The Bangkok Master Plan on Climate Change 2013-2023

Bangkok Metropolitan Administration (BMA)
and
JICA Expert Team

Preface

Climate change is one of the largest challenges to the current and future development of human society. The Intergovernmental Panel on Climate Change (IPCC) issued its Fifth Assessment Report warns that warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia, and the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases (GHGs) have increased.

Bangkok can severely be affected by negative impacts of climate change. While it is still not scientifically possible to determine whether or not a specific extreme event is due to climate change, in 2011, Bangkok and areas along the Chao Phraya River were hit by a large scale flooding, and historically economic and social damages were recorded. It reminded that the Metropolis would need to accelerate actions to respond to climate change, as similar negative impacts have been already warned in many scientific research papers. At the same time, it is also evident that Bangkok is contributing to emitting GHGs. As the largest city in Thailand, as well as a major global city in the Southeast Asia, and the world, economic and social activities in Bangkok have a trend of increasing emission, which should be mitigated through policies and measures.

The Bangkok Action Plan on Global Warming Mitigation 2007-2012 was established to reduce GHG emission by at least 15 % of the total GHG emission anticipated in the year 2012 under Business as Usual projection. It includes 5 initiatives, namely expand the mass transit rail system within Bangkok metropolitan area, promote the use renewable energy, improve building electricity consumption efficiency, improve solid waste management and wastewater treatment efficiency and expand park area. In order to achieve these goals, full support from the people of Bangkok as well as every sector is acquired for the successful implementation of the activities under the Bangkok Metropolitan Administration's action plan. The opinions and suggestions were put together and refined by number of interdisciplinary experts including 36 organizations such as Ministry of Natural Resources and Environment, Ministry of Energy, The Federation of Thai Industries, Thailand Environment Institute etc., and other organizations from both private and public sectors.

However, challenges still remain, the implementation of the Action Plan was successful in initiating work to address climate change issues at local government level in a systematic manner with a satisfactory result of 14 percent reduction of GHG emissions. The BMA also decided to design a Bangkok Master Plan on Climate Change during the period of 2013-2023, aiming to work on (1) environmental sustainable transport; (2) energy efficiency and alternative energy; (3) efficient solid waste management and wastewater treatment; (4) green urban planning; and (5) adaptation planning. To support this, BMA and Japan International Cooperation Agency (JICA) agreed on the Technical Cooperation Project for Bangkok Master Plan on Climate Change 2013-2023, and jointly worked during the initial period of the Master Plan, during 2013-2015, with strong support by the Thai government ministries and agencies of knowledge sharing by the City of Yokohama, Japan.

This Master Plan provides a framework for Bangkok to establish a low carbon and climate change-resilient city, by introducing future visions, prospects and proposed policies and measures in mitigation and adaptation, roles of BMA and its partners, roadmaps and mechanisms to implement efforts in a short, mid, and long-term. It is strongly hoped that the Master Plan will provide a useful and living platform for all stakeholders of Bangkok to make and strengthen their joint efforts to address climate change. And as a member of the global community, Bangkok decided to take a leading role to drive its efforts, in partnership with all parties.

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1. Background

1-1 Current situation of climate change

(1) Current situation of climate change in general

Climate change is one of the largest challenges to the current and future development of human society. The Intergovernmental Panel on Climate Change (IPCC) issued its 5th Assessment Report warns that warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia, and the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

(2) Thailand's national context of climate change

In 1994, the Kingdom of Thailand ratified the United Nations Framework Convention for Climate Change (UNFCCC) and established Sub-Committee on Climate Change for international negotiations and policy planning (was subsequently changed to National Climate Change Committee in 2006 putting the Prime Minister as a chairman). In January 2008, the cabinet approved the "National Strategy on Climate Change Management (2008-2012)". Also after the ratification to the Kyoto Protocol in 2002, the country extensively conducted GHG reduction projects under the clean development mechanism (CDM), promoting efforts toward a low carbon society in Thailand.

Responding to the development of international regime of climate change, the Royal Government of Thailand also strengthened its domestic policy actions. Currently Thailand is implementing the Eleventh National Economic and Social Development Plan (NESDP) (2012-2016) issued in October 2011. In the Plan, the Government highlights the importance of developing low-carbon-society that is resilient to climate change under one of the sixth focal areas "Strategy for Managing Natural Resources and Environment toward Sustainability". During the same period, there are significant efforts made in the relevant sectors.

In the energy sector, the Government introduced the Energy Efficiency Development Plan (EEDP) 2011-2030[1] and the Alternative Energy Development Plan (AEDP) 2012-2021. Also in the transport sector, the Environmentally Sustainable Transport Master Plan was prepared to promote measures to improve energy efficiency and reduction of GHG in the transport sector, while also improving the mobility and quality of life of people of Thailand.

Against this background, in November 2014, the National Committee on Climate Change (NCCC) endorsed key policy directions, which were authorized by the Cabinet, including endorsement of the Thailand Climate Change Master Plan (2012-2050), and the Thailand Nationally Appropriate Mitigation Actions (NAMAs), as well as preparation for an agreement for the Joint Crediting Mechanism (JCM) with Japan. The implementation targets to

[1] The EEDP sets its targets as follows;

- For all economic sectors, to reduce energy intensity (energy use per unit of GDP) by 25% (*1) in 2030, compared to 2005 levels;
- To reduce overall energy consumption by 20% (*2) (about a 30 million tons of oil equivalent (toe) reduction) in comparison to projected BAU levels in 2030; overall CO_2 emissions by 49 million tons and industrial sector energy consumption by about 11 million ton.
- For the short-term period of 2011 to 2015, total energy conservation of the whole economic sectors to be 5.0 million toe by 2015, compared to BAU; for the industry sector, total energy conservation to be 1.9 million toe by 2015, compared to BAU

reduce the national GHG emission from energy and transportation sectors by 7% by 2020 based on Business as Usual (BAU) emission level. The reduction target may reach 20% with the support from international society as stated by the Minister of Natural Resource and Environment at the 20th Conference of the Parties to the UNFCCC.

1-2 Current situations in BMA related to climate change

(1) Climate change and Bangkok

As pointed out in the IPCC AR 5, stress from climatic drivers, if not only, is increasing and influence on changes in precipitation patterns and coastal and marine systems, to which Bangkok Metropolitan Administration (BMA) is exposed its vulnerability. In 2009, the World Bank Study pointed out that the Bangkok Metropolitan Region (BMR) including BMA, might face a serious challenge by climate-induced large scale flooding within the next 50 years and urged actions to increase the readiness to cope with such extreme events. While it is still not scientifically possible to determine whether or not a specific extreme event is due to climate change, in 2011, Bangkok and areas along the Chao Phraya River was hit by a large scale flooding, and historical economic and social damages were recorded. At the same time, it further reminded that BMA would need to accelerate actions to respond to climate change.

While Bangkok can severely be affected by negative impacts of climate change, it is also the case that Bangkok is contributing to emitting GHG. As the largest city in Thailand, as well as a major global city in the Southeast Asia, and in the world, economic and social activities in Bangkok have caused large emission of GHG. In addition, climate related damage in Bangkok affects not only Bangkok itself but also many other cities and countries. In 2008 Thailand's national GHG emission per capita was estimated at 3.54 ton. Compared with those of major developed economies, such as the United States (19.1), Japan (9.68), Germany (9.71), it is still low, however, it is likely that compared with other parts of the country, the GHG emission of Bangkok is higher, and it is expected to increase due to its rapid economic growth. In other words, while Bangkok can be a victim of climate change, it is also responsible for climate change at the same time.

(2) Efforts by BMA

1) Past efforts by BMA

BMA implemented the Bangkok Action Plan on Global Warming Mitigation 2007-20012 aiming at the greenhouse gas (GHG) reduction of 15 % by undertaking five initiatives as follows; (i) Expansion of mass transit and improvement of traffic system, (ii) Promotion of the use of renewable energy, (iii) Improvement of building electricity consumption efficiency, (iv) Improvement of solid waste management and wastewater treatment efficiency, and (v) Expansion of park areas. Japan International Cooperation Agency (JICA) supported BMA since 2009 through 2012 by providing opportunities of organizing group training in Japan and dispatching short-term experts to BMA. With challenges remained, the implementation of the Action Plan was successful in initiating work to address climate change issues at local government level in a systematic manner.

2) Preparation for the Bangkok Master Plan on Climate Change 2013-2023 and the Technical Cooperation by

JICA

In November 7, 2012, BMA and JICA agreed to sign the Record of Discussion (R/D) on the Technical Cooperation Project for Bangkok Master Plan on Climate Change 2013-2023, which provided support to BMA for drafting a master plan as well as individual and institutional capacity development of BMA, by dispatching Japanese sectoral experts, organizing study tours to Japan, as well as other activities including providing local experts and organizing public seminar etc., in cooperation with the City of Yokohama, commencing on March 2013 for the period of 24 months. Later, due to the political turbulence in Thailand, the progress of project was delayed, and the cooperation period was extended until the middle of October, 2015.

Under this Technical Cooperation Project, BMA agreed to establish an institutional arrangement for drafting the Master Plan, consisting of a *Steering Committee (SC)*, a *Working Group (WG)*, and 5 *Task Forces (TFs)*, and a *Secretariat*. In terms of sectors, the following initiatives are made through the 5 Task Forces namely, (1) Environmental sustainable transport, (2), Energy efficiency and alternative energy, (3) Efficient solid waste management and wastewater treatment, (4) Green urban planning, and (5) Adaptation planning. With participation by key agencies of the national government, as well as departments of BMA, the Bangkok Master Plan on Climate Change 2013-2023 was gradually drafted based on their technical and policy-related discussion and consensus building. Through this process, the institutional arrangement made of the Steering Committee, the Working Group, the Task Forces, and the Secretariat functioned very well, and it has now been recognized as basic form of the institutional arrangement for the implementation of the Master Plan.

2. Basic approaches to the Master Plan

2-1 Approaches in general

The Bangkok Master Plan on Climate Change 2013-2023 is designed as a basic policy document to provide general direction on the following matters;

(1) Bangkok and climate change
(2) A future vision toward establishment of a low carbon and climate change resilient city
(3) Defining the scope of the Master Plan
(4) GHGs emission prospects and mitigation targets under the Bangkok Master Plan on Climate Change 2013-2023
(5) Adaptation concerns
(6) Planning mitigation and adaptation measures under the Master Plan
(7) Institutional arrangement for implementing the Master Plan
(8) Monitoring and evaluation (M&E) and measurement, reporting, and verification (MRV)
(9) Roadmap for implementation
(10) Capacity-building and outreach

2-2 Alignment with the national policies

Given the fact the Bangkok's local efforts should be an integral part of the entire national policy on climate change, the Bangkok Master Plan on Climate Change 2013-2023 is designed and should be implemented in alignment with the relevant national policies today and future.

To date, in particular, policy documents such as the Thailand Climate Change Master Plan (2012-2050), and the Thailand Nationally Appropriate Mitigation Actions (NAMAs) provided important references in elaborating future visions, mitigation and adaptation actions and targets, as well as measurement, reporting, and verification (MRV) of the Bangkok Master Plan. For some sectors like transport, and energy, these national documents provided a logical foundation in establishing quantification of the Business as Usual as well as emission reduction targets for BMA. While some of these documents are linked with Thailand's international pledges for mitigation, the Bangkok Master Plan on Climate Change 2013-2023 is not directly linked with international commitments, and it should be rather regarded as a local effort that could also a support national government's actions.

In future, during the implantation of the Bangkok Master Plan and beyond, the national policies are likely to be developed in an evolving nature. In this regard, the current Master Plan should also be developed with technical and policy review at an appropriate timing.

2-3 Quantification of GHGs

With regard to mitigation of climate change, it is important to see GHG emission amount by comparing cases without mitigation actions (Business as Usual or BAU) and with actions. In other words, how much GHG is reduced in

quantity is one crucial approach to assessing the degree of success in mitigation actions in an objective way. In this Master Plan, GHG emissions have also been quantified for the 2 emission scenarios, namely the case of BAU and the case with emission reduction by taking mitigation actions.

[Methodologies]

In terms of methodology, basically the logic was to simply apply to quantify GHG emission is to simply multiply activity data[2] and emission factor.

GHG Emission = Activity * Emission Factor

[Reference data]

In terms of source of reference data for the activities above, most of the sources are from the relevant national master plans, such as the EEDP, AEDP, Environmentally Sustainable Transport Master Plan, and others, as well as national statistical data. For emission factors, this Master Plan adopted factors officially used by the national government, and where not available, IPCC GHG Inventory Guidelines for 2006.

[Coverage of GHG emission]

The Master Plan basically covers all GHG emissions in the geographical jurisdiction under the BMA. In case of waste disposal site, where GHG emission and emission reduction occurs by actions of BMA, those outside of BMA are included. In terms of GHGs, the Master Plan covers CO_2 emissions from energy use (including transport), as well as CH_4 and N_2O emission from waste and wastewater treatment. Also, GHG absorption by green urban development is also included.

Among from GHG emission in BMA area, some of them are directly belong to BMA's activities. For example, GHG emission from electricity use in BMA owned building or from fuel use by BMA owned public vehicle. Others are GHG emission not directly by BMA but citizens, the private sector, and others contribute to GHG emissions (the attribution of GHG emissions are shown in the Figure 2-1 Attribution of GHG emissions in BMA below. In terms of actions to reduce GHG, this Master Plan also encompasses actions to be taken by BMA directly or indirectly through promotional efforts and cooperation with other stakeholders, as appropriate.

[2] Activity data are for example, amount of electricity used for lighting, fuels used for vehicles, etc.

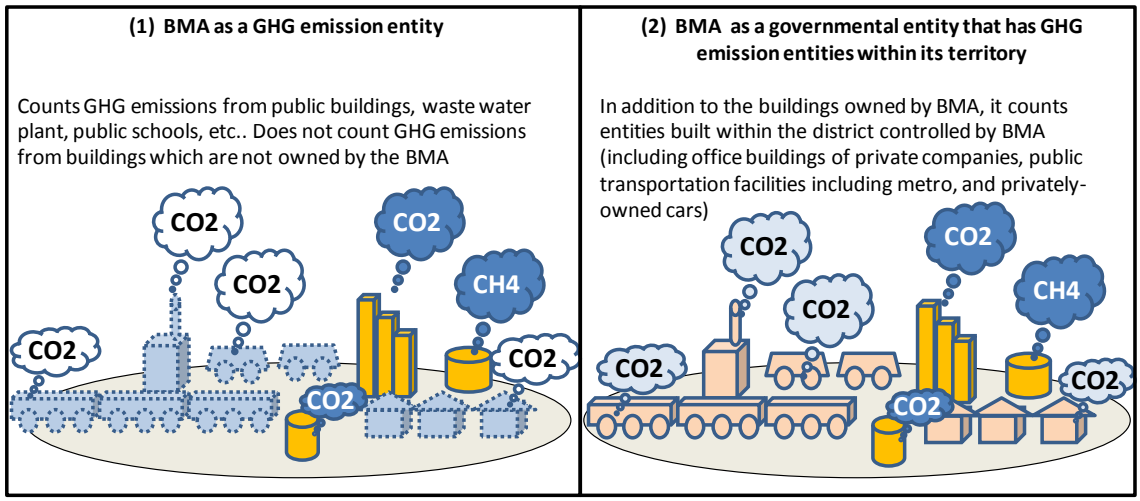


Figure 2-1 Attribution of GHG emissions in BMA

[Approaches to quantification at Bangkok level]

As mentioned above, some of the GHG emissions and emission reduction targets are calculated with reference to national statistical data and national master plans, amounts were developed through top-down approach with proportional distribution to BMA level. This is especially the case with the sectoral emission and emission reduction targets for transport and energy, since they are calculated by referring to the EEDP, the EST Master Plan, and the Thailand NAMAs.

However, other sectors such as the waste and wastewater and green urban development, emissions and emission reduction amount and absorption amount were calculated by aggregating those at activity level to BMA level. For individual actions in all sectors, including transport and energy, bottom-up approaches were used in order to enable measurement, report, and verification by BMA in a feasible way.

Table 2-1 Approaches to calculate GHG emission and emission reduction

Approach	Evaluation beforehand (ex ante)	Evaluation afterwards (ex post)	Application to Bangkok Master Plan on Climate Change 2013-2023
Top-down	Calculate by using macro-statistical data.	Evaluate progress record by using macro-statistical data.	GHG emission and emission reduction amount in the statistical data and/or targets are proportionally divided into the BMA level.
Bottom-up	Adding amount of emissions by each facility and entity.	Evaluate the aggregated emissions by each facility and entity	GHG emission and emission reduction amount at activity level is aggregated at the BMA level

2-4 Scope of the Master Plan

As mentioned above, the Bangkok Master Plan on Climate Change 2013-2023 covers whole geographical area of BMA, in the following sectors;

(1) Environmental sustainable transport;
(2) Energy efficiency and alternative energy;
(3) Efficient solid waste management and wastewater treatment,[3] ;
(4) Green urban planning; and
(5) Adaptation planning

This Master Plan contains description by sector. Mitigation related sector, in particular, environmental sustainable transport, energy efficiency and alternative energy, efficient solid waste management and wastewater treatment, and green urban planning, package of information contains their sectoral GHG emission (absorption) in BAU, and sectoral emission reduction (absorption) targets, respective emission reduction measures, and monitoring and evaluation (M&E) and measurement, reporting, and verification (MRV). With regard to adaptation, first rationale and priority setting are described, including present problem, current status of actions, future problems, and additions, actions needed. Then adaptation measures to be conducted under this Master Plan are described, together with M&E of the progress of such actions. All of the actions included information of stakeholders involved, timeframe of action, and roles to be played by BMA.

The main role of the Master Plan is to select mitigation and adaptation measures as practical projects based on the assessment of their priority, urgency and feasibility. In order to develop the comprehensive and action-oriented approach, the Master Plan includes provide objective assessment of the current and future situation, prioritizing possible interventions, proposing concrete implementation plan of feasible actions., Therefore, it contains a package of Business as Usual (BAU) setting, target setting, and actual mitigation and adaptation measures. In addition, Monitoring & Evaluation (M&E) as well as the Measurement, Report, and Verification (MRV) mechanisms were developed to ensure the successful implementation of the Master Plan. The following figures show structure of steps from the understanding of current situation to the selection of necessary measures.

[3] Final disposal sites of municipal solid waste are located outside of the BMA area, but since they are disposing waste generated in BMA. In this regard, mitigation actions by management of waste, including in these plants are regarded as part of efforts of the Master Plan.

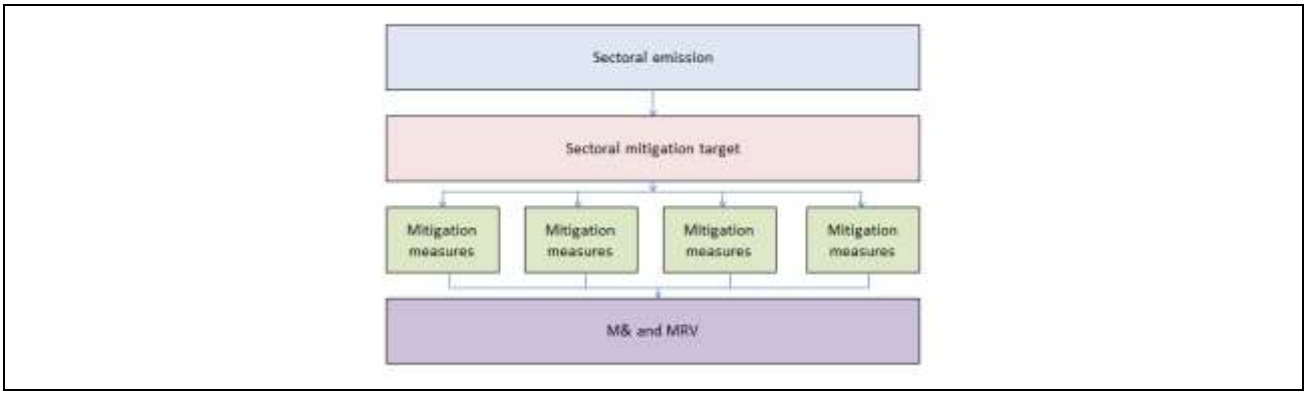


Figure 2-2 Mitigation package for sectors

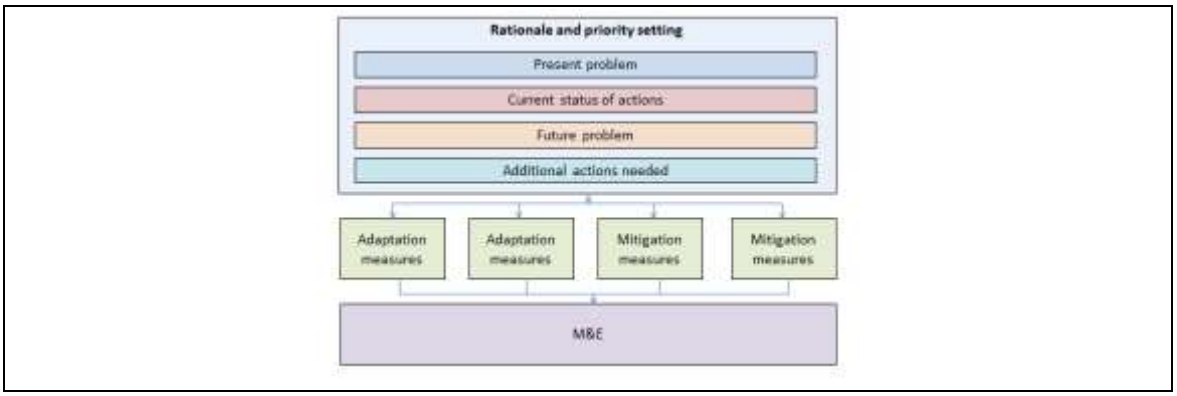


Figure 2-3 Adaptation package

2-5 Stakeholders and their roles

BMA is primarily responsible for the implementation of this Master Plan. However, it is impossible for BMA to achieve its goals. It is always important and necessary to promote cooperation and partnership with key stakeholders, such as the national government ministries and agencies, the private sector, academia, non-governmental organizations, and citizens.

The national government ministries and agencies are the main bodies of developing and implementing climate change and related policies of Thailand, and held major influence of the designing and implementation of this Master Plan. For example, many of mitigation actions under this Master Plan cover those planned and conducted within the geographical area of BMA. Naturally, many of such mitigation actions are originally developed under the national policies, such as the Thailand NAMAs. In other words, the full implementation of such mitigation actions under this Master Plan is highly dependent on the success of national actions. BMA is in a position to collaborate and support steady implementation of such national actions, by recognizing them as actions under this Master Plan.

The private sector's roles are the key to the implementation of this Master Plan. This Master Plan strongly recognizes that the Private Sector is one of the most important partners in harnessing sustainable economic and social development, and provides influence on mitigation and adaptation actions. Also, because this Master Plan support

the concept of co-benefits approach to climate change and development, it highlights that by working on climate change, the private sector would obtain economic and social development benefits in a sustainable manner.

Academia is regarded as a continuous source of scientific and technical information to promote and strengthen the implementation of this Master Plan. At the same time, educational institutions also play a crucial role in promoting and disseminating information to raise awareness of Bangkok people.

Non-governmental organizations and community organizations are regarded important partner to support BMA to implement activities under the Master Plan. It may include community-based activities, and awareness-raising of citizens and other stakeholders.

Citizens of Bangkok are the fundamental unit of implementation of the Master Plan. Citizens are welcomed to participate in actions to mitigate and adapt to climate change through their individual and collective actions, such as purchase and consumption of goods and services, conveying information, as well as any other matters relevant to this Master Plan.

3. Future visions of Bangkok

3-1 Bangkok as a low carbon, climate resilient and smart city in future

5 keys to Future vision of Bangkok

- ✓ BMA in partnership with the national government ministries and agencies, takes a major responsibility to mitigate and adapt to climate change.
- ✓ BMA endeavors to establish well balanced action to harness economic and social development and climate change concerns.
- ✓ BMA takes comprehensive approach to the low carbon and climate change-resilient urban development and action-oriented approach to the implementation of the Master Plan, as a vehicle in an evolving nature.
- ✓ BMA promotes actions by citizens, the private sector, academia, as well as other key players to mitigate and adapt to climate change, which should involve a multi-channel communication platform, innovative ways of promotional schemes and low carbon technology leapfrogging.
- ✓ BMA, as a leading city of Southeast Asia and the world, takes proactive measures to mitigate and adapt to climate change in short, mid and long terms.

As mentioned above, Bangkok is the largest economic zone of Thailand, which shares the largest part of the national GHG emission. In this regard, national actions to address to reduce and mitigate GHG emission are and will be conducted by the national government. For example, many actions listed in Thailand NAMAs involve transportation and energy-related measures to be implemented in Bangkok area. While BMA will take its own action to address GHG mitigation directly responsible for and controlled by itself, it will also take supportive and promotional actions in partnership with the national governmental ministries and agencies in a proactive way. This is also the case for adaptation measures.

Since Bangkok is a heart of Thailand's economic and social life, it is important to sustain its growth. As pointed out in the OECD Report on Green Growth (March, 2015), there are large potentials to promote its economy in a sustainable manner by introducing policies and measures in relevant areas. In this Master Plan, a number of actions are listed which reduced GHGs and vulnerability in a short term, but it also aims at realizing well balanced approach to harness economic growth while addressing climate change concerns.

This Master Plan serves as a vehicle, with which BMA and people of Bangkok take appropriate steps toward realizing a low carbon and climate change resilient society. It involves not only a concept but also a concrete actions to address climate change concerns in short, mid- and long terms. In order to respond to evolving nature of climate change, the progress of the implementation of the Master Plan and its actions will be monitored and evaluated and strengthened through necessary modification. In this regard, the Master Plan takes approach of Plan-Do-Check-Act (PDCA) cycle to the implementation.

BMA, as a local government, should play a proactive role in promoting concerned actions participated by citizens, the private sector, academia, as well as other key players to mitigate and adapt to climate change. By such promotional

efforts, all of them (as Bangkok citizens in a wider sense) may exploit their potentials to address climate change concerns. BMA may play a catalytic role by connecting one actor with another. In this regard, BMA will provide functions of platform for stakeholder to jointly make efforts to the same direction. Also, in order to involve players in an accelerated manner, BMA will consider developing innovative promotional schemes. In a mid and longer term, it is extremely important to mobilize technology inputs which enable to reduce GHG emission in a drastic way. When taking a development path of green economy, Bangkok should take a "leapfrog" step, by avoiding conventional high carbon growth, but directly jump to a low carbon society, by introducing appropriate technologies.

Bangkok is one of the largest mega-cities in the Southeast Asia region, and regarded as a major global city in the world. For this, efforts of Bangkok are quite influential not only to other cities in Thailand, but also to other cities in the same region and beyond. Since BMA initiated its efforts to address climate change earlier, it should take the lead in this area, and promote efforts by other cities through exchange of information and knowledge as well as possible international cooperation. In a way, Bangkok may become a center city of climate change-related policies and actions in the Southeast Asia region.

3-2 Mitigation targets under the Bangkok Master Plan on Climate Change 2013-2023

Based on the survey, due to the steady population and economic growth of the country as a whole, and in particular rapid urbanization of Bangkok, there is a general trend of increasing GHGs emission in all sectors. To address this situation, the Master Plan foresees GHGs emission in Business as Usual (BAU) from 2013 through 2020[4], and with implementation of measures hereby set forth, promotes to reduce GHGs emission and mitigate climate change. In this regard, while absolute GHG emission amount will still increase even with mitigation measures, the emission will be greatly reduced against the BAU scenario.

Conceptual diagram on GHG emission prospects in BAU and with mitigation measures

[4] The contents of the mitigation measures of this Master Plans vastly overlaps with the Thailand Nationally Appropriate Mitigation Actions (NAMAs), submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Namely, NAMAs planned and implemented in Bangkok area are also regarded mitigation measures under this Master Plan, and those emission reduction results will be a part of quantitative efforts of this Master Plan. Since NAMAs timeframe of the mitigation targets are set in 2020, the Master Plan also aligned itself.. In this regard, it is expected that Master Plan's mitigation target in the rest of years until 2023 will be considered in future, along with the development of the national climate change policy.

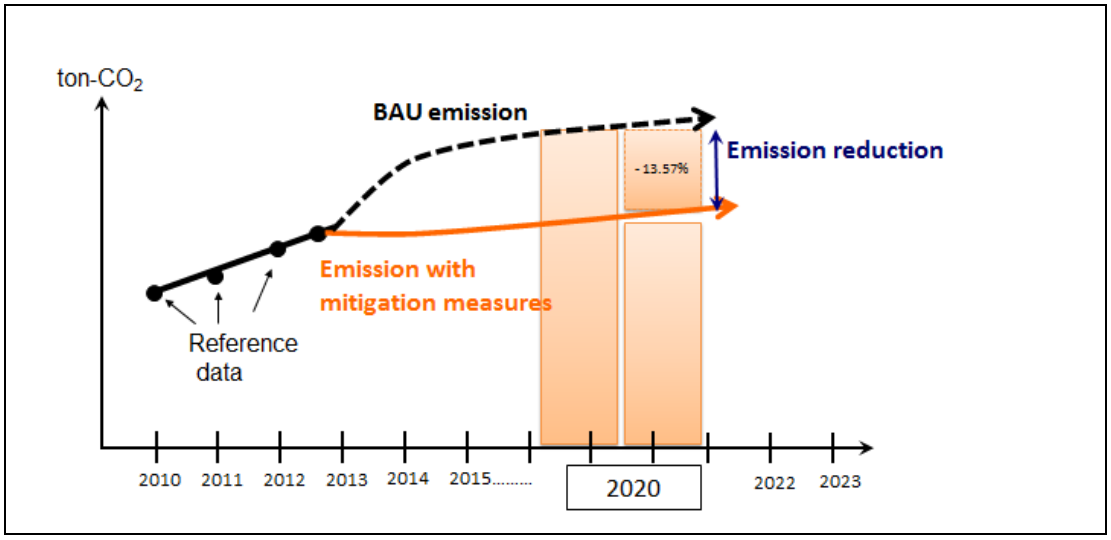


Figure 3-1 GHG emission prospects in BAU and with mitigation measures

Most of the BAU emissions and emission reduction targets are identified, based on the relevant national policies such as AEDP, EEDP, as well as EST Master Plan, as appropriate, by drawing the national figures and calculated proportionate volumes of GHG emission and emission reduction to Bangkok level. In other sectors, such as the waste and wastewater and green urban development, the calculation was made through bottom up approach, since activity data are directly available at BMA level, rather than allocating the national statistical data.

The GHG emission prospects and mitigation targets in the respective sectors are shown in the following diagrams and table. The assumption of these targets is full implementation of mitigation activities in alignment with the relevant national policies and aggregated efforts at the local level. In other words, many of them will be realized through actions at the national level, but located in BMA area. In this case BMA will support implementation of such national actions as the local government. Nevertheless, BMA is also responsible directly and indirectly for mitigation and adaptation actions to be implemented in BMA area. And the role varies by action to action, and also monitoring and evaluation as well as MRV should be conducted, by paying due attention to the difference of its roles in respective actions.

