Climate Change Master Plan

2015-2050

The Office of Natural Resources and Environmental Policy and Planning

Ministry of Natural Resources and Environment

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Index

Part 1

Introduction

1.1 Background

Thailand is facing major a challenge to sustainable development, namely the global phenomenon that is climate change. Initially linked to the burst in economic development heralded by the industrial revolutions of developed countries, climate change is now also the product of industrial activity which has spread inexorably to other nations with aspirations to the epithet of “developed”. This has dramatically accelerated the release of greenhouse gases into the atmosphere and exacerbated the severity of climate change. Climate change is now very much a global problem which affects not only the developed countries but also developing countries such as Thailand in two major ways:

Firstly, the changing weather patterns have a profound effect on Thailand’s economy. Thailand’s agricultural sector is a key pillar of the national economy which has lately been battered by the unpredictability and extreme variations in weather conditions caused by climate change. The changing climatic conditions have also resulted in changes to the patterns of how diseases spread as agents of diseases mutate to the changing conditions, leading to the re-emergence of infectious diseases thought to have been previously eradicated or contained. A disrupted ecological balance disrupts Thailand’s ability to plan for sustainable development, maintain economic growth and address poverty issues. Climate change directly threatens Thailand’s livelihood by challenging the conservation and management of natural resources.

Secondly, Thailand must face the complex challenges posed by greenhouse emissions. Rapid urbanization has resulted in an exponential rise in energy consumption, placing great pressure on an energy grid that relies chiefly on fossil fuels for energy production. This creates tension against the imperatives to address greenhouse gas emissions and adds another layer of complexity to Thailand’s efforts in confronting and adapting to climate change. The complexity does not end there; the growing importance of climate change in the eyes of the international community has led to the establishment of various initiatives for cooperation

among nations which have introduced yet more tension to Thailand's balancing act. Thailand can ill afford to shirk such responsibilities, yet in striving to meet the demands of international plans to tackle global climate change Thailand is placed in a handicapped position against partners and competitors alike who are enacting trading regulations from a position of technical advantage and greater economic maturity. Examples of the newly initiated rules concerning climate change include the EU ETS regulations for the aviation industry and mandatory carbon footprint labelling. As a country with an export-driven economy, Thailand cannot avoid being affected by these new regulatory responsibilities.

In recognition of the need for said cooperation, Thailand has participated in the early stages of the United Nations Framework Convention on Climate Change (UNFCCC) as a member state in 1991 as well as the ratification of the Kyoto Protocol in 2002 which brought the treaty into effect. As an early and regular participant of the international climate change resolutions framework meetings, it behoved Thailand to have a national strategy to handle the climate issues affecting the country.

To that end, Thailand first formulated the National Strategic Plan on Climate Change 2551-2555 B.E. (2008-2013). The cabinet passed a resolution on the 22nd January 2008 which ordered all government departments and agencies concerned to apply the strategy as a framework for planning. This was recently reinforced with the Climate Change Master Plan 2558-2593 B.E. (2015-2050) which has been developed as framework for long term planning. The expectation is that the parties concerned will use the framework contained within the Master Plan to develop an effective plan of action to tackle climate change in their respective areas.

1.2 Main Purposes of the Master Plan

(1) To provide a long-term national framework for climate change adaptation and low carbon growth promotion according to sustainability development principle;

(2) To provide a policy framework for the development of mechanisms and tools, at sectoral and national level, to achieve effective resolutions for climate change.

(3) To provide government agencies and relevant organizations with a framework for detailed action plans; facilitating awareness and mutual understanding by means of a common framework of reference points, thereby increasing integration and reducing redundant processes.

(4) To provide budgeting agencies with a clear framework for budget allocation, thus enabling the mobilization of concrete climate change resolutions.

1.3 Analytical Framework of the Master Plan

Given the depth and breadth of issues relating to climate change, a framework for the comprehensive analysis of situations is required. The Master Plan utilises the **Driving Forces-Pressure-State-Impact-Response** (DPSIR) framework, which is an evolution of the Pressure-State-Response framework. The DPSIR framework works by focusing first on the current environmental problems (e.g. climate change) and then by analysing the surrounding factors comprehensively in order to identify the causes and reach effective solutions. DPSIR Model is shown in Figure 1.1.

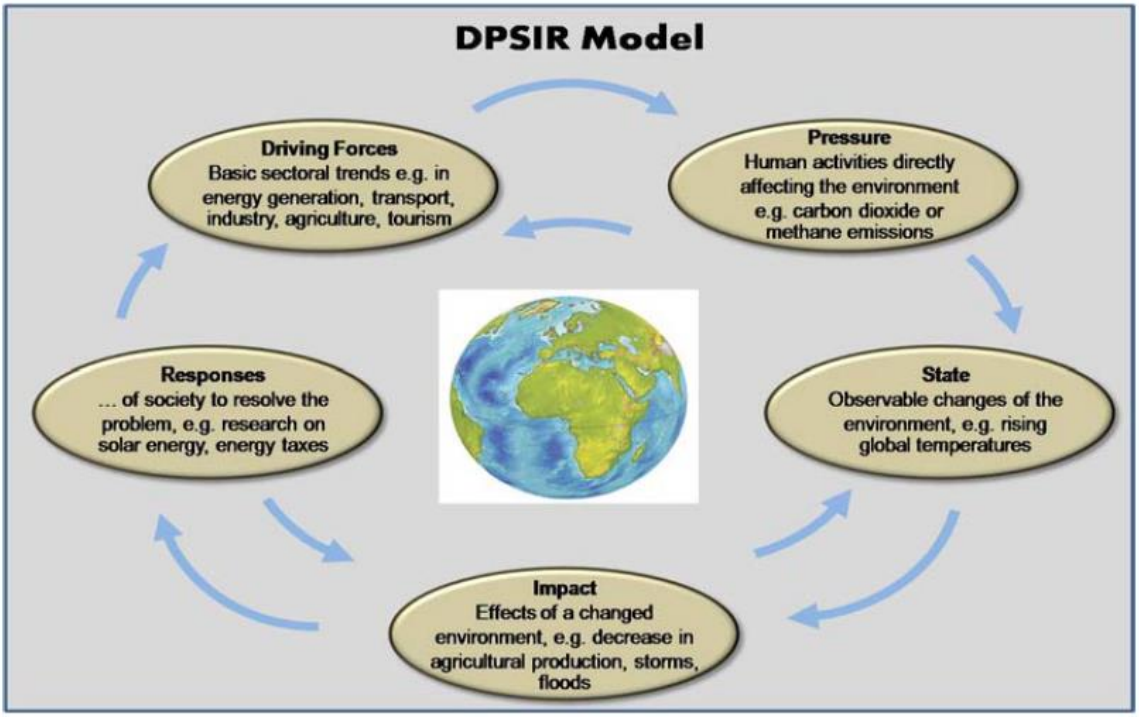


Figure 1.1 DPSIR Framework

DPSIR Framework

DRIVING FORCES: Factors that give rise to the activities and conditions which put pressure on the environment such as the structures and trends of local and international development.

PRESSURES: Activities and conditions which put pressure on the environment such as the emission of greenhouse gasses.

STATE: Changes in the state of the climate (e.g. changes to weather patterns, rainfall, temperature and sea levels).

IMPACT: The effects of climate change on various sectors (e.g. water management, agriculture and public health).

RESPONSES: Introducing approaches and responses to climate change by adapting to or dealing with DRIVERS, PRESSURES, and IMPACT.

In addition to the DPSIR framework, the Master Plan also incorporates the following factors:

Long-term Planning

Climate change is not a sudden development, but is rather a meta-climatic pattern that is far greater than the natural climatic patterns that are commonly acknowledged. Article 1 of the UNFCCC defines climate change as follows: *"Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."* Such changes happen slowly over time and the effects of conclusive evidence may take 30-50 years to become readily apparent.

The greenhouse effect, which is a cause climate change, is created by the concentration of greenhouse gases in the atmosphere. Some greenhouse gases have a short atmospheric lifetime so their atmospheric concentration is reduced when the emission of these greenhouse gases decline. However, other greenhouse gases such as carbon dioxide have a longer atmospheric lifetime so the atmospheric concentration does not immediately drop despite a reduction in greenhouse gas emissions.

Climate inertia such as the thermal transfer of the oceans and the melting ice sheets will still contribute to the rise in temperature and sea levels even when the atmospheric concentration of greenhouse gases has plateaued. Calculations reveal that it will take several centuries for global weather systems to rebalance (IPCC 2001). The two-pronged approach on climate change which consists of adaptation (focusing on increasing adaptive capacity and resilience) and mitigation (focusing on low carbon development, behavioural changes and carbon sinks, etc.) is therefore by necessity a long-term endeavour.

Moreover, since the emission of greenhouse gases is a trans-boundary problem for the environment, resolutions and solutions thereof require international cooperation as a precondition. The Climate Change Master Plan (2015-2050) has accordingly been developed as a long-term plan that accommodates the characteristics of the problem. This long-term Master Plan will ensure the continuity of state actions, establish practical indicators and evaluation systems for progress and allow Thailand to develop short and long term goals which are harmonised with the action plans of other countries.

Connections to Developmental Factors

The emission of anthropogenic greenhouse gases is a major factor of the greenhouse effect and climate change. Human activities which cause these emissions can be categorised into 7 areas: (1) Energy production and supply; (2) Transport; (3) Industrial activity; (4) Agricultural; (5) Energy consumption (residential and commercial); (6) Deforestation and changes in land use; (7) Waste and waste water (IPCC 2007). All of the aforementioned factors are products of activities resulting from economic development.

It is for these reasons that the tackling of climate change issues must include the careful consideration of the direction and pattern of local and global development. The developmental patterns of a country are influenced in large part by public health policy, the presence of energy, transport, and urban infrastructure and capital investment; especially investment in the manufacturing and service sectors which are major drivers of the economy.

In identifying the factors which contribute to the country's greenhouse gas emissions the Climate Change Master Plan (2015-2050) has taken in to account the vision and overarching direction for national development as per the policies and action plans of the government and governmental agencies. This inclusion will in turn lead to the appropriate guidance and adjustments to the emissions producing factors, leading to an overall reduction in greenhouse emissions. The earnest identification of vulnerabilities will also stimulate both proactive (i.e. increasing coping capacity) and reactive measures (i.e. reducing exposure and sensitivity to climatic factors) (Anont Sanitwongs Na Aydhaya, 2011).

Having said that, the policies, vision and overarching direction for national development as determined by governmental branches are subject to change and variation, as are the predicted climate patterns. Continuous review must therefore be conducted on the achievements and progress of the Climate Change Master Plan (2015-2050) in order to maintain alignment of goals, approaches and measures with situational and developmental changes.

Consistency with Global Operations

As with ozone layer depletion, climate change is a trans-boundary problem which requires global cooperation in order to reach solutions. Domestic operations must therefore be in alignment with international frameworks. Since the second Tokyo Protocol will end within the year 2020 and the UNFCCC milestones are set at the beginning of each decade

(2020, 2030, 2040, for example), the long term National Master Plan will align with this schedule; the medium-term milestone is therefore set at the year 2020 and the long term milestone is set at the year 2050.

1.4 Master Plan Preparation Process

The preparation process for the Climate Change Master Plan (2015-2050) emphasizes participation by all stakeholders. Forums are held to gather opinions and perspectives from industry executives, academics and other stakeholders in society. The draft Climate Change Master Plan has been approved by the Technical Sub-committee on Climate Change, the National Committee on Climate Change, and the Cabinet.

Master Plan Development Process

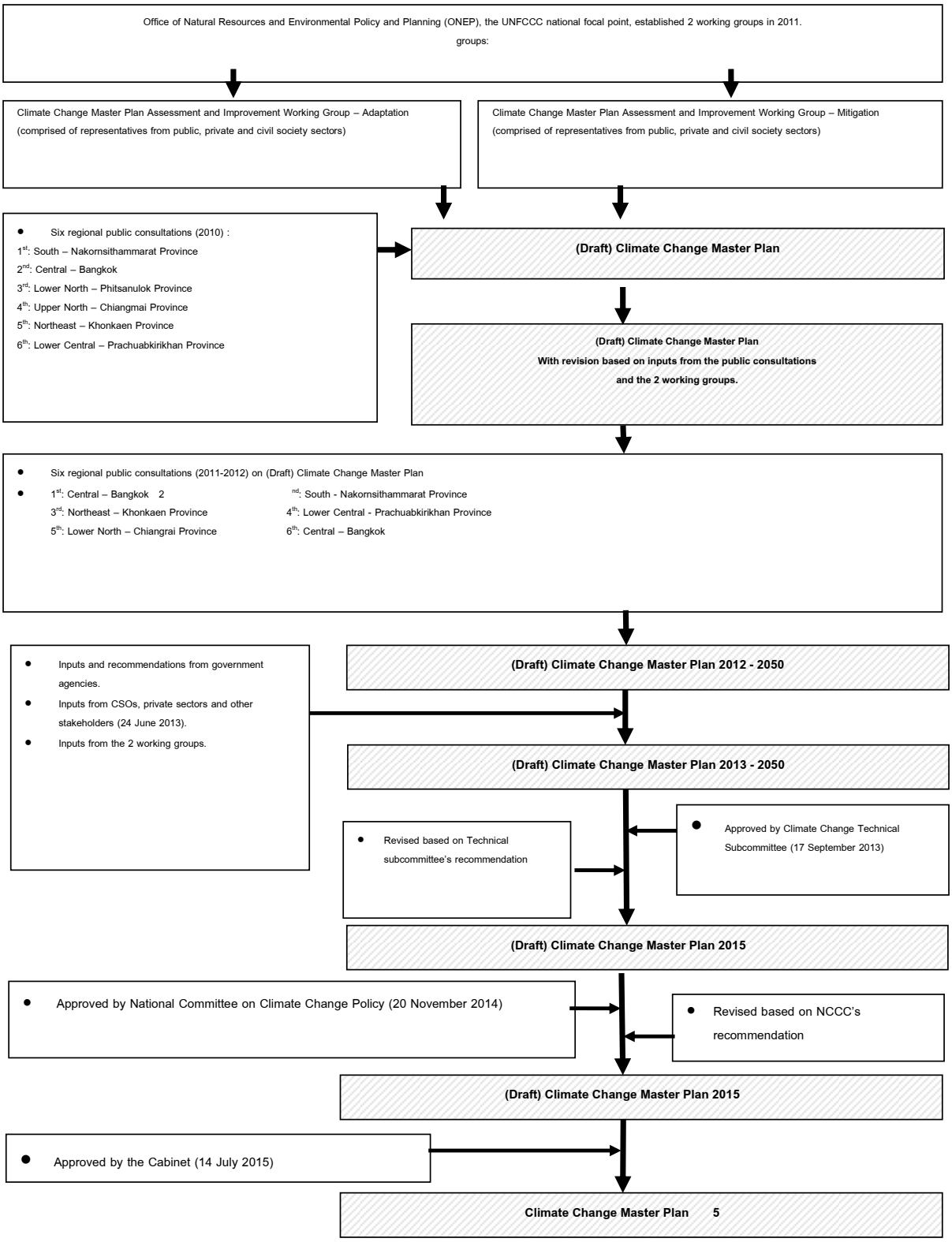


Fig 1.2 Climate Change Master Plan Development Process

Analysis

The making of the National Climate Change Master Plan 2015-2016 utilised the DPSIR Framework (Driving Forces-Pressure-State-Impact-Response Framework) in the analysis, which was then developed into guideline for responding to climate change - as discussed below.

2.1 Economic and Social Development - Trends and Directions

The National Economic and Social Development Board (NESDB) produced the 20-Year National Development Plan as a framework for the creation of 5-Year National Economic and Social Development Plans, which will take effect from the 11th National Economic and Social Development Plan onwards. Taking both domestic and international factors and trends that Thailand may encounter in the next 20 years into considerations, this plan dictates the country's vision for the year 2027. This is also a review on factors relating to climate change and national trends or directions that arise from responding to these factors. The main points are summarised below.

(1) The trends of regional economic integration and multiple economic centres in global economics. – The growth of new economic powerhouses in developing countries such as China and India has shifted more momentum towards Asia. The joining of the ASEAN Economic Community encouraged development of infrastructure which has led to greater interdependence among the countries at the regional and sub-regional levels. Examples include the development of the East-West Corridor that links Vietnam, Laos, Thailand, and Myanmar together, or the North-South Corridor that links Bangkok to Kunming in southern China. Interdependency of regional infrastructure tends to improve road and rail networks, in addition to telecommunication and transmission networks in the near future, which will drive rapid growth of trade and investment cooperation. Thailand's neighbour, Myanmar, has embarked on a plan leading to democratic reform and in doing so has welcomed more trade and investment opportunities than ever before. Furthermore, it will act as an ASEAN investment hub; drawing more investors to ASEAN, and connecting the region's economies to

India. Over the next 20 years, the ASEAN sub-regions will demonstrate high growth potential. Making adjustments so that Thailand has an appropriate role within ASEAN is essential to moving forward. Concrete policies and directions are thus necessary to drive different sectors accordingly and to complement one another in a timely manner. Nevertheless, the trend of economic integration is a global one and an opportunity to increase the economic bargaining power of ASEAN countries against those of other powerhouses. This economic integration has further impacts on trade barriers imposed through different measures such as environmental standards, food security, and labour practices. This trend, however, poses certain risks to Thailand whose economic growth greatly depends on exports.

Economic integration and the shift of the world's economic power toward Asia are driving forces on the following factors relating to climate change:

(1.1) Infrastructure development – Economic integration at the regional and sub-regional levels and special agreements on certain matters, e.g. Free-Trade Area Agreements and facilitation of immigration and customs processes, increase the free flow of goods and labour. Each country, therefore, needs to accelerate the development of transport networks to respond to rising demand. In the case of Thailand, the Ministry of Transport has prepared National Transport Infrastructure Development Strategy 2015-2022 to support future demands in transportation, establish Thailand's position as a regional logistics hub, and prepare for increased demand by travellers. The goal is to improve multimodal transport systems to achieve the highest degree of efficiency and reduce logistics costs. An example is reducing the volume of goods transported on roads and encouraging rail and ship transport instead. From data collected in 2010 (Office of Transport and Traffic Policy and Planning), over 80% of overall goods are transported by road at a cost of 1.72 baht/tonne-kilometre, compared to 0.93 baht/tonne-kilometre for rail transport, and 0.64 baht/tonne-kilometre for water transport.

Patterns of transportation infrastructure development significantly determine the future volume and rate of greenhouse gas emissions from Thailand. In addition, the types of transport systems chosen will eventually affect the development and expansion of cities. The aforementioned infrastructure development plan, therefore, should consider alternatives that offer low levels of GHG emissions, together with the BAU (business-as-usual) option. It should also consider the impacts on long-term development, energy requirements in the transport sector, and international obligations in mitigating possible GHG emissions. Furthermore, it

should also consider the opportunity to access and benefit from international mechanisms in affiliated countries in order to support investment for low-carbon emissions and environmentally-friendly infrastructure financially, technologically, and academically.

(1.2) Burdens in managing goods of low standards and investment that causes burdens on the environment – The free-trade policy has encouraged investment and imports from countries within the region, including China and Vietnam. Tracing and monitoring of imported goods that are low in energy-efficiency, product lifetime, result in high emission levels of greenhouse gases (GHGs), or are risks in terms of other efficiency and safety measures should be enacted. These products may emit high levels of GHGs during their lifetimes, which causes management burdens after the product's end-of-life; which is at odds with the waste reduction policy. Additionally, this hinders the development of environmental standards in locally-made products and the progress of local environmentally-friendly products and services procurement due to low-standard products competing with lower prices. It also inhibits Thailand's ability to secure a leading position in terms of environmental standards and approval standards at the regional and sub-regional levels. In regards to international investments; ventures from multinational companies should be regulated to promote and support efficiency, low GHG emissions, and environmentally-friendly management instead of focusing solely on economic benefits.

(1.3) Thailand's changes in economic structure – Economic integration has created opportunities to expand the resource base essential to production, and for each country to demonstrate different strengths in enhancing its competitive capacity at the regional and sub-regional economic levels. At the same time, it has introduced opportunities to resolve each country's weaknesses. For instance, moving industrial production base to countries with cheap labour or lower labour standards, or importing cheaper labour with better skills and qualifications. In this regard, Thailand has planned and prepared for such risks. In the 11th National Economic and Social Development Plan, the strategy of economic structure adjustment focuses on quality and sustainable growth. It aims at developing the economy creatively, adding value from innovation and environmental standards, developing industries that support skilled workers, along with trade and the service economy to relieve the impacts of the movement of the production base, while becoming a hub of air travel, tourism, and air

transport of goods. This has resulted in increased construction of office buildings, shopping centres, hotels, and the like. Moreover, there will be more goods transportation businesses to support this development. However, this trend in turn leads to anticipation of significant increases in GHG emissions from energy used in buildings and transportation in the future. Therefore, measures leading to expansion while limiting GHG emissions should be applied altogether. This includes green building standards, energy efficiency standards in buildings, lighting and air-conditioning codes, the promotion of highly efficient transport systems, use of renewable fuels in transportation, and fuel-efficient vehicles; including those traveling by land, water, and air. In addition, a guideline in improve skilled labour to reach qualifying standards, especially in environmental management skills, and boosting the standardisation of domestic technologies to reduce the costs of importing international technologies, is required. These guidelines need to work accordingly and facilitate one another.

(1.4) Rapid urbanisation – A leap in economic growth within the region unquestionably leads to rapid urbanisation and increases in the average income. Much like other developing countries, Thailand tends to experience rapid urbanisation. Rapid urbanisation and increases in income result in growing use of energy and consumption that exceeds basic needs. This stimulates production for trade and transitions in land usage (from agricultural to urban purposes); this is aggravated the by inability to enforce laws, leading to forest encroachment, which contributes to the emission of GHGs into the atmosphere and the reduction in GHG sinks. This increases sensitivity and risks of impacts caused by changes in the climate variables of ecosystems, natural resources, and local communities. Consequently, there should be measures that aim at increasing the efficiency of urbanisation and land use, infrastructure planning that supports efficient use of resources, energy conservation measures, waste reduction based on the 3Rs policy (Reduce, Reuse, Recycle), forest conservation and rehabilitation, ecosystem, and natural resources.

(2) Energy situation – Asia's maturation will result in the region's increasing need for petrol, no less than double the current usage, over the next 20 years, in spite of predictions of depleting global petrol resources that are expected to run out within 50-60 years. Other energy resources, such as natural gas in areas that Thailand can access, will only provide 20 years' worth of reserves (NESDB, 2008). It is urgent then that policies promoting energy

efficiency, energy security, and environmentally-friendly energy development must be created and encouraged. Only countries with energy efficiency and security will have the capacity to compete and be resilient to uncertain energy situations and pressures caused by energy limitations in the future. The aforementioned policies and measures should not only include the creation of alternatives sources, but also extend to infrastructure and energy demand management, which undeniable rely on the adaptation of businesses and the behaviours of the general populace.

Thailand Power Development Plan 2010-2030 (PDP2010) emphasises the stabilisation of energy security by reducing the proportion of natural gas used in power generation, while increasing shares of other fuels used and importing electricity from other countries as shown in Table 2.1. However, growing use of coal in power generation leads to increased carbon dioxide emissions into the atmosphere, despite use of clean coal to reduce emissions such as sulphur dioxide, nitrogen oxide, and residual particles. For that reason, the use of carbon capture and storage (CCS) technology may be considered for implementation. This technology, however, has not been used extensively on a commercial scale and requires importation. Studying the physical capacity of potential sites for setting up such technology is also mandatory; since it captures and stores carbon dioxide underground or in the sea, risks of leaks need to be examined. This level of scrutiny can be compared to the case of nuclear power; though it emits relatively little carbon, other plausible consequences must be thoroughly investigated, especially the risk of radiation leaks and the costs of radioactive waste management, among other things.

Table 2.1 Percentage of power generated by types of fuel, based on PDP2010

Fuel	PDP 2007 second revised edition		Draft PDP 2010		
	2015	2021	2015	2021	2030
1. Renewable energy	3	3	6	6	6
2. Natural gas	69	60	62	49	39
3. Hydropower	3	2	3	3	2
4. Import of electricity	6	9	8	16	19
5.. Coal	11	15	12	13	21
6. Lignite	8	6	9	7	2
7. Nuclear power	-	5	-	6	11
	100.0	100.0	100.0	100.0	100.0

Source: Thailand Power Development Plan 2010-2030

In addition, the Ministry of Energy has devised the 20-Year Energy Efficiency Development Plan (2011-2030) and aims to reduce energy intensity by 25% from 2015's amounts before 2030, and reduce final energy consumption by 20% in 2030, which is equivalent to approximately 30,000 tonnes of crude oil. The renewable energy and alternative energy development plan's target is for renewable energy to provide 25% of overall energy consumption within the 10-year span of 2012-2021. Resolving future energy limitations means supporting responses to climate change issues. This is carried out through policymaking that supports a renewable energy evolution that is environmentally-friendly and emits low levels of carbon dioxide to replace usage of fossil fuels. Studies of renewable energy capacity reveal that Thailand has high potential in this area, because it is an agricultural-producing country that contributes a large number of agricultural products and also possesses food processing plants, enabling the production of raw materials essential for the manufacture of biomass energy, bioenergy, biodiesel, and ethanol. Thailand also has potential in natural and renewable energy capacity. In terms of solar energy, for example, Thailand sees an average of 18.2 MJ/m^2 of solar radiation a day. However, renewable energy development, along with the infrastructure to support the use of renewable energy, currently relies on imported technologies that add to the high costs. Nevertheless, the ability to establish self-sustaining energy is an extremely vital dimension in the long run and has significant impact on the country's sustainable growth. Therefore, enhancing efficiency in technology and human resources in renewable energy production should be pushed forward.

