>                      | <b>123,597</b>        | <b>157,448</b> | <b>124,884</b> | <b>405,928</b> | <b>219,298</b>         | <b>2.4</b>  |

Source: World Bank analysis.

Notes: “% of GDP” figures calculated by dividing the NPV of recommended investments by the NPV of projected future GDP.

**Thailand also needs to mobilize climate finance at scale to fund the necessary adaptation and mitigation investments.** Globally, climate finance flows are available and substantial. The financial sector should play an active role in mobilizing and allocating this capital through instruments such as sustainability-themed bonds, green loans, and insurance.

**With substantial growth in recent years, Thailand's bond market has played an increasing role in channeling private capital towards climate investment.** Nevertheless, the green and sustainable finance markets have not yet reached the scale required to meet Thailand’s climate goals. While Thailand is ahead of some regional peers, its sustainable debt market—with less than 1 percent of GDP in new issuance annually—is much shallower than that in advanced economies and some emerging market and developing economy (EMDE) counterparts. The Thai government has been the largest issuer of Thailand’s sustainability bonds, accounting for almost 70 percent of the total ESG bond market. Thailand's voluntary carbon market shows significant growth, albeit off a very small base, and could play an increasing role in financing climate investment.

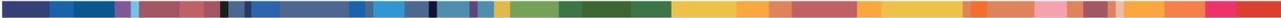
**Demand side challenges, including limited awareness, expertise and policy incentives, as well as high issuance costs, constrain further market growth.** ESG and climate finance literacy remains low among borrowers in Thailand, especially mid-sized corporates and SMEs, limiting demand for sustainability-linked loans, green credit lines, and labeled bonds. While large firms have made progress, smaller

enterprises often lack the resources and expertise to adopt ESG-aligned financial strategies. Policy incentives for green finance also remain limited; existing tax measures, such as those for energy efficiency, are not comprehensive enough to drive industrial decarbonization, EV adoption, or circular economy efforts. In contrast, peers like Viet Nam and Malaysia offer more structured tax incentives. The high cost of issuing sustainable bonds and accessing green loans further dampens demand.

**Investors also face several supply-side constraints, including information barriers and a lack of bankable projects.** Thailand's sustainable finance landscape is held back by inconsistent green finance definitions and a lack of standardized methodologies for identifying green assets, creating information barriers for financial institutions. While the taxonomy aims to address these gaps, its early-stage implementation requires greater capacity building and policy support. Climate projects are often not viewed as bankable because of regulatory uncertainty, inadequate de-risking tools, weak revenue structures, and a lack of standardized financial instruments. These challenges limit investment in sectors like blue finance, EV infrastructure, renewables, and industrial decarbonization. Moreover, most green finance currently targets mitigation: there may be opportunities to expand the supply of finance for adaptation but this would require strengthening institutional and technical capacity to prepare climate resilience projects.

## Key recommendations

1. In addition to revenues from carbon pricing instruments, additional tax reforms could further reduce the impact of pursuing recommended adaptation and mitigation investments on public debt. Increasing the Value Added Tax (VAT) to 10 percent and reducing exemptions, together with reforms to personal income tax and property taxes, could together increase revenues by 3.5 percentage points of GDP. When combined with social assistance reform (higher and better targeted benefits), the full package of measures can be progressive overall, while being more than sufficient to finance the additional spending needs highlighted in this CCDR.
2. Provide incentives to encourage financial institutions to deepen their offering of products like green loans, green bonds, and sustainability-linked bonds and loans. De-risking financial instruments should be provided to encourage private-sector participation in green infrastructure.
3. Customize climate financial solutions to fit MSME needs: smaller firms are particularly vulnerable to the impacts of climate change, yet they often lack the financial resources and expertise needed to adapt. Financial institutions should be incentivized to provide accessible, affordable financing options like green loans and grants with favorable terms to MSMEs.
4. Further strengthen the sustainable finance ecosystem through improved climate finance tracking, taxonomy implementation, and enhanced disclosure practices. More accurate climate finance data are required to support optimal decisions for capital allocations. With frameworks and tools such as the Thailand Taxonomy in place, the next step is rigorous implementation, which requires both regulatory and industry actions to develop practical guidelines, enhance enforcement, and incentivize adoption. ESG disclosure requirements could be strengthened.
5. Continue to strengthen market infrastructure for carbon credit issuance and trading and promote more financial innovations linked to the carbon market. As Thailand prepares to launch a national Emissions Trading System (ETS) alongside its existing voluntary program (T-VER) and continued participation in global compliance mechanisms (CDM, Article 6), there is an urgent need for a coherent legal and regulatory framework. Actions should also be taken to enhance the origination of high-quality carbon credits for sale in international markets by aligning Thailand's domestic standards with rigorous international benchmarks, and by developing effective credit aggregation mechanisms.