While this Master Plan covers BMA's actions between 2013 and 2023, the primary target year has been set at 2020. The reason for selecting 2020 is as follows: currently under the UNFCCC, Thailand submitted its NAMA, with the target year of 2020. While this Master Plan does not directly link with the Thai government's international pledge of mitigation, domestically, mitigation actions within BMA area constitutes a large part of such national government's actions announced. Furthermore, currently at the UNFCCC, future regime, including the Intended Nationally Determined Contributions (INDC), is being negotiated, and it is likely that Thailand's future mitigation actions and targets are further developed beyond 2020 later. In this regard, for the time being, the target year of mitigation actions of this Master Plan, in terms of GHG emission reduction against BAU, is set in 2020, but it is subject to review and further renew at the appropriate time setting.

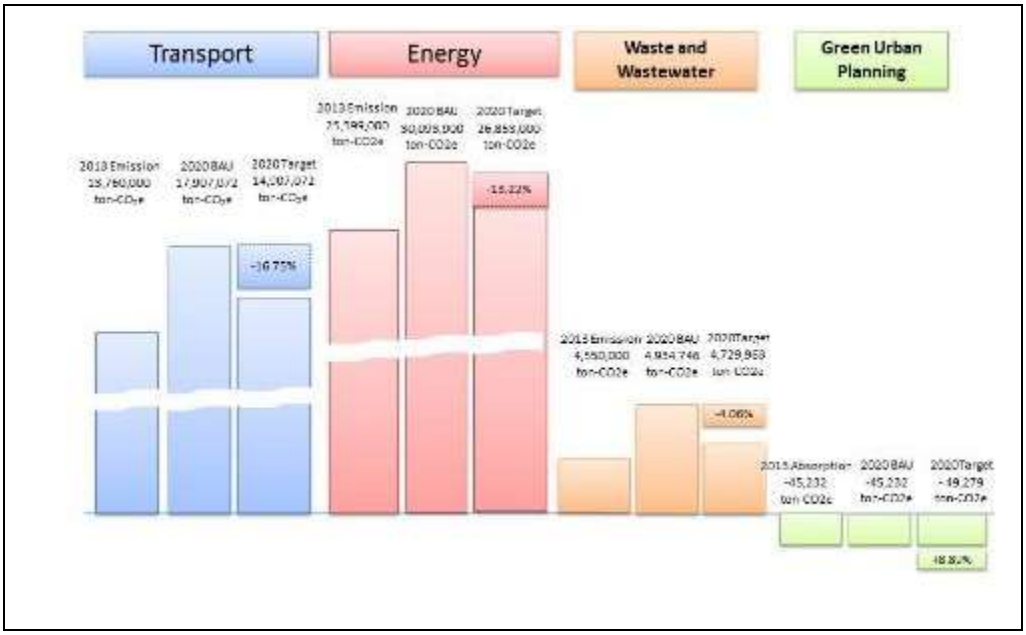


Figure 3-2 BAU emission and mitigation targets in 2020 (by Sector)

Table 3-1: Reduction of GHG emission/absorbed GHG against BAU in 2020[5]

Unit million t-CO_2e

Sector	**Year 2013**	**Year 2020**		
	Current GHG Emission	**Future GHG Emission under Business as Usual Scenario**	**Future GHG Emission under Bangkok Master Plan Implementation**	**Expected reduction/absorption amount (reduction rate against BAU)**
Transport	13.76	17.91	14.91	3.00 (-16.75%)
Energy	25.60	30.94	26.85	4.09 (-13.22%)
Waste and wastewater	4.55	4.93	4.73	0.20 (-4.06%)
Green urban planning	-0.045	-0.045	-0.049	-0.004(+8.89%)

3-3 Adaptation concerns

Given the fact that Bangkok is situated in a mega delta, one of the most vulnerable areas, and economic and social lives of the countries as well as the world heavily rely on the Metropolis. It is a pressing concern to address this adaptation needs. Measures to address issues like flooding, coastal erosion and draught and saline intrusion related

[5] The figures were estimated on the basis of multiple data sources and assumptions. When quoting these figures, please refer to the logics of the GHG quantification explained in the respective sectors, contained in "6. Mitigation and adaptation measures under the Master Plan". For the green urban planning sector, the figures are shown in “plus”, since its mitigation activities are increasing CO_2 absorption by expanding green areas.

to climate change turned out to be matters of priority. Thus in this Master Plan, countermeasures through short, mid, and long-term timeframe have been identified, together with responsibilities of divisions and other stakeholders, to work in coordination and collaboration.

Also, it is evident that adaptation is a concern that comes across different sectors, which usually recognized with mitigation focus, such as transport, energy, waste and wastewater, and green urban development. These sectors should also integrate adaptation concerns into their mitigation measures.

4. Current and future mitigation

4-1 Current status of GHG emission and future trend

(1) Transport sector

(a) Current status of GHG from the Transport sector

(i) Scope of emission

CO_2 emissions associated with transportation activities (road, railway, waterway) within BMA administrative area, also emissions associated with BMA owned vehicles.

(ii) Methodologies for calculation

Road

CO_2 emission from road sub-sector (motor vehicles) is calculated multiplying "Fuel consumption from road sub-sector in Bangkok by fuel types" by "CO_2 emission factor by fuel types (per liter etc.)". The methodology is based on "2006 IPCC Guidelines for National Greenhouse Gas Inventories". CO_2 emission from combustion of biofuel is accounted as zero. As for High Speed Diesel (HSD) fuel, the blending ratio of biodiesel (B100) is assumed as 6 %. "Fuel consumption from road sub-sector in Bangkok by fuel types" is provided by the Ministry of Energy, Thailand. "CO_2 emission factor by fuel types" is calculated by "CO_2 emission factor by fuel types (per energy unit)" provided by IPCC and "Net calorific value by fuel types" provided by the Ministry of Energy Thailand.

Railway

Railways include MRT (Blue line), Skytrain and ARL (Airport Rail Link). CO_2 emission from railway sub-sector is calculated multiplying "Electricity consumption of MRT and Skytrain in Bangkok" by "CO_2 emission factor of the grid electricity". "Electricity consumption of MRT and Skytrain in Bangkok" can be obtained from the companies of MRT and Skytrain. "CO_2 emission factor of the grid electricity" is provided by the local expert of the project.

Waterway

Waterways include Chao Phraya River ferries (operated by three companies) and canal boats (Saen Saep canal extension and Phasricharoen canal). CO_2 emission from waterway sub-sector is calculated multiplying "Fuel consumption of waterways" by "CO_2 emission factor of the grid electricity". "Fuel consumption of waterways" can be obtained from the companies of waterways. "CO_2 emission factor by fuel types" is calculated by "CO_2 emission factor by fuel types (per energy unit)" provided by IPCC and "Net calorific value by fuel types" provided by the Ministry of Energy Thailand.

BMA owned vehicles

CO_2 emission from vehicles owned by BMA is calculated multiplying "Fuel consumption from road BMA vehicles by fuel types" by "CO_2 emission factor by fuel types (per liter etc.)". CO_2 emission from combustion of biofuel is accounted as zero. As for HSD fuel, the blending ratio of biodiesel (B100) is assumed as 6 %. "Fuel

consumption from road BMA vehicles by fuel types" is available monthly from the responsible department of BMA. "CO_2 emission factor by fuel types" is calculated by "CO_2 emission factor by fuel types (per energy unit)" provided by IPCC and "Net calorific value by fuel types" provided by the Ministry of Energy Thailand.

(iii) Result of calculation

CO_2 emission from the road sub-sector in 2013 within BMA administrative area is estimated as shown in Table. CO_2 emission from the transport sector in BMA administrative area in 2013 is 13,693,732 tCO_2/year. Diesel fuel has the highest share, 32.7%, and natural gas is the 2nd highest proportion, 30.6%. The proportion of gasoline fuel including gasoline, gasohol E10, gasohol E20 and gasohol E85 is 24.9%. LPG is 11.8%.

The result indicates that, in Bangkok, fuel shifts from high carbon intensity fuel such as petroleum based gasoline and diesel to low carbon intensity fuel such as natural gas and biofuel-blended gasoline are well progressed. If such low carbon fuel is not used, the total emission from the transport sector in BMA administrative area would have been much higher.

Table 4-1 CO_2 emission from the road sub-sector in 2013 within BMA administrative area in 2013

Fuel types	CO_2 emission (tCO_2/year)
Natural Gas	4,193,268
LPG	1,622,395
Gasoline	216,030
Gasohol E10	2,815,147
Gasohol E20	358,616
Gasohol E85	17,177
Diesel (HSD)	4,471,099
Total	13,693,732

CO_2 emission from the railways in 2013 in Bangkok is estimated as shown in Table.

Table 4-2 CO_2 emission from the railways in Bangkok in 2013

Lines	CO_2 emission (tCO_2/year)
BTS	39,369
MRT (Blue line)	12,991
ARL (Airport Rail Link)	N.A.
Total	52,360

CO_2 emission from the waterways in 2013 in Bangkok is estimated as shown in Table.

Table 4-3 CO_2 emission from the waterways in Bangkok in 2013

Lines	CO_2 emission (tCO_2/year)
Chao Phraya River ferries[*1]	8,200
Canal boat[*2]	3,301
Total	11,501

*1: Operated by three companies, Chao Phraya Express Boat Company, Sap Thananakorn Ltd. and Supatra Ltd.

*2: Include Saen Saep canal extension (11 km, 9 station) and Phasricharoen canal (11.5 km, 15 station)

CO_2 emission from the BMA owned vehicles is estimated as shown in Table.

Table 4-4 CO_2 emission from the BMA owned vehicles in 2013

Fuel types	CO_2 emission (tCO_2/year)
Gasoline (ULG91)	7,688
Diesel (HSD)	87,534
GASOHOLE10	1,421
Total	96,643

* Emissions from garbage trucks are included.

* The emission is also counted in the emission within BMA administrative area

(b) Business-as-Usual (BAU) emission of the transport sector

(i) Scope of emission estimated

Future (BAU) CO_2 emissions associated with transportation activities (road) within BMA administrative area.

* BAU Emissions from railways and motorways are excluded, because of simplification since these emissions are very low (less than 1% compared to road transportation).

(ii) Methodologies for estimation

The BAU emission is estimated by multiplying “Current emission (year 2013)” by “Increase rate of BAU emission”. “Current emission (year 2013)” is described in (a). “Increase rate of BAU emission” should be set using appropriate parameter. Basically, CO_2 emission has high correlation with energy consumption, therefore, in this estimation, “Increase rate of BAU energy consumption in transport sector” is applied for “Increase rate of BAU emission”. One of the well-known data is provided in “Thailand 20-Year Energy Efficiency Development Plan (2011-2030), Ministry of Energy”. The plan estimated future energy consumptions by sectors in Thailand by 2030 as shown below.

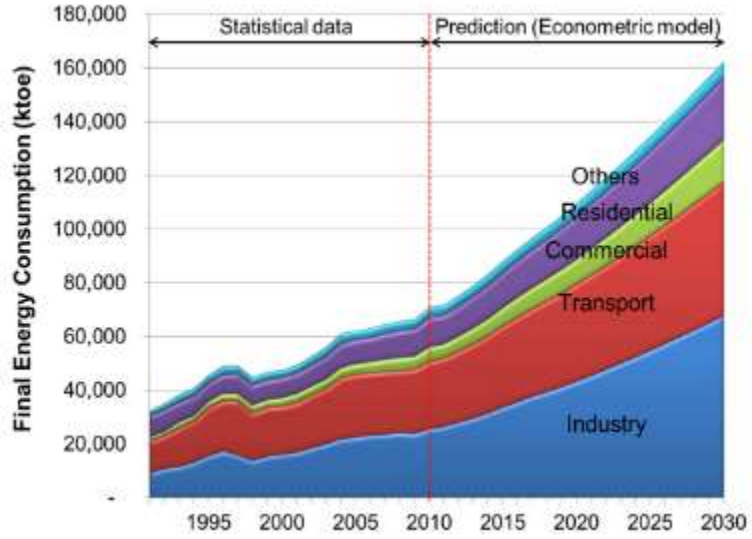


Figure 4-1 Future (BAU) energy consumptions by sectors in Thailand by 2030

Source: ”Thailand 20-Year Energy Efficiency Development Plan (2011-2030), Ministry of Energy”

(ii) Result of estimation

Future (BAU) CO_2 emissions associated with transportation activities (road) within BMA administrative area is shown in the figure below. Total GHG emission in BMA is projected to increase from 13.7 million tons of CO_2 in 2013 to 19.8 million tons of CO_2 in 2023.

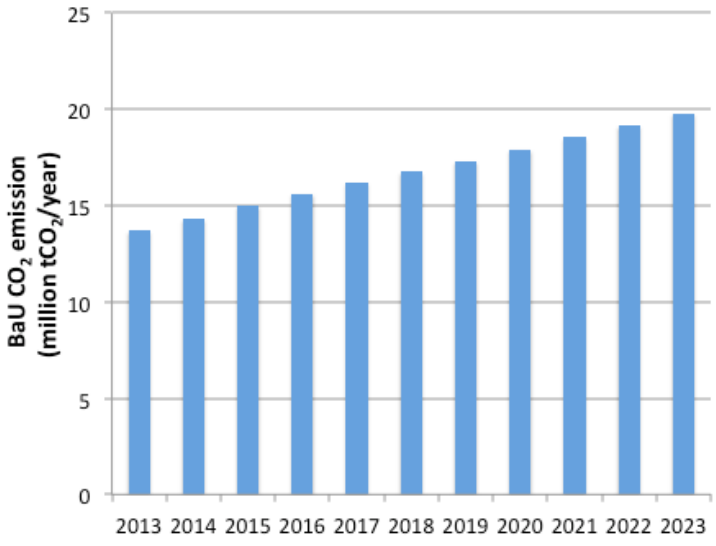


Figure 4-2 Future (BAU) CO_2 emissions associated with transportation activities (road) within BMA administrative area

(2) Energy efficiency and alternative energy sector

(a) Current status of GHG from the energy efficiency and alternative energy sector

(i) Scope of emission

Scope of emission is as below.

- GHG emissions related to energy consumption in the administrative boundary of BMA that BMA facilities and Non-BMA sector (residential/household part, commercial/business part, and industrial/manufacturing part).
- Energy consumption data is disaggregated into three main types; i.e. electricity consumption, fuel (oil, natural gas, and coal) consumption.
- Scope of this sector excludes the energy consumption in transport sector and efficient solid waste management and wastewater treatment sector.

(ii) Methodologies for calculation

[Data collection]

Data collection is the process of gathering information in an established systematic that enables one to answer stated research questions, test hypotheses, and evaluates outcomes.

*Primary Data

Primary data is a type of information that is obtained directly from first-hand sources by means of surveys, observation or experimentation. It is data that has not been previously published and is derived from a new or original research study and collected at the source.

*Secondary Data

Secondary data is data collected by someone other than the user. Common sources of secondary data for social science include censuses, organizational records and data collected through qualitative methodologies or qualitative research. Primary data, by contrast, are collected by the investigator conducting the research.

[Collection of data/information]

In Bangkok area, secondary data is the main source of collecting energy data which is divided into the data from all sectors responsible to BMA and entire Bangkok area which is not under BMA. All of collected data can be divided into 4 energy types which are electricity, oil, natural gas and coal as followings:

1) Electricity

Electricity data in Bangkok is collected as secondary data from the Metropolitan Electricity Authority (MEA) and it shows electricity consumption in the year 2009-2012. The data was collected from 12 districts, which is consisted of electricity consumption data from various sectors under the authorization of BMA and not covering in:

Residential

Small general service

Medium general service

Large general service

Specific business service

Government institute

Non-profit organization

Temporary user and public lighting

2) Oil

Oil data for Bangkok is collected as secondary data from Department of Energy Business (DOEB), Ministry of Energy in the year 2009-2012 as follows:

Gasohol

Gasoline

Diesel oil

Fuel Oil

LPG and

Other types of oil

3) Natural gas

Natural gas data for Bangkok is collected as secondary data from PTT PLC covering the year 2009-2012.

4) Coal

Coal data for Bangkok as collected in secondary data from Department of Alternative Energy Development and Efficiency (DEDE) covering the year 2009-2012.

[Convert from energy to GHG]

The method used to analyze is Emission Factor (EF) which is from 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy.

(iii) Result of calculation

[Electricity]

The amount of greenhouse gas emission from using electricity is from various sectors which are Residential, Small General Service, Medium General Service, Large General Service, Specific Business Service, and Government institutions and non-profit organization. The followings are the amount of greenhouse gas emission from using electricity in year 2009-2012.

Table 4-5 The amount of greenhouse gas emission from using electricity

(Unit: million tCO_2-eq)

Type	2009	2010	2011	2012
Residential	3.247	3.465	3.442	3.814
Small general service	2.489	2.632	2.610	2.774
Medium general service	2.542	2.696	2.371	2.533
Large general service	4.313	4.572	4.603	4.824
Specific business service	0.854	0.885	0.831	0.917

Type	2009	2010	2011	2012
Government institutions and non-profit organization	0.059	0.063	0.511	0.416
Total	13.503	14.312	14.368	15.278

[Fuel]

The amount of greenhouse gas emission from using fuel is from various types of fuel which are Gasoline and Gasohol, Diesel, Fuel oil, LPG, and Natural Gas. The followings are the amount of greenhouse gas emission from using fuel in year 2009-2012.

Table 4-6 The amount of greenhouse gas emission from using fuel

(Unit: million tCO_2-eq)

Type	2009	2010	2011	2012
Gasoline and gasohol	0.456	0.318	0.368	0.716
Diesel	3.166	3.053	3.765	3.771
Fuel oil	0.851	0.666	0.766	0.582
LPG	2.085	1.730	1.138	1.034
Natural gas	0.086	0.086	0.103	0.114
Total	6.644	5.854	6.141	6.217

Table 4-7 The amount of greenhouse gas emission from using fuel

(Unit: million tCO_2-eq)

Type	2009	2010	2011	2012
Electricity	13.503	14.312	14.368	15.278
Fuel	6.644	5.854	6.141	6.217
Total	20.147	20.166	20.509	21.495

(b)Business-as-Usual (BAU) emission of the energy efficiency and alternative energy sector

(i) Scope of emission estimated

Scope of emission estimated is as below.

- Expected GHG emissions related to expected energy consumption in the administrative boundary of BMA that BMA facilities and Non-BMA sector (residential/household part, commercial/business part, and industrial/manufacturing part).
- Expected energy consumption data is disaggregated into three main types; i.e. electricity consumption, fuel (oil, natural gas, and coal) consumption.
- Scope of this sector excludes the energy consumption in transport sector and efficient solid waste management and wastewater treatment sector.

(ii) Methodologies for estimation

- Annual BAU emissions are estimated in accordance with the expected amount of consumption data (both BMA and Bangkok entire area).

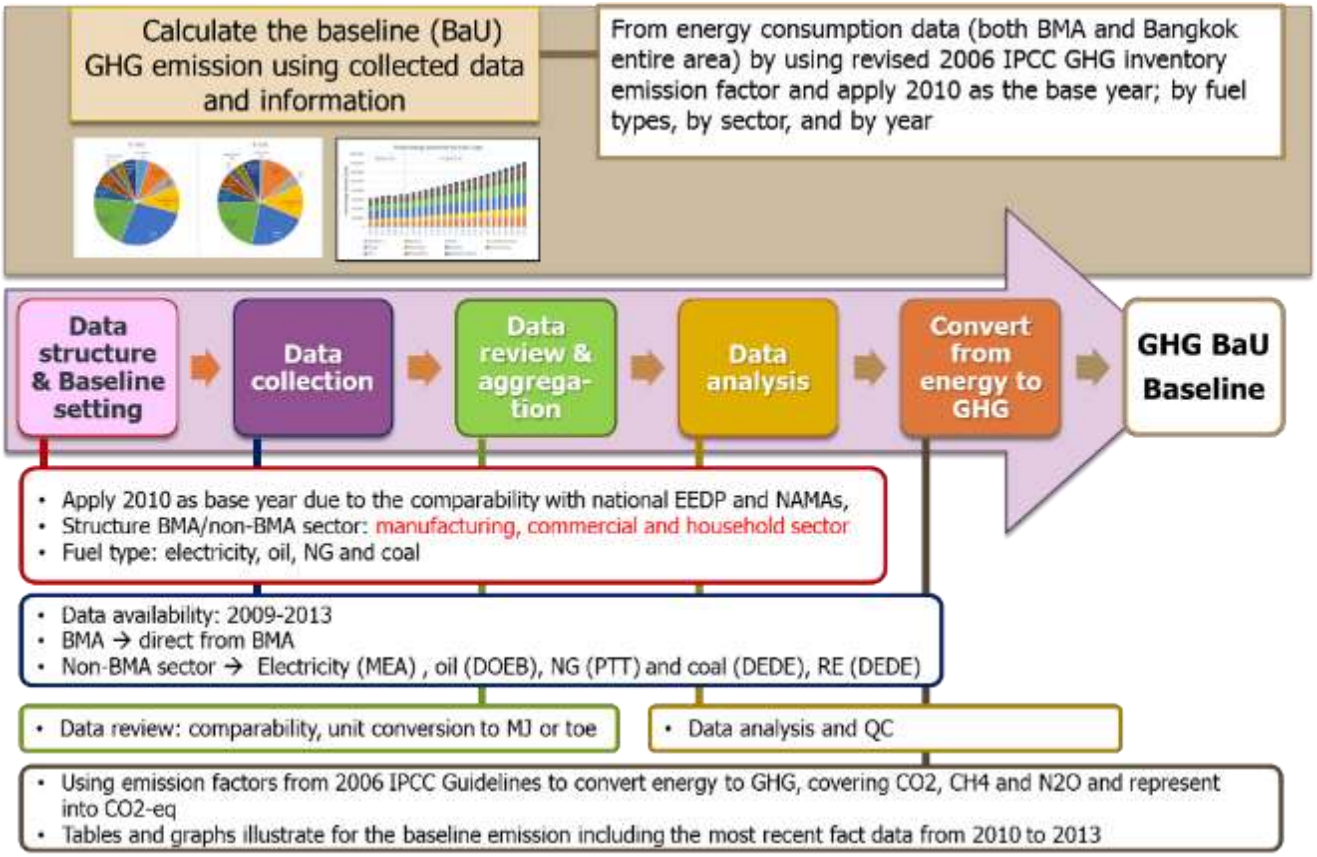


Figure 4-3 Flow of calculation of BAU GHG emissions

(iii) Result of estimation

BAU GHG emissions from Energy Efficiency and Alternative Energy sector are shown in the table and figure below.

Table 4-8 BAU emissions of energy efficiency and alternative energy sector

Sub-sector	BAU emissions (Million tCO_2-eq/year)							
	2009	2010	2011	2012	2013	2014	2015	2016
Electricity	15.755	16.699	16.764	17.826	18.552	19.185	19.817	20.449
Fuel	7.832	6.811	7.092	7.196	7.047	7.108	7.168	7.229
Total	23.587	23.580	23.856	25.022	25.599	26.292	26.985	27.678

Sub-sector	BAU emissions (Million tCO_2-eq/year)						
	2017	2018	2019	2020	2021	2022	2023
Electricity	21.082	21.714	22.346	22.979	23.611	24.243	24.875

Fuel	7.412	7.595	7.778	7.960	8.143	8.326	8.509
Total	28.493	29.309	30.124	30.939	31.754	32.569	33.384

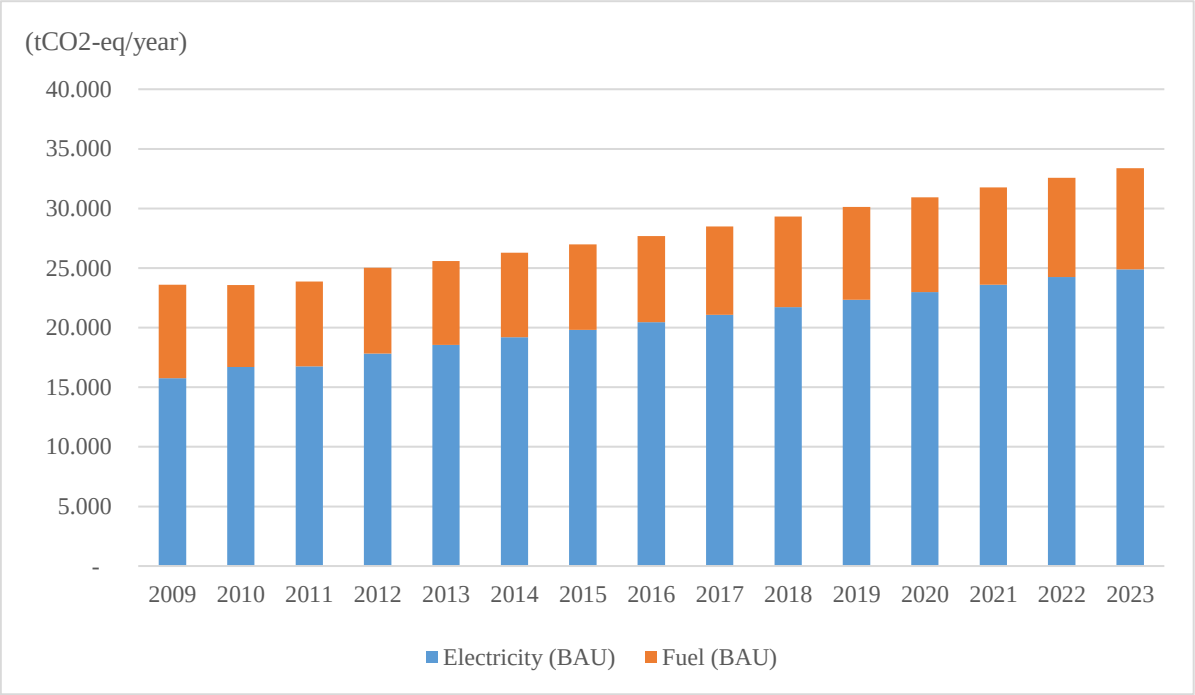


Figure 4-4 BAU GHG emissions from energy efficiency and alternative energy sector

(3) Efficient solid waste management and wastewater treatment sector

(a) Current status of GHG from the efficient solid waste management and wastewater treatment sector

(i) Scope of emission

Scope of emission is as below.

- GHG emissions related to municipal solid waste generated in the administrative boundary of BMA and various activities related to handling of such waste
- GHG emissions related to domestic and commercial wastewater generated in the administrative boundary of BMA and various activities related to treatment of such wastewater
- GHG emitted from the waste and wastewater that is originally generated in the administrative boundary of BMA but is transported to outside of its boundary, i.e. emissions from landfill sites located outside of Bangkok that accept municipal solid waste generated in Bangkok, and emissions from sludge sediment in canals located outside of Bangkok that is contained by wastewater from residential and commercial units and wastewater treatment plants in Bangkok

(ii) Methodologies for calculation

Methodologies for calculation are as below.

[Waste]

- CH_4 emission from disposed wastes is calculated by applying First Order Decay (FOD) model specified in 2006 IPCC Guidelines.
- Data of municipal solid waste generated in Bangkok such as waste amount and composition is taken from "Bangkok State of Environment 2013."
- IPCC default values are applied for some parameters except those values where Thailand's country-specific value or BMA's actual data is available.

[Wastewater]

- CH_4 emission from wastewater sludge accumulated at the bottom of canal is estimated by multiplying "volume of wastewater discharged into canal" by CH_4 emission factor per BOD.
- CH_4 emission from septic tanks is calculated by multiplying BOD concentration of wastewater discharged from septic tanks installed in selected residential and commercial units by IPCC default emission factors.

[Electricity consumption]

- All GHG emissions due to electricity consumption (at waste transfer centers, composting plant, wastewater treatment plants) are calculated by recorded or estimated electricity consumption data multiplied by CO_2 emission factor of the national electricity grid.

[Transportation of waste/sludge]

- GHG emissions due to fuel consumption by waste collection/ transportation trucks are estimated by using fuel emission factor calculated by Ministry of Energy and IPCC default data.
- Truck fuel consumption data is estimated from actual data provided by BMA districts.

(iii) Result of calculation

GHG emissions from the efficient solid waste management and wastewater treatment sector in 2013 are estimated as shown in Table below.

Table 4-9 Current GHG emissions from efficient solid waste management and wastewater treatment sector

Sub-sector	GHG emissions (tCO_2-eq/year) (2013)
Waste	3,837,438
Wastewater	714,388
Total	4,551,826

(b) Business-as-Usual (BAU) emission of the efficient solid waste management and wastewater treatment sector

(i) Scope of emission estimated

- Expected GHG emissions related to municipal solid waste generated in the administrative boundary of BMA

and various expected activities related to handling of such waste

- Expected GHG emissions related to domestic and commercial wastewater generated in the administrative boundary of BMA and various ongoing and expected activities related to treatment of such wastewater
- Expected GHG emitted from the waste and wastewater that is originally generated in the administrative boundary of BMA but is transported to outside of its boundary, i.e. emissions from landfill sites located outside of Bangkok that accept municipal solid waste generated in Bangkok, and emissions from sludge sediment in canals located outside of Bangkok that is generated by wastewater from residential and commercial units and wastewater treatment plants in Bangkok

(ii) Methodologies for estimation

- Annual BAU emissions are estimated in accordance with the expected amount or volume of waste and wastewater and relevant activities to treat or manage such waste and wastewater.
- A "future growth rate" is applied to some parameters referring to the BMA's future development plan (such as expected population growth rate) or sectoral plan.
- Activity data related to newly-constructed plants and facilities that will be constructed during the Master Plan period such as waste management plants and wastewater treatment plants, as well as their technical details such as plant size and operation hours is in line with the BMA's official plans. Where such plans are not available, activity data is estimated in accordance with information of existing same or similar technology that is currently used by BMA.

(iii) Result of estimation

BAU GHG emissions from Efficient Solid Waste Management and Wastewater Treatment sector are shown in the figure below.

Table 4-10 BAU emissions of Efficient Solid Waste Management and Wastewater Treatment sector

Sub-sector	BAU emissions (tCO_2-eq/year)					
	2013	2014	2015	2016	2017	2018
Waste	3,837,438	3,891,484	3,941,658	3,989,132	4,034,761	4,079,163
Wastewater	714,388	724,225	731,468	738,782	746,170	753,632
Total	4,551,826	4,615,710	4,673,125	4,727,914	4,780,931	4,832,795

Sub-sector	BAU emissions (tCO_2-eq/year)				
	2019	2020	2021	2022	2023
Waste	4,122,789	4,165,966	4,208,933	4,251,865	4,294,889
Wastewater	761,168	768,780	776,468	784,232	792,075
Total	4,883,957	4,934,746	4,985,401	5,036,098	5,086,964

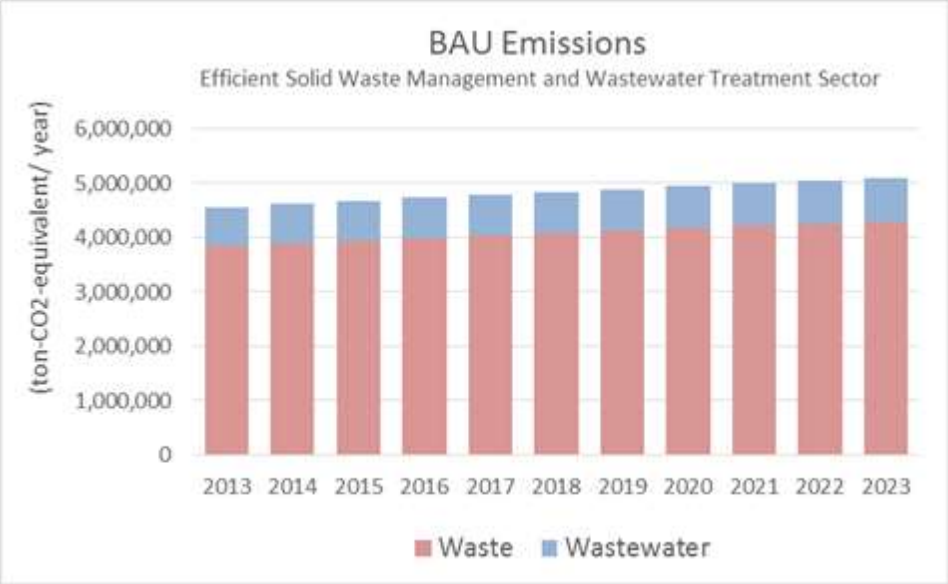


Figure 4-5 BAU GHG emissions from waste and wastewater sector

(4) Green urban planning sector

(a) Current status of GHG absorption in the green urban planning sector

(i) Scope of GHG absorption

CO_2 absorption of planted trees, which can be managed and monitored by BMA in BMA controlled area, including parks, roadsides, riversides, mangrove area, public facilities, excluding shrub, flower and turf.