(3) Climate change – This is a global challenge, apart from being a national issue, in terms of impacts caused by change in climate variables, more extreme storms and natural disasters, and rising sea levels, all of which affect human settlements, agriculture, industries, and public health. On top of that, climate change and environmental issues are brought up constantly as measures in raising trade barriers. Nevertheless, it provides opportunities to create new markets for new products. If Thailand can set policies as driving forces to elevate national environmental management and product standards, it will help improve the quality of the country's environment and also create sustainable business opportunities, thus increasing Thailand's competitive capacity altogether.

(4) Technological advancement and human livelihoods – The application of technology in products and services affects peoples' daily lives, existence, economic opportunities, and change in capacities of business competitiveness tremendously. In recent times, the influence of information technology has created a gap between people and countries that have access to and use of technology that bring about opportunities in development and people and countries that have been delayed in their access to and adoption of such. In addition, development based on more advanced technology often results in a significant leap in development. However, increased use of technology naturally results in higher energy demand. The burdens of managing technological equipment after its end-of-life or adopting new technology contribute to increasing emissions of GHGs. Furthermore, Thailand still imports technology which raises costs in application, especially for environmentally-friendly technology. Therefore, the development of technology and innovation at a national level should be supported rigorously; this includes technology transfer and advancement, and the development of skilled labour to support the development, production, and use of specific technology systematically.

The National Science Technology and Innovation Policy Office (STI) has assessed climate change technology needs for Thailand and prioritised Thailand's need for technology to handle climate change, dividing it into two categories. The first category is adaptation technology applicable to the agriculture sector which focuses on forecasting and early warning technologies, plant breeding, and precision farming. In the water resources management sector; integrated water resource management technology, seasonal climate forecasting, as well as flood and landslide detecting and monitoring system technologies are prioritised. Climate forecasting focuses on building a national climate information centre, information-gathering and information-processing technology, and climate simulation technology. For GHG emissions reduction technology (mitigation), the energy sector emphasises smart grids, waste-to-energy technology, second-generation biofuels, improvement of fuel combustion efficiency in the industrial sector, and CCS.

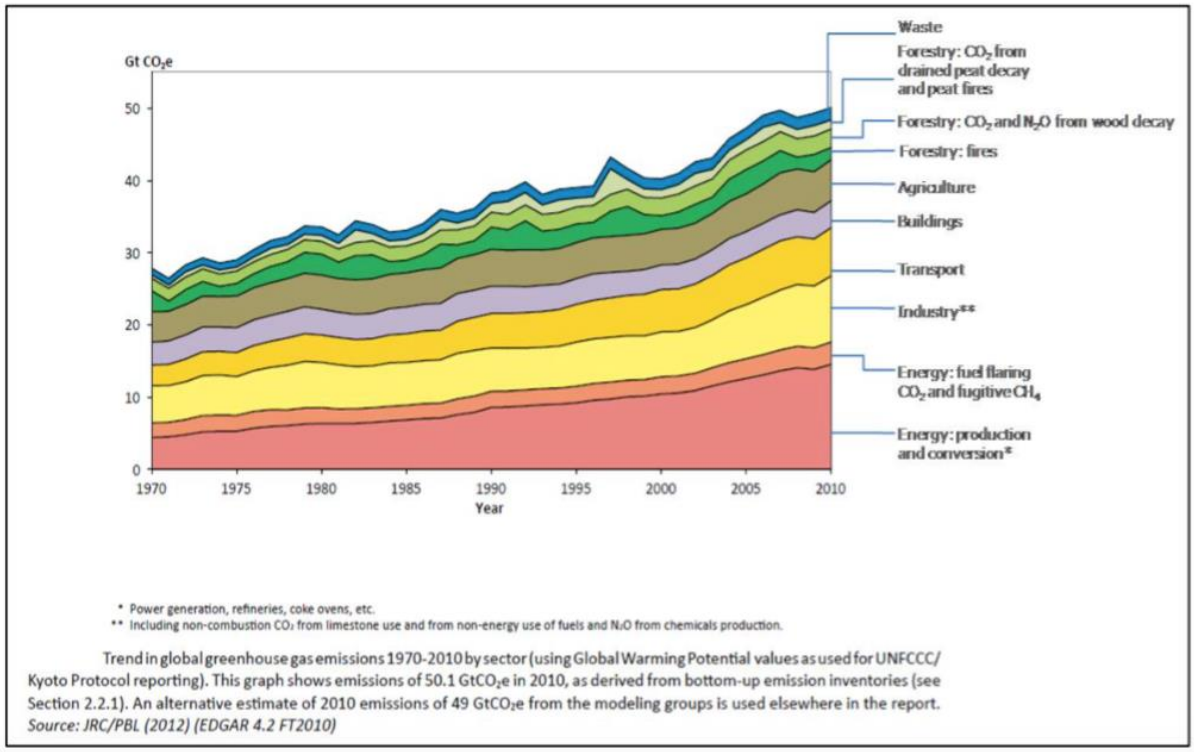
(5) Thailand's transition into an ageing society – This is Thailand's chance to develop and advance medical services and become the medical leader or regional medical hub in modern and alternative medicine, spa businesses, well-being restoration, and

infrastructure and services development to support senior citizens from Thailand and other countries. However, ageing populations are highly sensitive to climate factors like higher temperatures, sudden temperature fluctuations, and extreme natural disasters. The government sector needs to stress the importance of these developments to allow senior citizens equal access to healthcare and basic health hazard prevention, and develop alternative medicine, spa businesses, and other services that rely on the use of agricultural products and biological diversity (e.g. herbal extracts). There should be measures for sustainable conservation and use of alternative medicine development through encouragement of the participation of communities. Furthermore, the Payment for Ecosystem Services (PES) system should be adopted to distribute equal benefits to eco-villages that embrace green lifestyles and promote sustainable biodiversity and natural resource management. In addition, an ageing society means an insufficient working population, which results in the importation of labour from neighbouring countries and significant effects on public health, labour practices, and human rights, among other issues.

2.2 GHG emissions at the global level and in Thailand

(1) Global phenomenon

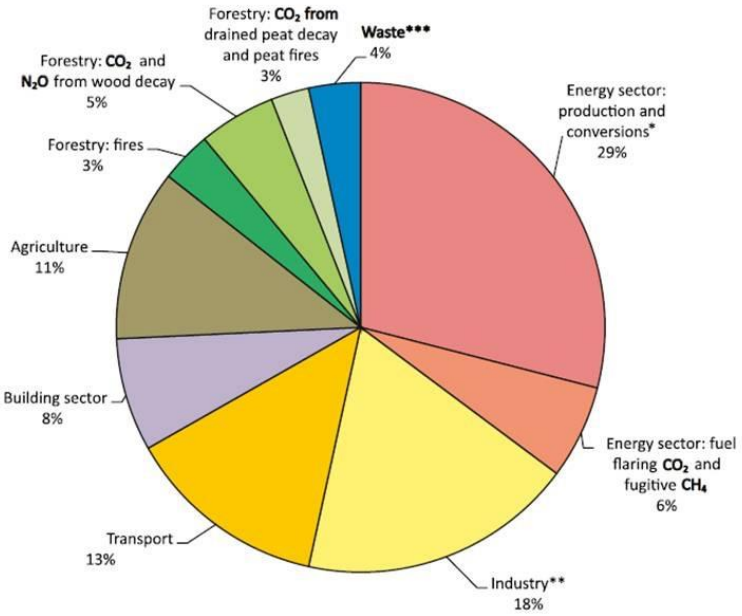
In November 2012, the United Nations Environment Programme (UNEP) published the Emissions Gap Report 2012, which revealed data on global GHG emissions. In 2010, the overall level of global GHG emissions was approximately 49-50 billion tonnes of equivalent carbon dioxide. Figure 2.1 depicts the trend of overall GHG emissions both worldwide and by sector from 1970-2010. This illustrates the rising trend of GHG levels and increasing proportions of GHG emissions caused by power production and conversions.



Trend in global greenhouse gas emissions 1970-2010 by sector (using Global Warming Potential values as used for UNFCCC/ Kyoto Protocol reporting). This graph shows emissions of 50.1 $GtCO_2e$ in 2010, as derived from bottom-up emission inventories (see Section 2.2.1). An alternative estimate of 2010 emissions of 49 $GtCO_2e$ from the modeling groups is used elsewhere in the report.
Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)

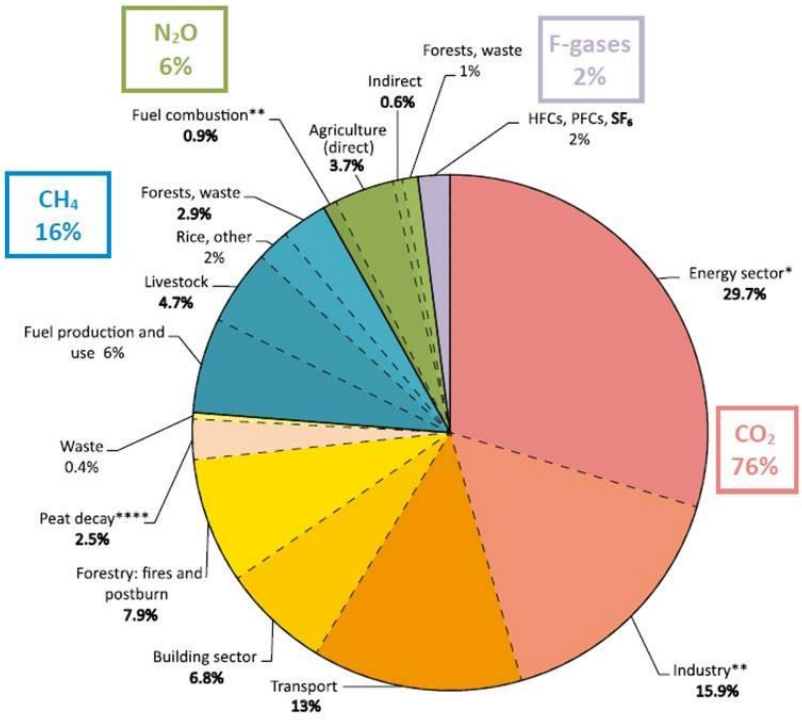
Figure 2.1 Trends in global GHG emissions 1970-2010 (overall and by sector) Source: UNEP 2012

Figure 2.2 and 2.3 show proportions of GHG emission levels by sector. The share of GHG emissions by the energy sector (from power production and conversions, as well as from carbon dioxide combustion and methane leaks) takes up 35%, where 18% is from the industrial sector, 13% from transport, 11% from agriculture, 11% from forestry, 8% from the building sector, and 4 % from the waste sector. The pie chart is also categorised by GHG types: carbon dioxide takes up 76%, methane 16%, and nitrous oxide 6%. Hydrofluorocarbon, perfluorocarbon, and sulphur hexafluoride combined make up 6% of the overall total.



Shares of sources of global greenhouse gas emissions in 2010 by main sector (in CO_2e using GWP values as used for UNFCCC/Kyoto Protocol reporting). *Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)*

Figure 2.2 Sources of global GHG emissions in 2010 by sector



Shares of sources of global greenhouse gas emissions in 2010 by main sector and gas type (in CO_2e using GWP values as used for UNFCCC/Kyoto Protocol reporting). *Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)*

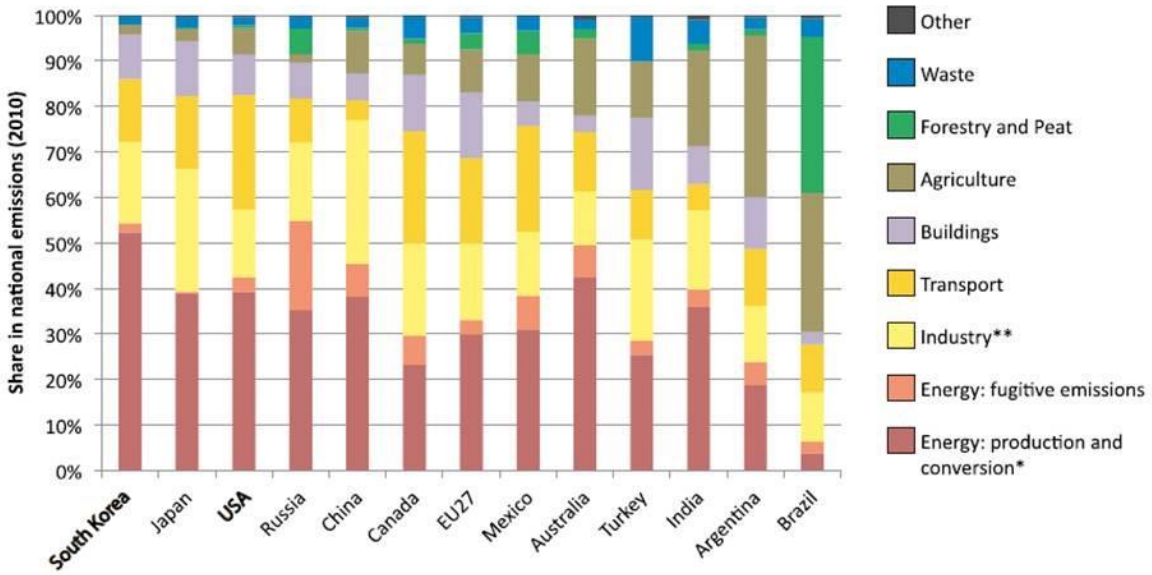
* Power generation, refineries, coke ovens.
** Including non-combustion CO_2 from limestone use and from non-energy use of fuels and N_2O from chemicals production.
*** Including wastewater.
**** Including peat fires.

Figure 2.3 Sources of global GHG emissions in 2012 by main sector and gas type

Source: UNEP 2012

Global levels of carbon dioxide emissions caused by fossil fuels and cement manufacturing in decreased by 1% in 2009 due to the economic recession. Nevertheless, emission levels rose again sharply between 2010-2011, with 5% and 3% increases, respectively compared to the year before, which was the equivalent of 34 billion tonnes of carbon dioxide (JRC/PBL 2012; Olivier et al. 2012). In 2010, the forestry and land use sector reduced gas emissions by 15%, with a 0.5% increase in emissions of methane and nitrous oxide, and a 7% increase of F-gases (hydrofluorocarbon, perfluorocarbon, and sulphur hexafluoride).

Figure 2.4 illustrates shares of national GHG emissions in 2010 by sector and countries included in the G20. It is obvious that the percentages of GHG emissions from different sectors vary based on context and each country' development patterns (UNEP 2012).



Sectoral shares of national greenhouse gas emissions in 2010 for countries included in the G20 with a pledge, taking European Union as a group. *Source: JRC/PBL (2012); EDGAR 4.2 FT2010.*

Figure 2.4 Sectoral shares of national GHG emissions in 2010 for countries included in the G20 with a pledge to reduce levels of GHG emissions

Source: UNEP 2012

(2) Thailand's GHG emissions

In 2000, Thailand's total GHG emissions were equal to 292.62 teragrams (or million tonnes) of carbon dioxide equivalents ($TgCO_2e$). The highest emissions came from the energy sector at 159.39 $TgCO_2e$ or 54.5% of the nation's overall gas emissions. This was followed by the land-use change and forestry sector with 55.64 $TgCO_2e$ (19%). The agricultural sector's gas emissions were 51.88 $TgCO_2e$ (17.7%). The industrial sector released 16.39 $TgCO_2e$ (5.6%). The waste sector had the lowest levels of GHG emissions at 9.32 $TgCO_2e$, or 3.2% of overall national gas emissions. However, in the land-use change and forestry sector, the amount of GHG removed by sinks was equal to 63.54 $TgCO_2e$, or 21.7% of total national GHG emissions, making the overall value of this sector equal to -7.90 $TgCO_2e$. Overall national levels of emissions by sources after removal by sinks came out to 229.08 $TgCO_2e$. Figure 2.5 illustrates the level of emissions by source and the proportion of emissions by sector (Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, 2010)

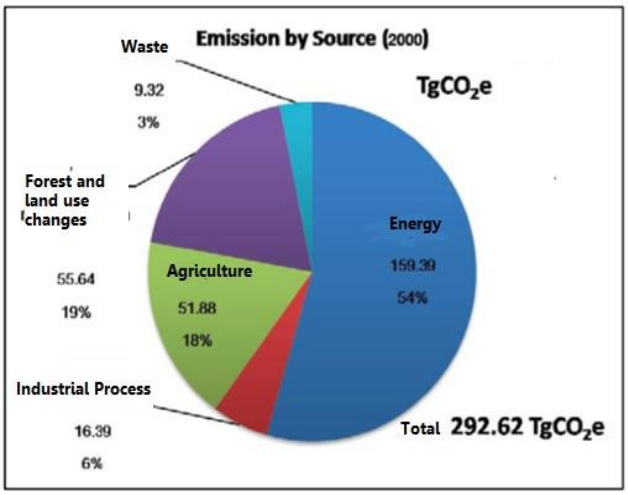


Figure 2.5: Thailand's emissions by source and proportions of emissions by sector in 2000

Source: Thailand Second National Report

GHG emissions trends in Thailand's Second National Report were recalculated using data on GHG emissions in 1994 from the First National Report and compared with the data from 2000-2004. It shows that during those 5 years, Thailand witnessed increasingly higher levels of GHG emissions that rose 3.9% per year, which were higher than emission levels during

the 11-year period from 1994-2004, which saw a 2.0% increase per year. Figure 2.6 depicts Thailand's trend of emissions by sources and removal by sinks in 1994 and between 2000-2004. Thailand's overall emissions and sinks by land-use change and forestry in 1994 and between 2000-2004 amounted to 238.30 $TgCO_2e$, 229.08 $TgCO_2e$, 225.04 $TgCO_2e$, 238.82 $TgCO_2e$, 251.74 $TgCO_2e$, and 265.82 $TgCO_2e$, respectively. Calculating the ratio per capita showed that the emissions were equal to 4.03 tonnes of carbon dioxide equivalents, 3.70 tonnes of carbon dioxide equivalents, 3.61 tonnes of carbon dioxide equivalents, 3.80 tonnes of carbon dioxide equivalents, 3.99 tonnes of carbon dioxide equivalents, and 4.29 tonnes of carbon dioxide equivalents respectively as demonstrated in Figure 2.7. Finally, the emissions to GDP ratios were equal to 1,649.68 tonnes of carbon dioxide equivalents/GDP (million USD), 1,866.59 tonnes of carbon dioxide equivalents/GDP (million USD), 1,947.78 tonnes of carbon dioxide equivalents/GDP, 1,882.30 tonnes of carbon dioxide equivalents/GDP, 1764.87 tonnes of carbon dioxide equivalents/GDP, and 1,647.57 tonnes of carbon dioxide equivalents/GDP, respectively, as illustrated in Figure 2-8.

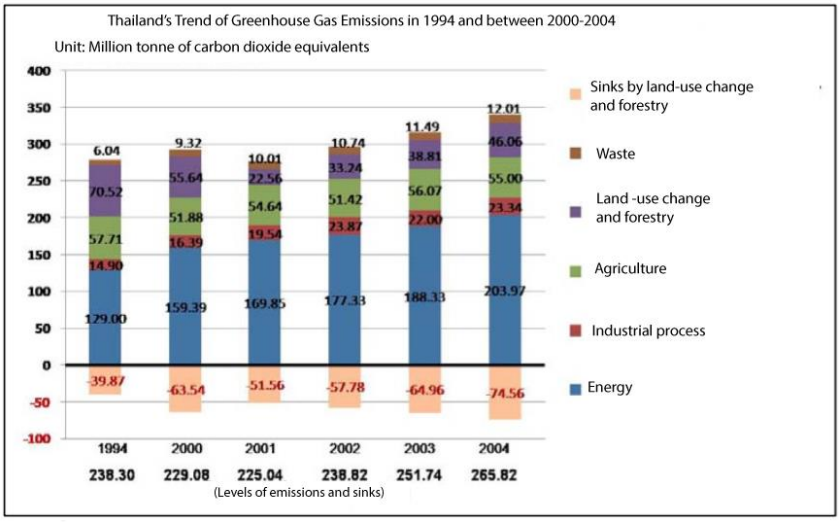


Figure 2.6: Thailand's trends of GHG emissions in 1994 and between 2000-2004

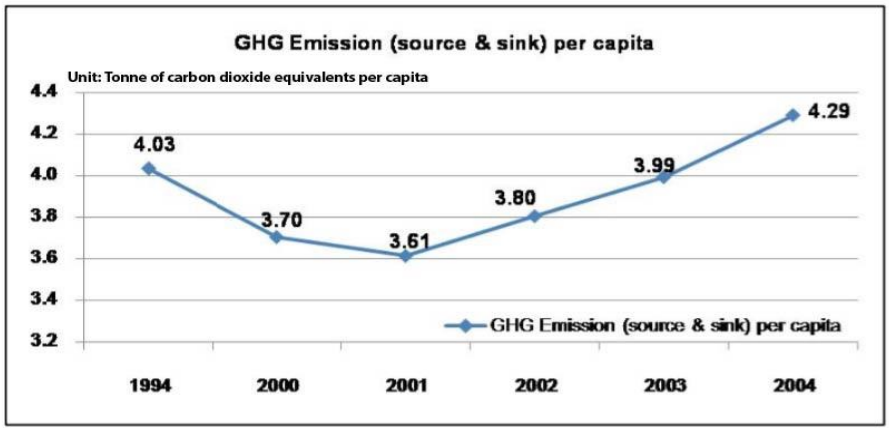


Figure 2.7: Levels of GHG emissions per capita in 1994 and between 2000-2004

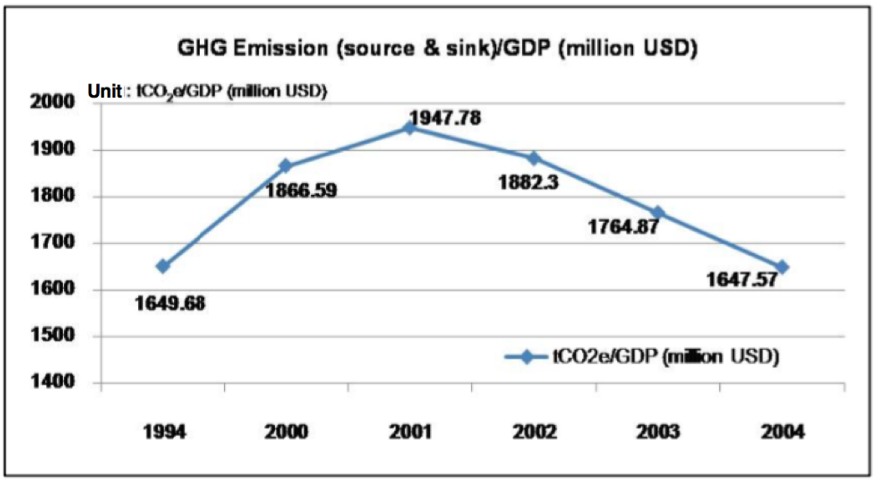


Figure 2.8: The ratio of GHG emissions to GDP in 1994 and between 2000-2004

Sources: (1) GHG emissions levels – Thailand's Second National Report

(2) Population – Department of Provincial Administration, Ministry of Interior

(3) GDP - Office of the National Economics and Social Development Board

(4) Exchange rates - Bank of Thailand

The energy sector – GHG emissions in the energy sector are divided into two main categories: Category 1A, emissions from fuel combustion, and category 1B, fugitive emissions from fuels. The energy sector saw rising levels of GHG emissions throughout the 11-year period between 1994-2004, accounting for 58.1% of total emissions, with output increasing by 4.7% per year, while from 2000-2004, there was a 28% increase, a rate of increase of 6.4% per year. From the data for 2000, the sub-sector of the emissions from fuel combustion category with the highest levels of GHG emissions was fuel combustion for power generation (1A1), with

66.44 $TgCO_2e$ or 41.7% of the emissions from the energy sector. However, in the energy sector, GHG emissions can be categorised into emissions from natural gas and coal. This is because most power in the country is generated by natural gas. This results in GHG emissions from natural gas being greater in quantity higher than those of lignite, despite natural gas having lower emission factors. However, it can be seen that the levels of emissions in this sector depend on power generation management. Therefore, the Thailand Power Development Plan (PDP)'s shifts in the types of fuels used may affect the levels of GHG emissions in this category. During the 5-year period between 2000-2004, the levels of GHG emissions in the category of fuel combustion for power generation increased by 5.8% per year. Overall however, increases in GHG emissions were based on power demand and production.