## An agenda for action

The table below provides a structured, actionable outline of the report's recommendations for policymakers. To guide implementation, the recommendations are prioritized based on their direct impacts (on adaptation, mitigation, green growth, and climate financing objectives), their co-benefits for Thailand's broader socio-economic development, and the desired time frame for implementation. Five key sets of measures (highlighted in blue) – on flood mitigation, water security, social protection, carbon pricing, and energy – emerge as the highest priority recommendations.

| Priority Area  | Key Actions   | Direct impacts* | Development co-benefits | Time frame  |
|--|---|-----------------|-------------------------|-------------|
| <b>Adapting to climate change</b>  |   |                 |                         |             |
| Flood mitigation   | Commence full implementation of the “Nine Plans” and complementary flood protection measures  | Very high       | High                    | Short-term  |
| Coastal protection   | Scale up nature-based solutions as part of an integrated approach to coastal protection   | High            | Medium                  | Medium-term |
| Water security   | Pursue a multi-pronged strategy to address water deficits in the EEC. Integrate provincial water planning and mobilize finance to strengthen water storage in the drought prone agricultural areas in the north and north-east.   | Very high       | High                    | Short-term  |
| Heat stress  | Support policies and investments to help cool indoor public and residential spaces, paying particular attention to the most vulnerable  | High            | Medium                  | Medium-term |
| Agriculture  | Repurpose public expenditure in agriculture away from distortionary price support schemes to R&D, extension and supporting climate smart agricultural (CSA) technologies.   | High            | High                    | Short-term  |
| Social protection  | Increase benefit generosity of programs such as the SWC. Integrate programs through the establishment of unified social registry and improve targeting by hybrid PMTs   | Very high       | High                    | Short-term  |
| <b>Supporting low-emissions growth</b>   |   |                 |                         |             |
| Carbon pricing   | Expedite the approval of the Climate Change Act to resolve private sector uncertainty and lay the groundwork for a transparent carbon pricing framework.  | Very high       | High                    | Short-term  |
| Energy   | Pursue market structure reform to promote competition in the power sector and accelerate adoption of renewable energy (RE). Invest in grid modernization and regional integration to enhance energy security and enable a renewables-led transition.  | Very high       | High                    | Short-term  |
| Industry   | Strengthen energy efficiency standards across buildings, appliances and industrial equipment and provide targeted subsidies and low-interest loans to households and businesses to accelerate adoption of energy efficient technologies. Enforce standards for low-carbon cement, mandating Environmental Product Declarations (EPDs) and incentivize clinker substitution. | High            | Medium                  | Short-term  |
| Transport  | Invest in public charging infrastructure to accelerate EV adoption. Implement biofuel incentives for hard-to-electrify vehicles.  | Very high       | Medium                  | Short-term  |
| Agriculture  | Support investment in biogas digesters, precision agricultural tools, implement anti-crop residue burning regulations and strengthen farmer education on emissions reducing techniques.   | High            | Medium                  | Medium-term |
| Forestry   | Invest in afforestation, prioritizing the restoration of critical ecosystems like mangroves in coastal provinces and degraded upland watersheds   | High            | Medium                  | Medium-term |
| <b>Seizing the economic opportunities associated with global decarbonization</b> |   |                 |                         |             |
| Investment climate   | Remove market-entry barriers, ensure fair competition and foster business-friendly regulatory environment to attract FDI  | High            | Very high               | Medium-term |
| Foreign investment   | Ensure that foreign investment in the EV industry builds local capacity   | High            | High                    | Short-term  |
| Skills   | Prioritize high-tech skill development in digital, engineering and sustainable manufacturing while implementing targeted talent attraction policies to bridge skill gaps in the short run   | High            | Very high               | Medium-term |
| Fiscal policy  | Review government support for green innovation and utilize newer and relatively underutilized instruments such as vouchers for innovation, innovation finance de-risking facilities, partial credit guarantees, early-stage support program for startups etc.   | High            | Medium                  | Medium-term |
| <b>Mobilizing finance for green and resilient development</b>                    |   |                 |                         |             |
| Fiscal policy  | Explore opportunities to boost domestic revenue mobilization beyond carbon pricing instruments. Efficient and equitable opportunities may exist in VAT exemptions, personal income tax and property taxes   | High            | Very high               | Medium-term |
| Financial sector   | Incentivize financial institutions to deepen offerings of green loans, green bonds and other sustainability-linked products, including products accessible and affordable to suit the needs of MSMEs. Strengthen sustainable finance ecosystem through improved climate finance tracking, taxonomy implementation and enhanced disclosure practices                         | High            | High                    | Short-term  |
| Carbon market  | Strengthen market infrastructure for carbon credit issuance and trading and further promote carbon market innovation  | High            | Medium                  | Short-term  |

\*Direct impacts are impacts relevant to Thailand’s adaptation, mitigation, green growth and/or climate financing objectives. The highest priority recommendations to emerge from applying the three criteria set out in this table are highlighted in blue.



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