(ii) Methodologies for calculation

GHG absorption is calculated by multiplying activity data such as number of planted trees by absorption factor per tree. Activity data such as number of planted trees, which can be managed and monitored by BMA in BMA controlled area, is measured by district office, and is compiled as statistical data in public park office in department of environment in BMA.

GHG absorption factor per tree is calculated as follows:

- Major species of 70% occupancy in distribution by type of whole species are selected using field survey in urban parks[*1] and main roadsides[*2] of Bangkok conducted by city planning department in BMA and Kasetsart University.
- GHG absorption factor per tree (tC/tree) by species is estimated using allometric equation of species in FAO database and DBH (Diameter of Brest Height) of species.
- Averaged GHG absorption factor per tree (tC/tree) is estimated using distribution by type of species and GHG absorption factor per tree (tC/tree) by type of species.

*1 : Santiphap Park(720 trees), Saranrom Park (356 trees) ,Rommaneenart Park (700 trees) and Chutchuk Park(845 trees)

*2 : 189,409 trees

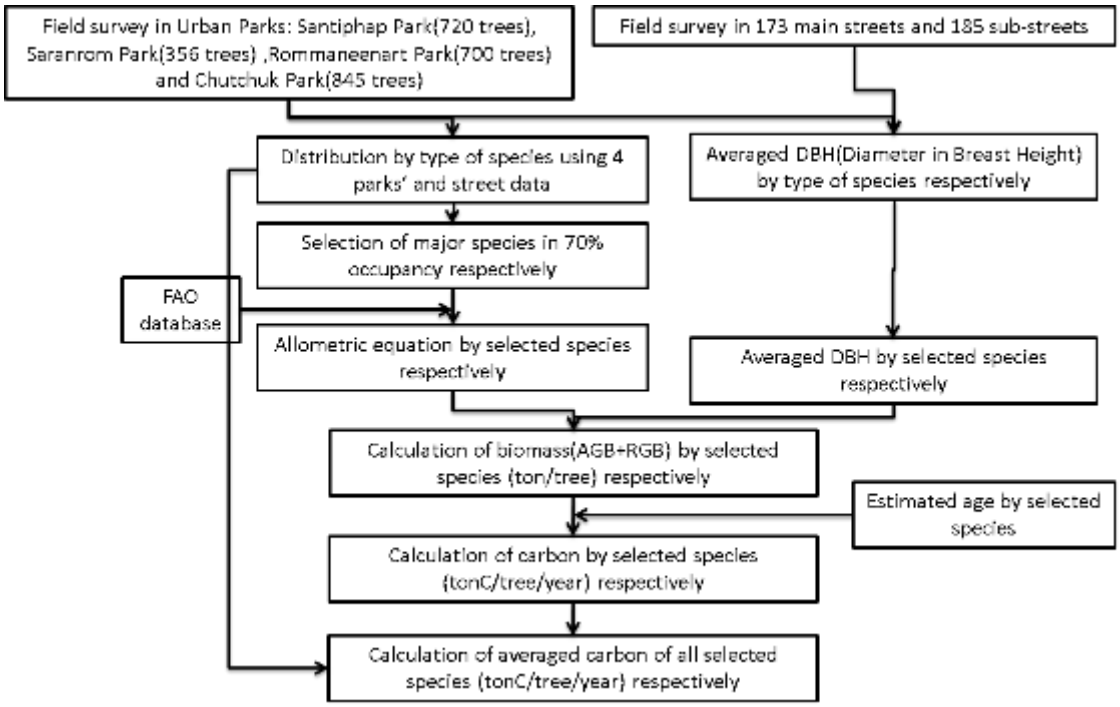


Figure 4-6 Flow of estimating GHG absorption factor

Equation)

$$GHG \quad Absorption = Activity\ Data \times Absorption Factor$$

Activity data: Number of planted trees (trees)

Absorption factor (whole area): 0.012tonC/ tree/year *1

(Road Side): 0.012 ton C/tree/year *1

(Urban Park): 0.009 ton C/tree/year *1

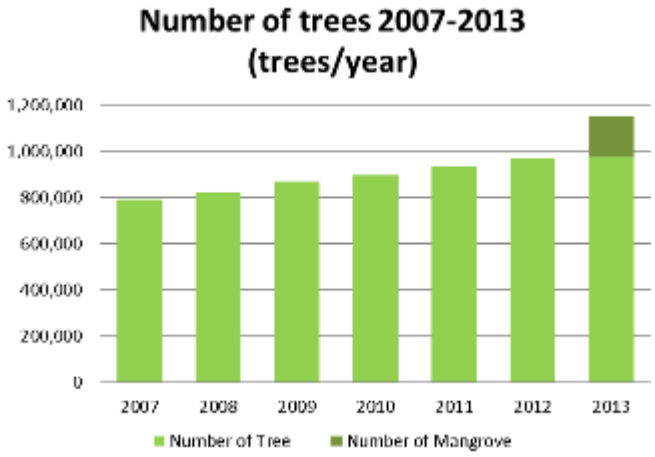
(Mangrove): 0.75 ton C/rai/year *2

Source: *1 Estimated by JICA expert team & Kasetsart University

*2 Kasetsart University

(iii) Result of calculation

Annual CO_2 absorption estimated using number of planted trees from year 2007 to 2013, which is managed and monitored by BMA in BMA controlled area, is shown below.



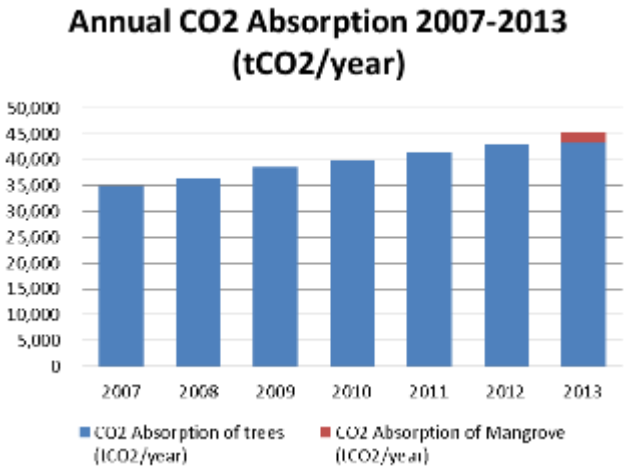


Figure 4-7 Number of trees 2007-2013 and Annual CO2 Absorption 2007-2013

Source; Measured by district office,
Database on http://dailyplans.bangkok.go.th/parks/
Mangrove area : 699 rai measured by satellite image
250 magroves/rai

(b)Business-as-Usual (BAU) GHG Absorption in the Green Urban Planning Sector

(1)Green Urban Planning

(i) Scope of absorption estimated

BAU value of CO_2 absorption of planted trees, which can be managed and monitored by BMA in BMA controlled area, including parks, roadsides, riversides, mangrove area, public facilities, excluding shrub, flower and turf.

(ii) Methodologies for estimation

In BAU case, number of trees planted in BMA controlled area is assumed to be kept due to the proper maintenance by BMA. BAU value of CO_2 absorption is calculated by multiplying number of trees planted by year 2013 by absorption factor per tree shown above.

(iii) Result of estimation

BAU value of CO_2 absorption in year 2020 is estimated to be 45,232 tCO_2-eq/year. It is similar to CO_2 absorption of year 2013 due to the proper maintenance of trees planted by year 2013. BAU value of CO_2 absorption from year 2016 to 2023 is shown below.

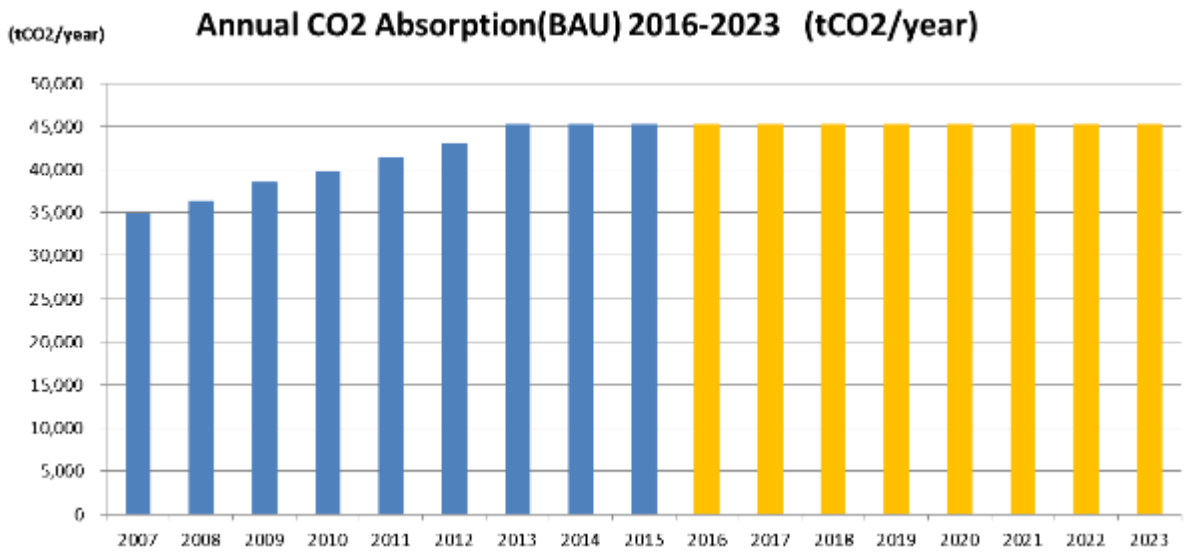


Figure 4-8 Annual CO2 Absorption (BAU) 2016-2023

5. Mitigation measures by sector

In order to realize the mitigation target and strengthening adaptation capacity, this Master Plan contains various measures implemented by BMA and its partners.

5-1 Mitigation measures for the transport sector

(1) Overview of the measures

GHG emission in the transport sector shares a large portion of the total emission and essentially related to the urbanization of Bangkok. Mitigation measures include development of environmentally sustainable transportation infrastructures and promotion of modal shifts, as well as public awareness-raising. To advance such measures, BMA will cooperate with the relevant national authorities, as well as the private sectors and citizens. By conducting such mitigation measures, it is also expected that the transportation modes will be upgraded and mobility and convenience are improved.

Table 5-1 Comparison of GHG emission in future in different scenarios in 2020 in the transport sector

Unit million t-CO_2e

Sector	Year 2013	Year 2020		
	Current GHG Emission	Future GHG Emission under Business as Usual Scenario	Future GHG Emission under Bangkok Master Plan Implementation	Expected reduction/absorption amount (reduction rate against BAU)
Transport	13.76	17.91	14.91	3.00(-16.75%)

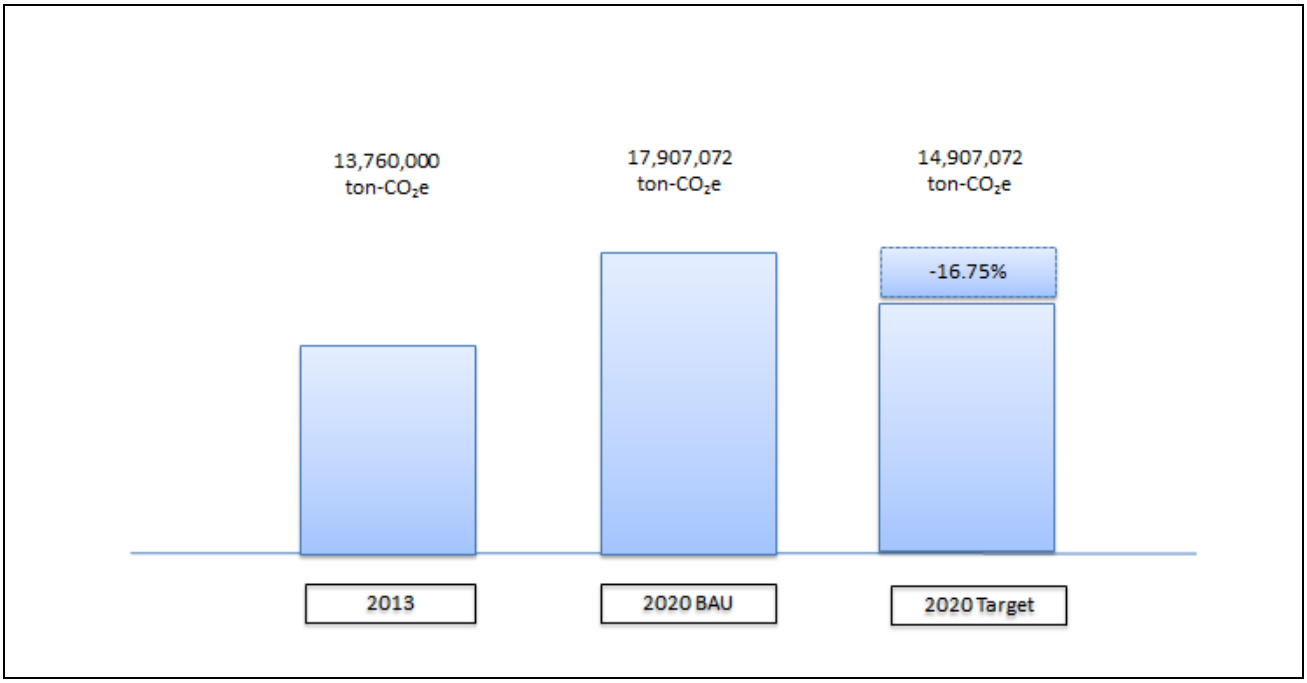


Figure 5-1 GHG emission in 2013 and BAU emission and mitigation targets in 2020 in the transport sector

GHG emission in 2013

The emission is the sum of emissions from road, railways and waterways in BMA administrative area. Each sub-sector emission is calculated multiplying activity data and emission factors of fuel or electricity. As for the activity data, "Fuel consumption from road sub-sector in Bangkok by fuel types", "Electricity consumption of MRT and Skytrain in Bangkok" and "Fuel consumption of waterways" in 2013 are used for respective sub-sector.

BAU emission in 2020

Future (BAU) CO_2 emissions associated with transportation activities (road) within BMA administrative area are estimated by multiplying "Current emission (year 2013)" by "Increase rate of BAU emission". As for increase rate of BAU emission, "increase rate of BAU energy consumption in transport sector" provided in "Thailand 20-Year Energy Efficiency Development Plan (2011-2030), Ministry of Energy" is applied.

GHG emission in 2020 with mitigation actions implemented

The figure is estimated by subtracting the emission reduction target in 2020 from BAU emission in 2020. The reduction target is estimated multiplying the national target value (12 million tCO_2/ year set by OTP) by the ratio of fuel consumption (energy base) of transport sector in Bangkok and Thailand (25% three year-average of 2011-2013).

Following table shows an overview of the mitigation measures for the transport sector. These measures include both measures which will be directly implemented by BMA and will be implemented by other entities but supported by BMA.

Table 5-2 Mitigation measures for the transport sector

Category	Measure
1. Public transportation (Infrastructure)	1.1 Development of Mono-rail and LRT
	1.2 Extension of BTS
	1.3 Development of MRT
	1.4 Development of BRT
	1.5 Development/improvement of water transportation
2. Public transportation (Supporting measures)	2.1 Improvement of connectivity of public transportation
	2.2 Improvement of bus service
	2.3 Development of passenger shelter at bus station
	2.4 Development/expansion of Park & Ride
	2.5 Introduction of common ticket system
3. Measures on motor vehicles	3.1 Introduction of low emission vehicles (LEV) to BMA vehicles
	3.2 Introduction of natural gas vehicle NGV to BMTA buses
	3.3 Promotion of Eco-driving
4. Non-motorized transport (NMT)	4.1 Development/expansion of bikeway
	4.2 Expansion of "Bike-for-Rent"
	4.3 Development/expansion of pedestrian
5. Traffic volume/flow control	5.1 Development/improvement of road, bridge, tunnel
	5.2 Improvement of signal system
	5.3 On-street parking control
6. Public awareness rising	6.1 Promotion of public transportation
	6.2 Classes for school to learn about environment/transport
	6.3 Organizing workshops and seminars

(2) Details of the measures

Details of each measure in the previous table are described below.

1) Public transportation (Infrastructure)

1-1 Development of Mono rail and LRT

Title	Development of 3 monorails and 1 LRT line
Details	- Monorail: Gray line (Watcharaphon - RAMA IX): 26 km, 21 stations, Along the Pradit Manutham Road, and connecting between Watcharaphon Road and RAMA IX Road.  - Monorail: Ramkhamhaeng University - Soithonglo line: 11.1km, 6 stations - Monorail: BMA hall 2 - Victory monument - Yothi road: 6.5km, 7 stations along Prachasongkhor Road, Dindaeng Road, Ratchaprarop Road, Yothi Road. - Light rail: Bangna - Suvarnabhumi: 15.3km (extend 3km), 12 station (extend 2 stations), Along the Bangna trad Road
BMA's Responsibility	Direct
Stakeholders	BMA (KT),MOT, passengers, landowners of along the lines etc
Implementation schedule[6]	Mid to long term
Estimated GHG emission reduction	*Emission reduction of the Grey line is included in 1-3. N/A for other lines.
Comments	- 4 development plans of Monorail are in the planning stage. - Feasibility study for Gray line has already done. The project of Gray line is high priority. - The feasibility studies for another 4 lines have already done. - Grey line is approved under M-MAP. - Other 3 lines are already approved by the cabinet.

[6] Short term (2013-2015), Mid term (-2018), Long term (-2023).

1-2 Extension of BTS

Title	Extension of BTS lines
Details	Either Line 1 (Buddha Monthol - Suanpak) or Line 2 (Bang Wa - Taling Chan)
BMA's Responsibility	Direct
Stakeholders	BMA (KT), MOT, passengers, landowners of along the lines etc
Implementation schedule	Long term
Estimated GHG emission reduction	N/A
Comments	-

1-3 Development of MRT

Title	Development of MRT
Details	- Purple line (Bang Yai - Bang Sue) (MRTA, 23.0 km, Short term (2015)) - Purple line (Bang Sue - Rat Burana) (MRTA, 19.8 km, Long term (2019)) - Blue line (Hua Lumphong - Bang Khae, Bang Sue - Tha Phra) (MRTA, 27.0 km, Mid-term (2017)) - Green line (Bearing - Samut Prakarn) (MRTA, 12.8 km, Mid-term (2018)) - Green line (Mo Chit - Saphan Mai - Cucot) (MRTA, 18.4 km, Mid-term (2018)) - Green line (Samut Prakarn - Bang Poo) (MRTA, 7.0 km, Long term (2019)) - Pink line (Kae Rai - Min Buri) (MRTA, 36.0 km, Mid-term (2017)) - Orange line (Taling Chan - Min Buri) (MRTA, 37.5 km, Long term (2019)) - ARL (Don Mueng- Phaya Thai) (SRT, 21.8 km, Long term (2019)) - Dark Red Line (Hua Lumphong - Bang Sue-Rang Sit-Thammasat) (SRT, 42.8 km, Short term (2016)) - Dark Red Line (Hua Lumphong-Bang Born) (SRT, 18.0 km, Long term (2019)) - Light Red Line (Bang Sue-Phaya Thai- Makkasan - Huamak) (SRT, 19.0 km, Short term (2016)) - Light Red Line (Bang Sue-Taling Chan) (SRT, 15.0 km, Short term (2016)) - Light Red Line (Taling Chan-Salaya) (SRT, 14.0 km, Long term (2019))
BMA's Responsibility	Indirect (Support)
Stakeholders	MRTA, SRT, Public-private participation
Implementation schedule	See "Details" and "Comments".
Estimated GHG emission reduction	950 thousand ton /year * Source: MRV Demonstration Study (DS) using a Model Project 2012, Modal Shift through Construction of Mass Rapid Transit (MRT) System, Final Report, JWA & ALMEC Consortium for MRV Demonstration Study
Comments	- BMA's contribution - Land acquisition - Support for the constructions, i.e. displacement of traffic signal and traffic sign, bus station, pedestrian, trees and etc. - Control of intersections in case of constructions for MRT - Progresses (as of August 2015)

Color Line	From - To	Organization	Progress (2015/04)	Remark
Purple	Bang Yai - Bang Sue	MRTA	Constructing (96%)	Proposed to operate in August 2016
	Bang Sue - Rat Burana		FS Study and public relation	
Blue	Hua Lumhong - Bang Kae	MRTA	Constructing	
	Bang Sue -Tha Phra		Constructing (56%)	Construction will finish in 2019
Green	Bearing - Samut Prakarn	MRTA	Constructing (44%)	Construction will finish in 2020
	Mo chit - Saphan Mai – Cucot	MRTA	Tendering	Get Contractor in April 2015
	Samut Prakarn - Bang Poo	MRTA	FS Study and public relation	
Pink	Kae Rai - Min Buri	MRTA	Propose to government	Proposed to start Construction in 2017
Orange	Taling Chan Min Buri	MRTA	FS Study and public relation	Proposed Tender in 2016
ARL	Don Mueng - Phaya Thai	SRT	FS Study and public relation	
Dark Red	Hua Lumphong - Bang Sue - Rangsit - Thammasat	SRT	Constructing (16%)	
	Hua Lumphong - Bang Born	SRT	FS Study and public relation	
Light Red	Bang Sue - Huamak	SRT	Construction complete	
	Taling Chan - Salaya	SRT	Propose to government	

1-4 Development of BRT

Title	Extension of BRT line
Details	BRT extension from Ratchaphruek to Talatphlu
BMA's Responsibility	Direct
Stakeholders	BMA (KT)
Implementation schedule	Long term
Estimated GHG emission reduction	N/A
Comments	- Just idea stage. BMA had already submitted evaluation of the current BRT project. Base on the report, the number of passengers have been increased, however, the profits of the project is not good. Therefore, the head of the department has been considering the change of policy. Now, construction of Monorail is alternative idea. - At this stage, we keep this measure on the list. BMA will decide whether they will remain this measure or not by the final stage. - There is a long term plan for BRT including 12 lines.

1-5 Development/improvement of water transportation

Title	Saen Saep canal extension, Phasricharoen canal
Details	1. Saen Saep canal extension; 11 km, 9 station  2. Phasricharoen canal; 11.5 km, 15 station 
BMA's Responsibility	Direct
Stakeholders	BMA (KT), Marine Department, MOT
Implementation schedule	SaenSaep canal extension: Short term (Pier construction finished and test operation started) Phasricharoen canal: Short to mid-term (Test operation started)
Estimated GHG emission reduction	N/A
Comments	-

2) Public transportation (Supporting measures)

2-1 Improvement of connectivity of public transportation

Title	Construction of 3 skywalks
Details	- Construct skywalk between BTS Station (Bangwa Station) and Taksin Petkasem pier station (on Phasricheroen Canel) 0.24 km - Construct skywalk between BTS Station (Bangna Station – Udomsuk Station) and Bangna transfer point 1.4 km - Construct skywalk (725 meters) and install walkalator (345 meters) between BTS Taksin Station and BTS Surasak Station (the existing BTS Taksin station will be removed to construct double track acrossing Chao Phraya River)
BMA's Responsibility	Direct
Stakeholders	BMA, Public – Private Partnerships
Implementation schedule	Short to mid-term (Construction start from the end of 2014)
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

2-2 Improvement of bus service

Title	Feeder bus service
Details	To operate feeder bus services
BMA's Responsibility	Direct
Stakeholders	BMA, OTP, MOT, BMTA, DLT
Implementation schedule	Long term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	- Project under consideration by BMA as an operator - BMA had to submit some proposal to the government. If the Feasibility Study (FS) will be submitted and the contents of the project decided, BMA will be able to implement the project within one or two years.

2-3 Development of passenger shelter at bus station

Title	Improvement/construction of passenger shelters at bus station
Details	Introduce LED lighting at bus station: 2,265 shelters (3 LED lights/shelter), 4,530 advertise sign (3 LED lights/pcs)
BMA's Responsibility	Direct
Stakeholders	BMA, Private company
Implementation schedule	Short to mid-term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

2-4 Development/expansion of Park & Ride

Title	Development of 4 Park & Ride facilities
Details	Bang Yai, Taling Chan, Bang Kae, Baring
BMA's Responsibility	Direct
Stakeholders	BMA, MOT, DOH, DRR
Implementation schedule	Long term
Estimated GHG emission reduction	N/A (*emission reductions will be included in 1-3 or other respective lines.)
Comments	Policy level by Governor

2-5 Introduction of common ticket system

Title	Introduction of common ticket system
Details	- Introduce common ticket system with BRT, BTS, MRT, ARL - Extend to buses and highway, etc.
BMA's Responsibility	Indirect (Support)
Stakeholders	OTP
Implementation schedule	Short term (2015) for BRT, BTS, MRT and ARL Long term for buses, ferry and highway
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

3) Measures on motor vehicles

3-1 Introduction of low emission vehicles (LEV) to BMA's public vehicles

Title	Introduction of low emission vehicles (LEV) to BMA's public vehicles
Details	Start discussion to revise the purchase rule with related department (after that introduce LEVs at the timing of replacement of each vehicles)
BMA's Responsibility	Direct
Stakeholders	BMA
Implementation schedule	Short to mid-term
Estimated GHG emission reduction	8.7 thousand ton /year
Comments	Number of BMA owned vehicles as of the end of 2013. Tractor 439 Road roller 12 Truck (pick-up etc.) 982 Trailer 4 Sedan (not more than 7 passengers) 1,281 Microbus & Passenger Van (more than 7 passengers) 1,950 Bus 131 Truck 4,106 Motorcycle 2,764

3-2 Introduction of NGV, LEVs to BMTA buses

Title	Introduction of NGV, LEVs to BMTA buses
Details	Introduction of 3,184 NGV to BMTA buses
BMA's Responsibility	Indirect (Support)
Stakeholders	BMTA
Implementation schedule	The timeframe is under consideration.
Estimated GHG emission reduction	25 thousand ton /year
Comments	-

3-3 Promotion of Eco-driving

Title	Eco-drive training to drivers of BMA and BMA officers
Details	- Eco-drive training to drivers of BMA (garbage truck, truck, other services cars) - Extend Eco-drive training to BMA officers - Organize seminar and training course about eco-driving
BMA's Responsibility	Direct
Stakeholders	OTP, DLT, DOH, EXAT: Seminar and training course
Implementation schedule	Short to mid-term
Estimated GHG emission reduction	120 thousand ton /year
Comments	-

4) NMT

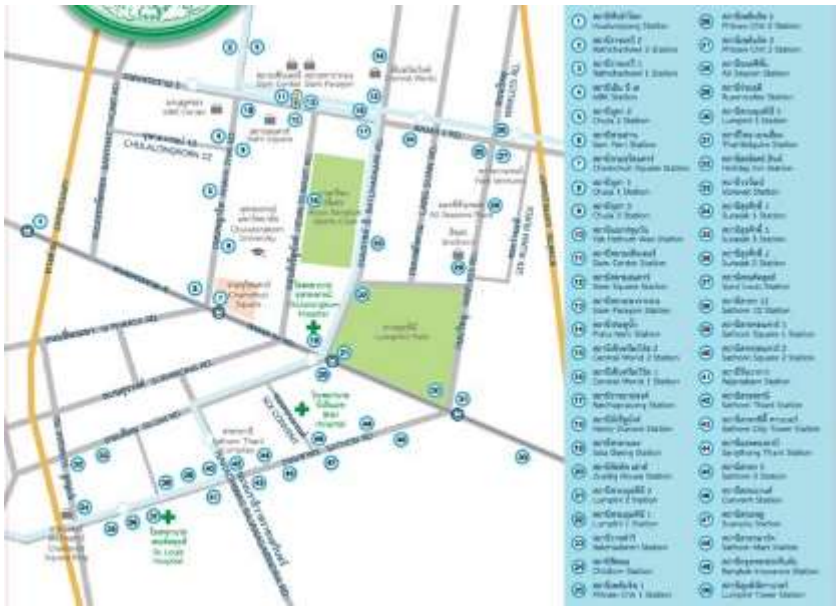
4-1 Development/expansion of bikeway

Title	Improvement of 12 bike routes/Extension of 1 bike route/Construction of new 9 bike routes/Improve connectivity of bike lanes between main and secondary roads/ Construction of "Bicycle routes under expressway"
Details	- Improvement of 12 bike routes 1. Sathorn Road 2.8 km 2. Bangkuntien Seaside Road 11.5 km 3. Praditmanutham Road 24 km 4. Petchakasem Road 16 km 5. Road around Koh Rattanakosin 12.5 km 6. Ladprao Road 21 km 7. Road around Taksin Monument 4.4 km 8. Bhuddamondhon Sai 2 Road 8 km 9. Utthayan Road 3.8 km 10. Jaransanitwong-Ratchadapisek Road 14 km 11. Klong Paisingto Road 1.3 km 12. Doungpitak Road 1 km - Extension of 1 bike route 1. Pattanakarn Road 2.8 km - Construction of new 9 bike routes 1. Paholyothin-Rattanakosinsompoth Road 5.25 km