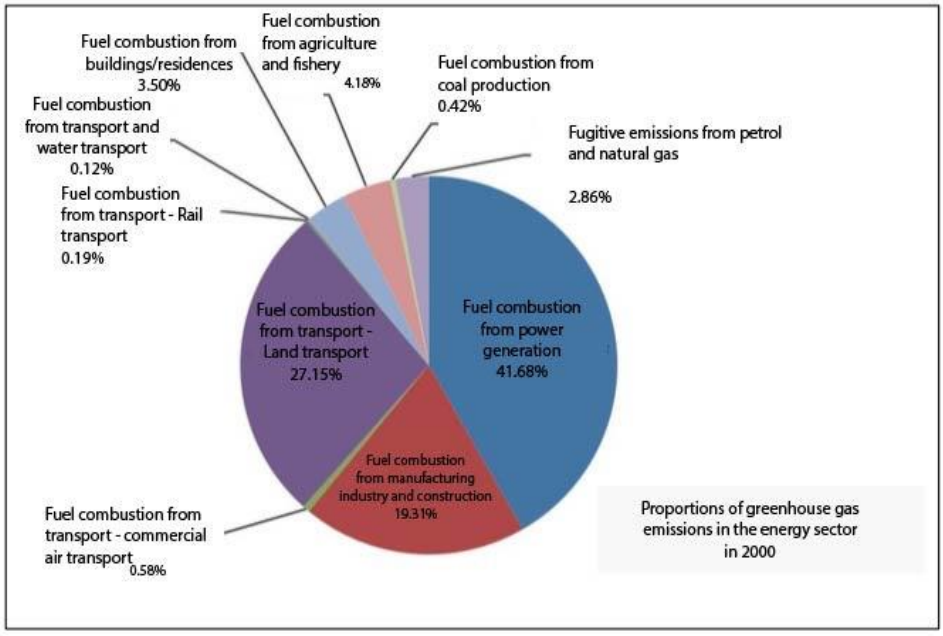


Figure 2.9 Proportions of GHG emissions in the energy sector in 2000

Source: Thailand's Second National Report

Two sectors with high levels of emissions are the transport sector and the manufacturing and construction sector, with output of 44.70 and 30.78 $TgCO_2e$, or 28.0% and 19.3% of the energy sector's GHG emissions, respectively. Most of the emissions from fuel combustion in the transport sector come from land transport, with a 6.0 % increase per year between 2000-2004. However, no data concerning gasohol and biodiesel is available. Most of the emissions from fuel combustion in the manufacturing industry and construction come

from energy intensive industries with high production capacity such as the non-metal industry and chemical industry. Emissions of this category began to increase from 2000-2004, accounting for 9.8% of overall output per year, a greater amount than that of the energy sector (6.4% per year). This was caused by industrial expansion during the period of study. Therefore, the future expansion of industries, especially of energy intensive ones, will be what decides whether emissions in the sector rise or fall. In addition to the above, fuel combustion from the agriculture/fishery and household sectors (residences) results in GHG emissions of 6.67 and 5.58 $TgCO_2e$, or 4.18 and 3.50%, respectively, of overall emissions from the energy sector. Fugitive emissions from fuels, however, accounted for 3.28 % of GHG emissions by the energy sector. Emissions of 4.56 $TgCO_2e$, equal to 2.86 % of the emissions from the energy sector, came from oil drilling and natural gas.

The industrial sector – The emissions of GHGs from this sector were categorised by emission process, that is, mineral products, chemical industries, steel industries, other manufacturing industries, as well as industries manufacturing and using halocarbon and sulphur hexafluoride. Most emissions were the result of mineral products; the cement industry's GHG emission levels were 16.05 $TgCO_2e$, accounting for 97.9% of overall gas emissions in this sector. The chemical industry and steel industry released emissions amounting to 2.0 and 0.04% of overall emissions, respectively. However, information concerning halocarbon in 2000 was not available; therefore, no data regarding any related output was reported. The industrial processing sector showed increasing levels of GHG emissions throughout the 11-year period from 1994-2004, a 56.6% increase overall, as emissions rose at a rate of 4.6% per year. From 2000-2004, the sector accounted for a 42.4% increase, with this occurring at a rate of 9.2% per year. Table 2.2 illustrates GHG emissions trends by industry.

Table 2.2 Trends in GHG emissions from the industrial sector categorised by industry.

Industry group/year	2000	2001	2002	2003	2004	Growth Rate[1]	Growth rate per year
Mineral products	16,052.62	18,649.04	21,614.89	19,156.07	20,267.06	26.3%	6.0%
Chemical industry	335.29	369.95	378.38	392.15	415.74	24.0%	5.5%
Steel industry	6.65	7.79	9.50	13.30	16.73	151.6%	25.9%
Industry using halocarbon and sulphur hexafluoride	0.00	509.58	1,867.05	2,436.73	2,638.00	417.7%	73.0%

Note: GHG levels (thousand metric tonnes of carbon dioxide equivalents)

1 Industries using halocarbon and sulphur hexafluoride had their growth rates calculated using figures from 2001 to 2004. Other industries' growth rates were calculated using information from 2000 to 2004.

Source: Thailand Second National Report

Increases in GHG emissions from the industrial sector were caused by the expansion of industries such as those dealing in iron and steel, resulting in a 25.9% increase in emissions per year. Emissions of F-gases were first observed between 2001 to 2004, along with a 137% surge in hydrofluorocarbon (HFCs) each year, along with an 87% rise in sulphur hexafluoride (SF_6) output on an annual basis. This resulted in an overall spike of GHG emissions caused by this industry of 73.0% per year. In the making of Thailand's Second National Report, the data used in analysing the aforementioned gas emissions was based mainly on the import and export reports from the Thai Customs Department. However, improving databases of halocarbon compounds used in industrial plants is highly essential to achieving more accurate information. The databases and data gathering processes of reports regarding imports and the use of such compounds should be further refined in order to monitor them more accurately on an annual basis.

The agricultural sector – In 2000, the agricultural sector released 51.88 $TgCO_2e$. The prominent GHG of this sector was methane (CH_4), with the sources of emissions being rice paddies, accounting for 29.94 $TgCO_2e$, or 57.7% of GHG emissions by the agricultural sector. Enteric fermentation accounted for 8.26 $TgCO_2e$ or 15.92% of GHG emission levels by agriculture. The agricultural soil sector had GHG emission levels of 7.6 $TgCO_2e$ (14.6%). Manure

management released 5.07 $TgCO_2e$ (9.8%). Field burning of agricultural by-products emitted 1.01 $TgCO_2e$ of GHGs, or 1.9% of overall emissions from this sector. Increases of GHG emissions held steady from 2000-2004 due to the stable nature of agricultural activities, especially rice paddy farms. Furthermore, the technology used in planting remains relatively unchanged; with emissions being caused mainly by the increased use of fertilisers.

The **land-use change and forestry sector–** In 2000, this sector recorded GHG emissions of 55.64 $TgCO_2e$, with GHG sinks removing 63.54 $TgCO_2e$ from the atmosphere, resulting in carbon sinks exceeding emissions by around 7.9 $TgCO_2e$. The calculation of GHG emissions and sinks can be divided into three categories. Forest and grassland change accounts for 44.47 $TgCO_2e$, or 79.9% of GHG emission levels by this sector (sinks excluded). Forest and biomass change accounts for 11.17 $TgCO_2e$ or 20.1% of output from the land-use change and forestry sector (sinks excluded). However, in the land-use change and forestry sector, GHG sinks exceeded emission levels, resulting in net sinks equal to 13.35 $TgCO_2e$. Deserted land restoration alone was worth 39.02 $TgCO_2e$. Table 2.3 illustrates trends in emission and sink levels of GHGs from the land-use change and forestry sector from 2000-2004 by sub-sector.

Table 2.3 Levels of GHG emissions and sinks in the land-use change and forestry sector from 2000-2004

Land use subsector	2000	2001	2002	2003	2004
5A Changes in forest and other woody stocks					
5A1 Plantation	- 24,521.20	- 22,149.67	- 28,121.94	- 34,764.25	- 43,356.43
5A2 Commercial harvest	11,169.66	6,670.80	4,678.96	10,099.36	15,638.59
Subtotal 5A	**- 13,351.54**	**- 15,478.87**	**- 23,442.98**	**- 24,664.90**	**- 27,717.84**
5B Forest conversion					
5B1 Carbon release by on-site burning	2,382.45	83.78	42.53	42.53	2,231.28
5B2 Carbon release by off-site burning	28,579.76	5,132.20	17,655.48	17,655.48	21,714.04
5B3 Carbon release by decay of biomass	13,271.90	10,660.32	10,855.31	11,011.29	6,251.56
5B4 Non-CO2 burning on-site					
- CH4 in CO2e	218.40	7.77	3.99	3.99	204.54
- N2O in CO2e	21.70	-	-	-	21.70
Subtotal 5B	**44,474.21**	**15,884.07**	**28,557.31**	**28,713.29**	**30,423.12**
5C Abandonment of managed land					
5C1 Carbon uptake by aboveground regrowth-first 20 yr	- 16,390.00	- 6,495.79	- 7,463.21	- 8,549.05	- 10,634.65
5C2 Carbon uptake by aboveground regrowth- > 20 yr	- 22,632.46	- 22,917.91	- 22,195.80	- 21,641.80	- 20,573.19
Subtotal 5C	**- 39,022.46**	**- 29,413.71**	**- 29,659.01**	**- 30,190.86**	**- 31,207.84**
Total emission (Gg CO2e)	**55,643.87**	**22,554.87**	**33,236.27**	**38,812.65**	**46,061.70**
Total removal (Gg CO2e)	**- 63,543.66**	**- 51,563.38**	**- 57,780.95**	**- 64,955.11**	**- 74,564.27**
Net total (Gg CO2e)	**- 7,899.79**	**- 29,008.51**	**- 24,544.67**	**- 26,142.46**	**- 28,502.57**

Note: GHG levels (thousand metric tonnes of carbon dioxide equivalents) / Source: Thailand Second National Report

Waste sector – In 2000, GHG emissions from the waste sector came out to 9.32 $TgCO_2e$, or 3.2% of the country's overall emissions. The responsible sub-sectors were waste treatment, wastewater treatment, and incineration. The most prominent gas released was methane, a result of biological processes. The amount of gases emitted in waste treatment and

wastewater treatment was similar: 4.86 and 4.43 $TgCO_2e$, or 52.1 and 47.5% of overall emissions from the waste sector, respectively. GHG emissions rose every year at a 6.5% growth rate from 2000-2004 due to an increasing number of industrial factories adopting anaerobic digestion. The calculation of GHG emitted from waste disposal plants required tracking of waste treatment management in each community, especially for waste screening, which affects waste composition before landfilling. Therefore, measurement, collection, and reporting of the amount of waste before landfilling should be conducted systematically. Yearly inspection of waste composition should also be carried out. In-depth reporting of the amount of GHGs released from wastewater, especially from industrial wastewater, should be improved at each factory, along with the technology used to do so.

2.3 Climate change at the global level and in Thailand

Climate change, according to meteorologists, is a change in the average weather patterns of an area. Average weather involves all attributes concerning the subject: temperature, rainfall, wind, and so on. However, according to the definition coined by the United Nations Framework Convention on Climate Change (UNFCCC), climate change means changes in climate that can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere. The Intergovernmental Panel on Climate Change (IPCC) in turn defines climate change as a change in the state of climates caused either nature or human activity (The Meteorological Department, 2013; Boonprakob, 2011).

(1) Global Change

It is evident that climate change is undoubtedly occurring in the present. Evidence from scientific studies suggests that global temperatures are rising, along with changes occurring in rainfall and sea levels. According to the IPCC's Fourth Assessment Report (2007), from 1995 to 2006, global average surface temperatures were the highest recorded since 1850 in 11 out of 12 years. Furthermore, from 1906-2005, average surface temperatures increased by 0.74°C. Between 1979-2005, increases in the average surface temperature were double those of the average sea surface temperatures (0.27 °C per decade in the case of the former, while the latter grew at a rate of 0.13 °C per decade). Overall, average sea surface

temperatures increased at a faster rate than in the past, this in turn is related to rising sea levels. According to data collected by water level stations' from 1961-2003, the average global sea level increased by 1.8 mm a year. Satellite monitoring of water levels showed that from 1993-2003, the average global sea level increased by 3.1 millimetres a year, increasing by 3.4 mm a year from 1993-2008 (Bindoff et al., 2007; Cazenave & Llovel, 2001). Rising sea levels are caused by (1) the expansion of seawater due to higher water temperatures and, (2) melting glaciers throughout the planet, including those in Greenland and Antarctica.

The cause of rising global temperatures is the emission of GHGs. Between 1970-2004, GHG emissions caused by human activity increased by 70%, from 28.7 gigatonnes of carbon dioxide equivalents per year ($GtCO_2$-eq/yr) in 1970, to 49 gigatonnes in 2004, with carbon dioxide (CO_2) having the highest rate of increase from the baseline year at 80%, as well as contributing to 77% of total emissions in 2004 as illustrated in Figure 2.10. Furthermore, GHG emissions increased more rapidly from 1995-2004, while the growth rate of GHG emissions was 0.92 $GtCO_2$-eq/yr. However, from 1970-1994, the growth rate of emissions was 0.43 $GtCO_2$-eq/yr.

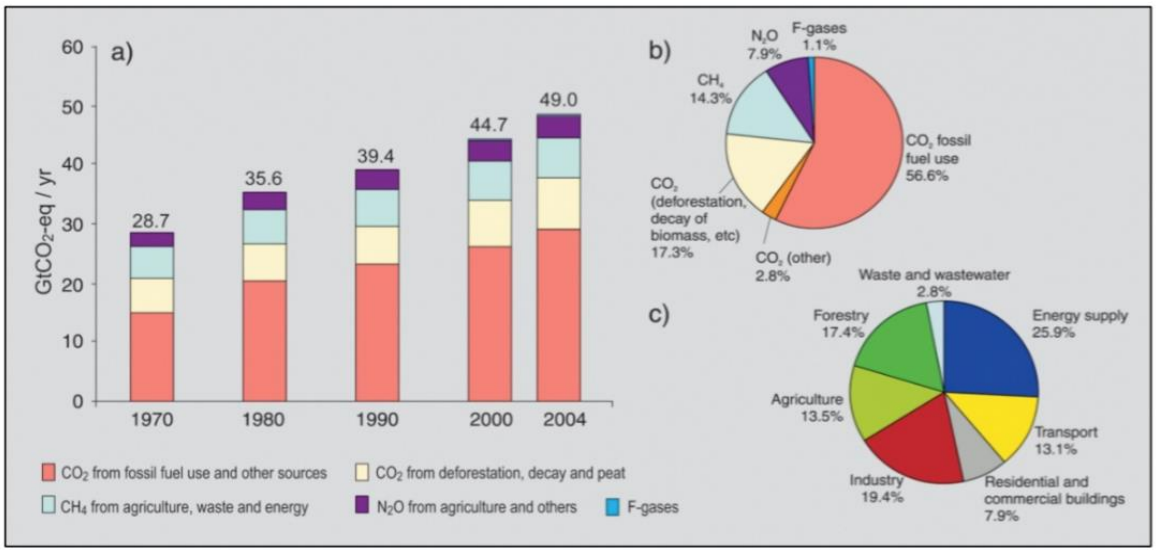


Figure 2-10: The amount of GHG emissions from human activity from 1970-2004

Source: IPCC 2007

Under GHG intensity simulations, it is predicted that by 2099, average global surface temperatures will increase to a greater degree than they did from 1980-1999, with the best estimates illustrated in various cases as follows: (1) When GHG concentrations in the

atmosphere amount to 600 parts per million (ppm), the average global surface temperature is expected to increase by 1.8 ℃. (2) At 700-800 ppm, the average temperature will increase by 2.4 ℃. (3) At 850 ppm, the average temperature is forecast to increase by 2.8 ℃. (4) At 1,250 ppm, the average temperature is predicted to increase by 4 ℃. (5) At 1,559 ppm, the average temperature should increase by 4 ℃ (IPCC, 2007). These circumstances will strongly impact global growth and development (Asian Development Bank, 2009). Figure 2.11 illustrates the projections of surface temperatures by the IPCC.

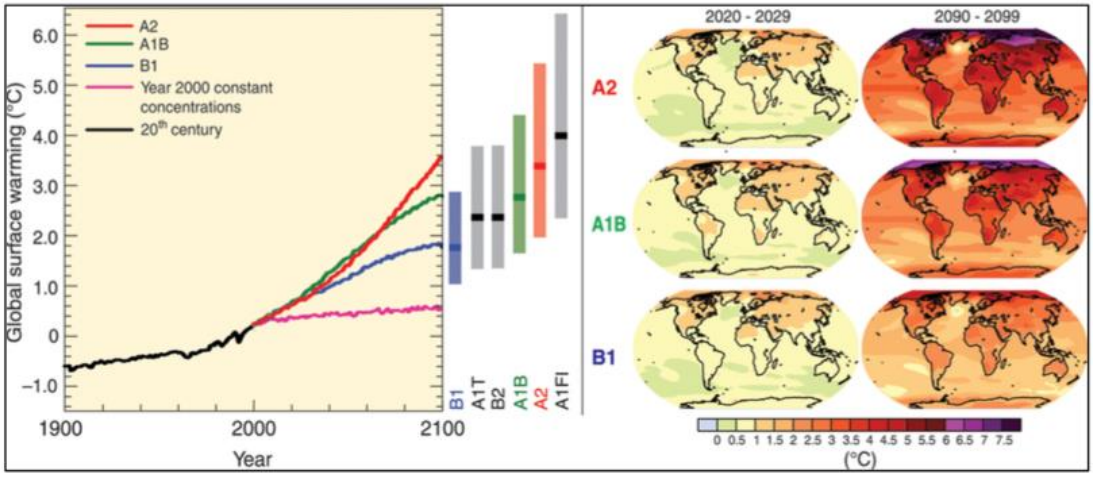


Figure 2.11: Various circumstances of GHG emissions and projections of global surface temperatures

Source: IPCC 2007

In May 2013, Mauna Loa Observatory in Hawaii, USA, published data on GHG intensity in the atmosphere showing that concentrations had increased to 400 ppm (NOAA, 2013).

GHG intensity in the atmosphere and changes in the average global temperature play a major role in altering the Earth's geographical features. They strongly impact areas inhabited by humans and animals alike. Figure 2.12 illustrates the relationships of the aforementioned changes and their predicted impacts on different ranges based on different averages (the 50th percentile) of GHG intensity in the atmosphere.

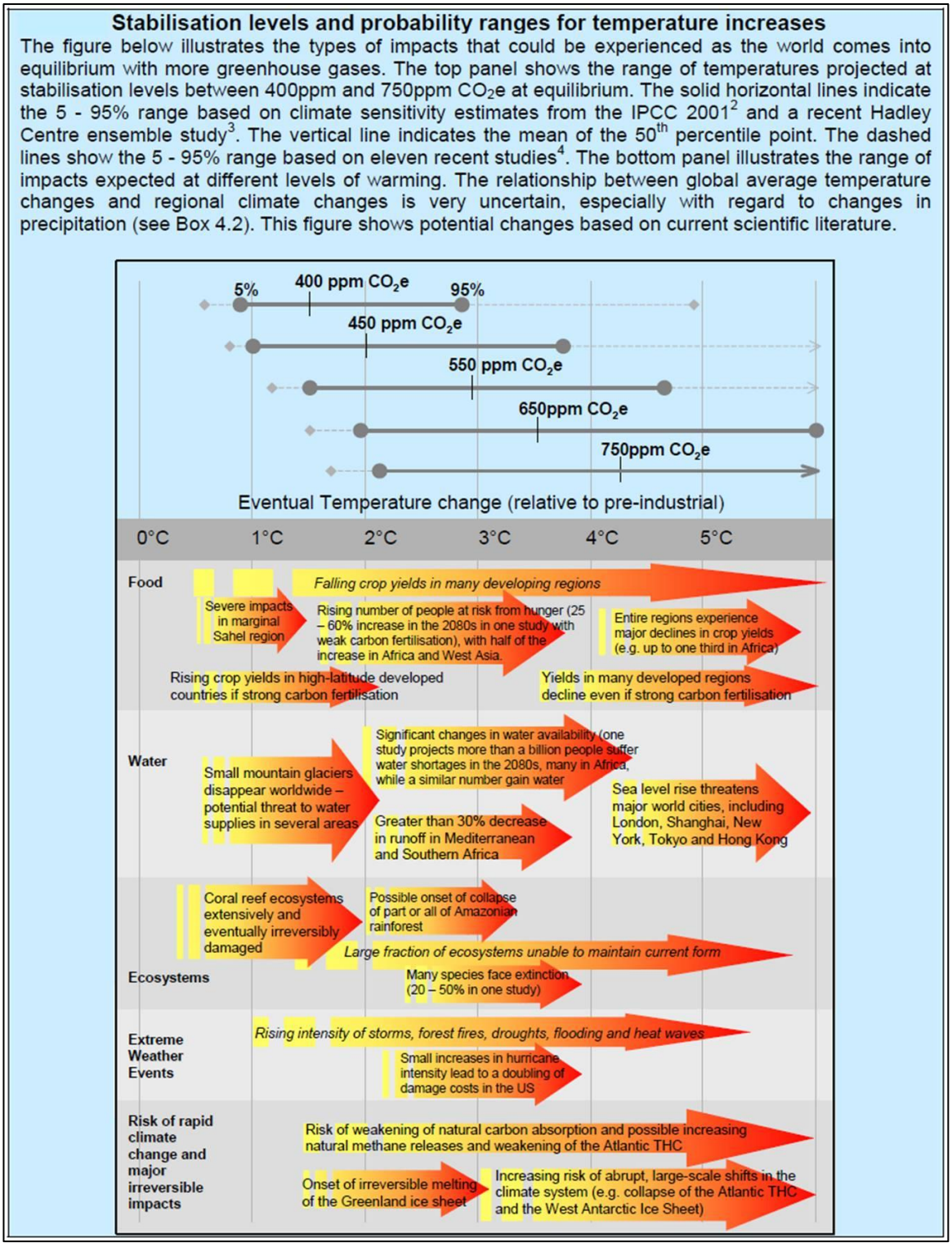


Figure 2.12: The probability of impacts caused by changes in the average global temperature

Source: Stern 2006

Apart from the projections of impacts caused by rising temperatures, there are also predictions concerning extreme weather events, extended summers, shortened winters, more

severe droughts during dry seasons, increased rainfall during rainy seasons, more frequent extreme weather fluctuations and climate events, and rising sea levels. Table 2.4 illustrates the trends and impacts caused by global climate change.

Table 2.4: Examples of impacts of climate change caused by extreme weather fluctuations and climate events

Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid- to late 21st century. These do not take into account any changes or developments in adaptive capacity. The likelihood estimates in column two relate to the phenomena listed in column one. (WGII Table SPM.1)

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry and ecosystems (WGII 4.4, 5.4)	Water resources (WGII 3.4)	Human health (WGII 8.2, 8.4)	Industry, settlement and society (WGII 7.4)
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food- borne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food- borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers; potential for population migrations; loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[c]	Likely[d]	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Notes:

a) See (WGI Table 3.7) for further details regarding definitions.

b) Warming of the most extreme days and nights each year.

c) Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1% of hourly values of observed sea level at a station for a given reference period.

d) In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. The effect of changes in regional weather systems on sea level extremes has not been assessed. (WGI 10.6)

Source: IPCC 2007

The impacts of climate change include rising temperatures, longer summers, shorter winters, and more severe droughts during the dry season. In the agricultural, forestry, and ecology sectors, cooler regions might benefit from higher production of agricultural products. However, in regions with higher temperatures, this could result in decreases in agricultural production along with soil depletion. Warmer temperatures create ideal conditions for pests to breed and spread. They may also result in frequent wildfires and higher mortality rates of livestock and wildlife. In terms of water management, climate change decreases water levels in countries that rely on melting snow for their water supply. In countries with hot weather, demands for water will increase, creating extensive water shortages in numerous areas; this can also lead to water quality issues such as red tide due to sudden increases in algal bloom. Climate change can reduce the number of deaths resulting from cold weather, but on the other hand, it could also increase the number of deaths related to hot weather, especially among populations that are sensitive to changes in climate, e.g. newborns, senior citizens, patients suffering from chronic symptoms, and the socially abandoned. There are also increased risks of water and food shortages, malnutrition, and outbreaks of water-borne and food-borne diseases. In the industrial sector, climate change affects human settlement and society in general. Demands for energy for heating may decline, while demand for energy for cooling purposes will increase. The air quality in cities will likely deteriorate, along with the quality of life for the homeless. Travel obstacles caused by snow will decrease, but at the same time, winter tourism and related activities will be impacted. Finally, water shortages may result in human migration.

Rainfall in the rainy seasons, weather fluctuations, and climate events will be more frequent. In terms of agriculture, forestry, and ecology, this will result in damage to agricultural products. Agricultural land areas will be negatively impacted by floods. Soil erosion, landslides, uprooted trees, and damage to coral reefs will be noticeable. In regards to water management, climate change could result in the contamination of surface and underground water. Water distribution systems may be severely affected by extreme storms. Morbidity and injury rates, storm and disaster deaths, and post-disaster stress could all see increases. Climate change would also impact the industrial sector, human settlement, and society in general, resulting in losses of property. Insurance companies might not cover certain

disaster-risk areas and human settlements.

Sea levels showed a tendency to rise. The agricultural, forestry, and ecological sectors will all be affected by seawater intrusions that would impact water management, as reductions in freshwater resources could lead to water shortages. There will be increases in the number of injuries and deaths caused by ocean waves and storms. In the industrial sector, human settlements and society would suffer from the impact of coastal erosion and rising sea levels, the results of which would be increased flooding.

(2) Changes in Thailand

In Thailand, the study was conducted using statistics and weather simulations. The data of surface and atmospheric temperatures recorded by weather stations throughout the country revealed that temperatures had increased significantly from 1955-2009 (the data was provided with a 99% confidence level ($p<0.001$)). The highest average annual temperature, average annual temperature, and lowest average annual temperature, all were predicted to rise by 0.86, 0.95, and 1.45 ℃, respectively. The rates at which they increased per decade were 0.156, 0.174, and 0.263 ℃, respectively. The rate at which Thailand's average temperature rose per decade (0.174 ℃ per decade) was higher than the global rate (0.126 ℃ per decade) (Limsakul & Limjirakan, 2011). Surface temperatures in the Gulf of Thailand and the Andaman Sea rose by 0.1 ℃ per decade from 1967-2006. Sea levels in the Gulf of Thailand also tended to rise. According to data collected from 1895-2004 by four sea level stations, sea levels in the Gulf of Thailand tended to rise at a rate of 3.0-5.0 mm per year. Data from the satellite sea level monitoring system collected from 1993-2009 also demonstrate an increase in the average sea level moving in the same direction. However, no studies were conducted properly in the Andaman Sea (Singharak & Pattarasathapornkul, 2011). Furthermore, average annual relative humidity and temperature showed overall increases, while the water evaporation rate fell. Thailand's average annual rainfall over the past 55 years showed slight decreases, although the results were without statistical significance at the 95 % confidence level. However, it was found that changes in Thailand's average annual rainfall were related to ENZO, with lower average annual rainfall during years the El Niño phenomenon occurred, and higher amounts of rain during La Niña (The Thailand Research

Fund, 2011).

Climate change simulations for Thailand forecasting the next 30-100 years were carried out by downscaling the global climate simulation over Thailand, following the patterns of future trends that might affect GHG intensity in the atmosphere. These were divided into three cases: (1) Case B2; GHG intensity is equal to 800 ppm, (2) Case A1B; GHG intensity is equal to 850 ppm, (3) Case A2; GHG intensity is equal to 1,250 ppm (IPCC, 2007). Four simulations were used; with all of them demonstrating consistent results; that is, increases in overall temperatures However, temperature growth rates varied. Certain simulations showed noticeable increases in temperature (4 °C) over the next 100 years. On the contrary, changes in the amount of rainfall were not as obvious, though most of the simulations indicated that increases were expected (The Thailand Research Fund, 2011). Table 2.5 illustrates changes in Thailand's temperature based on different GHG emission simulations.

Table 2.5 Projections for changes in Thailand's temperatures based on various GHG emission simulations

Simulation Name	Spatial Resolution	Year Range	Future Year Range of Simulation	Case of GHG Emissions Simulation	Increase in Temperature in the Final Year of the Year Range (Degree Celsius)
GFDL-R30	0.5° lat. x 0.5°long.	1965-1990	2010-2029 and 2040-2059	B2	0.56)average temperature(
MM5-RCM	45 x 45 km^2 and 15 x 15 km^2	1970-1990	2010-2039	A2	0.8-1.0)highest temperature(
				A1B	0.4-0.8)highest temperature(
PRECIS[2]	25 x 25 km^2	1980-1989	2010-2099	A2	2.0-4.0)highest temperature(
RegCM3[2]	20 x 20 km^2	1961-2000	2031-2070	A1B	2.0-2.5)average temperature(

Source: The Thailand Research Fund 2011

The Office of Natural Resources and Environmental Policy Planning collaborated with Chula Unisearch, which, through the Southeast Asia (SEA) START Regional Centre conducted a study project on climate change impacts, future climate fluctuations, and required adaptations for primary sectors. The study reviewed projections of the future climate; finding that the first phase of climate simulations with high spatial resolutions for Thailand and Southeast Asia

were conducted using the Conformal Cubic Atmospheric Model (CCAM). The conditions used as data inputs for this climate simulation study happened to be the GHG intensity in the atmosphere. At 360 ppm; it is the concentration used in current global climate calculations to use as a baseline for comparison. The intensity was then increased to 540 and 720 ppm for use in future climate simulations. Nevertheless, the results of climate simulations under these conditions on the CCAM showed that temperatures in Southeast Asia were expected to fall slightly when GHG concentration in the atmosphere was at 540 ppm; however, predictions showed a rise in temperatures when the simulation was at 320 ppm. Future temperature increases under these simulations were around 1-2 °C higher than current conditions. However, changes in temperature during periods with apparently hot or cold weather were more obvious; that is, the number of hot days, or days with temperatures higher than 33 °C, are expected to increase by 2-3 weeks per year, while the number of cold days, or days with temperatures lower than 15 °C, will likely decrease by 2-3 weeks per year. It can be concluded that in the future, summers in the region will be longer while winters will in turn become shorter. Furthermore, the results of the future climate simulations with GHG intensity increased to 540 and 320 ppm resulted in 10-20% more rainfall over the region (Southeast Asia START Regional Centre, 2006). The next part of the study is a summary of the future climate simulation project, “Future climate simulations of Thailand and its adjoining areas”: a consequence of collaborative efforts between the Southeast Asia START Regional Centre, and the Met Office Hadley Centre for Climate Change, a climate change research centre in the UK. These climate simulations consisted of maps using high spatial resolution to cover the entire area of Thailand and its neighbouring countries. The project was aimed at understanding climate change trends in the region while considering three possible scenarios: (1) Case A2; based on trends in economics and politics, as well as technological access. Development focuses on economic growth rather environmental sustainability, resulting in a GHG intensity of 1,250 ppm in the atmosphere by the end of the 21st century. (2) Case B2; balanced with development occurring simultaneously with the sustainable conservation of nature. It focuses on solving community issues sustainably, in economic, social, and environmental terms, leading to GHG intensity of 800 ppm by the end of the 21st century. (3) Case A1B; a balanced combination of technologies from difference sources. Biomass energy is integrated with other power sources, resulting in uniform development and conservation of the environment at the global and regional levels, in turn leading to a GHG intensity of 850 ppm in the atmosphere

by the end of the 21st century. In each climate trend analysis, four results from the simulations were used: daily rainfall, daily highest temperature, daily average temperature, daily lowest temperature, and daily wind speeds and directions. The study phases were divided into four periods of 30 years each: the 1980-2009 period, which served as the study's baseline, and three future periods consisting of the 2010-2039, 2040-2069, and 2070-2099 periods. The study summarises the projections of climate change for Thailand's overall picture based on the study periods in terms of average, variance, and deviation of predicted climate characteristics by province. The study results are detailed below.

Rainfall levels – Calculations showed that average annual rainfall levels are likely to be on the rise in every region of Thailand in terms of quantity and the expansion of areas with higher amounts of rainfall, especially towards the end of the century. The number of rainy days per year was measured by counting days with rainfall greater than three mm. It was found that the average number of rainy days per year in every area remained similar to historical patterns, suggesting that future rainy seasons which might not differ much from those in the present. However, the average annual rainfall in almost every area rose; this could mean that rainfall could become heavier than it was in the past. This could increase the risk of floods and other natural disasters caused by flooding situations.

Highest temperatures – Under the GHG simulation following the economic and social development of Case A2, Thailand's average annual highest temperature at the beginning of the century did not differ significantly from that of the end of the previous century. However, in the middle of and at the end of the century, the highest temperatures tended to rise continuously in every region. In Case B2, the average highest temperatures also tended to rise in almost every area of Thailand, although they were lower than those in Case A2. In cases of annual hot days, or days where the highest temperatures were at least 35 °C, the results showed, the results showed that in the previous century, the areas with the hottest days were located in the Central and Western Regions, as well as the middle part of the Southern Region. Hot days occurred during an annual span of 5-6 months, some lasting up to 7-8 in certain areas. The forecast results showed that summers will likely be prolonged by 2-3 months in almost every area of Thailand by the end of the century.

Lowest temperatures – Case A2 showed that areas throughout Thailand tended to experience increases in the average lowest temperature of up to 3-4 ℃ by the end of the century. Meanwhile, Case B2 also showed increases in the average annual lowest temperatures, although they were less remarkable compared to A2, at around 2-3 ℃. At the beginning of the century, areas in the Northern and upper part of Thailand's Northeastern Region were expected to experience a span of days where temperatures fell below 16 ℃ lasting around one to two-and-a-half months, with some areas near the upper parts of the regions having these periods extended for an additional two months. Nevertheless, such periods tended to shorten noticeably by the middle of the century, with this becoming more obvious by the end of it. In Case A2, the only areas left with temperatures under 16 ℃ are expected to be certain mountainous parts of the country. Case B2 demonstrates fewer changes, while certain areas of the upper Northern Region and upper Northeastern Region are predicted to experience periods of cold weather lasting around a month, although such patterns are likely to undergo declines as time goes on.

Wind direction and speed – The calculations show that in the next 100 years, the upper part of the country located further from the sea, namely the Northern, Northeastern, and upper Central Regions, are expected to undergo small changes in wind patterns. The average wind direction is predicted to be similar to that in the past. Changes in wind speed and direction are predicted in coastal areas of the lower Central Region and the Eastern Region. The changes, however, are expected to be particularly evident in the Southern Region's peninsula.

However, attempts to apply data from these climate simulations should take certain discrepancies caused by local phenomena into consideration. Examples include micro climate results affected by each locality's environment. Future studies of potential climate scenarios should take into account influences at the local level that might affect changes in climate in each locality to further reduce such discrepancies when creating simulations (Chula Unisearch Chulalongkorn University, 2011).

2.4 Consequences of climate change

Changes in climate variables like temperature and rainfall certainly affect the country's systems and sectors, altering ecosystems and natural resources such as forests and water sources. This in turn impacts sectors that rely on these elements, for instance, agriculture, tourism, and human settlement. Therefore, climate change adds more severity to the existing risks and pressures of unsustainable exploitation of natural resources and inefficient management of said resources and local environments, further intensifying these issues. Chula Unisearch's 2011 review of the study concerning the consequences of climate change in Thailand summarises the main points as follows.

Impacts on ecosystem and biophysical environment – Climate change impact assessments on 22 plant species in the Northern Region of Thailand were conducted under the future global climate change simulation HadCM3 GCM using Case A2. The possible impacts caused by climate change in the 2050s appeared to be insignificant. However, such changes are expected to alter the distribution of plant species along with causing higher turnover, especially among evergreens. In addition, the study found that 11 out of 22 plants would lose their ideal conditions for growth, while the other 12 species would gain better conditions in these new environments. Temperature deciduous plant species are predicted to expand their distribution range in the western and upper part of the Northern Region (Trisurat et al., 2009). Furthermore, increasing temperatures will likely affect ecosystems in mountainous areas, especially the hill evergreen forest in Khao Phanom Bencha National Park, Krabi. Temperatures are expected to increase in mountains at higher altitudes. Rising temperatures could also impact mangrove forests protecting coastlines from storm surges. These areas are spawning areas for fish and shelled animals, and are also rich sources of food and wood fuel for local communities. Furthermore, these areas enable nutrient cycles from headwaters and are also ecosystems that help improve water quality. According to the study, the impacts of climate change in Krabi will result in decreases in the number of mangrove forests and a retreat from the seaward edge of around 18 metres over the next 25 years (Southeast Asia START Regional Centre and WWF, 2008).

Impacts on the agricultural sector – Climate change impact simulations on rice production were performed under the condition in which GHGs in the atmosphere were doubled. Normally, increases in the amount of carbon dioxide result in increased production of agricultural products, while increasing temperatures yield the opposite result. The results of the simulation predicted temperatures rising by 4-5 ℃ along with an 8-15% increase in rainfall. As a result, Thailand's rice production might rise or fall between +9.3 to -0.9% or +6.4 to -11.6% (Matthews et al., 1997). Impacts on rice production in three areas of Thailand—Chiang Rai, Sakolnakorn, and Sa Kaeo—were also studied using the agricultural production simulation known as the Decision Support System for Agro Technology Transfers (DSSAT version 4.0) (Hoogenboom et al., 1998). In addition, data on predicted future daily climate from the CCAM climate simulation, consisting of the highest and lowest temperatures, amounts of rainfall, and solar radiation, were also used, along with that on agricultural management patterns and soil property. This information was gathered to calculate future rice production under a climate simulation with GHG intensity at 360 ppm in the atmosphere. This was compared with simulations wherein GHG concentrations were increased to 540 ad 720 ppm. It was found that only slight changes were predicted in rice production. However, in the climate simulation in which GHG concentrations were increased to 720 ppm, average rice production is predicted to increase slightly, along with more fluctuations in annual products. In the baseline year, the three provinces produced an average of 2,522 (+216) kilogrammes/hectare of rice. In the climate simulation in which GHGs in the atmosphere came out to 540 ppm, rice production was at 2,552 (+270) kilogrammes/hectare. Under the climate simulation in which GHGs in the atmosphere amounted to 720 ppm, rice production came out to 2,836 (+54) kilogrammes/hectare. Furthermore, it was found that when years with low, medium, and high amounts of rainfall were compared, rice production did not differ much (Buddhaboon et al., 2005). The simulation was carried out in the study area of Ubon Ratchathani Province using data from the crop simulation model DSSAT and the climate simulation CCAM. The results predicted that climate change would positively impact rice production in the area. The forecast lends itself well to increases in rice production, with output improving by somewhere between 1.48-15.29%, and 10-15% in certain areas (Southeast Asia START Regional Centre, 2006; Chinvanno et al., 2008a). The analysis of Jasmine rice varieties KDML 105 in Tung Kula Rong Hai also show a consistent outcome.

Other primary field crops in Thailand such as corn, sugarcane, and cassava are all affected by climate change. The study conducted in Khon Kaen found that climate change is increased corn and sugarcane yields in the area, while reducing that of cassava. As the levels of GHG rise, sugarcane growth stages shortened. At the same time, cassava production tends to fall in years with low to medium amounts of rainfall, but increases significantly during years with large amounts of rainfall under conditions where GHG intensity increases to 540 and 730 ppm. Furthermore, climate change accelerates the cassava branching phase and lowers the harvest index while raising leaf area index, except during years with low rainfall (Kongton et al., 2004). Moreover, the study, employing the same sets of instruments and data, found climate change had positive impacts on sugarcane production in Khon Kaen and Chiang Mai (Jintrawet & Prammanee, 2005). The analysis of the consequences caused by predicted climate change on rice production was based on forecasts for the 2020s, 2050s, and 2080s, and conducted in Ubon Ratchathani, Khon Kaen, and Roi Et. It employed the rice growth simulation CRES, and future climate data from the global climate simulation ECHAM4 GCM while using the conditions of Case A2, with added details using the regional climate simulation PRECIS. Compared to the baseline period of 1997-2006, rice production fell by 24%. Rice products expected to be negatively impacted are KDML 105, with a 15% decrease in production, and RD6, with a 5.5% decrease, both of which possibly caused by rising temperatures (Ansul, 2009).

The study project assessing the impacts of climate change on the agricultural products rice, sugarcane, cassava, and corn was supported by the Thailand Research Fund (Punnengpetch et al., 2009). The crop production simulation DSSAT4 was employed using climate data predictions from the global climate simulation ECHAM4 using simulations A2 and B2, which forecast conditions throughout the 21st century. Furthermore, added details were calculated using the regional climate simulation PRECIS. The results show that Thailand's agricultural production, apart from cassava, is not likely to be severely affected by climate change. However, future patterns of climate fluctuations are expected to impact agriculture. Even though the country's overall agricultural production is expected to undergo only slight changes, certain areas are considered threatened by climate change, which could impact future agricultural production significantly. For example, areas used for growing rice during the rainy seasons, along with sugarcane and cassava fields in the Northern Region, as well as rice

paddies and corn fields during the dry seasons, are considered particularly vulnerable. From the assessment, it was found that the main factors in lowered rice production were soil fertility and rainfall distribution. However, the causes of decreased cassava production are not related to the above. Changes in temperature are also a primary issue in the lower Northern Region. However, corn production also dropped due to water shortages during the periods in which the crop began to bloom and develop silk and tassels (Punnengpetch et al., 2009). Figure 2.13 to 2.17 project various changes in agricultural products in future climate simulations.

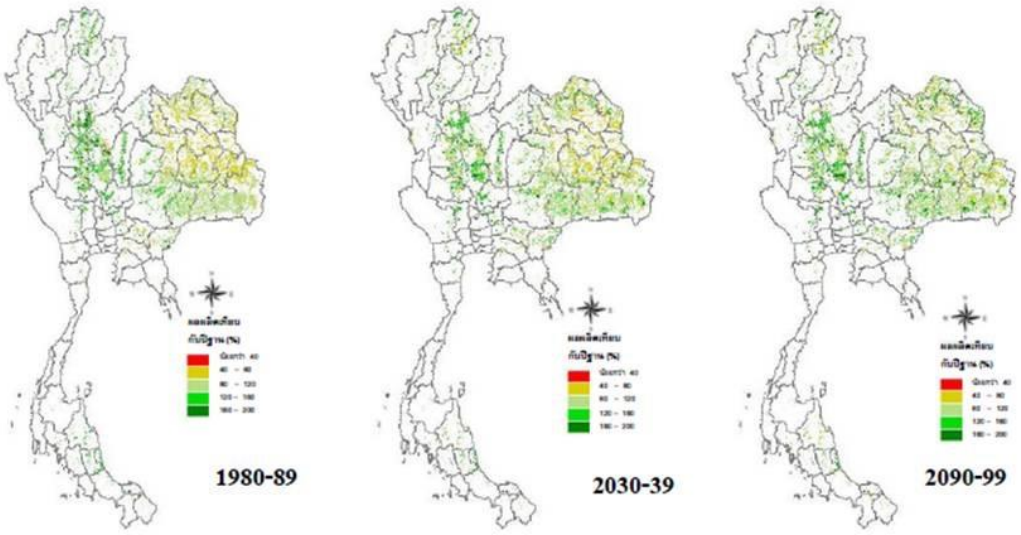


Figure 2.13 Changes in rice production during the wet and dry seasons under future climate simulations (percentage of yield compared to baseline)

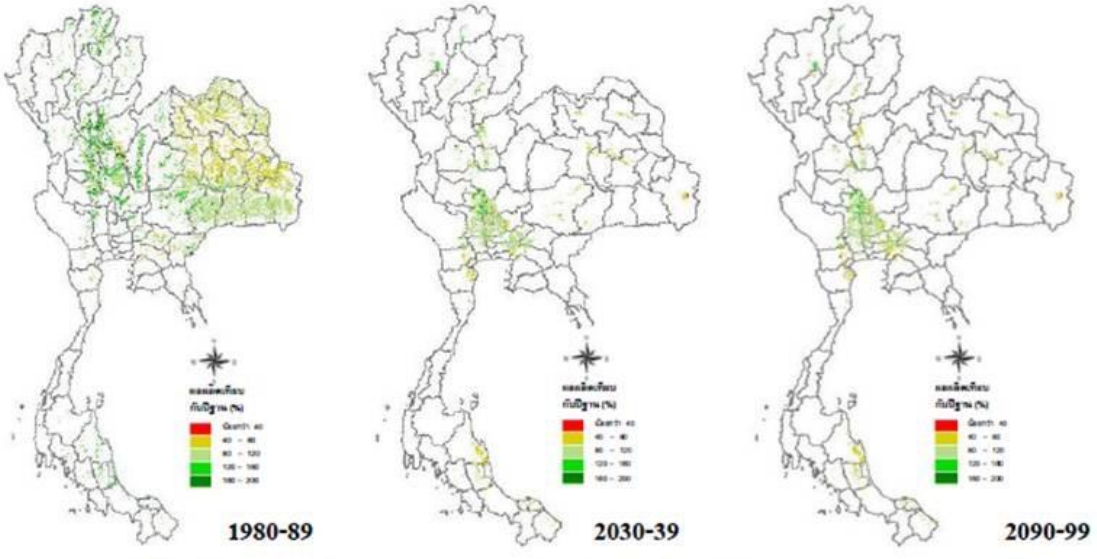


Figure 2.14 Changes in rice production by dry-season irrigated paddy fields/and dry-season paddies under various future climate simulations (percentage of yield compared to baseline)

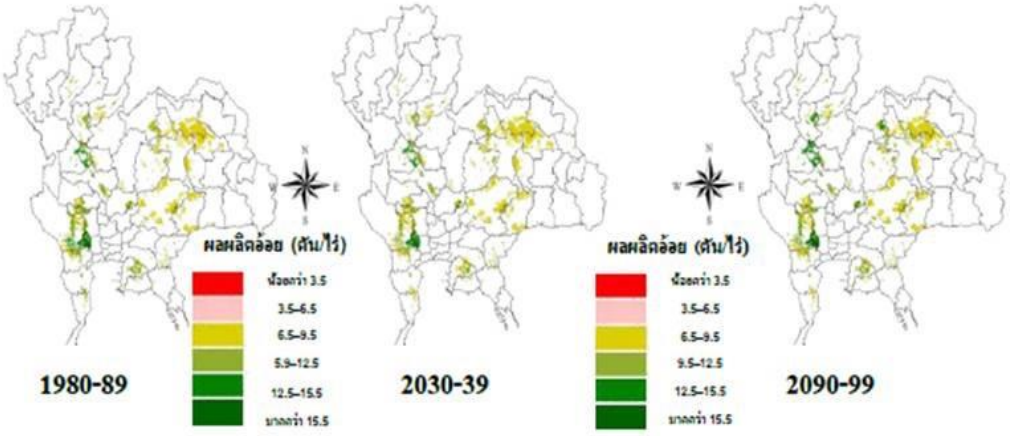


Figure 2.15 Changes in sugarcane production under future climate simulations (Tonnes/Rai)

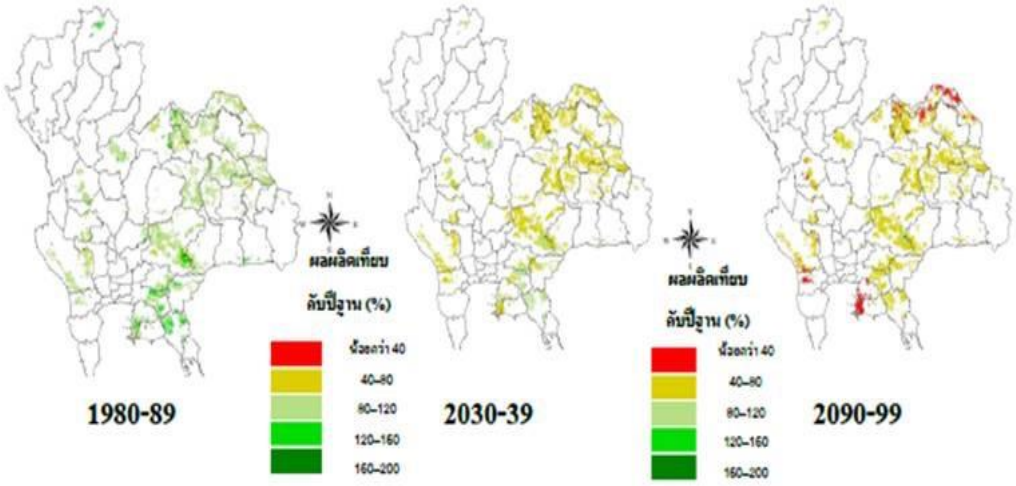


Figure 2.16 Changes in cassava production under future climate simulations (Percentage of yield compared to baseline)

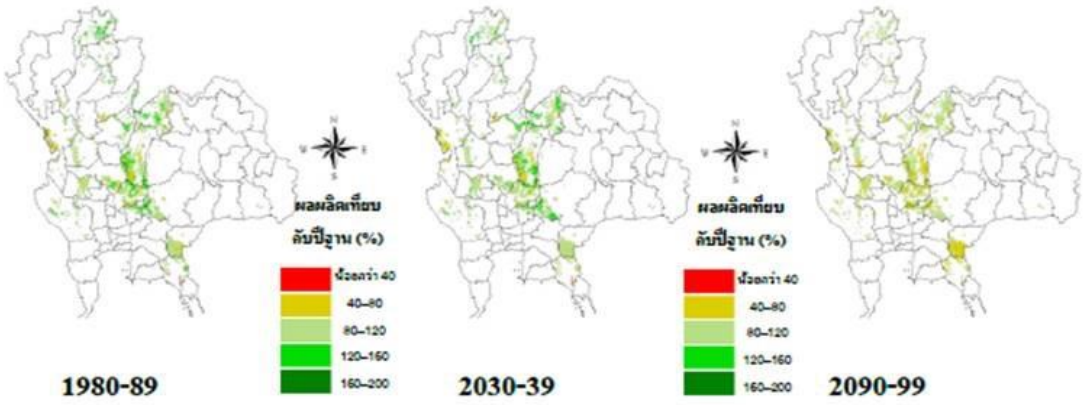


Figure 2.17 Changes in corn production under future climate simulations (Percentage of yield compared to baseline)

Source: Southeast Asia START Regional Centre 2011

Impacts on water resources – Climate change directly impacts water resources, particularly through changes in annual rainfall distribution and amount. Temperature changes, along with wind speed and direction, also contribute to such effects since these variables determine water levels in river basins. The results from the Variable Infiltration Capacity (VIC), using predictions from the climate simulation CCAM, show that many basins in Laos and Thailand that contribute to the Mekong are experiencing rising water levels due to higher levels of rainfall. During years with high amounts of rainfall during the decade when GHG intensity was 540 ppm, it was predicted that almost every river basin that flows to the Mekong River would have higher water levels. This increased when GHG concentration was raised to 720 ppm. However, in years with low amounts of rainfall, simulations showed many river basins contributing to the Mekong with lower water levels when GHG intensity was set at 540 ppm. Under the simulation where GHG concentration in the atmosphere was set at 720 ppm, water levels appeared to be higher than in the present even during years with low amounts of rainfall (Southeast Asia START Regional Centre 2006). Another study result, which focused on climate change forecasts for the Mekong River Basin by 2030, predicted rising rainfall levels in the Northern Region of Thailand during the dry season, along with decreases in rainfall in the Eastern Region. Nevertheless, it is predicted that Thailand's average annual rainfall will rise due to increased rainfall during the rainy season. Furthermore, speculation of the surface runoff and floods indicates an uptrend. The distinctive feature of this study is the usage of 11 global climate simulations, enabling more accurate forecasts of seasonal changes (Eastham et al., 2008).