<table>
<tr><td></td><td>2. Ratutit- Leapwaree Road 13.6 km
3. Srinakarin Road 7 km
4. Serithai Road (Sukapiban 2 Road) 10 km
5. Road link between Jaransanitwong-Kanjanapisek Road 2 km
6. Bhuddamondhon Sai 3 Road 10.4 km
7. Taweewattana Road 8.5 km
8. Bangkradi Road 3.6 km
- Improve connectivity of bike lanes between main and secondary roads
- Construct “Bicycle routes under expressway”</td></tr>
<tr><td>BMA’s Responsibility</td><td>Direct (Indirect (Construction of “Bicycle routes under express way”))</td></tr>
<tr><td>Stakeholders</td><td>BMA, OTP, EXAT (Bicycle route under expressway)</td></tr>
<tr><td>Implementation schedule</td><td>Short to mid-term (Some of the candidates of the project will be started within this year)</td></tr>
<tr><td>Estimated GHG emission reduction</td><td>* Check the progress of the measure for the MRV</td></tr>
<tr><td>Comments</td><td>For “Bicycle routes under express way” project, a pilot project will be done in Sriruth route. (MOT uses official of “expressway”)
- Progresses (as of August 2015)
<table>
<tr><td colspan="2">- Improve 12 bike route</td></tr>
<tr><td>1. Sathorn Road</td><td>Completed</td></tr>
<tr><td>2. Bangkuntien Seaside Road</td><td>Completed</td></tr>
<tr><td>3. Praditmanutham Road</td><td>Improving</td></tr>
<tr><td>4. Petchakasem Road</td><td>Study and design process</td></tr>
<tr><td>5. Road around Koh Rattanakpsin</td><td>Completed</td></tr>
<tr><td>6. Ladprao Road</td><td>Study and design process</td></tr>
<tr><td>7. Road around Taksin Mounment</td><td>Improving</td></tr>
<tr><td>8. Bhuddamondhon Sai 2 Road</td><td>Study and design process</td></tr>
<tr><td>9. Utthayan Road</td><td>Study and design process</td></tr>
<tr><td>10. Jaransanitwong-Ratchadapisek Rd.</td><td>Study and design process</td></tr>
<tr><td>11. Klong Oaisingto Road</td><td>Completed</td></tr>
<tr><td>12. Doungpitak Road</td><td>Study and design process</td></tr>
<tr><td>- Extend 1 bike route</td><td></td></tr>
<tr><td>1. Pattanakarn Road</td><td>Study and design process</td></tr>
<tr><td>- Construct new 9 bike routes</td><td></td></tr>
<tr><td>1. Phaholyothin-Rattanakosin..</td><td>Under construction</td></tr>
<tr><td>2. Ratutit-Leapwaree Road</td><td>Construction complete</td></tr>
<tr><td>3. Srinakarin Road</td><td>Construction complete</td></tr>
<tr><td>4. Serithai Road</td><td>Study and design process</td></tr>
<tr><td>5. Road link between Jaransanit…</td><td>Under constructing</td></tr>
<tr><td>6. Bhuddamondhon Sai 3 Road</td><td>Under constructing</td></tr>
<tr><td>7. Taweewattana Road</td><td>Under constructing</td></tr>
<tr><td>8. Bangkradi Road</td><td>completed</td></tr>
<tr><td colspan="2">- Improve connectivity of bike lane between main and sub road</td></tr>
<tr><td></td><td>Improving</td></tr>
<tr><td colspan="2">- Construct "Bicycle routes under express way"</td></tr>
<tr><td></td><td>Under constructing</td></tr>
</table></td></tr>
</table>

4-2 Expansion of “Bike-for-Rent”

Title	Expansion of “Bike-for-Rent”
Details	Increase 250 stations and 10,000 bikes CBD zone and along the BTS and MRT line

	
BMA's Responsibility	Direct
Stakeholders	BMA (Private company)
Implementation schedule	Short to mid-term (2013-2017)
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

4-3 Development/expansion of pedestrian

Title	Improvement of 10 pedestrian deck/Improvement of accessibility to 50 stations
Details	- Improve 10 pedestrian (Improve road surface and footpath) 1. Improvement of Prachasook's road surface and pedestrian starting from Sutthisan Winitchai road to Prachasongkroh Road, Dindang district 2. Improve the road surface of Bang Khun Tian Chaytalay from Klong Sanam Chai to Pittayalongkorn Intersection in Bang Khun Tian district 3. Improve Rural Development road surface from roads along motorway to Krungthep Kreetha road, Ladkrabang district 4. Improve pedestrian on Saimai Road starting from road along Klong 2 to Sukhapiban 5, Saimai district 5. Improve pavement on Bang Khun Thian road starting from Ekachai to Rama 2 road, Bangbon and Bang Khun Thian district 6. Improve Bangkwake road starting from identification point to Taweewattana road, Bangkae district 7. Restoration and reinforce structure of bridges over canals in Bangkok 8. Improve Chimplee road project starting from Boromaratjonani road to roads along railway in Talingchan district 9. Improve Luang Pang road project from Klong Phraya Pecth to Klong Kalong in Ladkrabang district 10. Improve Rajamontri road project starting from Puthamonthol 1 to Klong Lampradong in Phasi Chareon district

	- Improve accessibility to 50 stations, including improvement of pedestrian facilities, etc.
BMA's Responsibility	Direct /Indirect (Improvement of accessibility to 50 stations)
Stakeholders	BMA, MOT, OTP, MRTA, DOH, DRR
Implementation schedule	Short to long term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	- Progresses (as of August 2015) - Improve 10 pedestrian Improving - Improve accessibility to 50 stations Under construction

5) Traffic volume/flow control

5-1 Development/improvement of road, bridge and tunnel

Title	Construction on 1 new road/Construct 2 new tunnels/Construct 1 new bridge/Improve 7 roads/Extend 1 bridge
Details	- Construction on 1 new road 1. Srinakarin-Romklao Road (12.5km) - Construction on 2 new underpasses 1.Sriayutana-Rama 6 (0.8km) 2. Pattanakan- Ramkamhaeng-Taworn Thawat Road (0.9km) - Construction 1 new bridge 1. Klong Nongprue Lad-krabang Road (50m) - Improvement on 7 roads 1. Kum-Klao Road from Suwintawong Road to Motor Way frontage Road (10km) 2. Ramkamhaeng Road to Srinakarin Road (Soi Ramkamhaeng 24) (1.6km) 3. Mitmaitri Road from Vibhavadi Rangsit to Prachasongkro Road (0.8km) 4. Roads around BMA City hall 2 (Mitmaitri Road, Mitmaitri 3 Road, and Prachasongkhro Road) (1.6km) 5. Ratchawong Road from Yaowarat Road to Songwat Road (0.4km) 6. Sutthawas Road 7. Soi Rama 2 yak 82 Road (1.85km) - Extension of 1 bridge 1. Extension of Arun-ammarin Overpass (with road ascent and descent) and expand Sirirath Overpass
BMA's Responsibility	Direct
Stakeholders	BMA, MOT, OTP, DOH, DRR
Implementation schedule	Long term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	- Progresses (as of August 2015) - Construction new 1 road

	1. Sathorn Road	Tendering (E-auction)
	- Construction 2 new underpasses	
	1. Sriayutaya-Rama 6	Cost Estimate process
	2. Pattanakarn-Ramkamhaeng-Tavo..	Tendering (E-auction)
	- Construction 1 bridge	
	1. Khlong Nongprue	Tendering (E-auction)
	- Improvement of 7 roads	
	1. Kum-Klao Road	Re-Design process
	2. Ramkamhaeng Road	Cost Estimate process
	3. Mitmaitri Road	Cost Estimate process
	4. Road around BMA	Tendering (E-auction)
	5. Ratchawong Road	Under constructing
	6. Sutthawas Road*	Under constructing
	7. Soi Rama 2 Yak 82	Tendering (E-auction)
	- Extension of 1 bridge	
	1. Extend Arun-ammarin Overpass	Tendering (E-auction)

5-2 Improvement of signal system

Title	Install additional adaptive traffic signal system control 5 intersections
Details	- Install additional adaptive traffic signal system control 5 intersections 1. Rama 3 road – Ratchadapisek road intersection 2. Petchkasem road – Petchkasem 69 road intersection 3. Petchkasem road – Petchkasem 81 road intersection 4. Sukapiban 1 road – Happyland road intersection 5. Ramkamhang road – Ratpattana road intersection (Mistine intersection)
BMA's Responsibility	Direct
Stakeholders	BMA
Implementation schedule	Short term (The project is going on process of installation and will be finish by the end of this October)
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

5-3 On-street parking control

Title	On-street parking control project
Details	1. Ladprao raod (Ladprao intersection – Happyland intersection) 2. Rama 4 road (Hualampong train station – Ratchadapisek-Rama 4 intersection) 3. Sukhumvit-Pleonchit-Rama 1 road (Bangna intersection – Pongpraram intersection 4. Ramkamhang-Rama 9-Chaturatit road (Klongjek intersection – Ramkamhang intersection - Chaturatit road) 5. Ratchadapisek road-Asokedindaeng road-Asokmontri road (Prachanukul intersection – Ratchadapisek-Rama 4 intersection) 6. North Sathorn and South Sathorn Phaholyothin road (Victory monument – Saparnmai market) 7. Kasetnawamin road (Kasetsart University intersection – Nawamin intersection) 8. Petburi road-New Petburi road (Urupong intersection – Klongton intersection)

	9. Viphavadi rangsit road 10. Pracharat sai 1 road and Pracharat sai 2 road 11. Samsen road 12. Ramindra road 13. Chang-wattana road 14. Ngamwongwan road 15. Prachachuen road 16. Nawamin road 17. Ladkrabang road 18. Praditmanudham road 19. Srinakarin road 20. Serithai road 21. Cheroenkrung road 22. Chakpet road 23. Romklao road 24. Narathiwasratchanakarin road 25. Bamrungmueng road 26. Krungkasem road 27. Yaowarat road 28. Silom road 29. Charansanitwong road 30. Cheroennakorn road 31. Ratchapisek road - Rama 3 road 32. Ratchadapisek road – Talaad Plu 33. Somdejchao Phraya road 34. Krung Thonburi road 35. Somdetprachaotaksin road 36. Pracha-utit road 37. Petkasem road 38. Rama2 road 39. Ratchapluk road
BMA's Responsibility	Indirect (support)
Stakeholders	RTP
Implementation schedule	Short to mid-term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	-

6) Public awareness rising

6-1 Promotion of public transportation

Title	Promotion of public transportation
Details	- Launch campaign on public transport use - Promote public transport use (free of charge) on special day, i.e. Child day, Car free day

	
BMA's Responsibility	Direct
Stakeholders	BMA, MOT, OTP, MRTA, SRT, PCD
Implementation schedule	Short term (Annually)
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	BMA will have same kind of the project in this year.

6-2 Classes for school to learn about environment/transport

Title	Classes for school to learn about environment/transport
Details	Launch program on environment/transport for all schools in Bangkok (elementary school to high school)
BMA's Responsibility	Direct
Stakeholders	BMA, MOT, MOE, OTP, DOH, OTP, MOE, DOH
Implementation schedule	Short term (Annually)
Estimated GHG emission reduction	* Check the progress of the measure for the MRV
Comments	Education programs has already implemented every year at elementally school of Bangkok (BMA's 438 elementary schools. The officer of BMA is instructor. Main topics are relative to traffic safety. Including the environmental issues to the text should be good measure.

6-3 Organize workshops and seminars

Title	Organize workshops and seminars
Details	Workshops and seminars on environment/transport
BMA's Responsibility	Direct
Stakeholders	BMA, MOT, OTP, DOH, BMTA, DLT
Implementation schedule	Short to mid-term
Estimated GHG emission reduction	* Check the progress of the measure for the MRV

Comments	- Including the environmental issues in the contents of the seminar should be encounter on the good measures. - Include promotion of low emission vehicles - Review/re-regulate laws/measures/related action on social actions

5-2 Mitigation measures for the energy efficiency and alternative energy sector

(1) Overview of the measures

		GHG emission in the energy sector shares the largest part of the total emission. As the most GHG emissions in the energy sectors in Bangkok are related to those from buildings, mitigation measures focuses on introducing energy efficiency and renewable energy.

Table 5-3 Comparison of GHG emission in future in different scenarios in 2020 in the energy sector

Unit million t-CO_2e

Sector	**Year 2013**	**Year 2020**		
	Current GHG Emission	**Future GHG Emission under Business as Usual Scenario**	**Future GHG Emission under Bangkok Master Plan Implementation**	**Expected reduction/absorption amount (reduction rate against BAU)**
Energy	25.60	30.94	26.85	4.09 (-13.22%)

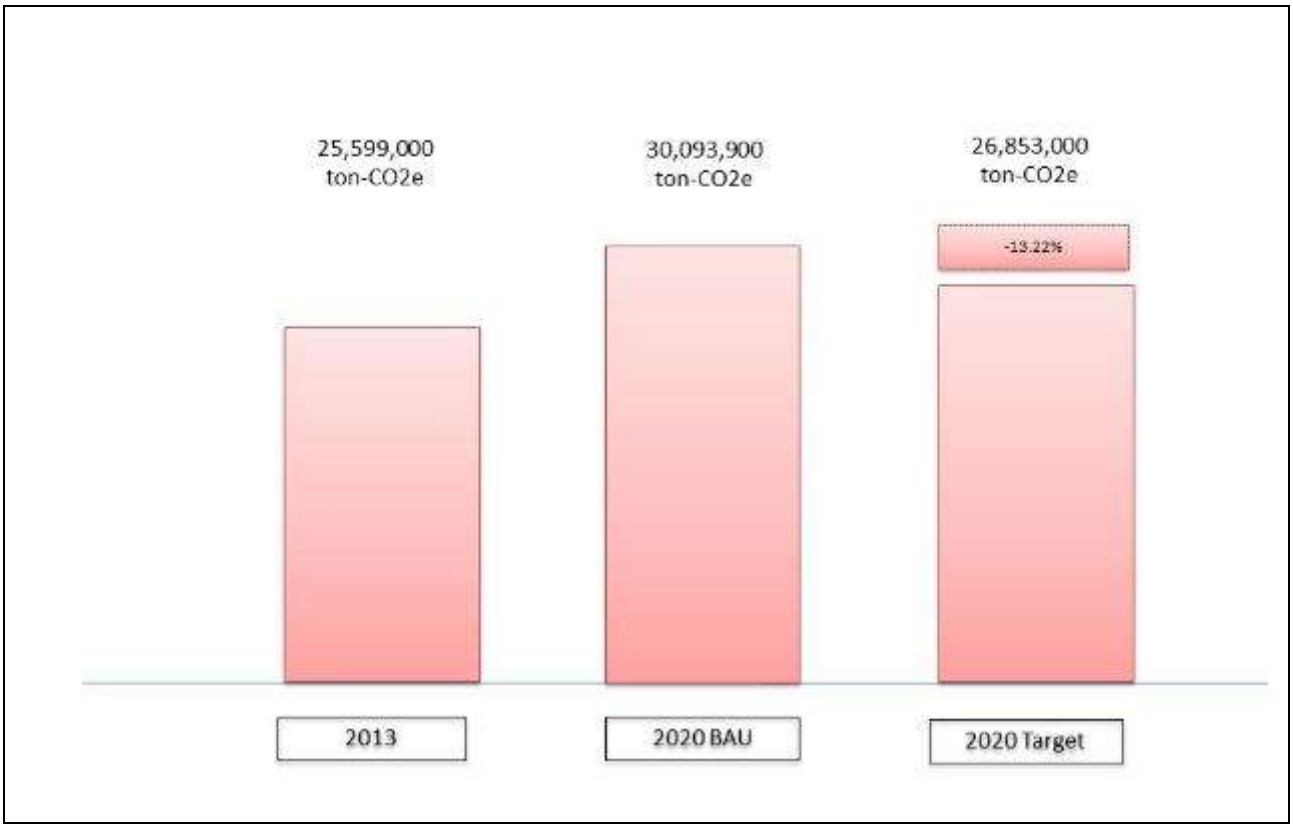


Figure 5-2 GHG emission in 2013 and BAU emission and mitigation targets in 2020 in the energy sector

GHG emission in 2013

Energy consumption data (mainly secondary data) from 2009 to 2012 was collected from the relevant authorities and organizations as follows:

- Electricity: Metropolitan Electricity Authority (MEA)
- Oil: Department of Energy Business (DOEB), Ministry of Energy
- Natural Gas: PTT PLC
- Coal: Department of Alternative Energy Development and Efficiency (DEDE)

The EEDP and other energy related plans at the national level are the main reference for estimating the current GHG emission of 2013. In particular, the Energy TF has collected future trends of electricity and fuel consumption in EEDP etc. and estimated GHG emissions by multiplying the appropriate CO2 emission factors with the trends. In other words, the GHG emission in 2013 is estimation from the trends, given the fact that the National GHG Inventory for 2013 is yet to be available as the time of calculating this.

BAU emission in 2020

As energy consumption in Bangkok is particularly large in Thailand, it is important to ensure consistency with this Master Plan and the national plans and measures in the calculation of future prediction and reduction of the GHG emission in energy sector. Therefore, the EEDP and other plans of national level are referred for the BAU setting. In

particular, Energy TF has collect future trends of electricity and fuel consumption in EEDP etc. and set the BAU GHG emissions by multiplying the appropriate CO_2 emission factors with the trends.

GHG emission in 2020 with mitigation actions implemented

The mitigation target is set by referring to the estimated value of CO_2 emission reduction when the energy conservation measures listed in EEDP is realized at the national level, and the assumption that these measures are realized also in Bangkok.

Following table shows an overview of the mitigation measures for the energy efficiency and alternative energy sector.

Table 5-4 Mitigation measures for the energy efficiency and alternative energy sectorCategory			Possible mitigation measures (countermeasures)	
1. BMA government buildings & facilities	1.1 Energy saving renovation/repair work for existing facilities	1.1.1 General tasks	1)	Developing systematic schedules of retrofitting BMA's existing building for appropriate management of energy
			2)	Systematic implementation of energy saving retrofitting works of BMA's existing building
			3)	Selection of model project for energy saving renovation work Intensive adoption of top-runner appliances
			4)	Energy saving requirements for retrofitting works of BMA facilities and setting of high-level of energy efficiency Acquisition of certification for energy saving renovation work (CASBEE or LEED etc.)
			5)	Consideration of renovation work, extension work, conversion at the time of facilities update (maximum utilization of existing stocks)
			6)	Efficient retrofitting/renovation work for energy saving by introducing private capital know-how
		1.1.2 Improving insulation performance (renovation technique)	1)	Introduction of thermal barrier roof coatings
			2)	Improving external insulation and waterproofing
			3)	Introduction of roof greening
			4)	Improving heat insulating window (high heat insulating glass such as low-e pair glass)
			5)	Improving heat insulating window (thermal barrier film)
			6)	Controlling solar radiation heat by installing louver or eaves
		1.1.3 Cutting down air conditioning / ventilation load (retrofitting technique)	1)	Replacing existing air-conditioning equipment by high-efficiency one
			2)	Introduction of variable flow controller
			3)	Introduction of task ambient air conditioning system - controlled by motion/temperature sensor, timer etc.
			4)	Introduction of high-efficiency fan (total heat exchanger)
			5)	Introduction of cogeneration system
		1.1.4 Cutting down lighting load (retrofitting technique)	1)	Introduction LED lighting or fluorescent lamp
			2)	Introduction of task ambient lighting
			3)	Installing motion sensor lighting to bathroom, corridor or staircase
			4)	Daytime energy reduction by daylight sensor

Table 5-4 Mitigation measures for the energy efficiency and alternative energy sectorCategory			Possible mitigation measures (countermeasures)	
1. BMA government buildings & facilities		1.1.5 Energy reduction by water-saving	1)	Upgrading water saving sanitary appliances
			2)	Introduction of rainwater recycling system
			3)	Introduction of waste water recycling system (reuse as toilet bowl flushing water)
		1.1.6 Others	1)	Introduction of Solar power generation systems
			2)	Introduction of BEMS, building energy management systems
			3)	Replacing street lighting to LED
	1.2 Energy saving for new construction	1.2.1General tasks	1)	Constructing high energy efficiency building
			2)	Introducing requirements of certificate for new construction of BMA facilities (Energy standard such as CASBEE or LEED etc.)
	1.3 Information campaign	1.3.1 Conducting campaign to citizens	1)	Promoting environmental education at school
			2)	Support to exhibition of energy saving merchandise for BMA facility
			3)	Visualization of energy saving of BMA facility Notify saving energy activities by panel or monitor
			4)	Promoting "Green Curtain" installation at school to reduce air conditioning load
			5)	Holding workshop on energy saving repair work for public participation (schools, public facilities)
	1.3 Information campaign	1.3.2 Conducting campaign to the officials	1)	Raising preset cooling temperature
			2)	Award for saving energy activity
			3)	Turning off lightings during lunch break
			4)	Thorough power saving setting on PC or OA equipment
	1.4 Promotion of low carbon city	1.4.1 Model areas	1)	Setting up low-carbon model area, each fields top runner measure, intensive equipment investment
2. Civil Categories (Residential/ Commercial/ Industries)	2.1 Residential part	2.1.1 Promotion of energy saving house	1)	Promotion of low-carbon/energy saving detached house (Publicity of cost benefit from the viewpoint of low carbon community , backup exhibition, provide advertising spaces at BMA facilities
			2)	Facility equipment introduction promotion of energy saving house (LED lights, energy-saving air conditioning system or hot‐water apparatus etc.)
		2.1.2 Promotion of energy saving repair work	1)	Publicity of cost benefit by repair work for energy saving
			2)	Promotion of repair work for energy saving: insulation upgrade by double glazing, heat barrier film, renew air conditioning device (subsidy system etc.)
		2.1.3 Promotion of energy saving home appliances	1)	Purchase promotion of energy saving home electric appliances (air conditioning, fridge, TV etc.)
		2.1.4 Promotion of energy saving measure	1)	Promote better understanding of air conditioner maintenance (conduct free cleaning)
		2.1.5 Others	2)	Promotion of solar panel installation （subsidy system or mediating installable roof）
	2.2 Commercial/ Business part	2.2.1 Promotion of energy saving building	1)	Incentive for constructing/repairing saving energy factory (tax reduction, subsidy, zero-interest finance etc.)

Table 5-4 Mitigation measures for the energy efficiency and alternative energy sectorCategory			Possible mitigation measures (countermeasures)	
2. Civil Categories (Residential/ Commercial/ Industries)		2.2.2 Promotion of energy saving repair work for existing building	1)	Conducting energy saving inspection of public buildings
			2)	Promotion of ESCO business for existing buildings (Explaining ESCO business, advertisement promotion support, subsidy system for energy saving diagnostic)
			3)	Promotion of repair work for energy saving: insulation upgrade by double glazing, heat barrier film, renew air conditioning device (subsidy system etc.)
			4)	Publicity of cost benefit by Electricity Peak-Cut Introduction support for automatic control facility of Electricity Peak-Cut
		2.2.3 Promotion of energy saving measure	1)	Promotion of saving energy activity (publicity of cost benefit etc)
			2)	Raising preset cooling temperature at public buildings Turn off lightings during lunch break
			3)	Thorough power saving setting on PC or OA equipment
			4)	Award for saving energy activity
		2.2.4 Others	a	Promotion of solar panel installation （subsidy system or mediating installable roof）
	2.3 Industrial part 2-3. Industrial part	2.3.1 Promotion of energy saving factory	1)	Incentive for constructing/retrofitting saving energy factory (tax reduction, subsidy, zero-interest finance etc.)
		2.3.2 Promotion of energy saving repair work for existing factory	1)	Conducting energy saving inspection of factories
			2)	Promotion of repair work for energy saving (subsidy system etc.)
			3)	Publicity of cost benefit by Electricity Peak-Cut Introduction support for automatic control facility of Electricity Peak-Cut
		2.3.3 Promotion of energy saving measure	1)	Promotion activity for factory's energy saving technique (for SMEs)
			2)	Commendation for saving energy activity
		2.3.4 Others	1)	Promotion of Solar Energy （subsidy system or mediating installable roof）
			2)	Promotion of beneficial use of factory exhaust heat

(1) Details of the measures

Details of each measure in the previous table are described below.

1) BMA government buildings & facilities

1-1 Energy saving renovation/repair work for existing facilities

1-1-1 General tasks

Title	Developing systematic schedules of retrofitting BMA's existing building for appropriate management of energy
Description	a. Correct the related data both type and amount of building and quantity and type of energy used, as well as other condition b. Correct the technology information of the renovation in term of price, process time and other condition c. Study of the related laws d. Arrange for projects, determine the responsible person and prioritize the projects. e. Project feasibility study. f. Form the systematic schedule.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	JICA, DEDE
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Urgently required; This is major key to other countermeasures. However, BMA's Climate change "action plan" is also required for long term systematic plan.

Title	Systematic implementation of energy saving retrofitting works of BMA's existing building
Description	a. Determine the responsible person in each sector. b. Study the information and plan thoroughly. c. Operate the building implementation by time frame plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE, MoEn
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Systematic implementation in "Housekeeping approach", require next step in "Process improvement and major change equipment". Have to start after finishing systematic schedule (Step 1-1-1a)

Title	Selection of model project for energy saving renovation work Intensive adoption of top-runner appliances
Description	a. Study and collect the appropriate models for improve the energy saving b. Selected the possible of top-runner models.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	BMA would try to apply top-runner appliances concept/policy in renovation works, but however, it should base on appropriate price/budget.

Title	Energy saving requirements for retrofitting works of BMA facilities and setting of high-level of energy efficiency Acquisition of certification for energy saving renovation work (CASBEE or LEED etc.)

Description	a. Study terms and conditions of device installation of high-level of energy efficiency (CASBEE or LEED etc.) b. Acquisition of certification for energy saving renovation work (CASBEE or LEED etc.)
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	Private consultant, TGBI
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	BMA would challenge with LEED or CASBEE, but will consider according to suitable criteria/opportunity of LEED (certificate type)

Title	Consideration of renovation work, extension work, conversion at the time of facilities update (maximum utilization of existing stocks)
Description	a. Study of the effect that may be occur while changing the equipment and machinery. Study of the approach to reduce the impact. b. Considered the appropriate adjustments.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Normally implemented, especially stock management.

Title	Efficient retrofitting/renovation work for energy saving by introducing private capital know-how (ESCO business etc.)
Description	a. Qualifying the contractors that have knowledge and expertise. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	-
Stakeholder	-
Plan	
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	No policy in collaboration with private capital due to government regulation/laws limitation.

1-1-2 Improving insulation performance (renovation technique)

Title	Introduction of thermal barrier roof coatings  
Description	a. Study the information and choose of the appropriate thermal barrier roof coatings b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)

GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Normally implemented to all BMA buildings.

Title	Improving external insulation and waterproofing 
Description	a. Study the information and choose of the appropriate external insulation and waterproofing. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Normally implemented to all BMA buildings.

Title	Introduction of roof greening  
Description	a. Study the information and choose of the appropriate roof greening b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DOE Other Organization: All departments and District offices
Stakeholder	TGO, ASA, TGBI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Old buildings: This policy emphasized by Bangkok governor to renovate for roof greening, based on appropriate conditions New building: Have to do in all new buildings since design phase.

Title	Improving heat insulating window (high heat insulating glass such as low-e pair glass) 
Description	a. Study the information and choose of the appropriate heat insulating window b. Select the building that appropriate with the equipment. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: -
Stakeholder	DEDE, ASA, TGBI
Plan	medium term (2016-2018)
GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Have to consider this countermeasure with ASA, TGBI due to character of Bangkok weather may not suitable with low e-pair glass.

Title	Improving heat insulating window (thermal barrier film)  
Description	a. Study the information and choose of the appropriate heat insulating window Select the building that appropriate with the equipment. b. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Normally implemented to all BMA buildings.

Title	Controlling solar radiation heat by installing louver or eaves
Description	a. Study the information and choose of the appropriate solar radiation heat controller. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE, ASA
Plan	medium term (2016-2018)
GHG Mitigation	Accumulate 10 years = 0.864 thousand CO_2-eq *(total 1-1-2 measures)
Comment	Based on appropriate situation/conditions of each building

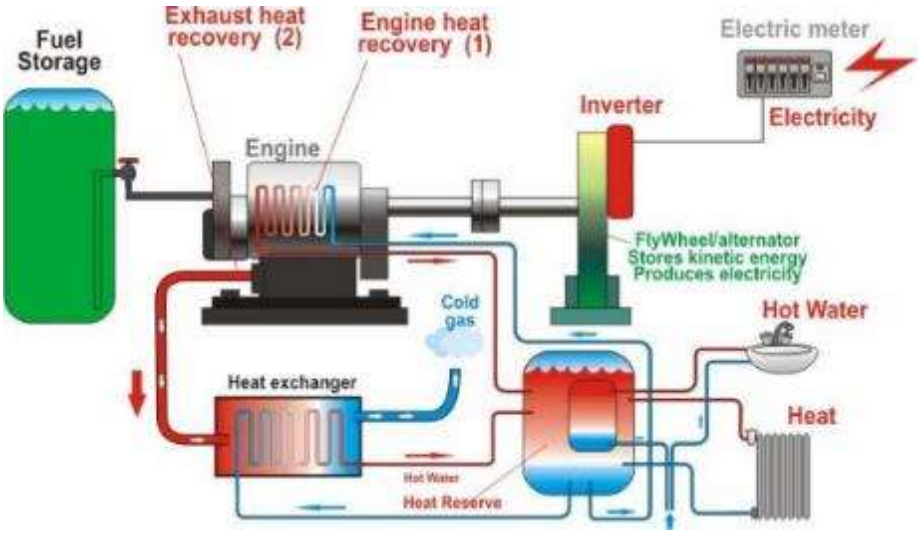
1-1-3 Cutting down air conditioning/ventilation load (retrofitting technique)

Title	Replacing existing air-conditioning equipment by high-efficiency one
Description	Study the information and choose of the high-efficiency existing air-conditioning equipment. Select the building that appropriate with the equipment. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 25.192thousand CO_2-eq
Comment	Normally implemented to all BMA buildings. Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Introduction of variable flow controller
Description	a. Study the information and choose of the variable flow controller. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Accumulate 10 years = 15.115 thousand CO_2-eq *(total 1-1-3 measures)
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Introduction of task ambient air conditioning system - controlled by motion/temperature sensor, timer etc.
Description	a. Study the information and choose of the task ambient air conditioning system. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Accumulate 10 years = 15.115 thousand CO_2-eq *(total 1-1-3 measures)
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Introduction of high-efficiency fan (total heat exchanger)
Description	a. Study the information and choose of the high-efficiency fan (total heat exchanger). b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	-
Stakeholder	-
Plan	
GHG Mitigation	Accumulate 10 years = 15.115 thousand CO_2-eq *(total 1-1-3 measures)
Comment	Policy and campaign on ventilation fan remove program. No heat exchanger due to require only cool air

Title	Introduction of cogeneration system 
Description	a. Study the information and choose of the cogeneration system. b. Select the building that appropriate with the equipment. c. Installation /modify the equipment according to the plan
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	-
Plan	-
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	May have no potential due to BMA only require in power and cooling system, but not steam.

1-1-4 Cut down lighting load (retrofitting technique)

Title	Introduction of LED lighting or HF fluorescent lamp 
Description	a. Study the information and choose of the LED lighting or HF fluorescent lamp. b. Select the building that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 19.378 thousand CO_2-eq
Comment	Normally implemented to all BMA buildings. Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Introduction of task ambient lighting 
Description	a. Study the information and choose of the task ambient lighting. b. Select the building or area that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Installing motion sensor lighting to bathroom, corridor or staircase
Description	a. Study the information and choose of the motion sensor lighting. b. Select the building or area that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015) and medium term (2016-2018)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Daytime energy reduction by daylight sensor
Description	a. Study the information and choose of the daylight sensor. b. Select the building or area that appropriate with the equipment. c. Install the equipment by plan.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

1-1-5 Energy reduction by water-saving

Title	Upgrading to water saving sanitary appliances
Description	a. Using motion sensor sanitary system for turn off the water, such as faucet. b. Choose sanitary that is designed to work on saving water
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Existing motion sensor in some water faucet system in toilet. However, normal flushing system may suitable in open-access office buildings due to its durable character.