The study conducted on Krabi found that the expansion of cities, deforestation, and land-use transformation into agricultural areas has already affected natural resources and water reservoirs in the present day. However, climate change is expected to result in lower levels of rainfall and a longer dry season, with this extended dry season eventually increasing demands for water for tourism purposes. Furthermore, in the future, if markets or government policies encourage palm oil planting, it could result in more water reserves being diverted for such purposes. These various factors contribute to increasing demands for water. In addition, rising sea levels lead to contamination of freshwater sources by saltwater, impacting local communities that use said water, in turn raising demand for more water from other natural sources (Southeast Asia START Regional Centre & WWF, 2008).

Higher temperature and extended summers will affect water evaporation, which will in turn contribute to imbalances between supply of and demand for water. A study was performed using the global climate simulations CCGCM2 and HadCM3 GCM, using GHG conditions A2 and B2, along with calculations for details on areas located on the lower side of the Chao Phraya River, in order to create forecasts for the 2020s, 2050s, and 2080s. The results suggested that both the highest and lowest temperatures will rise in the future while relative humidity levels will fall, resulting in an increase of the evapotranspiration rate, by 0.4-2.67% and 0.06-1.17%, respectively, compared to the baseline period of 1974-1985 (Chaowiwat & Likitdecharote, 2009). Such changes will impact demand for water. According to the CSIRO, when the GHG intensity in the atmosphere is increased from 360 ppm in the present to 540 and 720 ppm in the future, it was found that evapotranspiration tended to fall slightly under the simulation condition of 540 ppm, while it rose when the GHG intensity was raised to 720 ppm (Southeast Asia START Regional Centre, 2006). However, the results show fluctuations between seasons; evaporation is higher during the dry season and lower during the rainy season. Furthermore, calculation of water use efficiency suggested that paddies might require less water in the rainy season under the simulation wherein the GHG intensity was 540 ppm. However, more water was required at the beginning of the planting stage in the simulation where GHG concentration was at 720 ppm (Noimunwai, 2008).

Future changes in rainfall distribution may make water management more difficult. According to a study of water balance in the Maeklong River Basin that used future global climate simulation ECHAM4 and GHG projection A2, with details based on the regional climate simulation PRECIS in 2025, 2050, and 2095, despite expected increases in rainfall that should relieve water shortages, water management at the Srinagarind Dam and the Vajiralongkorn Dam will face more complications (Chinvanno et al., 2009). This is due to the need to release water in order to handle saltwater infusions into estuaries, especially during the dry season when water levels are low (Rojrungtavee, 2009). Furthermore, rising sea levels also intensify saltwater intrusions into estuaries. The study of the Tha Chin River employed the IPCC's climate simulation under the projections that GHG increases match those in the A1FI (GHG intensity in the atmosphere at 1,550 ppm) and the B1 scenarios (GHG intensity of 600 ppm). It was found that saltwater intrusion will likely be more severe in the future (Wongsa et al., 2009).

Impacts on rising sea levels and coastal erosion – Climate change affects sea levels, especially in areas near the Equator such as Thailand. This is due to melting glaciers and the expansion of water in the oceans as a result of rising temperatures (Parry et al., 2007). However, analysis of the sea levels in the Gulf of Thailand near Koh Lak, Prachuab Khiri Khan, and Sattahip, Chonburi based on statistics collected from 1940-1996, shows no visible signs of rising sea levels. On the contrary, sea levels in the Gulf of Thailand fell by 36 centimetres per decade as a result of crustal plate movements and coastal erosion caused by reduced sediments from primary rivers (Vongvisessomjai 2006). However, future patterns indicating change may differ from past ones. According to the Dynamic Interactive Vulnerability Assessment (DIVA), it was predicted that compared to the baseline year (1995), the mean sea level in Krabi would increase by 11 cm during the 2020s, and by 21 cm during the 2050s. Furthermore, the influence of local winds is likely to contribute to rising sea levels during certain seasons, especially the Southwest Monsoon Season (Southeast Asia START Regional Center and WWF, 2008).

Impacts on communities and human settlements – Changes in temperature, especially increases, will influence demand for electricity. A study assessed Thailand's daily demands for electricity in different seasons, with the results, based on changes in the highest

temperature from the global climate simulation HadCM3, show that Thailand's highest temperatures in summer will rise, which corresponds to the nation's period of peak power demand. Therefore, estimates of electricity demand, relying solely on economic growth without taking climate change into consideration, project results that are lower than reality (Parkpoom and Harrison, 2008). Furthermore, the study conducted by the Water Utilization Program – Finland team (WUP Fin) at the Mekong River Commission (MRC) forecasted changes in floodplain boundaries in the Songkhram River Basin using the future climate simulation CCAM with the simulation's future GHG intensity at 720 ppm (Southeast Asia START Regional Centre, 2006). The study shows that predicted rainfall levels in the Mekong River might contribute to wider floodplains on the Songkhram River Basin compared to the present, thus affecting nearby communities.

Impacts on health – Rising temperatures and rainfall in many areas are the cause of increases in vector-borne and water-borne diseases (Parry et al., 2007). According to a study based on the results of global climate simulations ECHAM1, UKTR, and GFDL89, it was found that during the 2050s, temperatures are expected to rise by 1.16 °C from the baseline period of 1931-1980, resulting in a higher likelihood of dengue outbreaks. The Epidemic Potential Model (EP Model) indicates that the tendency for outbreaks to occur peaks from April-May, although July and August tend to see the largest number of reported patients (Jonathan et al., 1998).

Impacts on tourism – Tourism is one of the primary sectors that contributes greatly to the Thai economy. It also will likely be affected in various manners by climate change such as through changes in rainfall and its patterns of distribution, temperature, and key factors in oceanography. Even though an impact assessment of climate change on Thai tourism has yet to be fully conducted, the Ministry of Tourism and Sports has already initiated risk assessments of climate change and the vulnerability of tourism clusters; with all 14 of these clusters posing different risks (Chula Unisearch, 2009).

The study on climate change assessments, predictions, and potential impacts indicated that Thailand still has limited knowledge of climate change due to limited research and coverage of the subject. Furthermore, climate change projections, based primarily on global

climate simulations with different scenarios of GHG emissions, pose certain limitations in terms of uncertainty; this includes consequences caused by climate phenomena and climate fluctuations that are interconnected, impacts at the local level, and adaptations to constant changes experienced by natural ecosystems and human ones. In addition, the GHG intensity in the atmosphere set in simulations is at the global level, this being based on the international development directions that could deviate with each period of time. Despite the effort put into projections, the actual future remains uncertain. Preparation by various systems and sectors—social, economic, and environmental—requires risk management as a foundation. While climate change does not pose direct threats to the systems or sectors, its impacts on biologically and physically-related areas may eventually affect sectors that rely on those systems. Therefore, the impacts on biological and physical aspects are used as proxies in risk assessments based on climate change. The risks of climate change within a certain period depend on the exposure of systems and sectors, and are enhanced by their vulnerability to its possible impacts. However, levels of risk vary by each area's context, depending on the patterns of relationships that systems or sectors have on each impact. Different geographical locations might also affect the levels of sensitivity to different climate variables. Climate change risk and impact assessment can be handled through assessment surveys and utilisation of different simulations. This includes agricultural or water resource simulations, for example, crop models and hydrological models that are more advanced than other simulations. The results retrieved from the analysis generated by such simulations are in quantities that facilitate the assessment. However, such results are not necessarily accurate or of the highest quality. Opinions are still required occasionally for the sake of qualitative analysis. Impacts are subsequently linked to the risks under the context of predicted development and whether it could lead to the target set in the future. If the development direction proceeds as expected under that climate simulation, with certain details adjusted, it shows that the systems or sectors are not as vulnerable, but instead possess adequate coping capacity. On the other hand, if the development direction cannot be achieved, the systems or sectors involved need more measures to prepare for climate change. Nevertheless, analysis of the costs and returns of implemented measures should be carried out. If they appear to be acceptable, those measures are considered appropriate, however, the opposite is true, then the expected development direction needs to be reviewed since it might not match the context of the area.

Vulnerability can be summarised as a relationship of risk, or exposure and sensitivity, relative to coping capacity.

$$\text{Risk} = \text{Exposure} \times \text{Sensitivity}$$ and

$$\text{Vulnerability} = \frac{\text{Risk}}{\text{Coping Capacity}} = \frac{\text{Exposure} \times \text{Sensitivity}}{\text{Coping Capacity}}$$

The degree to which a system or sector is vulnerable depends on the ratio between risk and coping capacity. However, reducing risk to 0 and/or keeping vulnerability extremely low by increasing coping capacity is difficult to execute economically and technologically. In general, systems and sectors need to manage risk by creating a greater balance between it and coping capacity. Furthermore, the issues that need to be emphasized in risk assessment for responding to climate and weather events are time and spatial scales (in geography). In systems or sectors, these factors are categorized into different stages that are related in time scale. For instance, cases involving weather processes in a short period of time are known as ‘weather events’. The characteristics of such events are only temporary, with a time span of up to a decade. Systems and sectors at the household or district levels usually respond to weather events in a short period, perhaps even only on a daily basis, or pay attention to the two to three years ahead. However, if the systems’ or sectors’ responses to climate events are greater in scale, for instance, at a regional, national, or greater scale where relevant areas exceed millions of *rai* in size, issues surrounding climate in the long run become more critical. Because this involves strategic planning with a tie span of over 30 years, the vision for change is also more extensive. Therefore, preparations for adapting to extensive changes will require management of continuous processes, knowledge transfers, and communications with related personnel in relevant areas to ensure proper coordination at all of management (Southeast Asia START Regional Centre, 2011).

2.5 Response to climate change issues

(1) International collaboration framework- In 1990, the IPCC published a climate change assessment report to confirm the existence of climate change, the consequences of GHG emissions to the Earth's atmosphere, and possible threats caused by climate change. The latter includes melting icebergs and glaciers, rising sea levels, and frequent and extreme natural disasters. The assessment results led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC), establishing the global stage for international collaborators to solve climate change issues. Being aware of the threat of climate change issues and the necessity of joining the global community in finding solutions, Thailand ratified the Convention on 28 December 1994. The Convention requires member countries to comply with obligations under the concept of "common but differentiated responsibilities" by dividing member countries into three categories: **Annex I Parties** are developed industrialised countries that have emitted a large amount of GHGs. These parties are obliged to take practical steps in reducing GHG emissions, an example being the creation of emission reduction targets. **Annex II Parties** are countries listed in Annex I, however, this category does not include countries that did not undergo the process of transitioning to a market economy (from socialism to capitalism). Members are required to provide financial resources, develop and transfer technology, and improve the efficiency of developing countries in reducing GHG emissions and adapting to impacts caused by climate change. **Non-Annex I Parties** are developing countries which, since the ratification in 1994, Thailand has been a part of. They are not obliged to set reduction targets. However, they are obligated to (1) create and improve their national GHG inventories and publish this data to inform all member nations, (2) create national plans for GHG reduction and adapting to the impacts of climate change, (3) support development and transfer of technology to reduce GHG output, including in the energy, transport, industrial, agricultural, forestry, and waste sectors, (4) support conservation of carbon sinks, which are forests, biomass, and terrestrial, coastal, or marine ecosystems, (5) work together to cope with and adapt to the consequences of climate change, (6) take climate change into account when creating policies, including economic and environment plans, (7) support any related research and development, (8) encourage exchange of academic, econometric, and legal data related to the execution of climate change solutions, (9)

encourage cooperation in public education, training, and awareness concerning climate change, and (10) publish national reports that include GHG inventory, as well as situations and implementations regarding climate change in (this particular case being) Thailand for other member countries. The Non-Annex I Parties are financially supported in the task of preparing national reports. Operations under the Convention can be categorised into two main phases as follows:

(1) Pre-2020 action

At the third Conference of the Parties (COP) held in Tokyo, Japan in 1997, the member countries agreed on the Kyoto Protocol, a legally-binding agreement under the Convention. Its objective is to determine obligations in GHG mitigation by setting an overall target number, individual targets for Annex I Parties, and setting commitment periods. In the first commitment period from 2008-2012, Annex I countries were required to reduce overall GHG emissions by 5% from 1990 emission levels. Furthermore, the Kyoto Protocol initiated three mechanisms to support the achievement of those targets: (1) Emission Trading or carbon credit among the Annex I Parties, (2) Joint Implementation of GHG mitigation among the Annex I Parties, and, (3) Investment in GHG mitigation projects between countries inside and outside the Non-Annex I category, or the Clean Development Mechanism (CDM). Thailand ratified the Kyoto Protocol on 28 August 2002, which resulted in Thailand's participation in the CDM with the Annex I countries. Later, at the Eighth session of the Meeting of the Parties to the Kyoto Protocol, in Doha, Qatar, the Kyoto Protocol member countries agreed on (by decision 1/CMP8) an amendment. The main points of it are (1) setting the overall GHG reduction target for Annex I Parties to 18% from 1990 GHG levels by the second commitment period (2013-2020), and (2) adding nitrogen fluoride (NF_3) to the GHG inventory. In the determination of targets and the second commitment period, Annex I countries that did not involve/provide targets were Japan, Russia, and New Zealand. Australia did not ratify the second commitment period but would adapt its second phase to an extent. However, Canada withdrew from the Kyoto Protocol. Thailand, as a Non-Annex I country, does not have obligation targets for GHG mitigation in either the first or second commitment periods (until the end of 2020).

The Kyoto Protocol is an international collaborative effort in setting concrete targets in GHG mitigation through a legally binding agreement. However, such collaboration still holds certain limitations which prevent complete solutions to climate change. One notable limitation is the United States of America, a member country in Annex I, which has emitted a great amount of GHGs from the past to the present, and did not join the Kyoto Protocol. Therefore, targets and mechanisms under the Kyoto Protocol do not include the United States, resulting in the Annex I Parties' concerns over unfair treatment as the United States does not have comparable concrete obligations or clear targets for GHG mitigation. However, the US' decision not to join was due to Congress' desire to avoid having the country become obliged to engage in GHG emissions reduction while the agreement did not include or require obligations from developing countries with heavy GHG emissions such as China. Therefore, negotiations under the Kyoto Protocol have recently focused on achieving a new agreement apart from the Protocol itself that includes countries that are responsible for heavy GHG emissions. This led to the establishment of the Ad Hoc Working Group on Long Term Cooperative Action (AWG-LCA) along with the goal of reaching an agreement by 2009 at the fifteenth COP in Copenhagen, Denmark. However, the Conference failed to come to terms with the new agreement. At the seventeenth session in Durban, South Africa in 2011, the Conference set a second negotiation process, the current session known as the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP), which set a target of achieving a new agreement by 2015 in the twentieth COP to be held in Paris, France.

Apart from the negotiation process at the COP, efforts are being made on setting a long-term target of ensuring that global temperatures do not rise more than 2 °C from those before the Industrial Revolution. This target however, is linked to GHG intensity in the atmosphere that is set at 450 ppm. Furthermore, mechanisms were also established to urge member nations to engage in the task of mitigating GHGs. They require the fulfillment of pledges made by developed countries (Nationally Appropriate Mitigation Commitments) and for developing countries to comply with the Nationally Appropriate Mitigation Actions (NAMAs) willingly. The target year is 2020, which aligns with the second commitment period of the Kyoto Protocol. This effort allows countries that did not ratify the commitment or provide their targets in the second commitment period to verify their pledges to achieve their targets for GHG mitigation. **Thailand has studied its own ability to deal with GHG mitigation and**

comply with the NAMA Pledges. The study includes the goal of reducing GHG output from that of the 2005 baseline year by 7-20% in the energy and transport sectors by the year 2020.

A United Nations Environment Programme (UNEP) report on global emission pathways argued that in order to keep temperatures from rising up to 1.5-2 °C by 2100 from levels common from before the Industrial Revolution, GHG emissions must peak by no later than 2020. In such a scenario, the median value of GHG emissions in 2020 should be at 44 $GtCO^2$-eq before falling rapidly afterward with a median rate of decline of 2.5 per year. In 2030, the median value of GHG emissions should then be at 37 $GtCO^2$-eq before falling further to 21 $GtCO^2$-eq by 2050 (UNEP, 2012). Furthermore, the UNEP's report also presents comparative analysis of emission pathways to achieving the targeted maximum temperature increase of 2 °C along with business-as-usual (BAU) pathways serving as a control group. It is clear that despite compliance with the pledges, the two-degree goal is still unachievable. There is still an emissions gap of around 8 $GtCO^2$-eq between the current state of things and what is needed in order to achieve the target. In the BAU pathway, the gap amounts to 14 $GtCO^2$-eq (The Thailand Research Fund, 2013). Evaluation of the gap led to the COP's agreement over the ADP negotiation process. An agreement on closing the emissions gap is set to be reached before 2020, along with considerations over how it will be enforced after the fact.

(2) Post-2020 Action

The ADP negotiations, held by the seventeenth COP, have as their main objective the establishment of a new stage for the Kyoto Protocol's new agreement discussion. It will be enforced after 2020 and will replace the Kyoto Protocol. The new agreement is expected to cover major countries that happen to be the world's biggest GHG distributors. The target for GHG reduction post-2020 is substantialised. As the current Climate Change Master Plan is being written, the negotiation process remains ongoing, and will be completed in 2015 at the twenty-first COP in Paris, France. Furthermore, at the nineteenth COP, the Conference had agreed that member nations, developed and developing, must prepare presentations on their Intended Nationally Determined Contributions (INDCs). The objective is for each country to demonstrate its pledge to mitigate GHG emissions as a foundation for the new agreement. Nations were

asked to have the data prepared early before the twenty-first COP (for example within the first quarter of 2015 for the countries that are ready to submit). The data to be presented should be clear, transparent, and easy to understand. In the meantime, developed countries are encouraged to support the preparations of developing countries. **Thailand is backed financially by the Global Environment Facility in the making of the country's INDCs; the study focuses on capacity in GHG mitigation, making it a long-term post-2020 target.**

Thailand is considered as a medium-income country, possessing economic capacity, good infrastructure and public utilities, as well as unceasing development. The country has a vision of becoming a developed country, meaning that its role on the international stage requires initiative and prominence. Thailand also needs to prepare data on its GHG emissions, both overall and by sector, along with its capacity and the economic value of GHG mitigation, all of which is to be taken into consideration for policy planning at the national and international levels. This process requires caution and good coverage; climate change, apart from being a global environmental issue, is significant to the country's development. This is because climate change is related to energy policy which serves as a basis for other development activities, as well as other sectors, for instance, industry, agriculture, commerce, and transport. Moreover, GHG emissions tend to become a condition that raises product standards for international trade. On the other hand, it encourages development of environmentally friendly products even as it becomes a non-tariff barrier to reducing cost competitiveness of products from developing countries. Though the UNFCCC specifies environmentally friendly technology support, there are still certain practice limitations due to conflicts over intellectual property rights mentioned by the WTO (World Trade Organization). Thailand, as a developing nation that receive funding to enhance capacity and technology transfers, should push forward this mechanism into practice. Furthermore, a leadership role in developing implementation of climate change policies at the regional or sub-regional levels should also be advocated.

(2) The Country's operational guideline – Considering the directions of Thailand's policies, it can be seen that major policies and plans illustrate ideas that support solutions to the issues caused by climate change. Examples include the Eleventh National Economic and Social Development Plan and the Environmental Quality Management Plan 2012-1016. The

making of these policies and plans has considered the specter of climate change. One plan directly concerning climate change was Thailand's National Strategy on Climate Change 2008-2012, which was created as the first framework guideline to climate change solutions. It consists of six strategies: (1) adaptation capacity to handle and reduce threats of impacts caused by climate change, (2) support of GHG mitigation and increasing the amount of carbon sinks on a sustainable basis, (3) support of research and development to better understand climate change, (4) create awareness of and participation in solving climate change issues, (5) enhance the ability of human resources and related institutes to handle, and (6) develop international collaborations. This Climate Change Master Plan is a framework guideline that follows the National Strategy Plan. Furthermore, Thailand also has policies and by-category measures that are related to climate change. This includes the 10-Year Plan to Reach 25% of Renewable and Alternative Energy, the 20-Year Energy Conservation Plan, the Climate Change Master Plan by the Department of National Parks, Wildlife, and Plant Conservation, the Agricultural Strategy on Climate Change, the Strategic National Environmental Sanitation Plan, and the Sustainable Transport Development Master Plan to Reduce Climate Change Issues 2013-2030. The energy and transport plan is also used as a foundation in the implementation of a GHG reduction scheme that is appropriate for the country. Implementation of the Climate Change Master Plan 2015-2050 is an extension of pre-existing work. It aims to cover every detail, yielding an uninterrupted process to prepare for long-term solutions that comply with international operations. In addition, the analysis of trends and situations can be further summarised into Thailand's primary frameworks in solving climate change issues to match the country's context.

Framework 1 aims to **enhance adaptation capacity and to handle** impacts caused by climate change in every sector practically. It **emphasises sectors with high sensitivity** to change that possess low capacity for handling the impacts. This includes low-income citizens, communities in areas with natural disaster risks, agricultural and business groups relying primarily on weather and natural resources, e.g. tourism, particularly those operated by small and medium-sized enterprises (SMEs). Furthermore, **nature conservation measures, sustainable use, and efficient environmental quality management measures should be promoted** to relieve pressure on natural sources and ecosystems. Conservation or enhancement of capacity of natural resources and ecosystems in handling and adapting to

climate change should also be encouraged, to prevent other possible consequences caused by depletion of natural resources. The latter, for instance, **helps reduce inequality of access to natural resources, which otherwise leads to income inequality.**

Framework 2 aims at mitigating GHGs **by pushing forward energy development policies that are low-carbon and environmentally friendly, in addition to conservation measures that enhance energy efficiency in each sector** for instance, transport, industry, building and urban management. This is related to the concept of **low-carbon infrastructure development** in many sectors. Directions in GHG mitigation should be expanded to cover every sector through use of **the win-win or co-benefits concepts**, e.g. **waste-to-energy**. Encouraging low-carbon and environmentally friendly products and services **adds value and expands the market of Thai products and services**. Furthermore, other sectors that contribute to GHG emissions should be more efficient in their efforts to mitigate such output.

Framework 3 aims to drive related policies and plans to create practical results and efficiently achieve targets. Since climate change plan implementation is **connected to development directions** to better adapt to climate change and achieve low-carbon growth, guidelines on **capacity enhancement of every sector** need to be planned out to make this possible. **Development of databases and knowledge** will improve policy planning. **Human resources and technology development** also, should be prepared to support new patterns of development. **Raising awareness in every sector** should be done to encourage participation and comprehension of their expected roles, thus creating sustainable performance. **Integration of work at national and international levels** should also be supported.

Analysis of the situation under the DPSIR has led to the development of a framework for responding to these issues; the guideline responds to the Driving Forces, Pressure, and Impacts comprehensively while also reinforcing the existing guideline. Figure 2.18 illustrates the connection between the DPSIR framework and the making of the National Climate Change Master Plan 2015-2050.

Figure 2-18: Application of the DPSIR framework in preparation for the National Climate Change Master Plan

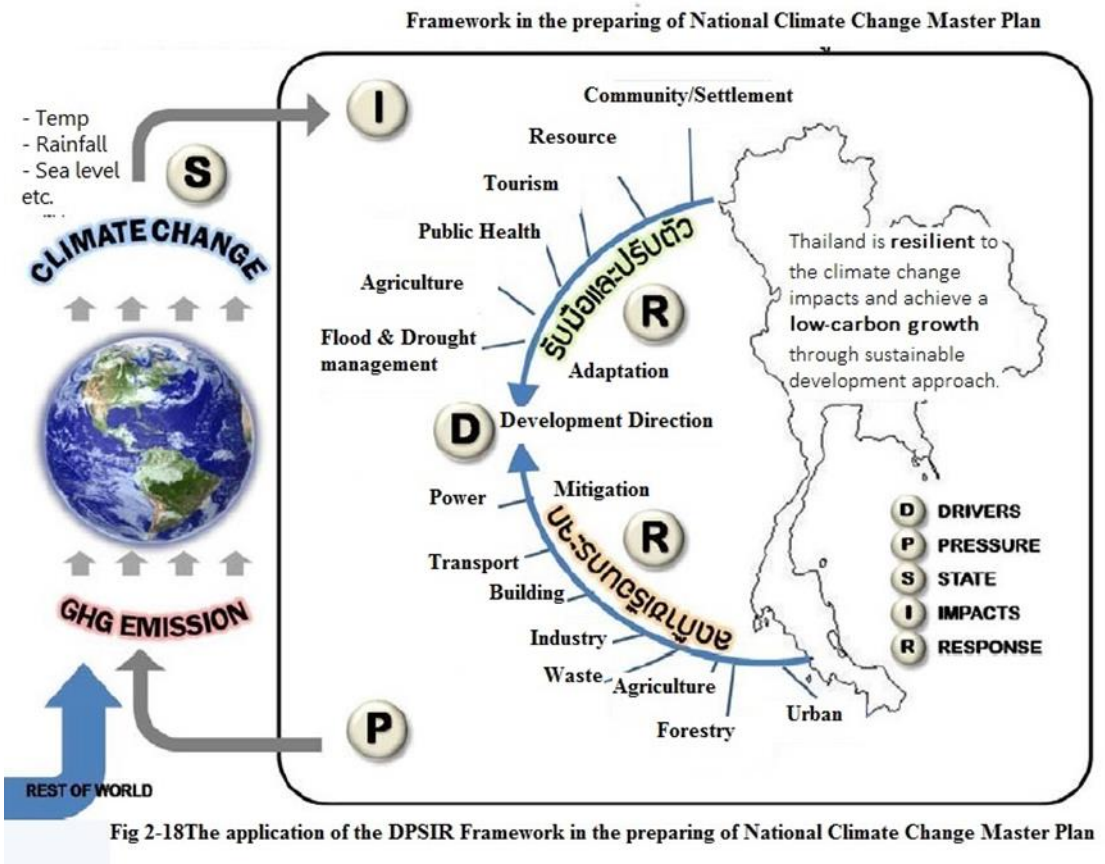


Fig 2-18The application of the DPSIR Framework in the preparing of National Climate Change Master Plan

In this framework, the **D**river is the general direction of development in Thailand. The consequences and by-products (such as greenhouse gas emissions, for example) from the activities of the various sectors (domestic and international) constitute the **P**ressures which are continually influencing our environmental conditions. The changes occurring to the **S**tate of our environment **I**mpact various sectors such as water management, agriculture, tourism, etc. in such a way as to demand a comprehensive **R**esponse from Thailand which engenders climate resilience, low-carbon growth and sustainable development.