Title	Introduction of rainwater recycling system
Description	a. The rainwater utilization, such as watering garden, watering plants, washing the car.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	-
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Based on appropriate situation/conditions of each building and based on appropriate price/budget

Title	Introduction of waste water recycling system (reuse as toilet bowl flushing water)
Description	a. Set up the system by bringing the treatment waste water reuse. b. Bring water from water treatment and reuse, such as toilet flushing and plants watering.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 0.775 thousand CO_2-eq
Comment	Normally implemented to some suitable BMA buildings. Recycled water is now using in toilet and garden. (New city hall)

1-1-6 Others

Title	Solar power generation systems
Description	a. Installation of solar energy to produce electricity in residential homes. b. Factory and Building Installed to generate electricity for some equipment, such as lighting. c. Installation to produce electricity for street light or the light at the bus stop.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015) and medium term (2016-2018)
GHG Mitigation	Accumulate 10 years = 1.550 thousand CO_2-eq
Comment	Focus in solar PV (for lighting and outdoor area including traffic signs) and based on appropriate price/budget

Title	Introduction of BEMS, building energy management systems
Description	a. Study BEMS system to better understand the process of implementation of the system. b. Planning system operations. c. Broadcast systems to the organization in BMA. d. BEMS systems are combined with energy conservation plan to be in line with the Department of Energy. e. This system has published continuously.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015) and medium term (2016-2018)
GHG Mitigation	Accumulate 10 years = 3.100 thousand CO2-eq
Comment	Based on appropriate situation/conditions of each building. Have to establish/set up the BMA's BEMS center unit.

Title	Replacing street lighting to LED
Description	a. Start with change the main street lighting. b. Extended to the secondary roads and minor roads around Bangkok. c. Solar cells are the source of LED system's electricity.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Already implemented in some area. Plan to extend this concept in future.

1-2 Energy saving consideration for new construction

1-2-1General tasks

Title	Construction of high energy efficiency building
Description	a. Building design focuses on building energy conservation. b. The lighting systems of the building is designed for saving the energy systems. c. The air conditioning systems are designed for saving the energy system.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 15.502 thousand CO_2-eq
Comment	New construction would base on existing Thailand Building energy code under DEDE

Title	Requirements of certificate acquisition for new construction of BMA facilities (CASBEE or LEED etc)
Description	a. Study all assessment system. b. Select the assessment system that the most appropriate for Bangkok. c. Set up a team for operation. Planning and operation for the assessment system has been selected. d. Provision of energy conservation system to all organization operating continuously.
BMA Responsibility	BMA: DPW Other Organization: All departments and District offices
Stakeholder	Private consultant, TGBI
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	BMA would challenge with LEED or CASBEE, but will consider according to suitable criteria/opportunity of LEED (certificate type)

1-3 Information campaign

1-3-1Conducting campaign to citizens

Title	Promotion of environmental education at school
Description	a. Organizing activities related to the environment for educate the students. b. Invention contest about energy saving and environmental conservation. c. The contest writing about energy saving and environmental conservation.
BMA Responsibility	BMA: DOE Other Organization: DOE
Stakeholder	DEDE
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	BMA have achievement this countermeasure. All schools have curriculum and activities based on energy conservation concept.

Title	Supporting opening exhibition of energy saving merchandise for BMA facility
Description	a. Prepare the area to organize an exhibition on energy saving. b. Invention contest about energy saving
BMA Responsibility	BMA: DOE Other Organization: All departments and District offices
Stakeholder	-
Plan	
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Exhibition events are hold at Taksin hospital twice per year. Other departments also support energy saving activities.

Title	"Visualization of energy saving of BMA facility Notify saving energy activities by panel or monitor"
Description	a. Operate the total energy management, begin with BMA's employees. b. PR the result of energy activities to other sector, such as community, education, etc. For the case study from the BMA organization. c. Operate activities continuously to show the BMA organization is focus on energy.
BMA Responsibility	BMA: DOE Other Organization: All departments and District offices
Stakeholder	-
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Installation of visualized equipment after BEMS countermeasures have been implemented.

Title	Promotion of "Green Curtain" installation at school to reduce air conditioning load
Description	a. Planning and design the projects. b. Start the projects with school in Bangkok. c. Expansion the projects to all schools.
BMA Responsibility	BMA: DOE Other Organization: All departments and District offices
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Already implemented in some buildings (DPW, Schools).

Title	Holding workshop on energy saving repair work for public participation (schoolchild, public facilities)
Description	a. Planning and design workshop to attract the attention from target. b. Set up workshop meetings to educate that star with BMA organization the extension to the schools.

	c. Operate the project continuously to be the most effective.
BMA Responsibility	BMA: DPW,DOE Other Organization: DOEd
Stakeholder	-
Plan	medium term (2016-2018)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Plan to set up workshop after major energy conservation countermeasures have been implemented.

1-3-2 Conducting campaign to the officials

Title	Raising preset cooling temperature
Description	a. Set the temperature at 25oC.
BMA Responsibility	BMA: ALL Other Organization: -
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Campaign started since 2005, as policy from governor. Next step should focus in "strictness behavior in all staff levels".

Title	Commendation for saving energy activity
Description	a. Introduce the saving energy activities to all organization, such as electricity, heat, petroleum, etc. b. Promote and support the activities related to energy efficiency. c. All employee involved in the presentation of concept of energy saving activities. d. Should be motivated by the results of the activities for to be more productive activities.
BMA Responsibility	BMA: ALL Other Organization: -
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Campaign started since 2005, as policy from governor. Next step should focus in "strictness behavior in all staff levels".

Title	Turning off lightings during lunch break
Description	a. Always turn off lightings during lunch break ช b. Always turn off lightings in the non-lighting area.
BMA Responsibility	BMA: ALL Other Organization: -
Stakeholder	-
Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Campaign started since 2005, as policy from governor. Next step should focus in "strictness behavior in all staff levels".

Title	Thorough power saving setting on PC or OA equipment
Description	a. Turn off the computer when leave for long. b. Turn off the monitor when not in use for over 15 minutes. c. Set up a screen saver to maintain the quality of the screen. d. Always turn on the energy saving function.
BMA Responsibility	BMA: ALL Other Organization: -
Stakeholder	-

Plan	short term (2013-2015)
GHG Mitigation	Do not have GHG mitigation on this measure.
Comment	Campaign started since 2005, as policy from governor. Next step should focus in "strictness behavior in all staff levels".

1-4 Promotion of low carbon city

1-4-1Model areas

Title	Setting-up of low-carbon model area, each fields top runner measure, intensive equipment investment
Description	a. Knowledge about low carbon city to all area. b. Select the prototype area. c. Planning and begin to build a low-carbon city. d. Define operational issues to the environment of the community as a low carbon city that is environmental, transportation, infrastructure community and buildings. e. All of organization must cooperate to achieve a low carbon city. f. Expand operation to other communities.
BMA Responsibility	BMA: DOE Other Organization: DPW
Stakeholder	TGO, DEDE
Plan	medium term (2016-2018) and long term (2019-2023)
GHG Mitigation/	Do not have GHG mitigation on this measure.
Comment	Focus in "New city hall" to be low-carbon and smart office building by applying more renewable energy and energy conservation technologies.

2) Civil Categories (Residential/Commercial/Industries)

2-1 Residential part

2-1-1 Promotion of energy saving house

Title	"Promotion of low-carbon/energy saving detached house (Publicity of cost benefit from the viewpoint of LCC, backup exhibition, provide advertising spaces at BMA facilities"
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Low-carbon/energy saving detached house awards
BMA Responsibility	BMA: Support Other Organization: DEDE, TGO
Stakeholder	ASA EIT, TGBI ONEP
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 29.392 thousand CO_2-eq *(total 2-1-1 measures)
Comment	Start from Energy Labeling& Design

Title	"Facility equipment introduction promotion of energy saving house (LED lights, energy-saving air conditioning system or hot‐water apparatus etc.)"
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Promotion of LED lights d. Promotion of energy-saving air conditioning system e. Promotion of energy-saving hot‐water apparatus
BMA Responsibility	BMA: Support Other Organization: DEDE, EGAT
Stakeholder	MEA, EPPO, MoEn, ASA, EIT, TISI, TGO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 29.392 thousand CO_2-eq *(total 2-1-1 measures)
Comment	Campaign for LED started from 2012 by EGAT

2-1-2 Promotion of energy saving repair work

Title	Publicity of cost benefit by repair work for energy saving
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE, EPPO
Stakeholder	ASA, EIT
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 19.595 thousand CO_2-eq *(total 2-1-2 measures)
Comment	Mass media promoting campaign started from 1996

Title	"Promotion of repair work for energy saving: insulation upgrade by double glazing, heat barrier film, renew air conditioning device (subsidy system etc.)"
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Subsidy for double glazing d. Subsidy for heat barrier film e. Subsidy for renew air conditioning device
BMA Responsibility	BMA: Support Other Organization: DEDE, EGAT
Stakeholder	EPPO, MoEn, MEA, MoE, TISI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 19.595 thousand CO_2-eq *(total 2-1-2 measures)
Comment	Promotion and labeling of glass, heat barrier film since 2010

2-1-3 Promotion of energy saving home appliances

Title	Purchase promotion of energy saving home electric appliances (air conditioning, fridge, TV etc.)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Promotion of energy saving air conditioning d. Promotion of energy saving fridge e. Promotion of energy saving TV
BMA Responsibility	BMA: Support Other Organization: DEDE, MoEn
Stakeholder	EGAT, MEA, EPPO, TISI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 19.686thousand CO_2-eq
Comment	One of measures of Ministry of energy 2008.

2-1-4 Promotion of energy saving action

Title	Promotion of better understanding of air conditioner maintenance (conduct free cleaning)"
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Promote better understanding of air conditioner maintenance d. Conduct free cleaning
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	JICA / Japan International Cooperation Agency DEDE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 59.057 thousand CO_2-eq
Comment	One of measures of Ministry of energy 2008. DEDE campaign in 2013

2-1-5 Others

Title	Promote solar panel installation)subsidy system or mediating installable roof("
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Promote solar panel installation d. Subsidy system or mediating installable roof
BMA Responsibility	BMA: Support Other Organization: DEDE, ERC
Stakeholder	EGAT, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 19.686 thousand CO_2-eq
Comment	Feed-in-tariff for Solar roof topped started in 2013

2-2 Commercial/Business part

2-2-1 Promotion of energy saving building

Title	Incentive for constructing/repairing saving energy building (Tax reduction, subsidy, zero-interest financial etc.)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Tax reduction d. Subsidy e. Zero-interest financial
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EPPO, MoEn, TCC
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 121.264 thousand CO_2-eq *(total 2-2-1 & 2-2-2 measures)
Comment	Performance & cost-based tax incentive program started for more than 10 years

2-2-2 Promotion of energy saving repair work for existing building

Title	Conducting energy saving inspection of public buildings
Description	a. Conduct energy saving inspection of public buildings b. Publicity of cost benefit c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EPPO, MoE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 121.264 thousand CO_2-eq *(total 2-2-1 & 2-2-2 measures)
Comment	Compulsory for Designated buildings according to ENCON Act since 1995

Title	"Promotion of ESCO business for existing buildings (Educate ESCO business, advertisement promotion support, subsidy system for energy saving diagnostic)"
Description	a. Promotion of ESCO business for existing buildings b. Educate ESCO business c. Advertisement promotion support d. Subsidy system for energy saving diagnostic e. Publicity of cost benefit f. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	TCC
Plan	short term (2013-2015)

GHG Mitigation	Accumulate 10 years = 121.264 thousand CO_2-eq *(total 2-2-1 & 2-2-2 measures)
Comment	ESCO fund program in Thailand started for more than five years

Title	"Promotion of repair work for energy saving: insulation upgrade by double glazing, heat barrier film, renew air conditioning device (subsidy system etc.)"
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Subsidy for double glazing d. Subsidy for heat barrier film e. Subsidy for renew air conditioning device
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	TCC, EPPO, MoEn, MEA, MoE, TISI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 121.264 thousand CO_2-eq *(total 2-2-1 & 2-2-2 measures)
Comment	Process improvement and major change equipment in energy intensive equipment have been common practices in Thailand since ENCON Act.

Title	"Publicity of cost benefit by Electricity Peak-Cut Introduction support for automatic control facility of Electricity Peak-Cut"
Description	a. Publicity of cost benefit by Electricity Peak-Cut b. Introduction support for automatic control facility of Electricity Peak-Cut c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: EGAT, ERC
Stakeholder	DEDE, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 121.264 thousand CO_2-eq *(total 2-2-1 & 2-2-2 measures)
Comment	Campaign for Peak cut applied during the Blackout avoidance in April 2014 in Southern region of Thailand

2-2-3 Promotion of energy saving action

Title	Promotion of saving energy activity (Publicity of cost benefit etc.)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE, EPPO
Stakeholder	TCC, MoE, EGAT, MEA, TCC, MoE, EGAT, MEA
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 363.791 thousand CO_2-eq *(total 2-2-3 & 2-2-4 measures)
Comment	Mass media promoting campaign started from 1996

Title	Raising preset cooling temperature at public buildings Turn off lightings during lunch break"
Description	a.
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EGAT, MEA, EPPO, MoEn, MoE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 363.791 thousand CO_2-eq *(total 2-2-3 & 2-2-4 measures)
Comment	Value engineering (VE) techniques with full energy saving consultant services have been applied in SMEs since 2001.

Title	Thorough power saving setting on PC or OA equipment
Description	a. Thorough power saving setting on PC or OA equipment

	b. Publicity of cost benefit c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EGAT, MEA, EPPO, MoEn, MoE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 363.791 thousand CO_2-eq *(total 2-2-3 & 2-2-4 measures)
Comment	Value engineering (VE) techniques with full energy saving consultant services have been applied in SMEs since 2001.

Title	Commendation for saving energy activity
Description	a. Commendation for saving energy activity b. Publicity of cost benefit c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	MEA, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 363.791 thousand CO_2-eq *(total 2-2-3 & 2-2-4 measures)
Comment	Thailand Energy Awards started from year 2000 and rewarded annually to various related categories.

2-2-4 Others

Title	Promoting solar panel installation"(subsidy system or mediating installable roof)
Description	a. Promote solar panel installation b. Subsidy system or mediating installable roof c. Publicity of cost benefit d. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE, ERC
Stakeholder	EGAT, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 363.791 thousand CO_2-eq *(total 2-2-3 & 2-2-4 measures)
Comment	Feed-in-tariff for Solar roof topped started in 2013

2-3 Industrial part

2-3-1 Promotion of energy saving factory

Title	Incentive for constructing/retrofitting saving energy factory (Tax reduction, subsidy, zero-interest financial etc.)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Tax reduction d. Subsidy e. Zero-interest financial
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EPPO, MoEn, FTI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 292.66 thousand CO_2-eq *(total 2-3-1 & 2-3-2 measures)
Comment	Performance & cost-based tax incentive program started for more than 10 years

2-3-2 Promotion of energy saving repair work for existing factory

Title	Conducting energy saving inspection of public factories
Description	a. Conduct energy saving inspection of public factories b. Publicity of cost benefit

	c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EPPO, MoE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 292.66 thousand CO_2-eq *(total 2-3-1 & 2-3-2 measures)
Comment	Compulsory for Designated factory according to ENCON Act since 1997

Title	Promotion of repair work for energy saving (subsidy system etc.)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Subsidy
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	FTI, EPPO, MoEn, MEA, MoE, TISI
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 292.66 thousand CO_2-eq *(total 2-3-1 & 2-3-2 measures)
Comment	Process improvement and major change equipment in energy intensive equipment have been common practices in Thailand since ENCON Act.

Title	Publicity of cost benefit by Electricity Peak-Cut Introduction support for automatic control facility of Electricity Peak-Cut"
Description	a. Publicity of cost benefit by Electricity Peak-Cut b. Introduction support for automatic control facility of Electricity Peak-Cut c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: EGAT, ERC
Stakeholder	DEDE, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 292.66 thousand CO_2-eq *(total 2-3-1 & 2-3-2 measures)
Comment	Campaign for Peak cut applied during the Blackout avoidance in April 2014 in Southern region of Thailand

2-3-3 Promotion of energy saving action

Title	Promotion activity for factory's energy saving technique (for SMEs)
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	EPPO, FTI, MoE
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 760.92thousand CO_2-eq *(total 2-3-3 measures)
Comment	Value engineering (VE) techniques with full energy saving consultant services have been applied in SMEs since 2001.

Title	Commendation for saving energy activity
Description	a. Commendation for saving energy activity b. Publicity of cost benefit c. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	MEA, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 760.92thousand CO_2-eq *(total 2-3-3 measures)
Comment	Thailand Energy Awards started from year 2000 and rewarded annually to various

	related categories.

2-3-4 Others

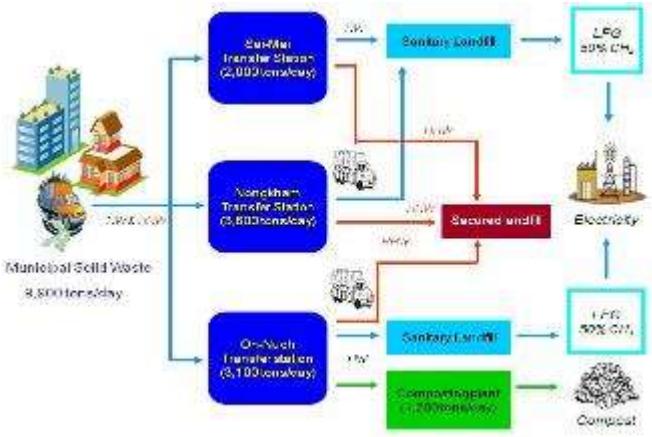
Title	Promotion of Solar Energy)subsidy system or mediating installable roof("
Description	a. Promote solar panel installation b. Subsidy system or mediating installable roof c. Publicity of cost benefit d. Backup exhibition and provide advertising spaces at BMA facilities
BMA Responsibility	BMA: Support Other Organization: DEDE, ERC
Stakeholder	EGAT, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 99.349thousand CO_2-eq *(total 2-3-4 measures)
Comment	Feed-in-tariff for Solar roof topped started in 2013

Title	Promotion of beneficial use of factory exhaust heat
Description	a. Publicity of cost benefit b. Backup exhibition and provide advertising spaces at BMA facilities c. Tax reduction d. Subsidy e. Zero-interest financial
BMA Responsibility	BMA: Support Other Organization: DEDE
Stakeholder	FTI, EPPO
Plan	short term (2013-2015)
GHG Mitigation	Accumulate 10 years = 99.349thousand CO_2-eq *(total 2-3-4 measures)
Comment	-

5-3 Mitigation measures for the Efficient Solid Waste Management and Wastewater Treatment Sector

(1) Overview of the measures

Waste and wastewater are sources of methane and CO_2 emissions as in landfills and waste transportation, and reduction of GHGs require the reduction of waste and wastewater amount generated. In order to do so, BMA endeavors to introduce upgraded technologies and facilities for waste management and wastewater treatment, and at the same time, promote the reduction of generated amount by separation of waste etc.



Solid Waste Management

Wastewater Management

Table 5-5 Comparison of GHG emission in future in different scenarios in 2020 in the waste and wastewater sector

Unit million t-CO2e

Sector	Year 2013	Year 2020		
	Current GHG Emission	Future GHG Emission under Business as Usual Scenario	Future GHG Emission under Bangkok Master Plan Implementation	Expected reduction/absorption amount (reduction rate against BAU)
Waste and wastewater	4.55	4.93	4.73	0.20 (-4.06%)

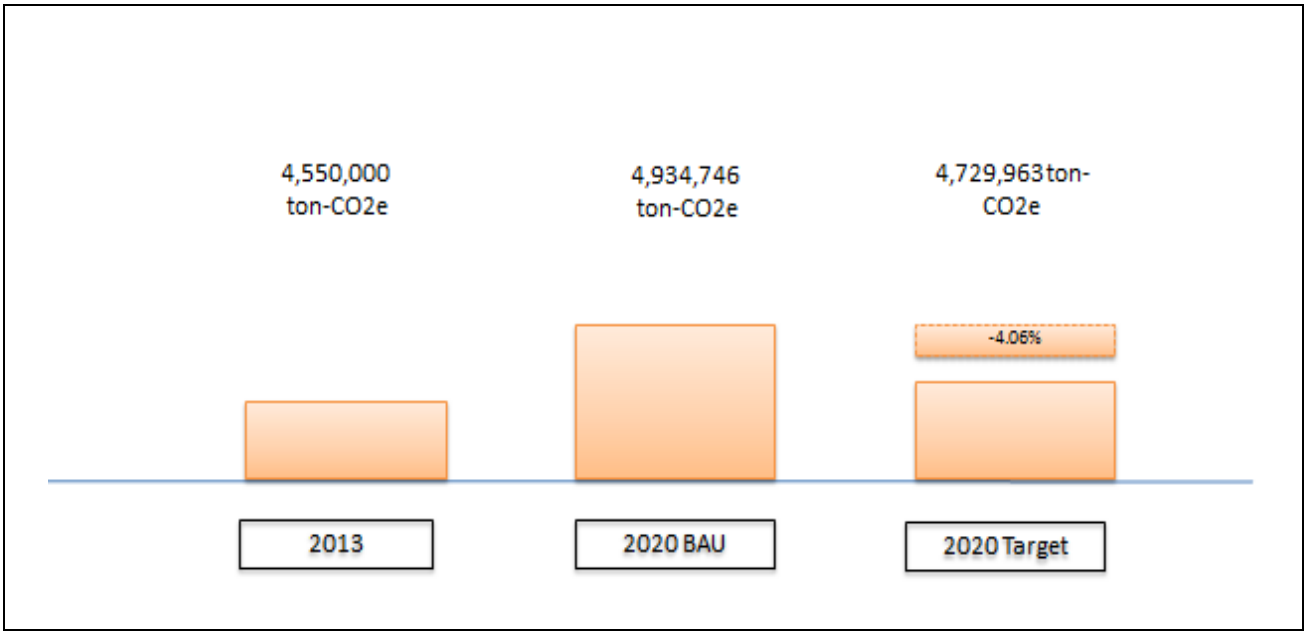


Figure 5-3 GHG emission in 2013 and BAU emission and mitigation targets in 2020 in the waste and wastewater sector

GHG emission in 2013

GHG emissions in 2013 are calculated based mostly on the actual activity data of 2013 related to waste management and wastewater treatment activities by BMA. Such data includes daily amount of municipal solid waste generated and volume of wastewater discharged in Bangkok, waste and wastewater composition, amount of electricity consumption by related plants and facilities, amount of fuel used for transportation, etc., many of which are taken from official statistical data or recorded data of 2013.

BAU emission in 2020

BAU emissions of 2020 are estimated based on the abovementioned 2013 GHG emissions data taking into consideration the BMA's future plans and policies related to waste management and wastewater treatment as well as expected population growth in Bangkok.

GHG emission in 2020 with mitigation actions implemented

Emissions in 2020 are calculated by deducting aggregated amount GHG emission reduction by all mitigation actions listed in the Master Plan from the above BAU emissions of 2020. Expected amount of GHG emission reduction from each mitigation measure is individually calculated using a suitable methodology.

All of the above calculation methodologies were selected with reference to the Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Following figure and table show an overview of the mitigation measures for the Efficient Solid Waste Management and Wastewater Treatment Sector.

Figure Categorization of mitigation measures according to basic flow of solid waste management [W: Waste]

Table 5-6 Mitigation measures for Solid Waste Management sub-sector

Category	Measure
1. Waste generation	1.1 Promoting participation on waste reduction and separation at source
	1.2 Reducing the amount of plastic waste
2. Waste collection and transportation	2.1 Improving fuel efficiency of waste collection and transportation system
3. Intermediate treatment	3.1 Promoting utilization of organic waste
	3.2 Constructing waste-to-energy incineration facility
	3.3 Constructing Waste segregation plant
4. Final disposal	4.1 Installing environment- friendly landfill system

Figure Categorization of mitigation measures according to basic flow of wastewater treatment [WW: Wastewater]

Table 5-7 Mitigation measures for the Wastewater Treatment sub-sector

Category	Measure
1. Wastewater generation	1.1 Promoting reduction of water usage at house
	1.2 Promoting collection of wastewater tariff
2. Wastewater collection	2.1 Feasibility study for construction of separated sewerage collection system
	2.2 Implementing separated sewerage collection system
	2.3 Constructing separated sewerage collection system
3. Wastewater treatment	3.1 Improving operation and equipment of existing WWTPs
	3.2 Constructing new energy efficient WWTPs
4. Sludge treatment	4.1 Promoting utilization of sludge
5. Water reuse	5.1 Promoting water reuse

(2) Details of the measures

Details of each measure in the previous table are described below.

1.1 Promotion of participation on waste reduction and separation at source

Title	1.1 Promotion of participation on waste reduction and separation at source
Details	a) Enhance public awareness and partnership on waste management through public relation and campaigns b) Develop waste management model in district office, BMA's school, BMA hall1&2, BMA's health center service and BMA offices c) Promote partnership with the private sector in the management of solid waste at source d) Consider establishing and reinforcing laws and regulations including incentive measures to accelerate waste reduction
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, district offices, community, schools, university, private sector
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	304 tCO_2-eq /year (2013) – 9,330 ton-CO2e /year (2023) (for mitigation measure b)

1.2 Reducing the amount of plastic waste

Title	1.2 Reducing the amount of plastic waste
Details	a) Encourage cloth bags and bio-packing use instead of plastic bags b) Promote plastic waste separation for recycling c) Promote manufactures and trader to reduce packaging and foam
BMA's Responsibility	BMA (Indirectly implemented)
Stakeholders	Dept. of Environment, district offices, community, private sector, scavenger
Implementation schedule	Mid to long term (2016-2023)
Estimated GHG emission reduction (average)	2,391 tCO_2-eq /year (a)

1.3 Consideration on establishing and reinforcing of laws and regulations including incentive measures to accelerate waste reduction and separation at source

(To be considered further during the implementation of the Master Plan)

2.1 Improving fuel efficiency of waste collection and transportation system

Title	2.1 Improving fuel efficiency of waste collection and transportation system
Details	a) Implement environmentally friendly trucks b) Improve waste collection and transportation routes c) Develop Eco-driver awards program
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, district offices, truck rental companies
Implementation schedule	Long term (2019-2023)
Estimated GHG emission reduction (average)	114 tCO_2-eq /year (b)

2.2 Promotion of the standard development of Green Junk Shops

(To be considered further during the implementation of the Master Plan)

3.1 Promotion of utilization of organic waste

Title	3.1 Promotion of utilization of organic waste
Details	a) Promote composting and utilization of organic waste, nightsoil, sludge and yard waste b) Construct composting plant with 600 tons/day at On-Nuch Transfer station c) Increase production of biogas in BMA's school, market, hotel, restaurant and community
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, private sector
Implementation schedule	Mid to long term(2016-2023)
Estimated GHG emission reduction (average)	5,567 tCO_2-eq /year (2015) – 38,517 ton-CO2e /year (2023) (a) 12,154 tCO_2-eq /year (2016) – 81,111 ton-CO2e /year (2023) (b) 12 tCO_2-eq /year (2013) – 37 ton-CO2e /year (2023) (c)

3.2 Constructing waste-to-energy incineration facility

Title	3.2 Constructing waste-to-energy incineration facility
Details	Construct waste-to-energy incinerator with 300 tons/day at Nong Khaem Transfer Station
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, private sector
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	31,364 tCO_2-eq /year (2015) – 65,691 ton-CO2e /year (2023)

3.3 Constructing Waste segregation Plant

Title	3.3 Constructing Waste segregation Plant
Details	Construct waste separation plant for recyclable wastes with 300 tons/day at On nut transfer station
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, private sector
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	-

4.1 Installing environment- friendly landfill system

Title	4.1 Installing environment- friendly landfill system
Details	a) Encourage methane collection and power generation from landfill b) Reduce GHG from landfill
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	Dept. of Environment, Private sector
Implementation schedule	Short to long term(2013-2023)
Estimated GHG emission reduction (average)	-

1.1 Promotion of reduction of water usage at house

Title	1.1 Promotion of reduction of water usage at house
Details	a) Promote use of water saving device b) Raise awareness of water saving
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Dept. of Environment, Sanitation Dept. of District Offices, Community, private sector (water saving devices manufacture, advertising), NGO, (private WWTP operators)
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	-

1.2 Promotion of collection of wastewater tariff

Title	1.2 Promotion of collection of wastewater tariff
Details	Prepare and implement the tariff collection
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Dept of Finance, Dept of Strategies and Evaluation Env, Sanitation Dept of District Office Community (service area) MWA (Metropolitan water Authority), NGO, private Sector
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	-

2.1 Analyzing feasibility of wastewater separate system

(To be considered further during the implementation of the Master Plan)

2.2 Expanding sewage area

Title	2.1 Expanding sewage area
Details	Rearrange existing sewage collection and improvement of BMA combined type sewage collection system and analyze feasibility of wastewater separation system
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Env, Sanitation Dept of District Offices, private sector (wastewater facilities construction manufacture), community
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	28,373 tCO_2-eq /year

2.3 Implementing separate collection system

Title	2.2 Implementing separate collection system
Details	a) Implement separate sewerage system pilot project at new urban residential/commercial area b) Implement separate Sewerage system pilot project at existing treatment area
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Dept. of Environment, Sanitation Dept of District Offices, community, private sector (establishments, manufactures, company, etc.)
Implementation schedule	Mid to long term (2016-2023)
Estimated GHG emission reduction (average)	-

3.1 Improving operation and equipment of existing WWTPs

Title	3.1 Improving operation and equipment of existing WWTPs
Details	a) Increase efficiency of wastewater treatment process b) Campaign regarding wastewater pollution resolution
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, academic and research institutions, private sector (WWTP operators)
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	151 tCO_2-eq /year (a)

3.2 Constructing new energy efficient WWTPs

Title	3.2 Constructing new energy efficient WWTPs
Details	a) Construct New Central wastewater treatment plants (WWTPs) 1. Minburi (10,000 m3/d) 2. Thonburi (160,000 m3/d) 3. Klongtoey (360,000 m3/d) 4. Nongbon (135,000 m3/d) b) Energy efficient improvement at new WWTPs c) Construct a new treatment system which can reduce sludge aeration from new WWTPs
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Ministry of Interior, Ministry of Finance, National Economic and Social Development Board
Implementation schedule	Long term (2019-2023)
Estimated GHG emission reduction (average)	434 tCO_2-eq /year (2018) – 28,849 tCO2e /year (2023) (a) 15 tCO_2-eq /year (2013) – 994 tCO2e /year (2023) (b) 4 tCO_2-eq /year (2013) – 11 tCO2e /year (2023) (c)

4.1 Promotion of utilization of sludge

Title	4.1 Promotion of utilization of sludge
Details	a) Promote sludge conversion to fertilizer b) Encourage energy creation by digestion gas c) Reduction of fuel by using sewage sludge as solid fuel
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, Public Parks Office, farmers, academic and research institutions, private contractors
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	797 tCO_2-eq /year (2013) – 2,387 tCO2e /year (2023) (a) 66 tCO_2-eq /year (2013) – 199 tCO2e /year (2023) (b) 66 tCO_2-eq /year (2013) – 199 tCO2e /year (2023) (c)

5.1 Promotion of water reuse

Title	5.1 Promotion of water reuse
Details	a) Increase quantity of treated wastewater use for agricultural and community application b) Reduction of heat exchange by using treated wastewater for cooling
BMA's Responsibility	BMA (Directly implemented)
Stakeholders	DDS, farmers, community, private sectors, academic and research institutions
Implementation schedule	Short to long term (2013-2023)
Estimated GHG emission reduction (average)	426 tCO_2-eq /year (a)

5-4 Mitigation measures in the Green Urban Planning Sector

(1) Overview of the measures

Green urban development provides many co-benefits of mitigation actions. By expanding green areas, it increases the amenity and attractiveness of the city. Also, measures such as green roof tops have additional benefits of helping the reduction of energy use. For this sector, BMA will make efforts in its parks, but it is also important that private land owners should participate in such actions.

Table 5-8 Comparison of GHG emission in future in different scenarios in 2020 in the green urban planning sector

Unit million t-CO2e

Sector	Year 2013	Year 2020		
	Current GHG Emission	Future GHG Emission under Business as Usual Scenario	Future GHG Emission under Bangkok Master Plan Implementation	Expected reduction/absorption amount (reduction rate against BAU)
Green urban planning	-0.045	-0.045	-0.049	-0.004(+8.89%)

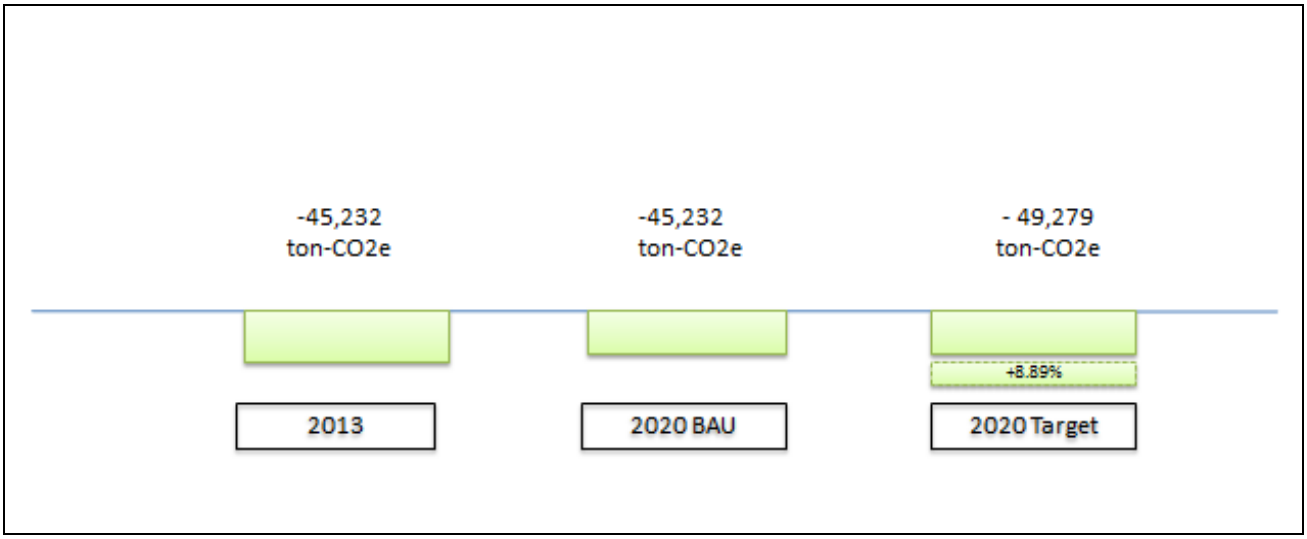


Figure 5-4 GHG emission in 2013 and BAU emission and mitigation targets in 2020 in the green urban planning sector

GHG emission in 2013

Current GHG absorption is calculated by multiplying activity data such as number of planted trees by absorption factor per tree. Activity data such as number of planted trees is measured by district office and is compiled as statistical data by public park office in department of environment in BMA.

BAU emission in 2020

In BAU setting, number of trees planted in BMA controlled area is assumed to be kept due to the proper maintenance by BMA. BAU value of CO2 absorption is similar to CO2 absorption of year 2013.

GHG emission in 2020 with mitigation actions implemented

Mitigation target of GHG absorption in year 2020 is estimated in 5 measures (Increasing new public parks, Increasing new green areas in public areas, Planting new trees along roadside areas, Increasing the Biotope Area Factor (BAF) in private lands, Mangrove reforestation) based on the implementing plan for green urban planning using the bottom up approach

Following table shows an overview of the mitigation measures for the green urban planning sector. These measures include measures which will be directly implemented by BMA.

Table 5-9 Mitigation measures in the green urban planning

category	No.	Measure
Quantitative measures	1	Increasing new green areas (Public parks)
	2	Increasing new green areas (Public area)
	3	Planting new trees along roadside areas
	4	Increasing the Biotope Area Factor(BAF) in private land
	5	Reforestation mangroves
Qualitative measures	6	Well-managing & maintaining of planted trees
	7	Rooftop greening and wall greening
	8	Public awareness campaign

(2) Details of the measures

Details of each measure in the previous table are described below.

1) Increasing new public parks in Bangkok

Title	Increasing new green areas (Public Parks)
Details	Constructf 15 new public parks: - 5 middle/large scale parks (200rais) in short/mid-term - 10 middle/large scale parks (450rais, 4-174 rais/park) in long term.
BMA's Responsibility	Directly implemented
Stakeholders	Implementation: Public Park Office of Environmental Department Maintenance: Public Park Office and 50 district offices Evaluation: Public park office, 50 district offices and Strategy and Evaluation Department
Implementation schedule	- 5 middle/large scale parks (200rais) in short/mid-term (2016-2018) - 10 middle/large scale parks (450rais) in long term (2019-2023).
Estimated GHG Absorption	165 tCO_2/year (5,000 trees planted) in short/mid-term (2016-2018) 371 tCO_2/year (11,250 trees planted) in long term (2019-2023) Data for estimation) -Number of trees per rai in park: 25 trees/rai. (source: averaged number of trees in 3 small scale parks such as Santiphap Park, Saranrom Park, Rommaneenart Park) -GHG absorption per rai : 0.825 tCO_2/rai/year = 25 trees/rai * 0.009 ton C/tree/year *44/12

2) Increasing new green areas in public areas

Title	Increasing new green areas in public areas
Details	1) Plant new young trees at public area (government office, public schools, public hospitals and temples): - Totally 2,000 rais in short/mid-term - Totally 3,500 rais in long term 2) It is based on "One Community : One Park" project and "One School : One Park" project. 3) Encourage district offices to build the pocket parks
BMA's Responsibility	Directly implemented
Stakeholders	Implementation : Public Park Office of Environmental Department Maintenance: Public park office and 50 district offices Evaluation: Public Park Office, 50 district offices and Strategy and Evaluation Department
Implementation schedule	- 2,000 rais in short/mid-term (2016-2018) - 3,500 rais in long term (2019-2023)
Estimated GHG Absorption	1,650 tCO_2/year (Short to mid-term)(50,000 tress will be planted) 2,888 tCO_2/year (Long term) (87,500 trees will be planted) Data for estimation: - Number of trees per rai : 25 trees/rai. (similar to the park case) - GHG absorption per rai : 0.825 tCO_2/rai/year

3) Planting new trees along roadside areas

Title	Planting new trees along roadside areas
Details	1) Plant 100 new trees per year along 40 roadsides that set back 2m. including increasing new young trees between existing trees based on the Open Space Plan of the Bangkok Comprehensive Plan 2013 2) Hold the competition on the concept of "Green Road" among district offices
BMA's Responsibility	Directly implemented
Stakeholders	Implementation : Public Park Office of Environmental Department Maintenance: Public Park Office and 50 district offices Evaluation: Public Park Office and 50 district offices, Strategy and Evaluation Department and City Planning Department
Implementation schedule	in short/mid-term (2016-2018) and long term(2019-2023)
Estimated GHG Absorption	13 tCO_2/year(Short to mid-term)(300 tress will be planted) 22 tCO_2/year(Long term) (500 trees will be planted Data for estimation: - Number of planted trees per year: 100 trees/year - GHG absorption per year : 4.4 tCO_2/year = 100 trees/year * 0.012 ton C/tree/year *44/12

4) Increasing the Biotope Area Factor (BAF) in private lands

Title	Increasing the Biotope Area Factor (BAF) in private land
Details	1) Increase green area by BAF law enforcement - totally 352 rais in short/mid-term (2016-2018) - totally 635 rais in long term (2019-2023) 2) Develop BAF database in GIS database and improving reporting system of BAF database in short/mid-term 3) All of permitted building construction will have BAF in their areas in long term - Promote new planting on private area expected to be implemented in the development project based on the Bangkok Comprehensive Plan. - Advertise the concept of Biotope Area Factor (BAF) to related stakeholders and citizens - Encourage the provision of Biotope Area Factor (BAF) in governmental buildings
BMA's Responsibility	Directly implemented
Stakeholders	Implementation: Environmental Department, City Planning Department, 50 district offices and Public Works Department Maintenance : 50 district offices, Public Works Department and City Planning Department Evaluation : 50 district office, Public Works Department and City Planning Department
Implementation schedule	in short/mid-term (2016-2018) and long term(2019-2023)
Estimated GHG Absorption	291 tCO_2/year(Short to mid-term) 523 tCO_2/year (Long term) Data for estimation:

	- Number of trees per rai: 25 trees/rai. (similar to park case) - GHG absorption per rai : 0.825 tCO_2/rai/year - Green area is estimated in the following process. 1. Statistical data of housing and building area during year 2005 to 2013 is collected. 2. Data is categorized into 5 groups using the number of stories; a) 1-4 stories, b) 5-7 stories, c) 8-10 stories, d) 11-20 stories, e) over 20stories 3. Floor area in year 2014 to 2023 is estimated using the average growth rate of each group. 4. OSR (Open space ratio) of each group is set; a) 1-4 stories = 10.0%, b) 5-7 stories = 6.5%, c) 8-10 stories = 4.5%, d) 11-20 stories = 4.0%, e) over 20stories = 3.0% 5. Area of OS(Open Space) is calculated by multiplying floor area by OSR 6. Finally, green area is estimated by multiplying Area of OS by 50%(BAF).

5) Mangrove reforestation

Title	Mangrove reforestation
Details	1) Plant mangrove trees: - totally 50 rais in short/mid-term (2016-2018) - totally 250 rais in long term (2019-2023) 2) Promote increase of new mangrove areas with cooperation with major companies 3) Promote the campaign for tree distribution(1 time/year, 10,000 trees/time) 4) Seeding, nursing or producing mangrove trees
BMA's Responsibility	Directly implemented
Stakeholders	Implementation: Public Park Office of Environmental Department, Bang Khun Thian district office and major companies Maintenance: Public Park Office and Bang Khun Thian district office Evaluation: Public Park Office and Bang Khun Thian district office
Implementation schedule	in short/mid-term (2016-2018) and long term(2019-2023)
Estimated GHG Absorption	138 tCO_2/year(Short to mid-term) 687 tCO_2/year(Long term) Data for estimation: - Number of trees per rai: 250 trees/rai. sourced by Department of Marine and Costal Resources -GHG absorption per rai : 0.75 ton C/rai/year

6) Well-managing and maintaining of planted trees

Title	Well-managing & maintaining of planted trees
Details	1) Maintain all of existing public parks and public areas (governmental offices, public schools, public hospitals, temples and mangrove areas) 2) Look after and maintaining planted trees in routine job done by Public Park Office 3) Train the involved staff on "how to correctly look after and maintain planted trees"

BMA's Responsibility	Directly implemented
Stakeholders	Implementation : Public Park Office of Environmental Department Maintenance: Public Park Office and 50 district offices Evaluation: Public Park Office and 50 district offices, Strategy and Evaluation Department
Implementation schedule	in short/mid-term (2016-2018) and long term (2019-2023)
Estimated GHG Absorption	-

7) Encouraging rooftop greening and wall greening

Title	Encouraging Rooftop greening and Wall greening
Details	Promoting rooftop greening and wall greening on government and private areas, with pilot project on "Rooftop and wall greening " by Public Parks Office - Studying the appropriate model for good practice and the appropriate standard related to design guideline and standard drawing - Rooftop greening and wall greening will be set as incentive measures in the Bangkok Comprehensive Plan in long term
BMA's Responsibility	Directly implemented
Stakeholders	Implementation: Public park office, City Planning Department Maintenance: Public park office, City Planning Department Evaluation: Public park office, City Planning Department, Strategy and evaluation department
Implementation schedule	in long term (2019-2023)
Estimated GHG Absorption	-

8) Raising public awareness in increasing green areas

Title	Public awareness campaign
Details	Promoting the public awareness campaign to children, student, and citizens with tree distribution(300,000 trees/year) to citizens in event - Recruiting the volunteers (50 persons/year) for looking after, preserving and maintaining the green area, and training them. - Encouraging the citizens, communities and land owners to preserve any Huge Trees in their areas
BMA's Responsibility	Directly implemented
Stakeholders	Implementation: Public Park Office of Environmental Department Maintenance: Public Park Office of Environmental Department and 50 district offices Evaluation: Public Park Office of Environmental Department, 50 district offices and Strategy and evaluation department
Implementation schedule	in short/mid-term (2016-2018) and long term(2019-2023)
Estimated GHG Absorption	-

6. Current and Future Adaptation

Given the fact that Bangkok is situated in a mega delta, one of the most vulnerable areas, and economic and social lives of the countries as well as the world heavily rely on the Metropolis, it is a pressing concern to address this adaptation needs. Measures to address major issues such as disasters related to climate change turned out to be matters of priority.

In this Master Plan, three issues are identified as priority, namely, (1) Flood, (2) Coastal erosion, and (3) Drought/saltwater intrusion. Ongoing and required adaptation measures are reviewed and analyzed through discussion of Adaptation Task Force members. These measures are listed in short, mid, and long-term timeframe, together with responsibilities of divisions and other stakeholders, to work in coordination and collaboration.

6-1 Current status of climate change negative impacts and future trend

(1) Flood

(a) Location of Bangkok is susceptible to flood and land subsidence

- Present problem
  - Bangkok is situated on the floodplains of the Chao Phraya River and subjected to the tides of the sea which results in trapped water from rainfall (flooding) and overflow from the river (BMA, 2013). In addition, withdrawal of groundwater is also a cause of land subsidence in the area.
  - Bangkok has a low elevation and is situated at the edge of the Chao Phraya River, in the past it was subjected to seasonal flooding; the monsoon season brings heavy rainfall thus management of the water becomes difficult and costly. Bangkok is also at the Chao Phraya River's delta and has a myriad of tributaries flowing through making it more susceptible to harsher waves during the rainy season and overflow of the river causing flooding (WWF, 2014).
  - The average land subsidence was 0.97 cm/year over 2002-2007 (World Bank, 2009)*[7].
  - Location of Bangkok cannot avoid the flow of water from upstream area and BMA also has no authority in managing water from upstream**[8].

- Current action
  - The World Bank, the Asia Development Bank, and the Japan Bank of International Cooperation have evaluated the effects of global warming by simulating it using mathematical hydrology (World Bank, 2009).
  - Information about flooding, from the past, was collected and analyzed and predicted flooding problems and finding solutions to flooding management in the city area using non-structural and structural methods (BMA, 2013).
  - The research team's proposal on policies and defensive measures

    1) All policies and problems that are caused by global warming should be included in all development plans

    2) The procedural options should be based on the analysis of the surveyed environment so that it can lead to the improvement of other measures and procedures (World Bank, 2009).

[7] "*" denotes information extracted by JICA Expert Team

[8] "**" denotes information obtained from Adaptation Task Force

- Plans developed to prevent and mitigate flooding and landslides are as follows:

  - Prevention

  1) Prevention and lessening of impact: Gathering of information to perform a risk analysis and developing a suitable procedural guideline

  2) Preparations: Setting up training centers for volunteers and increase the community's preparedness.

  - Response (Management during Emergencies)

  1) Setting up a control center and following the guidelines

  2) The control center delegates and distributes the received donations to help mitigate the situation

  3) Identification and proof of deceased (if casualties occur).

  - Aftermath (Recovery)

  1) Damage assessment and needs assessment

  2) Arrangement for temporary relief centers and care centers for physical and mental health

  3) Following the procedures dealing with casualties

  4) Provincial Public Health Offices

  5) Beginning recovery of physical and mental treatments

  6) Recovery and restoration of the communal environmental systems

  7) Restoration of building foundations

  8) Proceeding with basic damage restorations

  9) Studying and reviewing of incident to use to improve upon (BMA, 2013).

- The BMA installed a prevention system that protects and controls flood waters and increases the capabilities of the strategically placed water detention system to contain the overflow of canals and rivers during the rainy season and hot season (WWF, 2014).
- Increased the capabilities of the water gate to prevent saline water invasion and control floodwaters (WWF, 2014).
- The Thai government has found and arranged for rice to be stored at high elevations, to be protected from extreme flooding and droughts, so that there are no food shortages (WWF, 2014).
- Training different communities in basic preparedness for emergencies and preparing them for extreme storm surges (WWF, 2014).
- Protection and conservation of Mangrove forests (WWF, 2014).

- Future problem
  - Mean basin rainfall (June-August) for Bangkok would increase by 2-3% by 2050 (World Bank, 2009)*.
  - Sea level is expected to rise by 12.3 cm from 2009-2050 (World Bank, 2009)*.
  - Within 2050, land subsidence will increase from 0.05 m to 0.30 m due to these reasons:

    - Global warming in Bangkok and its perimeter have caused a temperature increase of 1.2-1.9 degrees centigrade

    - Problems due to storm movement

- Building foundations have been changed (World Bank, 2009).

- The change marks about a 30% increase in the flood-prone area between 2008 and 2050 (World Bank, 2009)*.
- Within 2050 floodable areas, they are at the western side of Bangkok, will increase to a larger area and flooding will impact approximately 1 million inhabitants within the Bangkok and Samut Prakan area. 1 of 8 of the effected live in the crowded areas and 1 of 3 affected people will be surrounded by water >0.5 m for at least 1 week. High risk areas include the Bang Khun Thian area (Bangkok) and the Phra Samut Chedi area (Samut Prakan) (World Bank, 2009).
- Under current climate and infrastructure conditions, economic damage from flooding (at current prices) would be 35 billion baht which might rise to 148 billion baht in 2050. However, 70% of the cost in 2050 would be attributed to land subsidence alone (World Bank, 2009)*.
- The commercial and industrial sectors will lose considerable income due to business suspension during flooding. It is estimated that value-added income losses will be 22 and 10 billion baht in commercial and industrial sectors respectively (World Bank, 2009)*.
- In 50 years the seawater level will rise by 50 and then 100 cm resulting in loss of occupational land and will cause the GDP (Gross Domestic Product) to fall by 0.36% and 0.69%, respectively, (300-600 million US dollars) each year; the most loss in the agriculture sector of Bangkok with a total monetary loss 38% and 61% (WWF, 2014).

● Action needed

- Reviewing the existing system and prevention plans for flooding levels of the ground where subsidence occur in Bangkok (World Bank, 2009).
- Campaigning and raising awareness about climate change (World Bank, 2009).
- Gathering all land usage plans and city plans to consider together**.
- Cooperation with neighboring provinces to control the use of ground water**.
- Capacity building for human resource in parallel with the development of prevention system management and other equipment required**.
- Facilitate the development of practices, measures, and regulations that is needed for flood prevention to reduce impacts of flood**.

(b) Ineffectiveness of government's countermeasure

● Present problem

- The government sector is inadequately prepared for an efficient response; they are not taking into account global warming and they are not informed enough to develop proper plans for improvement (World Bank, 2009).
- Low enforcement of existing law & regulations. Ex. City planning, zoning of land use (BMA, 2013).
- Lack of cooperation between government agency and stakeholders does not allow effective implementation of countermeasures**.
- Poor integration of water resource management at the national level → at least before the 2011 flood.. After

the flood, integrated national water resource management was proposed that will integrated upstream and downstream management together (BMA, 2013).

- Drainage canal has no clear boundary; all boundaries setting and construction of flood prevention system require cooperation from adjacent land owners to verify their property's boundary. In practice, local citizens' cooperation in this matter is low; therefore the boundary of public drainage canal is hardly verified**.
- There are also drainage canals and roads belonging to other government agencies that pass through BMA territory, therefore, BMA has no authority in the maintenance of such canals and roads. If the responsible agencies do not give BMA the right to carry out the maintenance activities (Ex. Removal of aquatic plant, restoration of canal's bank) BMA cannot do anything**.
- The bottleneck of drainage system due to other constructions such as road and rail system construction that block the original drainage system**.
- Infrastructure systems of other government agencies (such as electricity, telephone, water supply, express way, and sky train) also block the construction and improvement of flood prevention system**.

- Current action
  - The World Bank, the Asia Development Bank, and the Japan Bank of International Cooperation have evaluated the effects of global warming by simulating it using mathematical hydrology (World Bank, 2009).
  - All policies and problems caused by climate change should be included in all improvement plans**.

- Future problem
  - Existing and planned flood protection infrastructure (dikes and pumps) may be inadequate to save the area (World Bank, 2009)*.
  - Conflicts between affected communities will continue to exist if there is no public campaigning to raise awareness on disaster preparedness**.
  - Construction of flood barrier in the northern part of Bangkok will induce more flood in the lower BMA due to the fact that all water are diverted to Chao Phraya River directly**.

- Action needed
  - Mainstreaming climate change in national and sector development planning (World Bank, 2009)*.
  - Policy makers and city planners should take into consideration the problems that can occur in the future. Analysis of climate change effects that builds foundations is taken as first priority for continuous improvement for a sustainable city in the future (World Bank, 2009).
  - Some issues must be addressed as a matter of urgency such as inadequacy of the existing and planned flood protection dikes and drainage system in the future (World Bank, 2009)*.
  - Promote involvement of private sectors and industry that situated in flood risk area to develop disaster preparedness plan and adaptation measures**.
  - Improve Bangkok city planning to facilitate the implementation of flood prevention measures, zoning within the city or the setting of water catchment area, for instance**.

- Develop disaster preparedness plan for vulnerable communities in order to facilitate cooperation between government agency and local citizens in flood warning**.
- Establish Flood cooperation center before the disaster takes place**.
- Organize meeting, seminar and training for communities in the vulnerable areas in order to raise awareness for disaster preparedness**.
- Training and practice the action plan for disaster management for all levels involved especially the local government officers and communities**.

(c) Land use pattern changes

- Present problem
  - Land use pattern changes
    - Upper part of Bangkok → flood plain area/ water drainage and water catchment areas were changed into industrial and residential zones which result in the blockage of water flow and decreasing of retention areas**.
    - Lower part of Bangkok → land area were converted into aquaculture farm (after the owner sold soil in that area), industrial and residential areas**.
    - Mangrove forests were removed in order to convert the land into aquaculture farm**.
  - Flooding has caused shrimp and aquatic animal farms to have to be relocated while mangrove forests and the coast are damaged from the impact of waves (Rawadee and Areeya, 2009).
  - The BMA has not yet taken into account the potential impacts of climate change (Rawadee and Areeya, 2009)*.
  - Local citizens illegally construct their houses or other properties along the Chao Phraya River bank as well as other public drainage canals. This prevents the development of flood prevention and drainage systems. The BMA alone does not have complete authority to relocate or remove such properties**.

- Current action
  - Implementation by households in Bang Khun Thian area includes construction of new water gate and dikes, and relocation of the inhabitants of the mentioned area (Rawadee and Areeya, 2009)*.
  - The BMA and the Fishery Department have provided assistance to households affected by providing sandbags and flooding compensation (Rawadee and Areeya, 2009)*.

- Future problem
  - The worst scenario indicates approximately 600 meters inland from coastline in the upper Gulf of Thailand are estimated to be inundated in 2030 sea level rise (Rawadee and Areeya, 2009)*.
  - It is expected that the frequency of cyclone event will double compared with that in the past 30 years indicating more storm surges (Snidvongs, 2007; Rawadee and Areeya, 2009)*.
  - The annual adaptation cost is approximately US$ 3,130 per household, which is equal to 23 percent of the average household income (Rawadee and Areeya, 2009)*.

- Due to low educational attainment and lack of other knowledge skills, farmers could not shift to other occupations (Rawadee and Areeya, 2009)*.

- Action needed
  - A thorough study on the impacts of climate change in order for the concerned public agencies to prepare proper solutions to the problem (Rawadee and Areeya, 2009)*.
  - The cooperation of the national government, local governments, and the public is necessary to address the problem of coastal flooding (Rawadee and Areeya, 2009)*.

(d) Flood caused by natural and physical reasons

- Present problem
  - Floods are natural disasters that occur more frequently than other disasters; in the past 30 years the amount of floods in Asia make up 40% of all flooding that occurs in the world, with 90% of the world's flooding victims living in Asia. The floods not only directly damage the economy but also affect other areas of life in the long run, such as, sicknesses from waterborne diseases that come with the flood and food and clean water shortages which all interfere with the development of the country in the long run (Abhas et al., 2012).
  - Naturally occurring causes for the Bangkok floods includes:
    - Precipitation,
    - Agricultural water,
    - Northern waters,
    - Tidal waves,
    - Water level of Chao Phraya River in October and November, and
    - Others such as La Nina and sea level rise (BMA, 2013).
  - Manmade mistakes for the Bangkok flood include:
    - Poor implementation of city planning
    - Insufficient drainage system from rapid expansion of the community
    - Land use change
    - Intrusion into ditches
    - Land subsidence (BMA, 2013).
  - There are 6 main causes for the flooding problems in Bangkok and its eastern boundary. They are:
    1) Northern waters overflowing the banks of the Chao Phraya River as in 1973, 1976, 1980, 1983, 1995, 1996, 2002, 2006, 2010 the latest being in 2011
    2) Water from the north and the east
    3) Torrential downpours (>90mm/day)
    4) High tide
    5) Uncontrollable development of the land
    6) Intrusion and lack of maintenance of canals (BMA, 2013).
  - Natural cause – increasing rain water, changing of raining patterns from light shower for long time to heavy

rain in short period of time. BMA cannot drain the water fast enough resulted in flash flood**.

- Current action
  - Gathering of information about causes and factors of flooding in Bangkok (BMA, 2013).
  - The most effective method of flood management is the integration of structural measures and non-structural measures; this can be building of floodways which can help during the initial stages of flooding but costs a lot , for structural measures, while for non-structural measures include warning systems, organizing more urban greening areas, and planning land usage that avoids flooding**.
  - There should be a balance of using structural and non-structural measures**.
  - Since the massive flooding in 1983 the BMA and other agencies involved have proceeded in protecting and preventing flooding in Bangkok's eastern side, covering an area of approximately 650 m^2, following the royal idea for a dike through the Chao Phraya River. Then aid was given by the Japanese government through the JICA, who helped research and plan the appropriate flood prevention system and the drainage system of the east side of Bangkok in 1984 and the project was completed in 1986 (BMA, 2013).
  - The BMA proceeded in surveying, designing, and developing a master plan for the drainage system in the Sai Mai district and parts of the Bang Khen, Meenburi, Khan Na Yao, and Khlong Sam Wa districts from 2012-2013 (BMA, 2013).
  - Groundwater preservation charge is successfully applied to overcome groundwater extraction problem as groundwater management to prevent land subsidence (Abhas et al., 2012)*.
  - Annual report of Bangkok Flood Prevention Action Plan (2013) indicates:

    1. Management of Flood Areas in Bangkok

    - Using of sub-polder system to release floods in low area
    - Within the sub-polder building a drainage system (BMA, 2013)

    2. Prevention and solving of flooding in Bangkok

    - Providing dike and flood protection facilities for the prevention against overflow of the Chao Phraya River from high discharge from the north and tidal waves.
    - The dike for flood overflow on the eastern side of Bangkok (in accordance with the royal idea) starting building in 1984
    - The dike preventing overflow from the Chao Phraya River, Klong Bangkok Noi, and the Mahasawat which was started in 1996
    - The Drainage System for flooding around the Bangkok area should be capable of withstanding of rainfall of 60 mm/hour and improved to withstand 100 mm/hour within 2023 (BMA, 2013).

- Future problem
  - Mean basin rainfall (June-August) for Bangkok would increase by 2-3% by 2050 (World Bank, 2009)*.
  - Sea level is expected to rise by 12.3 cm from 2009-2050 (World Bank, 2009)*.
  - Within 2050, land subsidence will increase from 0.05 m to 0.30 m (World Bank, 2009).

- Where land subsidence problem cannot be sufficiently solved, it is in highest concern because flood prevention and drainage systems recently planned for will be insufficient or less effective in future (BMA, 2013)*.

- Action needed
  - Twelve key principles for integrated urban flood risk management includes:
    - Every flood risk scenario is different: there is no flood management blueprint
    - Designs for flood management must be able to cope with a changing and uncertain future
    - Rapid urbanization requires the integration of flood risk management into regular urban planning and governance
    - An integrated strategy requires the use of both structural and non-structural measures and good metrics for "getting the balance right"
    - Heavily engineered structural measures can transfer risk upstream and downstream
    - It is impossible to entirely eliminate the risk from flooding
    - Many flood management measures have multiple co-benefits over and above their management role
    - It is important to consider the wider social and ecological consequences of flood management spending
    - Clarity of responsibility for constructing and running flood risk programs is critical,
    - Implementing flood risk management measures requires multi-stakeholder cooperation
    - Continuous communication to raise awareness and reinforce preparedness is necessary
    - Plan to recover quickly after flooding and use the recovery to build capacity (Abhas, et al., 2012)*.

(e) Damages from 2011 flood

- Present problem
  - Bangkok's rapid growth causes it to outgrow the city plans and drainage systems and overuses of land and public utilities, which combined with land subsidence cause the massive flooding in 2011 and damaged physical assets and building foundations (BMA, 2013).
  - From surveys collected from 300 people as a sample of the population in the Khlong Luang and Nong Sua district, who were victims of the 2011 floods; it was found that the majority of the people knew about the flash flood, however, they did not expect it to flood that much, that the flood would be higher than 1.5 m, or that it would continue to flood more than a month (Sresunt et al. 2012).
  - Lack of asset security during flood leads flood-victim not to leave their house (Sresunt et al., 2012)*.
  - It was found that assistance among community members in the area was relatively low (Sresunt et al., 2012)*.
  - 2011 flood caused damage including:
    1) Damages of assets in households as well as agricultural products
    2) Social damages which includes stress within the household, loss of pets, loss of communications for contacting family members, and quarrelling amongst family members
    3) Damages towards health are the stress and worry due to flooding, injuries or illnesses that come with the flood waters, and people with chronic diseases suffer more severely (Sresunt et al., 2012).
  - Flood in 2011 caused damage to both infrastructures and public & private properties (BMA, 2013).

- Aiding system for flood-victims is still insufficient especially for poor people (Sresunt et al., 2012)*.

- Current action
  - Studying how to coexist with water for victims of the flooding and The objectives are:
    - Studying of the relationship between foundations of the household and how violent flood waters affect it
    - Looking at the response of the victims to the floods
    - Reviewing and analyzing the effectiveness of the community's management and aid for its own people (Sresunt et al., 2012).
  - Plans on coexisting with water if you become a victim of the flood; for example, building houses that can withstand a long period of flooding, applications of materials and equipment that are suitable for use during floods, and an effective warning system that gives enough time to prepare before the incident (Sresunt et al., 2012).
  - After the 2011 massive flood, the government created two committees which are the Strategic Committee for Reconstruction and Future Development (SCRFD) formulating strategies for the restoration of the country and the Strategic Committee for Water Resources Management (SCWRM) formulating strategies to prevent and solving floods. Therefore, later is for a continuation in the management of water resources of the country (BMA, 2013).
  - After the 2011 massive flood, BMA has formulated strategies in flood restoration, protection and prevention by developing guidelines to ensure readiness and course of action in 2 phases
    1) The immediate phase and
    2) The long term phase that is planned in accordance with the water management of plans of the government (BMA, 2013).
  - Gathering of information about causes and factors of flooding in Bangkok (BMA, 2013).
  - The massive flooding in 2011 invoked the population, government agencies and private agencies to prepare for the flooding in 2012; floodways were made and plans following the proposed plans for 2012 helped make the control and management effective (BMA, 2013).
  - From the data compiled from 2011 flood, action plan, flood prevention plan, and flood rescue plan were developed (BMA, 2013).