3.1 Vision 2050

Thailand is resilient to the impacts of climate change and achieves low carbon growth through sustainable development.

3.2 Mission

1) Develop the knowledge base and technology required to support low carbon development and sustainable adaptation to climate change.
2) Increase the resilience to climate change of national development by calling for an integrated approach to climate change adaptation measures between stakeholders at all levels.
3) Reduce national GHG emissions and develop sustainable low carbon growth modalities.
4) Raise awareness and capacity to implement climate change related policies and plans in developmental partners at all levels.

3.3 Goals

Goals of Thailand Climate Change Master Plan 2015-2050 are divided into 3 phases:

1) Short-term: Goals related to mechanisms and capacity building measures for issues which require immediate implementation. Target year 2016.
2) Medium-term: Goals related to mechanisms and capacity building measures which require time to implement, and goals reflecting the outcome of medium-term actions. Target year 2020.
3) Long-term: Goals reflecting long-term actions, including variable goals which require continuous monitoring of indicators. Target year 2050.

Figure 3.1 shows Roadmap of Climate Change Master Plan (2015-2050)

1 .Short-term Goals (2016)

Adaptation has four following targets:

1.1 Create comprehensive climate change risk maps which incorporate key socio-economic environmental aspects;

1.2 Increase the national proportion of biodiversity conservation areas with a minimum conservation area of not less than 19% and an increase of no less than 5,000 rai per year to mangrove forests;

1.3 Develop an integrated and ecologically friendly coastal restoration plan in half of the coastal provinces and;

1.4 Develop composite and sector-specific climate change resilience index.

Mitigation has two following targets:

1.5 Develop national medium / long term targets and roadmaps for GHG emissions reduction in collaboration with high-readiness industries and;

1.6 Establish integrated economic and legislative mechanisms to encourage low carbon development.

Enabling Environment has five following targets:

1.7 Establish a nexus for climate change related research and development (R&D);

1.8 Develop databases of supporting data to include:

1.8.1 Up to date sectoral (i.e. energy, transport, industrial, agriculture, land-use and forestry management, waste management, etc.) data on GHG emissions in a business-as-usual (BAU)[1] scenario.

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1 Business-as-usual (BAU) is an assumption that no mitigation measures have taken place. This assumption is used as a control compare with cases where mitigation measures have been applied.

1.8.2 Voluntary and mandatory GHG mitigation activities and carbon trading registry.

1.8.3 GHG emissions reporting system for major operators in high emission industries.

1.8.4 Climate change related negotiation and cooperation.

1.9 Develop a national climate change strategy with the following components:

1.9.1 Action plan for resilience and adaptation to climate change in high-priority sectors (e.g. water, flood and drought management, agriculture, tourism, public health);

1.9.2 Action plan for climate change R&D;

1.9.3 Action plan for technological development in aid of climate change mitigation and adaptation;

1.9.4 Action plan for the promotion of low carbon and environmentally friendly strategies for investment and technological development and;

1.9.5 Action plan for building capability to support climate change management and low carbon development.

1.10 All stakeholders must develop their own implementation strategies for climate change and;

1.11 Establish a national mechanism to facilitate financial, technological and capability building support from international partners.

2. Medium-term goals (2020)

Adaptation has seven following targets:

2.1 Develop effective and comprehensive early warning measures such as pest and meteorological forecasting for the agricultural sector and natural disaster management;

2.2 Establish a climate-based agricultural insurance scheme;

2.3 Establish a national fund for climate change related recovery, compensation and adaptation;

2.4 Increase forest coverage to 40% of the total national area;

2.5 Maximize the proportion of national biodiversity conservation areas;

2.6 Develop an integrated and ecologically friendly coastal restoration plan for all coastal provinces and;

2.7 Develop integrated regional climate change action plans for all areas that are at risk.

Mitigation has seven following targets:

2.8 Decrease GHG emissions in the energy and transport sectors by 7-20%[2] from BAU (by 2021[3]);

2.9 Increase consumption of renewable energy in the national grid to 25% of national final energy consumption (by 2021[4]) and;

2.10 Increase the number of municipalities with at least 10 square meters of green space per person.

Enabling Environment has two following targets:

2.11 Implement Smart Grid technology at a national level and;

2.12 Develop effective tools and mechanisms for climate change mitigation at a national level which are compatible to corresponding measures at an international level.

3. LONG-TERM AND ONGOING GOALS[5] (2050)

3.1 Increase the number of areas and farmers benefited by irrigation systems;

3.2 Increase water resource development for agricultural areas not served by irrigation systems;

3.3 Increase the proportion of farmers in areas at risk who have received training in natural disaster prevention, readiness and mitigation, including training and guidance on alternative income sources;

3.4 Increase the proportion of farmers participating in the agricultural insurance scheme;

3.5 Decrease the proportion of climate change induced loss to total productivity in the agricultural sector;

3.6 Increase soil and water restoration in areas with repeated natural disasters;

3.7 Increase the proportion of usable water in the overall water table;

3.8 Increase access to clean water;

[2] Mitigation potential depends on various factors, including policy success and domestic/international funding.

[3] 2021 is chosen as target year as per the 10-year 25% Alternative Energy Development plan (2011-2021).

[4] 2021 is chosen as target year as per the 10-year 25% Alternative Energy Development plan (2011-2021).

[5] Ongoing goals are goals which need routine evaluation. Specific targets and timelines are to be defined in action plans.

3.9 Increase vigilance and early warning systems for natural disasters in areas that are at risk;

3.10 Decrease the number of fatalities and losses due to natural disasters;

3.11 Decrease malnutrition in children under 5;

3.12 Increase disease surveillance in areas which are epidemic-prone;

3.13 Decrease per capita healthcare costs associated with climate change;

3.14 Decrease the number of endangered species;

3.15 Increase ecotourism and;

3.16 Increase climate change resilience (composite index).

Mitigation has eight following targets:

3.17 Decrease energy intensity by at least 25% from BAU (by 2030);

3.18 Increase usage of public transportation;

3.19 Decrease GHG emissions from land transport;

3.20 Increase investment in low carbon emission and environmentally friendly industries;

3.21 Decrease open dumping areas;

3.22 Increase organic and GAP-certified farming;

3.23 Decrease agricultural open burning and;

3.24 Decrease GHG emissions per GDP.

Enabling Environment has one following target:

3.25 Increase the use of human resources development plans that are in alignment with low-carbon development and climate change adaptation/mitigation among regional and local government bodies.

Components

The Thailand Climate Change Master Plan (2015-2050) consists of three key strategies: 1) Climate change adaptation 2) Mitigation and low carbon development and 3) Enabling environment on climate change management.

Strategy 1 Climate change adaptation

This adaptation strategy comprises actions and measures in the following six sectors:

1. Water resources, flood and drought management – focusing on integrated, effective and equitable water resource management to provide equal access to water supply whilst undertaking the drought and flood preparedness, mitigation and adaptation measures outlined below.

(Responsible parties: Ministry of Natural Resource and Environment, Ministry of Agriculture and Cooperatives, Ministry of Science and Technology, Ministry of Internal Affairs, Ministry of Digital Economy and Society, Ministry of Industry, Ministry of Energy, Ministry of Foreign Affairs, Ministry of Defence)

1.1 Integrated water resources management

1) Promote information exchange and integration concerning water resources among relevant agencies and develop/improve water footprints and data collection on water consumption to support planning for equitable water resource management. This is to be achieved by factoring forecasts and data such as precipitation, runoff, water forecast, water demand and water sources into water resource management;
2) Encourage active participation in river basin policy, planning and management by all stakeholders, including general consumers, farmers (energy and food crops) and industry;
3) Develop a master plan on water utility development to facilitate systematic and efficient utilization of water resources by promoting integrated use of surface and ground water according to basin-based capability in order to provide equal access to clean water for all;
4) Promote water conservation and increase the efficiency of water consumption in the service, industrial, agricultural and household sectors;
5) Strengthen the capability of local administrative bodies in efficient and sustainable water resource management;

6) Develop basin-based land-use plans and appropriate land-use zoning for municipal development, agriculture and conservation that is in alignment with climate change and local water resources management plans. These measures are to be implemented by provincial and local administrations and;
7) Accelerate the implementation of internationally recognized measures on sustainable water management.

1.2 Flood and drought mitigation and adaptation

8) Regenerate upstream forests to regulate water flow and maintain biodiversity; promote soil and water conservation in areas utilizing slope agriculture to prevent and minimise soil erosion and degradation;
9) Create water retention areas, flood diversion channels and river catchment boundary markers, etc., for flood preparedness that is in harmony with the local ecological conditions. Public participation is crucial in ensuring fairness and equity of provision in the local community;
10) Increase water supply and capability of water storage systems by restoring natural catchment areas, create a database of natural water resources, improve small water resources and groundwater sources in non-irrigation agricultural areas, expand irrigation coverage to areas with agricultural potential, and promote water storage systems for the dry season;
11) Update water resource management criteria for existing and new water reservoirs to ensure optimization to each river basin, taking into account climate variation factors and;
12) Conduct studies on local water consumption patterns to improve water demand management and explore measures to enhance the efficiency of consumption as options in adapting to climate change.

1.3 Flood and drought risk management

13) Assess the impact of climate change and evaluate predicted impact, especially in high-risk areas, on the hydrological cycles using climate model simulations. This includes

considerations such as the impact on water volume, flow and distribution which may affect major water basin management planning;

14) Create risk maps demonstrating flood and drought prone areas at national, regional, water basin, provincial, and community levels in order develop an effective risk management and preparedness plan;
15) Develop an early warning system that offers accurate and long-range predictions (including meteorological forecasts) along with standard operation procedures and practical guidelines for the public according to the magnitude and severity of the incident;
16) Develop networks for to facilitate early warning and relief for emergency situations at national and local levels with defined roles and responsibilities, together with integrated action plans for relief and;
17) Develop and promote insurance systems for natural disasters in areas that are at risk.

2. Agriculture and food security – focusing on managing the risks associated with climate change and natural disasters, fostering preparedness and adaptive capability to the impacts of climate change through measures which may include but are not limited to generating second incomes from environmentally friendly agricultural products, and ensuring sustainable food security by the actions and measures outlined below .

(Responsible parties: Ministry of Agriculture and Cooperatives, Ministry of Natural Resource and Environment, Ministry of Internal Affairs, Ministry of Digital Economy and Society, Ministry of Science and Technology, Ministry of Finance, Ministry of Industry, Ministry of Education, Prime Minister's Office, Ministry of Labour, Ministry of Tourism and Sports)

2.1 Natural disaster risk management

1) Research and develop accurate and long-range forecasting and prediction techniques for climate variation and extreme weather events. This will focus on high risk areas, such as drought or flood prone areas and important fisheries resources, etc.;

2) Develop agricultural risk maps that will aid in forecasting the occurrence of disasters such as outbreaks of plant and animal diseases flooding, drought, landslide, saltwater intrusion, and other extreme weather events which will support the planning of risk mitigation measures as well as the timely launching of effective countermeasures;
3) Develop an integrated, accurate and timely early warning system for agricultural purposes which incorporates both the latest technologies and local knowledge. The approach to communications and public relations must be well considered to ensure that the early warning information can reach stakeholders in a timely manner both at national and local level;
4) Establish farmers' networks to observe and monitor factors relating to climate change and their effects (i.e. cultivation calendars) and provide support for data collection and dissemination within the networks by the members themselves;
5) Establish a climate risk insurance system for agricultural produce, livestock and fisheries; support agricultural produce risk management mechanisms to mitigate the effects of market fluctuation (i.e. futures trading); continuously improve the risk evaluation and management capacities in the agricultural sector and;
6) Develop prediction and early warning systems for pests.

2.2 Capability building for climate change adaptation and mitigation

7) Systematically develop plans and strategies for the agricultural sector to adapt to climate change by assessing the most significant effects of climate change on the agricultural sector (i.e. changes in temperature, humidity, wind, water flow, seasonal shifts, precipitation, runoff, salinity and acidity of seawater, outbreaks of plant and animal diseases, etc.) and using them as indicators to predict the impact on key crops, fisheries and livestock, including the effects of climate change on the agricultural trading and processing industries;
8) Conduct research into the relationship between agriculture and water management with particular consideration paid to the forecasted water levels and how this might affect the adaptation strategies in the agricultural sector with regard to water;
9) Extend irrigation infrastructure to cover areas with high agricultural potential, thereby reducing the vulnerability of the farming communities therein to climate change. To this

end, support will be provided to small-scale farmers outside of the irrigation zones to help them adopt new agricultural methods which include the development of small-scale water resources and enhanced efficiency in agricultural water consumption in accordance with the sufficiency economy approach;

10) Regenerate degraded soil, especially in areas with high agricultural potential, in order to increase productivity, ensure food security and maximize land use which will help to ensure the resilience of farmers by increasing the stability of their income;
11) Integrate precision farming with the local knowledge of traditional farmers to achieve optimal resource management and further reduce the vulnerability of agricultural activities to climate change;
12) Raise awareness of the impacts, risks, and opportunities resulting from climate change by educating local leaders on the impacts of climate change. A community-centred approach will be used to empower all stakeholders in the local communities (private sector, educators, local government and farmers) to integrate their combined local knowledge with modern technology and methodologies such as to enhance their capability to adapt to climate change in a way that best suits their context;
13) Develop a readily accessible knowledge base on the physical and market factors (soil, water, roads, markets, factories, pricing, costing, competitors, farmers, land holding) to aid and facilitate the systematic development of agricultural products across the entire supply chain by the farmers themselves, thereby increasing the resiliency of the individual farmers as well as the agricultural sector as a whole;
14) Provide support to community enterprise networks in terms of knowledge regarding production, brand development, packaging, marketing, pricing strategy in order to increase the bargaining power of grass-roots agricultural producers. Gains in competitiveness within the AEC may also be realized by supporting the adoption of automation in farming and raising awareness regarding the health benefits of environmentally friendly agricultural products and;
15) Establish financial and resource management mechanisms for adaptation to climate change which will be of particular benefit to small scale farmers, such as facilitating ready access to funding, training for alternative employment in the period after the growing season and agro-ecotourism.

2.3 Ensuring food security

16) Assess the impact of climate change on the agricultural production system and sustainability of agricultural activities in various areas using forecasts based on climate models projection at different periods of time;
17) Protect areas with high potential for agricultural production and existing agricultural infrastructure in place. The process of establishing zones for food and energy crop farmland with the involvement of all stakeholders will help to integrate food security considerations with the management of other natural resources (e.g. water, land, forest) in a way that is fair and equal. In this way the adaptation to climate change will be baked into the land-use plans that are to be made;
18) Emphasis will be placed on research into genetic engineering and the establishment of a genetic bank to breed plants and animals that are particularly adapted to the effects of climate change (e.g. drought, flood, saltwater intrusion, low resource consumption, high yield) without adversely affecting biodiversity. Measures to promote and protect farmers' rights to access and benefit from biodiversity in a sustainable manner will also be implemented;
19) Assess the impact of climate change on food security at national and local level, taking into account the effects that future domestic and international demand for food will have on the food security, livelihood and nutritional quality of food available to the population, in particular those with high vulnerability to adverse effects due to low income;
20) Promote an ecosystem-based approach to fisheries to include proper training and management for the maintenance of sustainable fish stocks by the assessing fisheries stock. This necessitates community participation in coastal aquaculture management which entails the conservation of habitats for aquatic species and the breeding of high-yield, climate-resilient aquatic livestock;

21) Support the application of new agricultural methods in combination with safe, environmentally friendly cultivation practices among small scale famers to ensure

sustainable food security. This will reduce vulnerability to market and climate fluctuations for the individual households as well as the local communities.

2. **Tourism** – focusing on ecotourism and sustainable tourism to conserve natural resources and resilience to climate change in areas with a tourism industry. The risk of climate change in the tourism sector will be mitigated through the measures and actions outlined below

(Responsible parties: Ministry of Tourism and Sports, Ministry of Natural Resource and Environment, Ministry of Internal Affairs, Ministry of Education, Prime Minister's Office, Ministry of Science and Technology, Ministry of Digital Economy and Society, Ministry of Culture, Ministry of Industry, Ministry of Commerce)

3.1 Develop and promote sustainable tourism

1) Develop and certify sustainable tourist destinations for ecotourism at national, ASEAN, regional and international level;
2) Develop beneficial requirements and parameters for tourist destinations e.g. seasonal limits, infrastructure requirements, and physical appearance by considering the carry capacity. In addition to the regulation of tourist visits to sensitive locations, effective waste management and pollution control measures must also be established;
3) Encourage business operators to develop and adopt appropriate standards by rewarding compliance with incentives and privileges, such as Green Procurement listing, international trade promotion privileges, and Payment for Ecosystem Services (PES) to support the protection and restoration of ecosystems;
4) Strengthen the capability of local administrative agencies, tourism business operators and encourage public participation in the development of sustainable tourism and ecotourism destinations;
5) Conduct research and promote investment in sustainable tourism and ecotourism, such as applying biotechnology to waste management at tourist destinations, develop environmentally friendly materials and packaging for the tourism sector and;

6) Expedite the restoration of degraded tourist destinations.

3.2 Climate change risk reduction

7) Develop accurate weather forecasting, early warning system and evacuation plan in addition to having infrastructure that supports natural disaster management at tourist destinations;
8) Conduct research on the impact of climate change at major natural destinations and create risk and vulnerability maps appropriate for management and planning;
9) Assess water demands in the tourism sector and service sector in general, particularly in river basin areas which are at risk of water shortage. Measures to increase efficiency in water consumption may then be proposed with participation by all stakeholders;
10) Raise the awareness of stakeholders on the impact, risks and opportunities of climate change, especially in the areas at high risk. Appropriate alternatives such as tourism activities which are not highly dependent on climatic factors, such as exhibition centres, virtual reality, cultural tourism, etc. should also be explored. Consultations are to be held between local business operators, local communities, local administrative bodies and local businesses regarding the adaptation and integration of climate change issues into local and provincial strategic development plans and;
11) Evaluate the impact of climate change on global tourist destinations which has an impact on demands in the tourism sector that will lead to the formulation of National Adaptation Plan in the tourism sector.

4. Public health – focusing on disease surveillance, the impact of climate change on human health, prevention and control of epidemics, and equal access to quality healthcare services through the actions and measures outlined below:

(Responsible parties: Ministry of Public Health, Prime Minister's Office, Ministry of Education, Ministry of Science and Technology, Ministry of Internal Affairs)

4.1 Disease and health impacts surveillance and prevention

1) Research is to be conducted on the impacts of climate change on the lifecycle of disease vectors and carriers, including those of zoonotic diseases. The epidemiology of diseases associated with changes in the distribution pattern of disease vectors and carriers (e.g. dengue fever and malaria in mosquito, schistosomiasis in snails) is to be assessed in order to determine the potential risk of emerging and re-emerging diseases as well as changes in outbreak patterns in various areas;
2) Assess the severity of impact in order to develop precise risk and vulnerability maps which factor in the increased frequency of extreme weather events (e.g. storms, floods, heat waves and droughts), the changes in environment (e.g. distribution pattern and severity of air pollution, pollution and pathogen contamination in air and water, respiratory diseases, allergies, heart disease, stress, child development issues), the scarcity of human necessities (food, water supply, shelter, etc.) and migration due to the rise of sea level or other changes in order to develop the risk map or vulnerable areas map;
3) Develop an effective warning system and disease/health impact surveillance networks in areas at risk;
4) Develop mechanisms to increase the capability of healthcare professionals in preventing and mitigating climate changed related health problems and;
5) Promote disease prevention by raising public awareness regarding health risks and promulgate appropriate prevention guidelines, especially to those at high risk and vulnerability.

4.2 Improve access to quality healthcare services

6) Conduct research on basic healthcare needs and the capability to handle outbreaks which may have unusual patterns due to climate change. The relevant public health rules, regulations, measures and standards must then be updated accordingly and;

7) Expand the public health insurance system to cover specific population groups who are vulnerable to new and re-emerging diseases, such as children, elderly, livestock farmers and migrant workers.

5. Natural resource management – focusing on the restoration and conservation of natural resources and ecosystems as well as providing a regulatory framework for sustainable utilisation of natural resources through the actions and measures outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Ministry of Internal Affairs, Ministry of Science and Technology, Ministry of Justice, Public Sector, NGO)

5.1 Natural resource and ecosystem protection and restoration

1) Assess the effect that climate change will have on ecosystems and natural resources (e.g. forest distribution, richness, vulnerability, natural resources degradation, species distribution and biodiversity characteristics [especially endangered, vulnerable, threatened species]) in order to identify the areas vulnerable to environmental degradation or changes in ecology and natural resources;
2) Expedite the restoration of degraded natural resources and ecosystems (especially in vulnerable and highly exposed areas) to ensure timely recovery and regeneration;
3) Establish a central database and a monitoring/evaluation system for biological indicators in vulnerable areas across the country to monitor and evaluate the changes occurring to the ecosystems and natural resources within the local context. Public and community participation is key to the success of such measures;
4) Restore degraded upstream areas, surface water and ground water sources with public participation. Building and supporting the capability of local networks for the protection of upstream areas is key to effective and ongoing management of the main and tributary river basins;
5) Support forest restoration efforts and increase forest area by emphasizing the creation of forest corridors and buffers to bolster the resilience of ecology and biodiversity;
6) Support the role of local communities in the conservation of forests and ecosystems via mechanisms such as the Payment for Ecosystem Services (PES) scheme, i.e. the

Forest bond and REDD+ approach which engenders transparent and sustainable public participation in forest conservation. This gives explicit recognition of community rights to forest resources while the community protects and sustains the biodiversity of the ecosystem;

7) Encourage the business sector to play an active role in forest protection and conservation through initiatives such as corporate social responsibility (CSR) programmes;
8) Promote the use of information technology in observing, monitoring and tracking changes to the forest areas. Research and development of technology to conserve vulnerable ecosystems and reduce threats to biodiversity is to be encouraged and supported;
9) Develop community-based wildfire surveillance, prevention and control capability (especially in high risk areas) and provide the necessary support, such as by digging trenches around the edges of forest reserves and constructing adequate networks of check dams;
10) Protect and conserve wetlands by nominating important wetlands as Ramsar sites, and develop appropriate management plans with stakeholder participation accordingly;
11) Encourage the maintenance of genetic variety and biodiversity through the creation of gene banks and supporting technology and innovation that are conducive to biodiversity while protecting the rights of local communities to sustainably access their local biodiversity and natural resources;
12) Support in-situ and ex-situ conservation by promoting research on the breeding of species which are endangered and under threat. Laws, regulations and other measures for the protection and conservation of ecosystem biodiversity must be developed with an emphasis on species protection and ecological balance;
13) Promote programmes for the restoration of marine and coastal ecosystem balance. The knowledge based on changes in the oceanographic patterns induced by climate change must be developed and expanded;
14) Expedite the declaration of marine, coastal and delta protection areas. Improve the management of marine reserves and parks with participation from all stakeholders. Measures such as the restoration of marine and coastal resources by constructing artificial coral reefs, re-vegetating sea grass, expanding mangrove forest areas, restoring

eroded coastal areas and re-establishing balanced marine ecosystems must all be done with community participation and;

15) Improve the flexibility of the Environmental Fund and facilitate access to funds for ecological balance restoration to local administrative bodies, NGOs and the general public.