- Future problem
  - With current flood management measures, the larger area at the west side of BMA has high risk to be flooded and may be inundated for a period of 1 month in 2050 (BMA, 2013).
  - Since the building and improvement flood prevention systems cost a lot of money and will take no less than 10 years to finish. There will be funding and continuation problems (BMA, 2013).
  - Severe flood (like the one in 2011) that may happen in the future will create conflicts between citizens inside and outside of the flood barriers if the integration of water management system does not exist**.

- Action needed

- Policymakers should increase their understanding of the causes and risks of flooding in the city, so that they can efficiently control and manage the problems in the present and future, since the rapid expansion of the city forces the integration of the analysis of flooding risks into city planning (World Bank, 2009).
- Reviewing the system that deals with flooding in the Bangkok area (World Bank, 2009).
- Giving training and education to increase the understanding of floods (Sresunt et al., 2012).
- Changing behavior and actions towards problems relating to water and coexisting with water (Sresunt et al., 2012).
- Before any disastrous events there should be warnings and clear instructions on the actions that need to be taken; warnings made through a media center isn't as effective as warnings from the local leader, relatives, and people living in the area, who can assess the situation and determine which precise action to take; this encourages more participation from the people to help each other which is more effective than having a third party interfere (Sresunt et al., 2012).
- There should be an overseeing third party that is formed specifically for policy making and arranging budgets for the purpose of this project and they will announce their progress for the public to ensure progress (BMA, 2013).
- Integration of the analysis of flooding risks in city planning (Sresunt et al., 2012).
- Enforcing a mandatory law that prevents the expansion of houses and communities that invade waterways (Sresunt et al., 2012).
- This can be solved by
    1) Digging new drains and cleaning old ones
    2) Installation an electrical water pumps
    3) Increase the efficiency of the water pumping station
    4) Installation of devices for measuring the flow rate of the river and drainage system. (BMA, 2013)
- Considering human right and social equity to all flood victim (Sresunt et al., 2012)*.
- Reliable warning systems are key core to mitigate flood impacts, and leader of community should be active to disseminate flood information to their community members (Sresunt et al., 2012)*.
- Giving training and education to increase the understanding of floods (Sresunt et al., 2012).
- Adding defensive measures to prevent flooding in area communal and household areas to lessen damage done to assets and the economy (Sresunt et al., 2012).
- Revise law and regulations if needed as well as to improve the enforcement level (Sresunt et al., 2012).
- Reviewing overall system and prevention for flooding in the city and integrating it with other systems. (BMA, 2013).
- Compensation for affected household should reflect the real damage caused by flood**.

(f) Damages from public hazards

- Present problem
    - The effects of public hazards damage lives and business in the country but its issues are never properly brought up in national level discussions or in policy making and arranging a budget for development (DDPM, 2013)

- Current action
  - Studying the thorough process and procedures that are important to mitigating the effects of natural disasters especially against flooding in the city. Learning as a community to help build a stronger more prepared community and to increase adaptability to lessen damages caused by public hazards (DDPM, 2013).
  - There is the procedural guidelines for the structural method such as construction of building and transportation routes resistant to public hazards, strengthening of river banks, growing of tree and shrubs, building of dams and water retention/detention systems, waterways, irrigation ways, and dikes, strengthening areas at the base of the mountain and expansion of the waterways (DDPM, 2013).
  - There is the procedural guidelines for the non-structural method such as setting up an agency or law that supports the building up an effective structure, and training and teaching of people involved about the skills needed to make design and construct an effective structure that is standardized and is suitable for the environment (DDPM, 2013).

- Future problem

  (No information)

- Action needed
  - Creating a procedural guideline for the mitigation of public hazards, for the prevention, response, and aftermath, all the way through to the increase of understanding of public hazards and the development of hyper relations of both the good and bad (BMA, 2013).
  - Increasing in education and raising awareness towards social responsibilities concerning public hazards (BMA, 2013).
  - Arranging of information, about the risks and prevention of floods, to be distributed more efficiently for the population that lives in high risk areas, whether it be through social media or broadcasting the news online to increase awareness (BMA, 2013).

(2) Coastal erosion

(a) Erosion continuously increasing

- Present problem
  - Cause of coastal erosion in Bang Khun Thian includes:
    - Use of groundwater leading to land subsidence,
    - Decrease in sediment transport in the Chao Phraya River due to dams blocking the sediment flow,
    - The growing and raising of aquatic animals and drilling of wells,
    - Destruction of mangrove forests,
    - Coastal currents,
    - Large waves in the monsoons, and
    - Seawater levels (BMA, 2014).

- The Bang Khun Thian coast has eroded a total of approximately 800-1,000 m with a rate of 1.4-4.5 m/year, the receding shorelines are caused by 1) decrease in sediments in the Chao Phraya River due to dams that block the sediment flow 2) Large waves that occur during the monsoons 3) Coastal currents 4) The subsidence of the sea floor (BMA, 2014).
- From the analysis of aerial surveilance images, it was found that the coastal erosion around the Bang Khun Thian area has dramatically increased. From 1952-1991 the sea has eroded the coast by 7-12m/year at 8 different points, especially during 1987-1991 where the rate of erosion has increased to 33.1m/year (Ittaro, 2001).
- The coast at Bang Khun Thian has suffered 500 m of coastal erosion or equivalent to losing 400 hectare in the past 30 years especially at the estuary (BMA, 2002).
- From the analysis of aerial surveillance images, it was discovered that there is a tendency for coastal erosion of the Bang Khun Thian front which has significantly shown changes (Winterwerp et al., 2005).
- 2 sub-districts which are village number 9 and 10 in the district of Tha Kham in Bang Khun Thian area, suffered directly as a result of coastal erosion in 2005 which resulted in the impacted 382 households and 327 households, respectively (BMA, 2006).
- 30 spots along the coast, in the provinces of Samut Sakhon, Samut Prakan, and Bangkok (Bang Khun Thian), suffer from extreme coastal erosion (Jarupongsakul, 2006).
- Chulalongkorn University has conducted a research on coastal erosion at the Gulf of Thailand and the Andaman Sea and concluded that there was an 11% erosion in the Gulf of Thailand and 2% erosion in the Andaman Sea where the erosion rate exceeded 5m/year which is an estimate of 156 million US dollars each year (World Bank, 2006).
- The Bang Khun Thian seafront is approximately 5 km long and has extensively suffered erosion damages over the past 28 years, which totals to more than 800 m of land**.
- Ban Khun Samutchin village is located in a coastal erosion hot spot. Over the past 28 years, erosion and land subsidence have decreased the village shoreline by more than one kilometer (World Bank, 2006)*.

- Current action
  - The information and effects of coastal erosion were studied and analyzed by Ittaro (2001), BMA (2002 and 2006), Winterwerp et al., (2005), Jarupongsakul (2006), and Chulalongkorn University.
  - Rawadee, J and Areeya, M. analyzed landmarks in the Bang Khun Thian area and discovered that productive land areas along the coast has decreased. (Rawadee, J and Areeya, M., 2009).
  - BMA has implemented a variety of measures to mitigate coastal erosion problems as follows (BMA, 2014):
    - In 1991, the BMA placed rocks along the coast with a total length of 80 m,
    - In 1993, The BMA added more rocks along the coast with a total length of 4,320 m,
    - In 1995, the BMA added extension to the wall to a width of 6 m, height of 2 m and a total length of 5,020 m (presently the wall is beyond repair and not in use),
    - In 2008, the community in the Bang Khun Thian area built bamboo wave breakers a total length of 900 m,

- In 2009, the BMA built 1st length of bamboo wave breakers a total length of 4,190 m,
- In 2010, the BMA continued on building bamboo wave breakers with length of 4,900 m,
- In 2012, the 3rd installment of the bamboo wave breakers with a length of 4,200 m.
- From 2005-2007, the BMA assigned the Department of City Planning to continue the policy to prevent erosion and repair damages caused by coastal erosion in Bang Khun Thian area (BMA, 2014).

- Ban Khun Samutchin is rallying to save its temple, Wat Khun Samut Taraward using their personal savings to save the temple (World Bank, 2006)*.

- Future problem
  - The coast at Bang Khun Thian has suffered from coastal erosion and it is evident that the rate of erosion is increasing (Ittaro, 2001)
  - Jarupongsakul (2006) estimates that the sea level at the upper Gulf of Thailand would rise to 10-100 cm in next 50 years. When effect of land subsidence is factored in, about 6-8 km inland from the current shoreline will be inundated in the next 100 years (Rawadee and Areeya, 2009)*.
  - Without comprehensive action and support from the national government, Ban Khun Samutchin and other villages like it will keep moving until no land and no village remains (World Bank, 2006)*.
  - BMA has not yet taken into account in its coastal protection plan the potential impacts due to climate change particularly sea level rise (Rawadee and Areeya, 2009)*.
  - Climate change leads to more frequent and more severe storm that speed up the erosion**.

- Action needed
  - To develop a plan for prevention and be familiar with early signs of coastal erosion (Ittaro, 2001).
  - To develop a plan and know about the early signs of coastal erosion (Jarupongsakul, 2006).
  - To develop a plan and increase knowledge of coastal erosion (Rawadee and Areeya, 2009).
  - Restoration of the intertidal area through entire or part of current coastline, and by scarifying part of the fish and shrimp ponds (Winterwerp et al., 2005)*.
  - Use of permeable groynes perpendicular to the coast to protect the coastal area from lateral transport of sediment (Winterwerp et al., 2005)*.
  - An internal mangrove belt of about 300-500 m is required to re-initiate sedimentation process, hence to restore a favourable habit for mangrove forest (Winterwerp et al., 2005)*.
  - For the protection structure to be effective in protecting the shore, it should be planned for the whole upper Gulf of Thailand. Thus, the cooperation of the national government, local governments, and the public is necessary to address the problem of coastal erosion/flooding (Rawadee and Areeya, 2009)*.
  - A thorough study on the impacts of climate change in order for the concerned public agencies to prepare proper solutions to the problem (Rawadee and Areeya, 2009)*.

(b) Coastal area losing previous stability

- Present problem

- From the analysis of the balance of resources at the coast of Bang Khun Thian area, it was discovered that the coast of Bang Khun Thian no longer has its previous stability and resilience (BMA 2007).
- Conversion of mangrove forest into aquaculture farm**.
- Less sediment due to dams construction upstream**.

- Current action
  - The 4 main actions to prevent and solve the problem:
    1) Not doing anything
    2) Evacuation to a safer area or retreat
    3) Creating stability and resilience of the shore using non-structural methods
    4) Creating stability and resilience of the shore using structural methods (BMA, 2007).
  - The most effective structure is the T-Groins and growth mangrove forests in a total area of 550 rai to use as breakers and restore the ecology along the coast (BMA, 2007).
  - Construction of Bang Khun Thian Coastal Erosion monitoring center**.

- Future problem
  - Within 10 years the remaining mangrove forest will be destroyed leaving the inhabitants of the area to lose > 50 m. If nothing is done to prevent the retreat of the shorelines, in 30 years, the shorelines will recede to behind the present day location of the mangrove forest, where the shrimp farms are, and may continue to recede to the Klong Long area (BMA, 2007).
  - Although with implementation of groins, it is likely that the coast along Samut Prakan province in next 15 years will be 10.2 m/year while it will be 9.8 m/year in case of no groin implementation (BMA, 2007)*.

- Action needed
  - In order to prevent increasingly continuous coastal erosion in the coast along Samut Prakan province as consequence of groin implementation in Bang Khun Thian, construction of mole along and expansion of groins to the coast of Samut Prakan province are needed (BMA, 2007)*.
  - Campaign to raise awareness of local citizens especially on the linkage between type of land use and economic activity that will facilitate the implementation of coastal erosion protection plan. For example, local citizen should aware that the selling of soil or sediment from their land will reduce the stability of the region and thus speed up the erosion process**.

(c) Coastal fisheries affected

- Present problem
  - Studies in the area of the local community, in the Chom Thong district in Bangkok, show that households in the provinces of Samut Sakhon and Samut Prakan, which are in the areas affected by the coastal erosion, suffer from the decrease of produce, produced by occupations raising and selling aquatic animals as well as aquaculture farms. (Rawadee, J and Areeya, M., 2009).

- From the analysis of landmarks in the Bang Khun Thian area, from past to present, the coast has eroded a total of 4-800 m with a rate of 20-25 m/year due to the decrease of collected sediment, the construction of dams, and the rising levels of seawater; this has also affected shrimp and cockel farms of 2 sub-districts (Rawadee, J and Areeya, M., 2009).

● Current action

- Rawadee, J and Areeya, M. (2009) conducted a study with emphasis on the adaptableness behavior of households.
- There are 3 types of strategies

  1) Prevention (i.e. building a wave breaker, using a wall of rocks, bamboo dams, and permanent dams)

  2) Evacuation

  3) Adjusting the elevations of the house. Each household may use more than one strategy and they do not have to be the same strategies. (Rawadee, J and Areeya, M., 2009).
- The BMA and the Fishery Department have provided assistance to households affected by coastal erosion/flooding including provision of small structural protections such as tire breakwater and sandbags (Rawadee and Areeya, 2009)*.
- The BMA is addressing the problem by emphasizing foundations that involve engineering designs or engineering structures**.

● Future problem

- Seawater levels, at the coast of the Gulf of Thailand in year 2030 will cause two types of risk namely, inundation (permanent flood) and extreme flood incidences (episodic extremes) (Rawadee and Areeya, 2009).
- The annual adaptation cost for Bang Khun Thian is approximately US$ 3,130 per household which is equal to 23 percent of the average household income (Rawadee and Areeya, 2009)*.
- Due to low educational attainment and lack of other knowledge skills, farmers could not shift to other occupations (Rawadee and Areeya, 2009)*.

● Action needed

- For the protection structure to be effective in protecting the shore, it should be planned for the whole upper Gulf of Thailand. Thus, the cooperation of the national government, local governments, and the public is necessary to address the problem of coastal erosion/flooding (Rawadee and Areeya, 2009)*.
- A thorough study on the impacts of climate change in order for the concerned public agencies to prepare proper solutions to the problem (Rawadee and Areeya, 2009)*.

(d) Sediment reduction and land subsidence

● Present problem

- The decrease of the sedimentary area, ground subsidences, rising seawater levels, crashing waves, storms, and the receding of the coast causes the ground to sink 1 cm each year; which shows definitively that there is coastal

erosion at a rate of 5 m/year (Rawadee, J and Areeya, M., 2009).

- The decrease in sediment is caused by the Chao Phraya River as a result of the construction of the Bhumipol and Sirikit dams (Winterwerp et al., 2005)*.
- Groundwater utilization in Bangkok area has been controlled, however, the neighboring provinces still cannot control the use and that lead to the area land subsidence**.

- Current action
  - Rawadee, J and Areeya, M. cited Winterwerp et al., 2005, Jarupongsakul, 2006, and Ittaro, 2001, and conducted a research to understand the reasons for ground subsidence. (Rawadee, J and Areeya, M., 2009).
- Future problem
  - Jarupongsakul (2006) estimates that the sea level at the upper Gulf of Thailand would rise to 10-100 cm in next 50 years. When effect of land subsidence is factored in, about 6-8 km inland from the current shoreline will be inundated in the next 100 years (Rawadee and Areeya, 2009)*.

- Action needed
  - Use technology that will keep the sediment behind the structure and finally new land can be formed**.
  - Extension of water supply system to cover more area and define area where groundwater drilling and utilization are prohibited to reduce the land subsidence problem**.
  - Efforts should be made to create cooperation between neighboring provinces to control the use of groundwater**.

(e) Mangrove forest decreasing

- Present problem
  - In the past 30 years the mangrove forest was subjected to severe deforestation and the Bang Khun Thian area has lost a total of 483 ha of mangrove forest. These mangrove forests are the key to lessen the force of impact of Storm Surges against the coast. The residents of the sub-district of Ban Khun Samut Jeen were forced to evacuate permanently due to coastal erosion. (WWF, 2014).
  - Mangroves at the shoreline have been fallen by strong waves because their root system does not provide sufficient anchoring anymore (Rawadee and Areeya, 2009)*.

- Current action
  - In 1989 the Cabinet resolved to distributing an area of 2,735 rai for mangrove trees from the land reserved for permanent forest and left the BMA in charge of overseeing the prevention of more erosion and conservation of the mangrove forest (BMA, 2014).
  - Protection and conservation of the Mangrove forests. (WWF, 2014).

- Future problem
  - In 50 years in the future the seawater levels is predicted to rise, causing erosion at a rate of 15-25 m/year while

the intertidal forest is being cut down at an frightening rate, causing a 2,667 km loss of coastal area which damages the perimeter of the province of Bangkok and the tourism industry (WWF, 2014).

- Action needed
  - Restoration of the intertidal area through entire or part of current coastline, and by scarifying part of the fish and shrimp ponds (Winterwerp et al., 2005)*.
  - An internal mangrove belt of about 300-500 m is required to re-initiate sedimentation process, hence to restore a favourable habit for mangrove forest (Winterwerp et al., 2005)*.

(f) Sea level rising

- Present problem
  - The southern coast of Bangkok lies within the 9th and 10th sub-district, in the district of Tha Kham in the Bang Khun Thian area, and suffers from erosion due to seawater (BMA, 2007).
  - The changing global temperature has caused the average seawater level abruptly increase by 0.09-0.88 m, which causes changes in the delicate state of torrential waves and coastal erosion which effects the coastal ecology, occupations, tourism and the country's economy. (TGO, 2014).

- Current action
  - Understanding on the side-effects and cause of fluctuations on seawater level and the impact on the country (TGO, 2014).

- Future problem
  - The sea level rise estimates for 2100 in the Gulf of Thailand is in wide range between 17.3 and 319.0 cm depending on future scenario (World Bank, 2006; Jarupongsakul and Suphawajruksakul, 2005)*.
  - Jarupongsakul (2006) estimates that the sea level at the upper Gulf of Thailand would rise to 10-100 cm in next 50 years. When effect of land subsidence is factored in, about 6-8 km inland from the current shoreline will be inundated in the next 100 years (Rawadee and Areeya, 2009)*.

- Action needed
  - There should be changes to adapt and to learn and know the causes and factor of the rising levels of seawater (WWF, 2014).

(3) Water resources, salinization etc.

(a) Many areas experiencing drought every year

- Present problem
  - From December to May, of each year, the average temperature of Thailand increases and in April temperatures can reach 40-43 degrees Celsius causing the natural convection to slow down and with combination of little rainfall it results in droughts in some areas including outer area of BMA including Khan Na Yao District and

Hui Khwang District suffers from drought (BMA, 2013).

- Invasion of saline water affects the amount of consumable water and water for agricultural needs (WWF, 2014).
- Poor management of water resource**.

- Current action
  - Plans for preparation and mitigation of droughts

    - Preparation

    1. To prepare for and mitigate the impact of droughts; information was gathered to perform a risk analysis to develop procedural guidelines
    2. Preparations to increase readiness includes arranging and training of volunteers and readying the community

    - Response (Management Administration during Emergencies)

    1. Setup a control center and proceed according to the developed plans
    2. The control center announces news regarding the situation for all citizens
    3. Finding and distributing water for consumption
    4. Delegating and spreading different groups to help smooth operations

    - Aftermath (Recovery)

    1. Damage assessment and needs assessment
    2. Begin rehabilitation of the physical and mental states
    3. Begin basic restoration of damages
    4. Studying and learning of the incident to collect more information to improve upon (BMA, 2013).

  - The Thai government has found warehouses, at places with high elevation, to store rice to prepare for severe flooding and subsequent drought to maintain a stable flood supply (WWF, 2014).
  - Setting up a system for the prevention and control of flood waters and at the water source install equipment to prevent saline water invasions and to help control flood waters (WWF, 2014).
  - Setting up training seminars for the community to prepare for emergencies and to increase readiness for severe droughts brought on by rising sea levels and storm surges (WWF, 2014).

- Future problem

  (No information)

- Action needed
  - Development of plans and increase knowledge for prevention (WWF, 2014).
  - Short run**:

    - Rehabilitate drought affected area through soil and water conservation program (use of compost, grow

ground-covering plant such as vetiver grass)

- Drought monitoring and warning system
- Immediate compensation payment to affected communities

- Long run**:
  - Develop small scale water reservoir in agricultural land area
  - Accurate warning system so that farmers and communities can plan their type of crop based on water availability
  - Employ appropriate technology: Conversion of saline water to freshwater (desalination water) and the use of artificial rain for instance.

(b) Sea level rising causing damages

- Present problem
  - Bangkok lies just 2 m above current sea level indicating high risk of saltwater intrusion (WWF, 2014)*.
  - The changing of the Earth's temperature has increased the average water level by 0.09-0.88 m since 1993. Researchers have evaluated the factors causing the rising of sea levels and calculated that if the seawater levels rise by approximately 0.5-1 m the coast at the Gulf of Thailand will receive more damages than the coast at the Andaman Sea. The coasts that will receive more damages are in the Bangkok area and areas nearby which include the coast at Rayong, Petchaburi all the way down to Narathiwat (TGO, 2014).
  - Saltwater intrusion occurs because of sea level rise and groundwater extraction (TGO, 2014).

- Current action
  - Research has shed light on the effects and cause of the sea level rise in Thailand (TGO, 2014).
  - At the water source, install water gate facilities to prevent saltwater intrusion and to help control floodwater (WWF, 2014).

- Future problem
  - In the next 50 years the seawater levels will rise by 10-100 cm increasing the saline water invasion into the Chao Phraya River which will cause a decrease in usable water for agriculture and consumption. The severe increase of frequency in saline water invasion and storm surges results in an increase of seawater levels, by 50 cm and 100 cm, and a loss of occupational land which in turn decreases the GDP-Gross Domestic Product. (WWF, 2014)
  - Saltwater intrusion is also exacerbated by stronger and more frequent storm surges (WWF, 2014)*.

- Action needed
  - Protecting existing mangrove forests and restore ones that have been lost due to cutting. These measures can result in high benefit for relatively low cost of implementation (WWF, 2014)*.
  - There is a need for adaptation and learning of the factors that influence the seawater levels (TGO, 2014).

(4) Others

Besides the above mentioned three priority issues, many types of impacts related to climate change might occur such as damage to human health, infrastructure and energy security. In some cases, combined impact might be included as possible worse damage; e.g., longer rainfall cause worse outbreak of pest and might affect human health, or loosen the ground and might cause landslide, especially combined with earthquake.

These possible problems should be reviewed, analyzed and incorporated to the list of the adaptation measures periodically.

6-2 Adaptation targets and future prospects

(1) How to set adaptation target

Compared to mitigation targets, it is difficult to set adaptation targets because there is no common quantitative indicators such as the amount of GHGs. There are many existing adaptation plans without target, in both national and city level.

For the Bangkok Master Plan on Climate Change, adaptation target is set in qualitative description, considering desirable situation as follows:

(2) Adaptation target

The Thailand Climate Change Master Plan 2013 - 2050 (Draft) has three key strategies; adaptation, mitigation and capacity strengthening. Concerning the targets, they have short-term (by 2016), mid-term (by 2020) and long-term (by 2050) targets. The Adaptation sector of Bangkok Master Plan also sets short (1-3 years), mid (3-5 years) and long (5-10 years) term timeline as described in Chapter 7. Therefore, the adaptation targets for the Bangkok Master Plan are set as follows, considering its timeline and priority sectors as well as referring the targets of master plan at national level.

Short-term targets (1 - 3 years)

- Complete the ongoing adaptation-related measures,
- Establish appropriate organizational structure in BMA to carry out adaptation measures, including cross-cutting efforts.
- Promote understanding of BMA's personnel and public awareness about adaptation.

Mid-term targets (3 - 5 years)

- Develop tools to promote citizen's participation to adaptation measures (e.g., hazard maps),
- Establish a facility for monitoring as well as awareness raising (e.g., Coastal Monitoring Center),
- Promote cooperation with other national/local governmental organizations and public participation for the implementation of adaptation measures.

Long-term targets (5 - 10 years)

- Implement integrated land use planning based on the enhanced scientific knowledge and developed tools such as hazard maps,
- Improve related laws and regulations to enhance adaptation capacity.

7. Adaptation measures by sector

Necessary adaptation actions in future can be classified by time scale and acceptability level of impact

- Time scale

  Time scale classification is categorized by adaptation measures which correspond to occurrence time and certainty objected impact. Urgent response measures and restoration measures are needed against impacts which has been occurred already or occurrence likelihood is high. To cope with the impact that is projected to occur in medium/long term, the measures are important which accommodative management based on impact assessment or monitoring, and fundamental improvement of vulnerability. This classification can distinguish between measures to be begun promptly and measures to be considered carefully through monitoring or impact assessment etc.

  - Short term (1-3years)
  - Medium term (3-5years)
  - Long term (5-10years)

- Acceptability level of impact

  Classification depending on acceptability level of impact are; Protection which is prevention of climate change impacts itself, Minimize impact which is to accept certain level of impacts with mitigating them, and Change/Reconstruction which is vulnerability improvement in regional/social side against unavoidable climate change impacts. These classifications can make adaptation measures more diverse.

  - Protection (Level1)
  - Minimize impact (Level2)
  - Change/Reconstruction (Level3)

- Classification of adaptation direction by time scale and acceptability level of impact

  When time scale and acceptability level of impact are considered together, adaptation measure can be further categorized into three types based on implementation direction namely,

  - Strengthen existing adaptation measures,
  - Acclimatize/Accommodate to medium/long term impacts, and
  - Fundamental improvement of vulnerability (Hosei University, 2015[9]).

[9] Hosei University, the S-8 Project, "Comprehensive Study on Impact Assessment and Adaptation for Climate Change," implemented by the Environment Research and Technology Development Fund of the Ministry of the Environment, Japan, Guideline for Climate Change Adaptation, 2015, http://www.adapt-forum.jp/tool/pdf/tekiousaku-guideline_last.pdf accessed 1 July 2015

The categorization is introduced through discussion within adaptation Task Force. Due to various benefit from the implementation, it is possible that one measure contains more than one direction

7-1 Flood

The below measures addressing flood are proposed under the Master Plan for implementation.

1	**Flooding**	
Time scale of impact	Adaptation level	Adaptation measure
Short term 1-3 years	Level 1 Prevention	1. Strengthening measures for retention areas e.g., construct and improve temporary retention basins (BMA et al., 2009)
		2. Dredging of drainage channels
		3. Installing drainage pumps
		4. Improving small scale irrigation facilities e.g., gates, weirs and etc. (NESDB et al., 2013)
		5. Constructing flood protection system (e.g., pumping station, water gate, flood dyke, tunnel) with proper supporting system such as alternative power sources and transmission lines
	Level 2 Minimizing impacts	1.Providing catchment area to store water and reduce volume of flood water flow rate
		2.Ensuring feed for livestock (NESDB et al., 2013)
		3.Designating evacuation areas (MOEJ, 2010) with appropriate facilities/equipment
		4.Developing disaster evacuation plan and revise the plan as necessary
		5.Developing emergency preparedness plan
		6.Strengthening emergency communications (BMA et al., 2009)
		7.Promoting people's participation to maintain community canal
		8.Educating/informing citizens on flood related issues e.g., risk of residing in flood prone area, health care during flood, situation of flood
		9.Establishing "Flood Aid Units" which are ready to help promptly and thoroughly
		10.Compensating for damaged farmland and properties
	Level 3 Chang and Reconstruction	1.Coordinating with government/related organizations/neighboring provinces to develop agreement on flood water management
		2.Formulating business continuity plans (MOEJ, 2010)
		3.Providing financial support during inundation period (NESDB et al., 2013)
Midterm 3-5 years	Level 1 Prevention	1.Continuing the implementation according to the plan
		2.Constructing community-based small scale retention pond
		3.Maintaining canals/rivers and increase drainage capacity (NESDB et al., 2013) e.g. maintenance of levees and river bank dredging
		4.Developing Ayutthaya bypass channel regulation
		5.Operating existing dams effectively and revise dam water management plan as appropriate
		6.Constructing and elevate outer ring road as alternative for transportation during flood
		7.Providing alternative power source and power transmission lines of drainage system
		8.Constructing flood proof buildings (BMA et al., 2009)
		9.Effectively utilizing existing flood protection facilities and extending their lifetime via regular maintenance (MOEJ, 2008)
	Level 2 Minimizing impacts	1.Establishing flood hazard maps
		2.Improving accuracy of weather forecast and upgrade monitoring and warning systems (MOEJ, 2008)
		3.Developing flood management information system with link to other sectors e.g., planting schedule
		4.Establishing guidelines for flood control facilities operation
		5.Enforcing law on land use and adopt integrated land use planning e.g., prohibit construction in flood prone area
		6.Implementing intervention measure in agricultural sector when appropriate (NESDB et al., 2013)
		7.Developing emergency preparedness plans (BMA et al., 2009)

1	Flooding	
Time scale of impact	Adaptation level	Adaptation measure
		8Providing more catchment areas
		9.Relocating housing in flood prone areas
	Level 3 Change and Reconstruction	1.Utilizing urban planning measures
		2.Conducting research and develop countermeasures technologies (MOEJ, 2010)
Long term 5-10 years	Level 1 Prevention	1Continuing the implementation of Flood Prevention Plans
	Level 2 Minimizing impacts	1. Continuing the implementation of Flood Prevention Plans
		2.Ensuring operational guidelines for flood control facilities
		3.Enforcing law on land use and integrated land use planning (BMA et al., 2009)
		4.Improving flood management information system (NESDB et al., 2013)
		5.Upgrading monitoring and warning systems (MOEJ, 2008)
Long term 5-10 years	Level 3 Change and Reconstruction	1.Continuing the implementation of plans
		2.Providing government sponsored flood insurance (for areas outside of flood protection facilities) (BMA et al., 2009)
		3.Establishing funds and subsidies for post disaster restoration (MOEJ, 2008)
		4.Conducting research and develop countermeasures technologies (MOEJ, 2010)

(1) Short term (1-3 years)

In level 1, structural measures would be taken, and it would be classified into 1) Strengthening flood prevention and draining system and 2) Strengthening flood prevention and control systems.

In level 2, non-structural measures would be taken, and it would be classified into 1) Addressing how to live together with the flood water, 2) Making flood prevention and amendment plans, 3) Raising awareness, promoting community's participation, and R&D, 4)Providing financing support. For 1) , storing water as much as possible, for 2), designating evacuation areas, improving disaster evacuation facilities, drilling evacuation plan, for 3), promoting people's participation on maintenance of community canal, educating community people to understand risk of residing in the area, for 4), compensating for damaged farmland, would be listed.

In level 3, major actions are integrate efficiency measures, especially, regarding "how to live together with the flood water", coordinating with government/related organizations, formulating business continuity plan, providing financial support.

(2) Medium term (3-5 years)

In level 1, following short term, major actions are strengthening flood prevention and draining systems. Constructing community-based small scale retention pond, maintaining canals and increasing drainage capacity, effective operating of existing dams, diversifying power supply would be listed.

Level 2 would be classified into 1) Making flood prevention and amendment plans, 2) Strengthening flood prevention and control systems. For 1), producing hazard maps, improving effectiveness of weather forecast and warning system, providing agricultural guidance, for 2), providing more catchment areas, relocating housing in anger zones would be listed.

In level 3, making flood prevention and amendment plans, raising awareness, promoting community's participation, R&D would be important.

(3) Long term (5-10 years)

Basically, necessary actions would be continued based on plans in all levels. In addition, making proper operation rule for flood control facilities, developing flood management information system, providing publicly sponsored flood insurance, establishing funds and subsidies for post-disaster restoration would be listed.