5.2 Monitoring and controls of sustainable natural resource utilisation

16) Promote the transition of communities around the forest reserves into eco-villages which exist in harmony with the surrounding natural environment and in doing so strengthen the roles of communities in forest protection. Mechanisms and modalities to support the sustainable utilisation of forest resources should be introduced with the support of government and developmental partners (e.g. tree banks, permaculture and agroforestry), especially in upstream and buffer areas;
17) Expedite the amendment of existing legislation and regulations to ensure equitable and sustainable natural resource management, such as revising the National Park Act (1961), National Forest Reserve Act (1964) and Forest Act (1941), and expediting the passing of legislation, such as the Community Forest Act, National Water Resource Act, Community Rights and Allocation of Biodiversity Benefits Act, and Marine and Coastal Resource Management Act, etc.;
18) Promote commercial forestry in private woodlands in accordance with the sustainable forest management (SFM) approach and increase research and development into effective identification of the declared origin of timber (e.g. DNA fingerprint);
19) Establish integrated natural resource and biodiversity databases which can be integrated into regional and international databases;
20) Develop integrated coastal management plans to cover all critical and immediate erosion areas with the participation of all stakeholders. Priority should be assigned to areas based on the degree of urgency and the magnitude of the problem (current and future status) to efficiently determine the appropriate protection and restoration initiatives;
21) Educate the general public, community organisations and local administrative bodies in coastal areas on the protection and restoration of marine and coastal resources in

order to prevent construction and other activities which may lead to coastal erosion. Land-use regulations are to be strictly enforced with regard to carrying capacities and to prevent illegal exploitation of mangrove forests;

22) Improve and expand artisanal fisheries by promoting the participation of local fishing communities in marine and coastal resources conservation. The use of destructive fishing equipment and practices are to be strictly controlled or banned as appropriate and local fishermen surveillance networks are to be established to prevent illegal fishing;
23) Issue a mandatory impact assessments on the carrying capability of natural resources and ecosystems as a part of the Strategic Environmental Assessment (SEA) in any development plan and;
24) Strictly control the use of groundwater, taking into consideration the sustainable carrying capability of area, especially in areas that are in a critical state or at risk of subsidence, saltwater intrusion and coastal erosion.

6. Human settlement and security –focusing on reducing risks and damages arising from natural disasters and building preparedness and capability through the actions and measures outlined below:

(Responsible parties: Ministry of Social Development and Human Security, Ministry of Internal Affairs, Local Municipalities, Ministry of Natural Resources and Environment, NGOs)

6.1 Natural disaster risk reduction

1) Assess the potential impact on human settlements in areas at risk of repeated and long-term flooding, torrential floods, drought, and landslides, etc. Risk and vulnerability maps are to be created by assessing the capabilities and resilience of local communities;
2) Raise awareness concerning the potential risk and impact of natural disasters while providing education on options for adaptations;

3) Build community-based natural disaster surveillance and relief networks; clearly define the responsibilities of all parties and provide support on continual capability building;
4) Develop infrastructure with the capacity to withstand natural disasters in all areas at risk. Formulate natural disaster preparedness plans with the participation of all stakeholders and disseminate the information to the public accordingly;
5) Establish remedial and relief mechanisms in readiness for natural disasters by improving existing ones or setting up new ones to support people in emergencies in a timely manner;
6) Encourage the private sector to develop natural disaster insurance packages for areas deemed to be at risk at the national, sub-regional and regional level and;
7) Conduct feasibility studies to ensure effective designation and implementation of long term development plans for at-risk areas. The systematic updating of land-use plans, building codes and infrastructure development plans to take climate change into account is absolutely crucial.

6.2 Community-based mitigation and adaptation capability building

8) Assess the impact that climate change will have on social structure and livelihood of human settlements that are close to highly dependent on natural resources and geographical features which may be affected by climate change along with the preparedness and adaptive capacities of said communities;
9) Explore alternatives for adaptation, such as innovations in architecture, materials science, economic activities, health and sanitation;
10) Conduct assessments on the effectiveness of various adaptation measures in collaboration with communities and civil groups, including the assessments on the value of livelihood system and ecosystem services, to be used in the economic analysis of adaptation solutions and processes at local level;
11) Encourage local communities to develop their own climate change adaptation and coping plan in alignment with their development visions and strategies, which should

be the combination of local wisdom and state-of-the-art technology with respect to the diversity of the communities and local contexts;

12) Examine the administrative and institutional structure, policies and procedures which may affect the ability of communities to adapt to climate change. The influence that markets and financial institutions have on such factors should also be analysed in order to identify an optimal role for the government in helping the communities to create effective mechanisms for adaptation and;

13) Develop comprehensive indices to measure climate change vulnerability, ability to cope and adaptive capacity at community, municipal, provincial and national levels.

Strategy 2 Mitigation and low carbon development

The mitigation and low carbon development strategy comprises actions and measures in the following eight sectors:

1. Power generation and energy supply – focusing on decreasing fossil fuel consumption, increasing/developing renewable energy production and developing infrastructure which facilitates low carbon development whilst simultaneously lowering GHG emissions. This is to be achieved through the measures outlined below:

(Responsible parties: Ministry of Energy, Ministry of Industry, Ministry of Natural Resources and Environment, Ministry of Science and Technology, Prime Minister's Office, Ministry of Education, Ministry of Agriculture and Cooperatives)

1.1 Renewable energy sector development

1) Provide subsidies (such as adder and/ or feed- in tariffs) to encourage clear and continuous development in the renewables sector. Price guarantee schemes are to be developed specifically for agricultural products which constitute raw materials for the renewables sector. Measures such as (but not limited to) these will help to ensure that communities and the business sector see a clearly and conducive return on investment by participating in the generation and use of renewable energy;
2) Collaborate with all stakeholders in integrating the renewable energy development plan with other local development plans (e.g. conservation and agricultural plans) to ensure proper zoning and avoid conflicts regarding the use of land and natural resources. Effective and fair resource management to achieve sustainable food and energy security must also be promoted;
3) Identify the impact of climate change on key energy crops (e.g. sugar cane, cassava, oil palms) along with appropriate measures for mitigation, to include the exploring the viability of alternative energy crops which are more resistant to the effects of climate change;

4) Continuously build the capability of farmers by developing environmentally friendly technology and techniques to increase yield-per-rai of energy crops while optimizing the factors of production;
5) Build up the capabilities and competencies required to accommodate the production, development and management of renewable technology and;
6) Promote renewable energy production at community and household level (e.g. household solar energy production, waste-to-energy, biogas, community grids) and revise infrastructure-related laws and regulations to support transactions between the community/household and the national grid.

1.2 Development of infrastructure and support for efficient, low- carbon power generation

7) Establish decision making criteria for power development plans via transparent public participation processes which take into account factors such as energy security, production and consumption efficiency, GHG reduction, safety, eco-friendliness and socio-economic impact (e.g. job creation and income distribution to small business operators and farmers);
8) Improve and increase electricity production efficiency by incentivizing power plant operators (through tax exemptions or credits, for example) to adopt environmentally friendly practices and technologies or by introducing new stipulations on power plant equipment and machinery;
9) Expedite the development of smart grid technology to increase the efficiency of power transmission efficiency and accommodate decentralized renewable power generation and;
10) Conduct feasibility studies on Carbon Capture and Storage (CCS) in the power production sector.

2 .Transport – focusing on increasing the efficiency of transport and logistics, developing low-carbon transport infrastructure and applying sustainable principles to the management of transport demand. This will be achieved via the following measures and initiatives:

(Responsible parties: Ministry of Transport, Ministry of Energy, Ministry of Natural Resources and Environment, Ministry of Internal Affairs, Ministry of Finance, Ministry of Labour / Private Sector)

2.1 Increasing transport and logistics efficiency

1) Encourage the shift to energy efficient vehicles (e.g. electric vehicles, hybrid vehicles, eco-cars, vehicles with high-efficiency diesel engines) for personal and commercial uses by offering incentives (e.g. lower tax rates or tax rebates);
2) Improve emissions and fuel economy standards for all types of vehicles and facilitate consumer decision-making by mandating energy efficiency/GHG emissions labelling on vehicles;
3) Set fuel prices which reflect the true cost and use tax mechanisms to promote energy conservation and renewable energy consumption in the shift towards high efficiency transportation;
4) Educate the general public on fuel-efficient driving behaviour and vehicle maintenance by including them as compulsory elements in driving licence test;
5) Use Intelligent Transportation Systems (ITS) to improve traffic management efficiency;
6) Improve the quality and safety of public buses by mandate an effective and interconnected network of bus lanes and rigorously enforcing them;
7) Adopt intelligent logistics management systems which will increase efficiency by increasing the use of freight distribution networks, reducing the number of empty truck journeys while simultaneously shifting to more efficient and low-emission transport modalities (e.g. rail freight and water navigation) and;
8) Promote the use of energy efficient technology in the aviation industry.

2.2 Developing high efficiency, low-carbon transport infrastructure

9) Develop skills of the workforce and other supporting structure to attract foreign investment into energy efficient automotive industry and develop mechanics with according maintenance skills;
10) Extend natural gas pipeline network, with a focus on safety, to reduce the logistical cost of natural gas and the resultant GHG emissions;
11) Increase coverage and connectivity of urban rail, bus and short-distance public transit networks. Common ticketing systems and complimentary infrastructure (e.g. park-and-ride, connecting bridges and escalators, etc.) must also be expanded to facilitate even greater adoption of multi-modal transit;
12) Improve the coverage and safety of bicycle lanes and public walkways and encourage non-motorised transport (NMT) for short distance journeys by building convenient bicycle parking facilities in community areas;
13) Apply and strictly enforce urban planning measures such as land-use zoning to encourage urban development that is conducive to the adoption of public transportation;
14) Improve the efficiency of water and rail logistics networks (e.g. establish new networks and hubs, restore, develop and maintain existing ones, develop ICT infrastructure and safeguard system, expand coverage area) while minimising the negative environmental and social impacts;
15) Improve the quality and coverage of rail networks to provide a feasible alternative to the currently preferred modalities for inter-provincial travel.

2.3 Travel demand management

16) Encourage a modal shift through the introduction of congestion pricing, parking fees in inner-city areas with sky-train/ subway infrastructure, carpool parking, school bus parking areas, and mandatory safety standards for school bus service, etc. and;
17) Decrease the demand for travel by introducing distance-based insurance premiums and service fees, encouraging staggered working hours, and encourage more effective use of the ICT tools available (e.g. teleworking, remote study, e-commerce).

3. Energy consumption in buildings – focusing on improving energy conservation and efficiency in buildings through the actions and measures as outlined below:

(Responsible parties: Ministry of Energy, Ministry of Internal Affairs, Ministry of Industry, Ministry of Natural Resources and Environment, Prime Minister's Office, Private Sector)

3.1 Increasing energy efficiency in buildings

1) Progressively raise the energy efficiency requirements in commercial building codes, taking into account the applicability of relevant technology;
2) Mandate the display and labelling of energy efficiency in residential, small and large commercial buildings to facilitate the decision making of consumers;
3) Support R&D in architecture, engineering and materials science (e.g. wall materials) that is suited to the tropics by applying the combination of traditional knowledge and local wisdom with modern technology and management; promote R&D in energy efficiency architecture and engineering practices to be incompliance with and prepared for more stringent standards and become the regional leader in energy saving innovation for buildings;
4) Mandate minimum energy efficiency standards for equipment and appliances that consume electricity in buildings;
5) Promote the use of technology and intelligent management systems to achieve energy efficiency gains in cooling, lighting and water heating systems along with the promotion of complimentary renewable power usage in all types of residential and commercial developments;
6) Create a database of electrical appliance lifecycles to accurately inform the setting of ecological and carbon footprint standards;
7) Collaborate with industry to encourage consumers to opt for energy-saving electric and electronic equipment (e.g. trade-up programmes) to increase energy efficiency and facilitate systematic electronic waste management;
8) Increase the proportion of green procurement in commercial building, focusing on the shift to energy-saving equipment and;

9) Promote green building with emphasis on green design and the sourcing of energy efficient and eco-friendly materials.

3.2 Reducing energy consumption in buildings

10) Initiate long-term campaigns to raise awareness for energy conservation to be promulgated via school curricula and media outlets;
11) Mandate monitoring and reporting systems in the energy management systems of buildings and commercial facilities and;
12) Promote voluntary agreements on energy efficiency between the government and business/industrial sectors, especially with business associations and large corporations.

4. Industry – focusing on improving the performance of machinery, energy efficiency and waste reduction through measures such as the promotion of renewable energy production and consumption, and investments in low-carbon and environmentally friendly industries as detailed below:

(Responsible parties: Ministry of Industry, Ministry of Natural Resources and Environment, Prime Minister's Office, Ministry of Science and Technology, Ministry of Education, Ministry of Energy, Ministry of Finance, Ministry of Commerce, Ministry of Internal Affairs, Private Sector)

4.1 Increasing production efficiency and reduce waste

1) Encourage the use of high efficiency technologies (e.g. cooling systems, motors, boilers) with financial incentives such as tax credits;
2) Encourage greater energy efficiency through the application of modifications such as insulation, motor regulators and economisers;
3) Raise the skills and competencies in the workforce to accommodate the operation of high-efficiency technologies whilst applying management principles to extract the greatest efficiency and performance out of equipment. These measures will be supported by R&D and the provision of training for small and medium sized enterprises

provide training to small and medium-sized enterprises for transition to environmentally friendly production;

4) Encourage industry, especially those with the highest GHG emissions, to develop GHG reduction plans;
5) Encourage the reduction or discontinuation of GHG use in industry, such as switching from CFCs, HCFCs and HFCs to environmentally friendly compounds in the refrigeration and air-conditioning;
6) Create a public-private forum to develop GHG mitigation mechanisms with a focus on economic measures (e.g. carbon tax, carbon trading);
7) Facilitate access to international GHG mitigation mechanisms and encourage GHG reduction in the CSR projects of the private sector;
8) Develop a more comprehensive industrial GHG emission database and reporting system, especially in GHG intensive industries (e.g. cement, iron, steel industry, food, ceramic, paper, and textile production) with the appropriate baseline for each industry;
9) Develop resource recovery and recycling capabilities further;
10) Conduct feasibility studies on the development and management of CCS technology in the appropriate industries and;
11) Encourage the development of domestic energy service companies (ESCO).

4.2 Promoting production and consumption of renewable energy in the industrial sector

12) Promote waste heat recovery in various industries such as the cement, food processing, ceramics, pulp & paper, and textile industries;
13) Promote power generation using biogas produced from waste in various industries, such as palm oil extraction, potato starch, ethanol, alcoholic distillation, sugar, food processing and pulp & paper industries;
14) Encourage the replacement of bunker oil with biomass as fuel for steam boilers along with the installation of electricity/steam co-generation systems and;
15) Promote the harnessing of other renewable energy sources such as solar and wind power in the industrial sector.

4.3 Promoting investment in low carbon and environmentally friendly industries

16) Incentivise the use of clean / zero waste / low carbon / otherwise environmentally friendly technology across the entire value chain to maintain the existing industries of the country with measures such as investment privileges, tax exemptions, and soft loans;
17) Promote investment in industries with low environmental impact and low carbon emissions with the appropriate financial incentive mechanism. Service industries, healthcare industries, creative industries and innovation-driven industries with high economic potential (e.g. clean energy, bioplastic, pollution treatment and management) are among key industries to be considered;
18) Promote foreign investment that align with low carbon, eco-friendly technology transfer policies and will result in capability building for the domestic workforce;
19) Promote eco-industrial town developments with integrated management systems for renewable resources, raw materials and waste. Such developments must have effective communication mechanisms to ensure mutual understanding among all stakeholders, especially the local community, before development commences.

5 .Waste management – focusing on integrated life cycle waste management by prioritising source reduction and the 3R (Reduce, Reuse, Recycle) in accordance with the waste hierarchy. Waste management efficiency will be increased by supporting waste-to-energy programs through the actions and measures outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Ministry of Internal Affairs, Ministry of Finance, Ministry of Industry, Ministry of Commerce, Ministry of Justice, Prime Minister's Office, Ministry of Science and Technology, Ministry of Education, Private Sector)

5.1 Waste reduction

1) Raise public awareness by promulgating the principles of waste reduction, reuse, recycling and separation through the school curriculum, extracurricular activities and through various media outlets;
2) Design and devise economic instruments (e.g. volume-based waste management fees and deposit-refund systems) to encourage waste reduction;
3) Promote and support waste reduction at highly visible and responsive points, such as educational institutions, government offices and commercial buildings;
4) Promote the reuse and recycling industry by encouraging business operators to explore options for reuse, recovery, and recycling;
5) Promote non-hazardous waste exchange in the industrial sector and;
6) Promote waste banks and separation centres to encourage reuse and recycling along with encouraging separation of organic waste to feed the waste-to-energy programme.

5.2 Waste management efficiency and the waste-to-energy programme

7) Support waste management clustering to facilitate the waste-to-energy programme;
8) Enhance the capability of local administrative bodies to provide efficient solid waste and wastewater management in alignment with the waste-to-energy programme;
9) Replace open dumping sites with sanitary waste management facilities to reduce methane emissions and upgrade existing landfills to the required standard;
10) Encourage local administrative bodies to charge waste management fees in order to finance solid waste and wastewater management services which will ensure the sustainability of said services while discouraging waste production;
11) Introduce municipal regulations on solid waste separation (general, organic, recycling, hazardous waste) and prohibit the mixing of hazardous waste with general waste;
12) Promote the development of localised waste recovery and waste-to-energy technology (e.g. large-scale composting, anaerobic digestion, biogas capturing systems and landfill gas capture technology) with an emphasis on non-toxic modalities;
13) Issue Waste Electrical and Electronic Equipment (WEEE) law according to the Extended Producer Responsibility (EPR) and product charge principles and;

14) Encourage private sector investment in collection, transportation, and management services for both general and hazardous waste.

6. Agriculture - focusing on low emission agricultural practices with environmental and financial co-benefits; increasing the capacity of farmers to accommodate GHG reduction technologies and management systems through the actions and measures outlined below:

(Responsible parties: Ministry of Agriculture, Prime Minister's Office, Ministry of Science and Technology, Ministry of Education, Ministry of Internal Affairs, Ministry of Finance)

6.1 Promote agricultural practices with low GHG emissions and co-benefits

1) Improve the efficiency of agricultural practices, resource management and water consumption;
2) Reduce the practice of burning in agriculture through collaboration with buyers of agricultural commodities. Farmers must be educated on proper production techniques to reduce the need for burning while the market for recoverable agricultural waste is developed;
3) Promote the production and use of biogas from animal manure in livestock farms while developing techniques (such as new feeding plans) to reduce GHG emissions from livestock;
4) Develop cost-effective agricultural management techniques to efficiently reduce GHG emission from rice farming;
5) Promote sustainable agriculture, Good Agricultural Practice (GAP) and eco-friendly livestock farming and fisheries to reduce adverse environmental and ecological effects. Standards for organic farming, sustainable farming, and other standards (e.g. GAP, GMP, HACCP and CoC) are to also be widely promulgated and implemented;
6) Incentivise small-medium holder farmers to apply GAP or other beneficial standards through financial aid such as soft loans, tax exemption, etc. together with other supportive measures and infrastructure such as technology transfer and new water sources and;

7) Conduct research and develop pilot projects to demonstrate eco-friendly agricultural practices (e.g. seed bank development, use of appropriate technology, yield maximising, land and water efficiency, harvesting and post-harvesting management, agricultural waste management, food processing, marketing and distribution). Establish educational networks with successful communities or farmers as role models.

6.2 Competency development and capability building for farmers

8) Develop the capabilities of farmers in applying GHG reduction technologies and management concepts (e.g. water management in rice paddies, appropriate use of fertilisers, nutrient management and groundcover crops.);
9) Promote R&D on GHG emissions reduction in the agricultural sector (e.g. improve breeding, feeding, and management techniques);
10) Develop GHG emissions databases that are relevant to the agricultural context, e.g. with data on crops which constitute the raw materials of other industries and;
11) Build the capability and knowledge base required by smallholders to take appropriate and effective action and support them with increased access to the factors of production and funding.

7. Forestry – focusing on the creation of carbon sinks via forest conservation, restoration, reforestation, and afforestation .Measures that affect communities in forested areas should be evaluated on the merits of their environmental and social impact via public hearings of sufficient duration and transparency, which will ultimately aid the decision and policy making processes as outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Prime Minister's Office, Ministry of Science and Technology, Ministry of Education, Ministry of Internal Affairs, Private sector)

1) Support afforestation, tree banks and agroforestry to create and preserve carbon sinks in accordance with the Sustainable Forest management (SFM) approach. R&D on timber origin identification (e.g. DNA fingerprint technique) methods must also be expedited;

2) Conduct R&D on forest bonds to raise funds from public and private entities in accordance with the Payment for Ecosystem Services (PES) principle and the REDD+ approach to the conservation of natural balance. Reduce GHG emissions from land-use change with emphasis on the rights of ecologically friendly communities to sustainably utilise the natural resources that they are protecting and maintaining;
3) Promote GHG reduction in the forestry sector by encouraging sustainable production and livelihoods in accordance with the local community context. Promote society-based learning to build upon local wisdom and incorporate them into policy recommendations and sustainable options on GHG reduction in the forestry sector;
4) Encourage the business community to be active in forest conservation and restoration through corporate social responsibility (CSR) programmes which are conducted in concert to avoid redundancy;
5) Develop community-based wildfire surveillance networks with the participation of local communities. The wildfire prevention and control capabilities of the general public (especially in high risk areas) must be enhanced and the necessary support for wildfire prevention, such as digging trenches around the edges of forest reserves and constructing adequate networks of check dams must be provided;
6) Conserve and restore wetlands and mangrove forests to increase carbon sinks and prevent coastal erosion and;
7) Conduct research into the carbon capture capacity of soil in various ecosystems.

8. Urban management – focusing on increasing urban green spaces to act as carbon and pollution sinks which can also help to mitigate GHG emissions from human activities in major cities. We will work towards sustainable cities through the actions and measures outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Ministry of Internal Affairs, Ministry of Transport, Prime Minister's Office, Private Sector)

8.1 Urban greening

1) Assist local administrative bodies in increasing green spaces in urban and community areas, thereby creating recreational spaces that also act as carbon and pollution sinks;
2) Develop guidelines on green space management in urban and community areas with an emphasis on planting tree species with the characteristics of high carbon absorption ability, versatile timber, and ease of maintenance without being non-native species which may be a threat to native biodiversity and ecological balance and;
3) Encourage the business sector and NGOs to participate in the greening of cities through CSR initiatives.

8.2 Reducing GHG emissions from human activities in major cities

4) Analyse urban GHG emission and carbon sink capacities based on area and sectoral activities with final aim to develop urban GHG emission monitoring and evaluation systems;
5) Support the low carbon city development plans of all provinces in accordance with the sustainable cities concept with the participation of all stakeholders. Apply mixed use planning approaches to reduce the need for transit and regulate area density to facilitated transit-oriented developments. Adopt land-use zoning and other appropriate urban planning measures to protect green spaces, important ecosystem and suburban agricultural areas which will in turn reduce logistic costs including other urban planning measures;
6) Promote climate friendly design in the architecture and construction of buildings, infrastructure, urban planning and land-use planning to achieve climate change adaptive capacity;
7) Develop sustainable urban transportation systems that are built and run on sustainable foundations, increase efficiency, reduce GHG emissions, and promote transit oriented development;
8) Support further development of waste management and effective application of waste-to-energy technologies in major municipalities and;

9) Raise environmental awareness among urban populations through public campaigns and activities.

Strategy 3 Enabling environment for climate change management

The capability building strategy comprises actions and measures in the following four sectors:

1. Data, research, and technology development – focusing on improving the quality and standard of data, information, research, and the application of technology in climate adaptation through the actions and measures outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Prime Minister's Office, Ministry of Science and Technology, Ministry of Education, Ministry of Agriculture and Cooperatives, Ministry of Commerce, Ministry of Transport, Ministry of Industry, Ministry of Digital Economy and Society, Ministry of Foreign Affairs)

1.1 Developing data and research

1) Develop national research and development (R&D) strategies and plans on climate change, including frameworks for international cooperation on R&D within the country and ASEAN. A database of domestic and international researchers or experts should also be maintained;
2) Establish a centre to coordinate and link research and the resulting data between policy making and operational branches of government, research and academic institutes;
3) Update existing databases on natural water sources with reliable statistics (e.g. volume, flow and consumption) at main and sub basin level, in order to properly, prioritise the management and regulation of water consumption in each basin;
4) Formulate effective integrated strategies by examining the relationships and correlations between changes in the following factors as a result of climate change; the quality and quantity of output from farming, livestock and fishery sectors (including changes in the growing and harvesting seasons); the commercial system of domestic and overseas markets, and supply chains;

5) Research and assess measures for adaptation and risk management in the water management, agriculture and energy sectors, taking into account the interrelationships between water, food and energy security;
6) Increase preparedness and develop resource management systems that are resilient to climate uncertainties. To this end, government responses and the adaptive capacity of supply chains for necessities must be evaluated;
7) Conduct research to support the integration of climate change issues into the policy and planning of all sectors;
8) Develop a comprehensive and up-to-date national GHG emission database to aid in the forecast GHG emission trends. Define economy-wide and sector-by-sector BAU scenarios to be used as basis for management and forecasting;
9) Establish voluntary and mandatory GHG reduction activities, mitigation volumes and an emissions trading registration system;
10) Develop a GHG reporting system for the industrial sector by targeting the large operators in high emissions industries first before expanding to cover all sectors;
11) Assess the benefits of GHG reduction and technical capacity thereof in sectors with a tendency for GHG emissions (i.e. energy, transport, manufacturing, waste management and building) as a basis for policy formation and prioritising GHG reduction activities;
12) Develop integrated plans for research into renewable energy and energy efficiency;
13) Conduct life cycle assessment, ecological footprint and carbon footprint research into the manufacturing, production, logistics and consumption of widely used products;
14) Support the development of a comprehensive energy and raw materials database in accordance with international standards to further facilitate life cycle and carbon footprint assessment;
15) Explore sustainable consumption alternatives as a climate change mitigation measure and;
16) Conduct research to identify GHG reduction approaches for industries and businesses that still lack the knowledge to expand on or move beyond existing measures.

1.2 Technological development

17) Expedite action plans for the development of human resources competencies in order to support the innovation and application of technologies for climate change;
18) Expedite the application of technologies and methods for accurate and reliable weather forecasting, climate modelling, extreme weather event projection (e.g. tropical cyclones, severe flooding and droughts) and improve early warning systems;
19) Support the development of and application of technology for the surveillance and monitoring of hydrological parameters (e.g. water level, speed, flow). Effective water management will depends on the ability to accurately model and forecast conditions;
20) Support the development and application of technology in the breeding of climate change resistant plants (e.g. Marker Assisted Selection MAS, genetic engineering) in accordance with the (draft) Biotechnology Safety Act and other related regulations;
21) Support the development of surveillance and early warning systems for climate-related plant pests and diseases in the agricultural sector to effectively forecast and prevent possible losses;
22) Support the development of precision farming technologies for use in combination with local knowledge to achieve effective resource management and reduce vulnerability to climate change;
23) Develop technologies and innovations to facilitate infrastructure design and resource management systems (e.g. dams and weirs design and management system) that are responsive to climate change;
24) Expedite the development of smart grid technology to increase the efficiency of power transmission and support renewable-based power generation;
25) Support the commercialisation of affordable, energy efficient technologies, especially those which are domestically manufactured and have large sales volumes such as energy efficient construction materials for residential and commercial construction;
26) Promote the demonstration of proven energy efficient technologies in the domestic market, and provide the necessary support to ensure successful commercialisation;
27) Support waste-to-energy technology development with an emphasis on environmentally friendly practices that can be adopted by local administrative bodies;

28) Develop the knowledge base on efficiency gains from Gen I renewables technology and conduct further research on Gen II and III renewables technologies to enable domestic development and application;
29) Develop mechanisms to facilitate international cooperation in technology transfer and management.

2. Development support mechanisms for climate change adaptation and mitigation – focusing on developing mechanisms to support GHG emissions reduction, low carbon development incentives, mobilisation of developmental partners, climate change adaptation and mitigation mechanisms, as outlined below:

(**Responsible parties: Ministry of Natural Resources and Environment, Ministry of Justice, Ministry of Finance, Ministry of Agriculture and Cooperatives, Ministry of Commerce, Ministry of Foreign Affairs, Ministry of Industry, Ministry of Internal Affairs, Prime Minister's Office, Private Sector, NGO)**

2.1 Climate change adaptation and mitigation

1) Expedite the National Water Resources Management Act to increase the efficiency of water resources management with the participation of stakeholders and related partners throughout the entire process;
2) Establish financial mechanisms to support climate change adaptation measures (e.g. recovery and compensation funds) with special attention to small-scale farmers and those with low income. The coverage of existing mechanisms, such as the National Environmental Fund should be expanded while access to international funding sources must be enhanced;
3) Develop disaster and crop insurance schemes for communities and population in at-risk areas;
4) Expedite the revision and amendment of existing laws and regulations to ensure equitable and sustainable natural resource management and;

5) Develop mechanisms to connect and mobilise international cooperation on climate change.

2.2 Support mechanisms for low-carbon development

6) Expedite low-carbon development support mechanisms in the form of incentives (e.g. carbon tax, benefit schemes, carbon fund, domestic carbon credit markets with international trading options, GHG emission limits, GHG emission allowances) The cost-effectiveness of all measures must be thoroughly evaluated and the Polluters Pay Principle (PPP) and the Common But Differentiated Responsibilities principle are to be adopted for fairness;
7) Develop effective and robust GHG reduction measures and tools that are compatible with international mechanisms and measures. The opportunities and potential for Thailand to become a developmental leader in the ASEAN region must also be identified and analysed;
8) Incentivise environmentally friendly and low carbon emission investment by providing investment benefits, tax privileges and soft loans from financial institutes/funds. The approval of support for foreign investment is subject to the satisfying of criteria for GHG management, technology transfer and environmental management;
9) Establish Nationally Appropriate Mitigation Actions (NAMAs) and appropriate domestic MRV mechanisms for GHG reduction in accordance with international standards. Develop databases to facilitate the building of domestic capabilities with regard to MRV certification systems;
10) Develop basic infrastructure to support low carbon growth and development, such as rail transport, multi-modal transport, safe non-motorised transport (NMT), renewable power plants, smart grid systems, and efficient telecommunication systems, etc.;
11) Update existing legal mechanisms (e.g. building codes, energy efficiency standards, traffic management and urban planning) to drive low-carbon development;
12) Mandate carbon footprint labelling of major commercial products to provide consumers with information for their decision-making and as selection criteria of green products and services for green procurement;

13) Stipulate the minimum ratio of green procurement for government and business sectors with clear pre-qualifications and capacity, such as companies listed on the Stock Exchange of Thailand;
14) Assess the suitability of including GHG management criteria in the Environmental Impact Assessment (EIA) and Environmental and Health Impact Assessment (EHIA) for high GHG emission projects.

2.3 Mobilising developmental partners

15) Develop national and local action plans for climate change adaptation;
16) Develop national GHG reduction plans and strategies (to include short - medium term targets) with the participation of related developmental parties;
17) Develop action plans for the reduction of GHG emissions in major cities;
18) Expedite the development of climate change strategies in all relevant agencies to mobilise climate change action in all sectors. Create a public forum to galvanise and crystalise momentum;
19) Add a budget code for climate change impact management in the national budget in order to stimulate climate change projects and provide a tracker for the analysis of climate change management effectiveness based on expenditure;
20) Support high-emission industries with the appropriate capabilities in developing GHG emission reduction plans and create a forum where the private and public sectors can discuss and agree on appropriate support mechanisms needed from the government;
21) Develop and promote a climate change CSR manual for the business sector which focuses on projects/activities corresponding to and expanding on existing government projects and;
22) Support collaboration between academia and society at the local, national and international levels in tackling climate change issues in accordance with sustainable development approaches and national policies.

3. Raising climate change awareness and increasing adaptive capacity – focusing on raising awareness and understanding among target groups (e.g. educational institutions, academia, related agencies, mass media and the general public) to enable the accurate assessment and analysis of climate change policies and equip them with the necessary knowledge and competencies to effectively prevent and mitigate climate change impacts through the actions and measures outlined below:

(Responsible parties: Ministry of Education, Prime Minister's Office, Ministry of Science and Technology, Ministry of Internal Affairs, Private Sector)

3.1 Academic and educational institutions

1) Encourage discussions, research expansion and collaboration between academic networks and other sectors in human resource development and the application of research findings in policy-making, planning and implementation;
2) Establish centres of excellence on specific climate change issues at local and national level with the aim of becoming a hub for climate change action in ASEAN. To this end there must be a high level of international coordination among academic institutions to continuously improve the quality of climate change research and human resources;
3) Encourage academics in related fields (e.g. engineering, science, architecture and urban planning, agriculture, forestry, public health, business administration, social science, political science) to integrate climate change and environmentally friendly sustainable development concept into the curriculum;
4) Incorporate environmental and climate change concepts into school curricula at all levels; support extracurricular activities to raise environmental awareness and responsibility in the community, society and the nation;
5) Promote the establishment of courses and degrees with a high content of knowledge and training concerning environmental issues and;
6) Encourage companies with CSR projects relating to environmental issues to include the local community and youth in the process.

3.2 Mass media

7) Support the media in communicating climate change issues (e.g. climate change policy and cooperation at national and international levels); uphold media ethics; promote creative communication on climate change issues;
8) Ascertain the level of awareness of climate change in the general public and identify and formulate appropriate strategies for raising awareness in target groups with a focus on broadening basic understanding for practical application and the ability to analyse climate change policies;
9) Promote environmentally friendly lifestyles into mainstream culture and create a culture of environmental responsibility in partnership with targeted media channels and public figures who could serve as positive role models for environmental responsibility and;
10) Educate consumers to encourage environmental friendly products and services.

3.3 Governmental sector

11) Develop manuals and guidelines for area-based action for climate change adaptation and mitigation to improve the capabilities and understanding of local administrative bodies concerning climate change. To this end the capability of local government officials must be enhanced so that they may effectively and efficiently implement environmental projects;
12) Create human resources development plans for climate change related fields (e.g. renewable technology, energy and materials science, environmental economics, international environmental law or environmental studies) to support policy planning and implementation. Such plans must be integrated into nationwide human resources development plans such as those of the Ministry of Education or the civil service in general;
13) Mandate the regular and systematic monitoring of climate change knowledge and awareness at all levels. This can be facilitated by the creation of public-private forums as an ongoing communication channel for policy related issues;

14) Strengthen the capacity of climate change coordination agencies, inter-agency bodies (committees, sub-committees, working groups) and Climate Change Coordinator (CCC) mechanisms by providing sufficient human resources, regular capability building and transparent, effective, and integrated implementation mechanisms.

3.4 Business Sector

15) Create ongoing public- private forums for transparent identification and communication concerning the respective readiness and obstacles of all stakeholders. Good communication is key to successful public-private partnerships for low carbon and environmentally friendly production and consumption;
16) Establish networks for environmentally friendly and low carbon production and services between the public, private and academic sectors to exchange knowledge, best practices and research on technology and innovations with commercial potential and;
17) Promote green marketing by educate the consumers on the direct benefits of environmental friendly products and practices (e.g. saving money on utility bills), in order to encourage positive behavioural changes and assist consumers with decision-making in product selection.

4 .International climate change cooperation –focusing on facilitating international climate change negotiations via trade and environmental cooperation to harmonise policies and produce win-win outcomes through the actions and measures outlined below:

(Responsible parties: Ministry of Natural Resources and Environment, Ministry of Foreign Affairs, Ministry of Finance, Ministry of Science and Technology, Prime Minister's Office, Ministry of Education, Ministry of Commerce, Ministry of Industry, Ministry of Justice, Private Sector)

4.1 Increasing capability for international climate change negotiations and cooperation

1) Appoint a team of national negotiators for climate change with clear roles and responsibilities. Input will be sought from related agencies in forming the criteria, qualifications and serving terms of members and in the designation of the head negotiator and deputies in the team;
2) Create databases of key negotiating partners/groups of countries and negotiation topics to monitor and analyse their standpoints on a variety of issues to facilitate smooth transfers between negotiation teams;
3) Analyse specific interests or considerations (e.g. trade, investment, political-economic trends and related domestic policies) of negotiating partners/groups of nations which may affect their climate change negotiation stance. Alliances and bi-lateral cooperation frameworks are to be actively sought in all topics. Mandates and action plans must be developed to ensure consistent and unified objectives in negotiation by all teams and team members;
4) Collaborate with academia and related sectors on a regular basis in holding discussion forums to promote knowledge exchange and increase the overall capability of the negotiation team; conduct studies and develop databases to support climate change negotiation:
5) Host international conferences on climate change in Thailand to provide opportunity for local staff to observe the events and improve their capabilities;
6) Evaluate the preparedness of the nation on climate change adaptation, mitigation, research, technological development and capability building to determine appropriate approaches for international cooperation and;
7) Assess the country's potential to become the regional leader in climate change adaptation (emphasising finance mechanisms, technology transfer, research and development and capability building in the relevant sectors) to determine appropriate approaches for cooperation at ASEAN level. In order to achieve a unified regional negotiating stance there must be continuous and consistent coordination among all of the ASEAN member states.

4.2 Integrating trade and environmental negotiation

8) Study domestic subsidy programmes for low- carbon products in key trading countries/groups of nations and develop an appropriate knowledge base for trade and environmental negotiations;
9) Assess the country's potential in penetrating markets for climate-friendly goods and services. Seek bilateral/multilateral opportunities to promote Thai goods and services. Consider the possibility of becoming a leader in ASEAN or APEC for environmentally friendly goods and services;
10) Improve trade and investment promotion policies to realise the goal of becoming a hub in ASEAN for environmentally friendly goods and services. Promote and support Thai direct investment in environmentally friendly projects and business ventures overseas, such as solar power, hydro power, wind farms, etc. which will ultimately benefit similar ventures in Thailand through the cross-pollination of know-how and experience;
11) Craft and revise trade and investment related laws and regulations to facilitate the manufacturing, import and export of environmentally friendly and low carbon emission goods and services (e.g. Investment Promotion Act B.E. 2520 - promotion of environmentally friendly investment and investment promotion strategy section) by mandating GHG emission and environmental management standards and technology /knowledge transfer, as criteria for the approval certain investments. Develop trade agreements, revise import regulations on high environmental impact/high management burden products (e.g. plastic-based products, low quality electronics) based on non-discrimination principles;
12) Create a public private discussion on the improvement of environmental standards for Thai products (e.g. carbon footprint standards) to determine the appropriate approaches in international negotiations concerning financial support, technology transfer and capability building of the private sector and to deal with any possible trade barriers and;
13) Increase the competitiveness of the industrial sector by promoting clean manufacturing, life cycle assessment, carbon footprint of products, green labelling, and green design. Establish a fund to support SMEs in raising the quality standards of products and services as well as increasing manufacturing efficiencies.

Guidelines to implementation, monitoring and evaluation of the master plan

The Climate Change Master Plan 2015 – 2020 is a national plan that will be used as an overall guide for the nation in adapting to the effects of climate change and provide solutions to problems occurring as a result of climate change. It is crucial that the master plan is implemented in a methodical and holistic manner for truly effective and efficient solutions to climate change to be successfully realized. Although climate change is primarily an environmental phenomenon, it calls for nothing less than the full involvement of all national stakeholders and sectors; energy, transport, industry, agriculture, public health, government, private sector and civil society across the central, regional and local levels of administration and organization within the nation. In meeting this great challenge it is therefore necessary for the master plan to be as clear as possible so that the contributions from stakeholders may be sustainably synthesized into comprehensive solutions. The 35 year span of the climate change master plan also necessitates periodic evaluations in order to identify the course correction and revisions that will allow the plan to meet any unforeseen challenges whilst remaining true to the original objectives. We therefore present the guidelines for the implementation, monitoring and evaluation of the climate change master plan 2015 – 2020 as shown in the diagram 4.1, the details for which are as follows:

4.1 Guidelines for putting the master plan into practice

1. Putting climate change at the forefront of the national agenda by instilling the matter of climate change into all aspects and levels of developmental policy. This is to ensure that all sectors are equipped with the resilience and adaptive capacity that is necessary to deal with climate change, especially those who are at the most risk such as low-income members of society, small holdings and small business owners, to name but a few. This will help to address the matter of inequality in terms of access to resources which will in turn reduce income inequality and ultimately, reduce social inequality. The implementation of low-carbon development will help to add value to goods and services and the national economy as a whole, open up new opportunities for development that goes hand in hand with the preservation of natural resources and environmental conservation, and improve the efficiency of national natural resource management. The fulfilment of this vision requires a reconsideration of the nation's developmental path. To that end, putting climate change at the fore of the national agenda will help to drive significant policy changes in the following sectors:

1.1 Energy Development Policies to establish low greenhouse gas emission development as a main objective of national energy development policy in addition to the cardinal objectives of strengthening energy security, reducing reliance on foreign energy imports, promoting the renewable energy industry as an environmentally friendly business opportunity while being an access point to energy sources in local communities. All of this can be supported by existing international mechanisms such as financial support, technology transfer and development of technical capacity.

1.2 Transport Policies for the development of transport infrastructure that is efficient, effective and low in pollution. It is imperative that this transport infrastructure is readily accessible to the majority of society as this will lower the transportation costs for society and business. To this end, the existing international mechanisms for developing transport infrastructure should be utilized.

1.3 Investment promotion and industrial development policies to reduce greenhouse gas emissions, encourage environmentally friendly practices in the field of business and industry, develop green industries and eco-industries, reduce negative effects of industry on the environment, and adaptive measures for the tourism industry.

1.4 Sustainable urban development policies for sustainable, low-carbon and climate-resilient urban development that takes climate change into account. Prioritize awareness of the effects of climate change among local agencies and improve the effectiveness of knowledge management systems.

1.5 Comprehensive water management policies to take into account the effect that climate change is having on the factors which affect the volume and quality of water in natural watersheds, as well as considering the implications for sustainable and equitable water management, which includes natural disasters such as flooding and drought.

1.6 Agricultural policies to improve readiness for climate change among farmers, which will in turn contribute to ensuring food security which is particularly important for low-income members of society. Encouraging the development of sound agricultural land management practices in a way that is in accordance with capacity and achieve a good balance between food and energy production. Promote environmentally friendly agriculture and increase the capacity and opportunities for efficiency gains in production. Add value to the agricultural production process by transitioning towards low-carbon, environmentally friendly agriculture.

1.7 forest of conservation sustainable on focus which **policies Forestry** resources, preservation ecological and diversity bioligcal.

1.8f which **policies health Public** ocus on prevention of diseases and threats to health as a result of climate change by disseminating knowledge and information to the target groups while developing the effectiveness of basic health services in managing the health risks arising from climate change.

2. Developing practical tools and mechanisms to lower the barriers to contribution and involvement from all stakeholders in building climate change resilience and contributing to low-carbon growth. Priority will be given to the tools and mechanisms which promote wider engagement from the private sector and society at large:

2.1 Economic mechanisms that put the Polluters Pay Principle into effect through mechanisms such as carbon taxation, emission certificates trading or creating a domestic carbon market linked to international carbon markets, creating a carbon fund and incentives for low-carbon investments, etc. This is to be achieved through targeted reductions within the industries with the highest rate of greenhouse gas emissions and encouraging energy conservation and efficient energy use within society. The readiness and capacity of the various sectors, the effects on the cost of production, the effectiveness of these economic mechanisms on reducing greenhouse gas emissions, and the equality of access to resources, especially for the low-income members of society, must be established through studies.

2.2 Strategic Environment Assessment (SEA) of the risks arising from change in climatic factors as well as the risk from the greenhouse gas emissions of large areas and projects.

2.3 Climate insurance scheme to be developed by collaborating with the private sector in developing and implementing mechanisms for managing the risks associated with climate change to improve climate change resilience and adaptive capacity. Priority will be given to groups with lowest adaptive capacity. These measures will also facilitate development that carries low risk in the face of climate change.

3. Promote understanding of the goals and objectives of the climate change master plan among developmental partners to engender awareness and willingness to participate in the practical fulfilment of the master plan. This is to be achieved by incorporating the incorporating and reflecting the master plan within their own action plans via the following mechanisms:

3.1 Create processes to disseminate understanding of the climate change master plan for Thailand to all levels and organisations within the government, starting with the central government such as the Ministry of Natural Resources and Environment and other relevant ministries such as the Ministry of Energy, Ministry of Industry, Ministry of Transport, Ministry of Agriculture and Cooperatives, Ministry of Interior, Ministry of Public Health, Ministry of Social Development and Human Security, Ministry of Foreign Affairs, and the Ministry of Tourism and Sports. Regionally this involves the regional environment offices and other regional government agencies and offices. At the provincial level this will involve the provincial Office of Environmental Resources and Environment and the provincial strategic development

office which can ensure that the plans for provincial development are in accordance with the climate change master plan in order to receive budgetary access to the funds for climate change management. At the local level the Department of Local Administration will ensure that local strategic development appropriately incorporates the Climate Change Master Plan. Additionally, the principles of the Climate Change Master Plan must be promulgated and understood throughout all educational administration areas at regional and local level. The promulgation of understanding will be facilitated by a ministerial-level working group composed of the various governmental functions relevant to climate change.

3.2 Public promulgation of the master plan via the media in an appropriate and methodical manner so that the target audiences can be reached efficiently via personal, mass and online media both at the national and local level. This networked exposure will ensure that the information will be spread widely among the target audience in a sustained manner. To this end, appropriate personnel shall be trained to communicate the aims and objectives of the master in a way that leads to lasting awareness and concrete action among in society.

3.3 Collaborate with stakeholders in turning the Climate Change Master Plan 2015 – 2020 into practicable 5-year action plans for each sector and group. These plans should expand on the master plan in greater detail as appropriate. Handbooks for the practical application of master plan principles in local planning should be made available to local groups and organizations. Local administrations and communities which have already developed their action plans should be used as case studies.

3.4 Provide training and knowledge for making action plans which include the use of key performance indicators and project plan writing skills. This is to increase the capacity of local officers in developing action plans in accordance with the visions and goals of the Climate Change Master Plan.

3.5 Create a network with the private sector and civil society; this will be achieved by clearly defining and communicating the respective roles, responsibilities and limitations of the public sector, private sector and civil society. This will lead to the formulation of policies which meet the requirements of the private sector and civil society, thereby encouraging the private sector and civil society to assume ownership in dealing with climate change. In doing so the private sector and civil society will have the agency to

independently expand on the principles set forth by the master plan which will lead to greater climate change resilience and low-carbon development.

4. Ensure alignment and understanding with the agencies with budgetary control to facilitate the expedition of projects relating to the Climate Change Master Plan as follows:

4.1 Ensure alignment and understanding within the government to promulgate the matter of climate change as a priority on the national agenda and guarantee that the Climate Change Master Plan is given budgetary priority as it is a cross-cutting issue.

4.2 Coordinate understanding with the Bureau of the Budget to ensure that the Climate Change Master Plan for Thailand and all relating projects receive the appropriate level of budgetary support towards the fulfilment of all objectives. To this end, the new budget code ("climate change management) should be added into the government budget plan.

4.3 Coordinate with the agencies responsible for the environmental fund to ensure appropriate level of understanding regarding the expanded role of the environmental fund in the management of climate change by providing funds to support the various projects of local administrations and civil society organisations which are aimed at fulfilling the visions and goals of the Climate Change Master Plan. The funds may be used for remedial, regeneration and aid in cases of urgent need arising from climate change.

4.4 Coordinate with organisations overseas to ensure that they receive budgetary support, personnel and the know-how necessary for projects which are in accordance with the Climate Change Master Plan for Thailand.

5. Create effective regulatory, monitoring and evaluation processes

5.1 Define climate change management as a key performance indicator for budgetary access by local administrations and support the local administrations which demonstrate climate change management capabilities in being able to access larger budgets than their counterparts which have yet to demonstrate the ability to manage climate change.

5.2 Create a regulatory framework for the implementation of projects in accordance with the Climate Change Master Plan through national mechanisms and a National Climate Change Policy Committee chaired by the Prime Minister. This committee shall be responsible for defining the objectives and key performance indicators for the Climate Change Master Plan 2015 – 2020 and may release reports to the public on an annual or

biannual basis. Implementation of policy and direct networking between the central, regional and local levels shall be directly expedited by the Climate Change Coordinator which is composed of representatives from 19 Ministries and 11 independent agencies under the Office of the Prime Minister. The Climate Change Coordinator shall facilitate networked* collaboration in planning and implementing of national, regional and local climate change projects to ensure that they are comprehensively realised in accordance with the master plan. A key component of this is involvement of the public and other stakeholders who can provide ongoing oversight for the implementation of the Climate Change Master Plan for Thailand.

5.3 Create systematic monitoring and evaluation procedures for project planning and implementation. Working groups shall be tasked with the collection of data for evaluating projects relating to the Climate Change Master Plan for Thailand and reports shall be released to the public periodically as appropriate.

(*) Networks are defined as groups of persons or organizations which willingly exchange information or participate in activities together under a model in which the persons, groups or organizations retain their respective independence. The parties to the network to provide oversight on the implementation of the Climate Change Master Plan consist of the following; the public sector, the citizenry, communities, local communities, conservationist groups, the private sector, academics, private developmental organizations, educational institutions, and the mass media. In creating this network the organization responsible must ensure that there is mutual understanding, mutual communication and mutual exchange of information and knowledge through periodic collaborative activities.

4.2 Monitoring, evaluation and revision of the master plan

The monitoring and evaluation of the projects relating to the Climate Change Master Plan 2015 – 2020 shall be carried out to ascertain whether the planning and implementation of said projects were in accordance with the visions and goals stated in the Master Plan, and the degree to which the results of the implementation are in accordance with the vision, objectives and key performance indicators. Because the Climate Change Master Plan 2015 – 2020 is a long term plan spanning many years during which many changes can occur, it is therefore inevitable that there should be a comprehensive review of this Master Plan every 5 years. The Office of Natural Resources and Environmental Policy and Planning shall review the

information and situation pertaining to the implementation of the national strategy on climate change, which is a medium-term 5 year plan, along with other information that is available domestically and from overseas which shall be used to revise the master plan accordingly. Revisions to the master plan shall be made upon review of at least the following 4 factors: (1) implementation which shows the responsiveness of the ministries, especially the line ministries, (2) local administration readiness, (3) awareness and understanding among the various stakeholders of climate change, (4) evaluation of the problems and obstacles to implementation in accordance with the guidelines set forth by the master plan. Consideration will also be given to any gaps or unmet needs that arise within the effort to address climate change, which will be used to revise and refine the next phase of the plan. Finally, it is imperative that the private and civil sector play an active and continuous part in the national effort by contributing their views and suggestions to the monitoring and evaluation process for the improvement of the Climate Change Master Plan 2015 – 2020.

ANNEX

Acronyms and abbreviations

OPM	Office of the Prime Minister
MOD	Ministry of Defence
MOF	Ministry of Finance
MFA	Ministry of Foreign Affairs
MOTS	Ministry of Tourism and Sports
M-SOCIETY	Ministry of Social Development and Human Security
MOAC	Ministry of Agriculture and Cooperatives
MOT	Ministry of Transport
MONRE	Ministry of Natural Resources and Environment
MICT	Ministry of Digital Economy and Society
MOEN	Ministry of Energy
MOC	Ministry of Commerce
MOI	Ministry of Interior
MOJ	Ministry of Justice
MOL	Ministry of Labour
M-CULTURE	Ministry of Culture
MOST	Ministry of Science and Technology
MOE	Ministry of Education
MOPH	Ministry of Public Health
M-INDUSTRY	Ministry of Industry