7-2 Coastal erosion

The below measures addressing coastal erosion are proposed under the Master Plan for implementation.

2	**Coastal erosion**	
Time scale of impact	Adaptation level	Adaptation measure
Short term 1-3 years	Level 1 Prevention	1.Constructing temporary coastal area protection fence (Bamboo)
		2.Improvement of dike system (BMA et al., 2009)
	Level 2 Minimizing impacts	1.Promoting people's knowledge on benefits of mangrove forest and its conservation
		2.Promoting mangrove forest plantation
		3.Developing emergency preparedness plans (BMA, et al., 2009)
		4.Public information campaigns and training exercises (World Bank, 2010)
	Level 3 Change and Reconstruction	1.Setting clear goal for coastal area protection measures and develop action plan accordingly
		2.Setting up joint committee of stakeholders to develop the coastal area management master plan by adopting integrated coastal zone management approach (MOEJ, 2008)
Midterm 3-5 years	Level 1 Prevention	1.Constructing permanent coastal erosion defense wall (Stone dike)
		2.Maintaining and improve coastal area protection facilities (MOEJ, 2008 and MOEJ, 2010)
		3.Comprehensive sediment control along rivers and coastal areas (MOEJ, 2008)
		4.Designing proper wastewater discharge
	Level 2 Minimizing impacts	1.Prohibitng and restrict construction in high risk zones (MOEJ, 2008)
		2.Enforcing law on land and fisheries and enhance the role of communities in coastal protection tasks
		3.Improving coastal ecosystem to ensure coastal stability and to maintain existing capacity in supporting food security.
		4.Rehabilitating mangrove forest along the shoreline of Bang KhunThian (The World Bank, 2010)
		5.Relocating community from high risk zones
		4.Developing integrated land use plan
		5.Initiating and develop hazard maps
		6.Developing emergency preparedness plans (BMA et al., 2009) including early warning system (ONEP, 2011), and monitoring system (MOEJ, 2008)
		7.Coastal Monitoring Center
		8.Public information campaigns and training exercises (The World Bank, 2010)
		9.Operating harbor/port
	Level 3 Change and Reconstruction	1.Implementing integrated coastal zone management according to the plan (MOEJ, 2008)
		2.Conducting research and develop countermeasure technologies (MOEJ, 2010)
Long term 5-10 years	Level 1 Prevention	1.Implementing integrated coastal zone management according to the plan
	Level 2 Minimizing impacts	1.Implementing integrated coastal zone management according to the plan
		2.Monitoring ecosystem changes for protection purpose (BMA et al., 2009)
		3.Implementing integrated land use plan

2	Coastal erosion	
Time scale of impact	Adaptation level	Adaptation measure
		4.Upgrading monitoring system (MOEJ, 2008)
	Level 3 Change and Reconstruction	1.Implementing integrated coastal zone management according to the plan
		2.Conducting research and develop countermeasure technologies (MOEJ, 2010)

(1) Short term (1-3 years)

In level 1, structural measures would be implemented, that aims to improve hardware which should be initiated 、early or to respond temporarily. For example, constructing and improving levees and dykes, constructing temporary coastal defense.

In level 2, non-structural measures would be implemented, and it would be classified into 1) Addressing the mangrove forest decreasing, 2) Addressing other problems. For 1), Promoting people's knowledge on mangrove conservation, promoting mangrove plantation, for 2), making emergency preparedness plans, implementing public information campaigns and training exercises would be listed.

In level 3, major actions are integrate efficiency measures, it would be classified into 1) Addressing the increasing erosion, 2) Addressing other problems. For 1), setting clear goal for plan of operation for constructing coastal defense and deliberately working on, for 2), setting up joint committee of stakeholders to make the master plan, implementing integrated coastal zone management would be listed.

(2) Medium term (3-5 years)

Level 1 would be classified into 1) Addressing increasing erosion, 2) Addressing the reduction of sediment, 3) Addressing other problems. For example, for 1), improving coastal protection facilities and erosion control facilities、for 2), comprehensive sediment controlling of rivers and coasts、for 3), designing waste discharge would be listed.

Level 2 would be classified into 1) Addressing the increasing erosion, 2) Addressing the affected ecosystem, 3) Addressing the mangrove forest decreasing, 4) Addressing the land use pattern changes、5)Addressing other problems. In general, measures which depend on the non-structural method and try to minimize damage by soft measures would be listed, for example, enforcing law, producing hazard maps, improving early warning system, public awareness.

In level 3, following short term, comprehensive management and strengthen the foundations such as R&D would be important.

(3) Long term (5-10 years)

Basically, necessary actions would be continued based on plans in all levels. For example, upgrading monitoring system, conducting research and developing technologies would be listed.

7-3 Draught and salinine intrusion etc.

The below measures addressing draught and saline intrusion and other water resources issues are proposed under the Master Plan for implementation.

3	**Draught and Saline Intrusion**	
Time scale of impact	Adaptation level	Adaptation measure
Short term 1-3 years	Level 1 Prevention	1.The drought cannot be prevented as Bangkok situated at the end of the river area; and Bangkok is dependent on water from the north and weather
	Level 2 Minimizing impacts	1.Expanding water supply service area
		2.Constructing small water reservoirs
		3.Supplying water from other sources/areas
		4.Promoting water conservation measures, use water efficiently
		5.Develop drought management and emergency preparedness plans and monitoring system
		6.Strengthening emergency communications (BMA et al., 2009)
		7.Public information campaigns and training exercises (The World Bank, 2010)
	Level 3 Change and Reconstruction	1.Cooperate with government units and concerned agencies to plan for water allocation
Midterm 3-5 years	Level 1 Prevention	-
	Level 2 Minimizing impacts	1.Implementing drought management plan
		2.Drought hazard map
		3.Implementing water and energy conservation measures
		4.Planting trees (BMA et al., 2000)
		5.Public information campaigns and training exercises (The World Bank, 2010)
		6.Developing warning and monitoring systems (MOEJ, 2008)
	Level 3 Change and Reconstruction	1.Implementing drought management plan
		2.Conducting research and developing technologies for countermeasures (MOEJ, 2010)
Long term 5-10 years	Level 1 Prevention	-
	Level 2 Minimizing impacts	1.Implementing drought management plans with proper monitoring and warning systems (MOEJ, 2008)
		2Implementing integrated land use planning
		3 Implement water and energy conservation measures
		4 Planting trees
	Level 3 Change and Reconstruction	1.Establishing funds and subsidies for post-disaster recovery (MOEJ, 2008)
		2 Implementing measures as planned
		3.Conducting research and develop countermeasures technologies (MOEJ, 2010)

(1) Short term (1-3 years)

In level 1, since Bangkok situated at the end of the river area and Bangkok is dependent on water from the north and weather, measures are limited. Following short term, major actions include diversion of water from the northeast part of BMA to affected area, rehabilitation of drought affected area through soil and water conservation program (use of compost, grow ground-covering plant such as vetiver grass), drought monitoring and warning system, and immediate compensation to affected communities.

In level 2, non-structural measures would be implemented. For example, using recycle water, raising awareness, making emergency preparedness plans, training exercises would be listed.

In level 3, major actions are integrate efficiency measures, for example, cooperating with government units and concerned agencies to plan to allocate water would be listed.

(2) Medium term (3-5 years)

In level 1, there is no actual action at this stage.

In level 2, producing hazard maps, conserving water and energy, planting trees would be listed as well as implementing actions as planned.

In level 3, R&D would be listed as well as implementing actions as planned.

(3) Long term (5-10 years)

Basically, necessary actions would be continued based on plans in both level2 and level3. Upgrading monitoring system, conducting research and developing technologies, establishing funds and subsidies for post-disaster restoration would be included.

7-4 Cross-cutting efforts

Climate change adaptation and mitigation have different roles. Adaptation aims at moderating or avoiding harm or exploiting beneficial opportunities while mitigation is a human intervention to reduce the sources or enhance the sinks of GHG[10]. Adaptation and mitigation depend on one another, they can reduce climate risks but they do so at different time scales. Adaptation addresses current and committed climate change, while mitigation reduces future climate risks[11].

Integration of mitigation and adaptation responses can generate mutual benefits and co-benefits with sustainable development, but they may have negative consequences if choices not carefully analyzed. For instance, implementing adaptation measures may sometimes lead to increase in the amount of GHG emissions (e.g., excessive use of air conditioners to accommodate heat waves), and may sometimes lead to decreases (e.g., forest management)[12].

With good cooperation and planning with other Task Forces, several benefits can be gained including:

- Duplication of measures can be avoided, thereby the cost of adaptation can be reduced, and
- Synergized measures can enhance the effectiveness to relevant sectors..

[10] Allwood J. M., V. Bosetti, N. K. Dubash, L. Gómez-Echeverri, and C. von Stechow, 2014: Glossary. In: Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, http://mitigation2014.org/report/publication/ accessed 16 June 2015

[11] Asun Lera St.Clair, Lead Author chapter 1, Climate resilient pathways: relationship between adaptation, mitigation and sustainable development, IPCC presentation file, https://www.google.co.jp/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&uact=8&ved=0CB0QFjAA&url=https%3A%2F%2Fwww.ipcc.ch%2Fpdf%2Funfccc%2Fsbsta40%2FSED%2F4_st.clair_sedpart2.pdf&ei=7zWTVaGAE5be8AX0y7uoBQ&usg=AFQjCNF24Rp4WTj-Syjx180qm_XmAzcOqw&bvm=bv.96952980,d.dGc

[12] The Committee on Climate Change Impacts and Adaptation Research Japan, Wide Adaptation to Climate Change: Part I: Wise Adaptation to Climate Change, https://www.env.go.jp/en/earth/cc/wacc_080618.pdf accessed 16 June 2015

Hence, addressing cross-cutting efforts is necessary and important for the Bangkok Master Plan. Tables 7-1, 7-2 and 7-3 show relationship of adaptation measures and priority measures with other Task Forces for flood, coastal erosion and drought/saltwater intrusion, respectively.

Relationship with other Task Force sectors:

In this Master Plan, the relationship between adaptation measures and mitigation measures under other Task Forces can be divided 3 types based on implementation time and/or order as follows:

(1) Adaptation measure and other Task Forces can be/should be implemented at the same time. Examples include:

- Mangrove reforestation is to prevent coastal erosion. Simultaneously, it can contribute to climate change mitigation by increasing green area of BMA. This adaptation measure can be implemented at the same time with Green Urban Planning Task Force, and
- Constructing and elevating outer ring road which is primarily designed as an alternative for transportation during flood event however out of flood event the increased number of road may reduce traffic congestion. Therefore, GHG emissions from vehicles can be decreased. This adaptation measure can be implemented at the same time with Transport Task Force.

(2) Adaptation measure is needed to be implemented before measures by other Task Forces. Examples include:

- Use of pumping station, water gate and tunnel installed with alternative power sources and transmission lines can ensure operation of such facilities during flood event. Applying alternative power sources such as PV and biofuels can decrease amount of fossil fuels needed for energy generation, therefore reduce GHG emissions. This adaptation measure is needed to be implemented before Energy Task Force, and
- Community-based small scale retention pond which is primarily designed for flood protection, water quality in the pond may be in poor condition. Therefore, treatment is required prior to discharging for environmental protection. This may imply more energy demand for operation of wastewater treatment plant, therefore can increase GHG emissions. This adaptation measure is needed to be implemented before Waste and Wastewater Task Force.

(3) Adaptation measure is needed to be implemented after measures by other Task Forces. At current stage, no adaptation measure are identified as this type in the Tables 7-1, 7-2 and 7-3 However, when adaptation measures will be updated in near future, new adaptation measures might be classified as this type of relationship.

Priority measure:

All measures in relationship with other Task Forces is categorized into 3 types of priority as follows:

High: Considered as first priority, or it should be given as highly urgency and should be

primarily implemented,

Middle: Considered as moderate priority, and

Low: Considered as lower priority or less urgency than others.

It is noteworthy that although some adaptation measures may increase GHG emissions, if the measure is urgent and important for human life security, the measure should be implemented[13].

Above priority measure and relationship with other sectors are based on only discussion within adaptation Task Force. It is desirable that a meeting with all Task Forces to discuss the relationship and priority of their mitigation and adaptation measures for the effective and co-beneficial implementation.

[13] The Committee on Climate Change Impacts and Adaptation Research Japan, Wide Adaptation to Climate Change: Part I: Wise Adaptation to Climate Change, https://www.env.go.jp/en/earth/cc/wacc_080618.pdf accessed 16 June 2015

Table 7-1 Flood (Present problem – current activities – future problem – required activities)

"*" denotes information extracted by JICA Expert Team

"**" denotes information obtained from Adaptation Task Force

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
Location of Bangkok is susceptible to flood and land subsidence - Bangkok is situated on the floodplains of the Chao Phraya River and subjected to the tides of the sea which results in trapped water from rainfall (flooding) and overflow from the river (BMA, 2013: p.71-74)[14] - Bangkok has a low elevation and is situated at the edge of the Chao Phraya River, in the past it was subjected to seasonal flooding; the monsoon season brings heavy rainfall and management of the water becomes difficult and costly. Bangkok is also at the Chao Phraya River's delta and has a myriad of tributaries flowing through making it more susceptible to harsher waves during the rainy season and overflow of the river causing flooding (WWF, 2014)[15] - BMA has no authority in managing water from upstream**	- The World Bank, the Asia Development Bank, and the Japan Bank of International Cooperation have evaluated the effects of global warming by simulating it using mathematical hydrology (World Bank, 2009). - Information about flooding, from the past, was collected and analyzed and predicted flooding problems and finding solutions to flooding management in the city area using non-structural and structural methods (BMA, 2013). - The research team's proposal on policies and defensive measures 1) All policies and problems that are caused by global warming should be included in all improvement plans 2) The procedural options should be based on the analysis of the surveyed environment so that it can lead to the improvement of other measures and procedures (WB, 2009) - Plans developed to prevent and mitigate flooding and landslides are as follows: Prevention	- The research team of Tokyo University predicts that within 2050 land subsidence will increase (from 0.05 m to 0.30 m) due to these reasons: 1) Global warming in Bangkok and it's perimeter have caused a temperature increase of 1.2-1.9 degrees centigrade 2) Problems due to storm movement 3) Building foundations have been changed (World Bank, 2009) - Within 2050 floodable areas that are at the western side of Bangkok will increase to a larger area and flooding will impact approximately 1 million inhabitants within the Bangkok and Samut Prakan area. 1 of 8 of the effected live in the crowded areas and 1 of 3 effected people will be surrounded by water >0.5 m for at least 1 week. High risk areas includes the Bang Khun Thian area (Bangkok) and the Phra Samut Chedi area (Samut Prakan) (World Bank, 2009)	- Reviewing the existing system and prevention plans for flooding and levels of the ground where subsidence's occur in Bangkok (World bank, 2009) - Gathering all land usage plans and city plans to consider together** - Cooperation with neighboring provinces to control the use of the ground water** - Capacity building for human resource** - Facilitate the development of flood prevention practices, measures and regulations** - Campaigning and raising awareness about global warming (World Bank, 2009)

[14] BMA. (2013). Bangkok Disaster Prevention and Mitigation Plan During 2010-2014: Bangkok. (A19)

[15] WWF International. (2014). Mega-Stress for Mega-Cities: A Climate Vulnerability Ranking of Major Coastal Cities in Asia, Switzerland, 25-26. [ออนไลน์]. เข้าถึงได้จาก: http://awsassets.panda.org/downloads/mega_stress_cities_report.pdf (20 เมษายน 2557) (เอกสารประกอบ 2)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
	1) Prevention and lessening of impact: Gathering of information to perform a risk analysis and developing a suitable procedural guideline 2) Preparations: Setting up training centers for volunteers and increase the community's preparedness Response (Management During Emergencies) 1) Setting up a control center and following the guidelines 2) The control center delegates and distributes the received donations to help mitigate the situation 3) Identification and proof of deceased (if casualties occur) Aftermath (Recovery) 1) Damage assessment and needs assessment 2) Arrangement for temporary relief centers and care centers for physical and mental health 3) Following the procedures dealing with casualties 4) Provincial Public Health Offices 5) Beginning recovery of physical and mental treatments 6) Recovery and restoration of the communal environmental systems 7) Restoration of building foundations 8) Proceeding with basic damage restorations 9) Studying and reviewing of incident to use to improve upon (BMA, 2013: p.72-74) - The BMA installed a prevention system that protects and controls flood waters and increases the capabilities of the strategically placed water detention system to contain the overflow of canals and rivers during the rainy season and hot season (WWF, 2014)	70% of the future flood economic damage cost would be attributed to land subsidence alone (World Bank, 2009)* - In 50 years the seawater level will rise by 50 and then 100 cm resulting in loss of occupational land and will cause the GDP (Gross Domestic Product) to fall by 0.36% and 0.69%, respectively, (300-600 million US dollars) each year; the most loss in the agricultural sector of Bangkok with a total monetary loss 38% and 61% (WWF, 2014)	

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
	- Increased the capabilities of the Watergate to prevent saline water invasion and control floodwaters (WWF, 2014) - The Thai government has found and arranged for rice to be stored at high elevations, to be protected from extreme flooding and droughts, so that there are no food shortages (WWF, 2014) - Training different communities in basic preparedness for emergencies and preparing them for extreme storm surges (WWF, 2014) - Protection and conservation of Mangrove forests (WWF, 2014)		
Ineffectiveness of government's countermeasure: - The government sector is inadequately prepared for an efficient response; they are not taking into account global warming and they are not informed enough to develop proper plans for improvement. (World Bank, 2009)[16] - Low enforcement of existing law & regulations Ex. City planning, zoning of land use (BMA, 2013) - Lack of cooperation between government agency and stakeholders**	- All policies and problems caused by climate change should be included in all improvement plans**	- Insufficient existing and planned flood protection infrastructure (World Bank, 2009) - Conflicts between flood-affected communities** - Lack of integrated flood prevention system between upstream area and downstream (BMA)**	- Mainstreaming climate change in national and sector development planning (World Bank, 2009) - Policy makers and city planners should take into consideration the problems that can occur in the future (World Bank, 2009) - Address urgent issues such as inadequacy of the existing and planned flood protection systems (World Bank, 2009) - Promote involvement of private and industrial sectors in flood-risk area** - Develop disaster preparedness plan for vulnerable communities**

[16] World Bank. (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region [ออนไลน์]. เข้าถึงได้จาก: http://www.worldbank.org/eap/climatecities. วันที่สืบค้นไม่ระบุ (เอกสารประกอบ 2)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
- Poor integration of water resource management at the national level (BMA, 2013)			- Training and practice the action plan for disaster management at all levels involved**
Land use pattern changes: - Flooding has caused shrimp and aquatic animal farms to have to be relocated, while Mangrove forests and the coast is damaged from the impact of waves (Rawadee and Areeya, 2009)[17] - Construction of infrastructure in flood plain area in both upstream and downstream areas** - Flooding has caused aquatic farms to relocation ((Rawadee and Areeya, 2009) - BMA has not taken into account the potential impacts of climate change ((Rawadee and Areeya, 2009)*	- Assistance by BMA and the Fishery Department to households affected by providing sandbags and flooding compensation ((Rawadee and Areeya, 2009)* - Relocation of the mentioned area ((Rawadee and Areeya, 2009)	- Due to low educational attainment and lack of other knowledge skills, farmers could not shift to other occupations ((Rawadee and Areeya, 2009)*	- A thorough study on the impacts of climate change ((Rawadee and Areeya, 2009)* - Cooperation of the national government, local governments, and the public (Rawadee and Areeya, 2009)*
Flood caused by natural and physical reasons: - Floods are natural disasters that occur more frequently than other disasters; in the past 30 years the amount of floods in Asia make up 40% of all flooding that occurs in the world, with 90% of the world's flooding victims living in Asia. The floods not	- The most effective method of flood management is the integration of structural measures and non-structural measures; this can be building of floodways which can help during the initial stages of flooding but costs a lot , for structural measures, while for non-structural measures include warning systems, organizing more urban greening areas, and planning land usage that avoids flooding**	- Where land subsidence problem cannot be sufficiently solved, it is in highest concern because flood prevention and drainage systems recently planned for will be insufficient of less effective in future (BMA, 2013)*	

17 Rawadee, J. and Areeya, M. (2009). Adaptation Strategies to Address Coastal Erosion/Flooding: A Case Study of the Communities in Bang Khun Thain District, Bangkok, Thailand, Economy and Environment Program for Southeast Asia, Singapore. (เอกสารประกอบ 8)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
only directly damage the economy but also affect other areas of life in the long run, such as, sicknesses from waterborne diseases that come with the flood and food shortages which all interfere with the development of the country in the long run (Abhas, Robin and Jessica L., 2012)[18] - Causes for the Bangkok floods include both the naturally occurring and manmade mistakes they are: Naturally occurring: 1) Precipitation 2) Agricultural water 3) Northern waters 4) Tidal waves 5) Water level of Chao Phraya River in October and November 6) La Nina and sea level rise Manmade mistakes: 1) Poor implementation of city planning 2) Rapid expansion of the community causing insufficient drainage ststem 3) Land use change 4) Land subsidence 5) Intrusion of ditches (BMA, 2013)[19]	- Since the massive flooding in 1983 the BMA and other agencies involved have proceeded in protecting and preventing flooding in Bangkok's eastern side, covering an area of approximately 650 m^2, following the royal idea for a dike through the Chao Phraya River. Then aid was given by the Japanese government through the JICA, who helped research and plan the appropriate flood prevention system and the drainage system of the east side of Bangkok in 1984 and the project was completed in 1986 (BMA, 2013: p.12-17) - The BMA proceeded in surveying, designing, and developing a master plan for the drainage system in the Sai Mai district and parts of the Bang Khen, Meenburi, Khan Na Yao, and Khlong Sam Wa districts from 2012-2013 (BMA, 2013: p.25-29) - Department of Preventing and Solving Floods Bangkok (2013): 1. Management of Flood Areas in Bangkok o Using of sub-polder system to release floods in low area o Within the sub-polder building a drainage system (BMA, 2013: p.45) 2.Prevention and solving of flooding in Bangkok		

[18] Abhas K. Jha , Robin Bloch and Jessica Lamond. (2012). *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century. The World Bank, 1818 H Street NW, Washington DC.* (เอกสารประกอบ 6)

[19] BMA. (2013). Department of Drainage and Sewerage: Bangkok. (เอกสารประกอบ 1)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
- There are 6 main causes for the flooding problems in Bangkok and its eastern boundary; they are: 1) Northern waters overflowing the banks of the Chao Phraya River as in 1973, 1976, 1980, 1983, 1995, 1996, 2002, 2006, 2010 the latest being in 2011 2) Water from the north and the east 3) Torrential downpours (>90mm/day) 4) Hide tide 5) Uncontrollable development of the land 6) Intrusion and lack of maintenance of canals (BMA, 2013: p.1-10)[20]	○ Providing dike and flood protection facilities for the prevention against overflow of Chao Phraya River from high discharge from the north and tidal waves ○ The dike for flood overflow on the eastern side of Bangkok (in accordance with the royal idea) starting building in 1984 ○ The dike preventing overflow from the Chao Phraya River, Klong Bangkok Noi, and the Mahasawat which was started in 1996 - The Drainage System for flooding around the Bangkok area should be capable of withstanding of rainfall of 60 mm/hour and improved to withstand 100 mm/hour within 2023 (BMA, 2013: p.46-49)		
Damages from 2011 flood: - From surveys collected from 300 people as a sample of the population in the Khlong Luang and Nong Sua district, who were victims of the 2011 floods; it was found that the majority of the people knew about the flash flood, however, they did not expect it to flood that much, that the flood would be higher than 1.5 m, or that it would continue to flood more than a month (Sresunt et al., 2012) - The damages done are: 1) Damages of assets in households as well as agricultural products 2) Social damages which includes stress	- Studying how to coexist with water for victims of the flooding. The objectives are: 1) Studying of the relationship between foundations of the house and how violent flood waters effect it 2) Looking at the response of the victims or the floods 3) Reviewing and analyzing the effectiveness of the community's management and aid for its own people (Sresunt et al., 2012) - Plans on coexisting with water if you become a victim of the flood; for example, building houses that can withstand a long period of flooding, applications of materials and equipment that are suitable for use during floods, and an effective warning system that gives enough time to prepare before the incident (Sresunt et al., 2012)	- Since the building and improvement flood prevention systems costs a lot of money and will take no less than 10 years to finish there will be funding and continuation problems (BMA, 2013) - With current flood management measures, the larger area at the west side of BMA has high risk to be flooded and may be inundated for a period of 1month in 2050 (BMA, 2013) - Conflicts between citizens inside and outside of the flood barriers if the integration of water management system does not exist**	- Reviewing overall system and prevention plans for flooding in the city and integrating it with other systems (BMA, 2013) - Proposing that policy makers should increase their understanding of the causes and risks of flooding in the city, so that they can efficiently control and manage the problems in the present and future, since the rapid expansion of the city forces the integration of the analysis of flooding risks into city planning (World Bank, 2009) - Reviewing the system that deals with flooding in the Bangkok area (World Bank, 2009) - Giving training and education to increase the understanding of floods (Sresunt et al., 2012)

20 BMA. (2013). Department of Drainage and Sewerage: Bangkok. Flood Control and Management of the Bangkok Metropolitan Area. (A22)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
within the household, loss of pets, loss of communications for contacting family members, and quarrelling amongst family members 3) Damages towards health are the stress and worry due to flooding, injuries or illnesses that come with the flood waters, and people with chronic diseases suffer more severely (Sresunt et al., 2012)[21] - Bangkok's rapid growth causes it to outgrow the city plans and drainage systems and overuse of land and public utilities, which, combined with land subsidence, cause the massive flooding in 2011 and damaged physical assets and building foundations (BMA, 2013) - Lack of asset security during flood leads flood-victim not to leave their house (Sresunt et al., 2012)* - Flood in 2011 caused damage to both infrastructures and public & private properties (BMA, 2013) - It was found that assistance among community members in the area was relatively low (Sresunt et al., 2012)*	- After the severely massive flooding of 2011 the government created two committees which are the Strategic Committee for Reconstruction and Future Development (SCRFD) which formulates strategies for the restoration of the country and the Strategic Committee for Water Resources Management (SCWRN) which formulates strategies to prevention and solving floods (and droughts) So that there is a continuation in the management of water resources of the country (BMA, 2013: p.35-42) - After the 2011 flood, BMA has formulated strategies in flood restoration, protection and prevention by developing guidelines to ensure readiness and course of action in immediate and long term (BMA, 2013) - Gathering of information about causes and factors of flooding in Bangkok (BMA, 2013) - The massive flooding in 2011 invoked the population, government agencies and private agencies to prepare for the flooding in 2012; floodways were made and plans following the proposed plans for 2012 helped make the control and management effective (BMA, 2013) - From the data compiled from 2011 flood, action plan, flood prevention plan, and flood rescue plan were developed (BMA, 2013)		- Changing behavior and actions towards problems relating to water and coexisting with water (Sresunt et al., 2012) - Before any disastrous events there should be warnings and clear instructions on the actions that need to be taken; warnings made through a media center isn't as effective as warnings from the local leader, relatives, and people living in the area, who can assess the situation and determine which precise action to take; this encourages more participation from the people to help each other which is more effective than having a third party interfere (Sresunt et al., 2012) - Adding defensive measures to prevent flooding in areas communal and household areas to lessen damages done to assets and the economy (Sresunt et al., 2012) - Enforcing a mandatory law that prevents the expansion of houses and communities that invade waterways (Sresunt et al., 2012) - This can be solved by 1) Digging new drains and cleaning old ones 2) Installation an electrical water pumps 3) Increase the efficiency of the water pumping station 4) Installation of devices for measuring the flow rate of the river and drainage system (BMA, 2013) - There should be an overseeing third party that is formed specifically for policy making and arranging budgets for the purpose of this project and they will announce their progress for the public to ensure progress (BMA, 2013: p.44)

[21] Sresunt et al. (2012). Life with Floodwater: Response of Flood Victims of Disaster, The Graduated Volunteer Centre, Thammasat University. (เอกสารประกอบ 5)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
- Aiding system for flood-victims is still insufficient especially for poor people (Sresunt et al., 2012)*			- Considering human right and social equity to all flood victim (Sresunt et al., 2012) - Compensation for affected people should reflect the real damage caused by flood** - Reliable warning systems (Sresunt et al., 2012) - Giving training and education to increase the understanding of floods (Sresunt et al., 2012)
Damages from public hazards: - The effects of public hazards damages lives and business in the country but public hazard issues are never properly brought up in national level discussions or in policy making and arranging a budget for development (DDPM, 2013)[22]	- Studying the though process and procedures that are important to mitigating the effects of natural disasters especially against flooding in the city. Learning as a community to help build a stronger more prepared community and to increase adaptability to lessen damages caused by public hazards (DDPM, 2013) - Procedural Guidelines for the Structural Method 1) Construction of building and transportation routes that are resistance to public hazards 2) Strengthening of river banks, growing of trees and shrubs, building of dams and water retention /detention systems, waterways, irrigation ways, and dikes, strengthening areas at the base of the mountain and expansion of the waterways (DDPM, 2013) - Procedural Guidelines for the Non-structural Method (supports the structural method and used to prevent and mitigate the incident) 1) Setting up an agency or law that supports the building up an effective structure		- Creating a procedural guideline for the mitigation of public hazards, for the prevention, response, and aftermath, all the way through to the increase of understanding of public hazards and the development of hyper relations of both the good and bad (BMA, 2013) - Increasing in education and raising awareness towards social responsibilities concerning public hazards (BMA, 2013) - Arranging of information, about the risks and prevention of floods, to be distributed more efficiently, especially for the population that lives in high risk areas, whether it be through social media or broadcasting the news online to increase awareness (BMA, 2013)

[22] Department of Disaster Prevention and Mitigation. (2013), Ministry of Interior. (เอกสารประกอบ 7)

Flood in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
	2) Training and teaching of people involved about the skills needed to make design and construct an effective structure that is standardized and is suitable for the environment it will be set in (DDPM, 2013)		

Table 7-2 Coastal erosion (Present problem – current activities – future problem – required activities)

"*" denotes information extracted by JICA Expert Team

"**" denotes information obtained from Adaptation Task Force

Coastal Erosion in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
Erosion continuously increasing - From the analysis of aerial surveillance images, it was found that the coastal erosion around the Bang Khun Thian area has dramatically increased. From 1952-1991 the sea has eroded the coast by 7-12m/year at 8 different points, especially during 1987-1991 where the rate of erosion has increased to 33.1m/year (Ittaro, 2001)[23] - The coast at Bang Khun Thian has suffered 500 m of coastal erosion or equivalent to losing 400 hectare in the past 30 years especially at the estuary (BMA, 2002)[24] - From the analysis of aerial surveillance images, it was discovered that there is a tendency for coastal erosion of the Bang Khun Thian front which has significantly shown changes (Winterwerp et al., 2005)[25] - 2 sub-districts (9, 10), in the district of Tha Kham in the Bang Khun Thian area, suffered directly as a result of coastal erosion in 2005 which resulted in the impacted 382 households in the 9th sub-district and 327 households in the 10th sub-district **(**BMA, 2006)[26]	***Research in coastal erosion*** - The information and effects of coastal erosion were studied and analyzed by Ittaro (2001), BMA (2002 and 2006), Winterwerp et al., (2005), Jarupongsakul (2006), and Chulalongkorn University - Rawadee, J and Areeya, M. analyzed landmarks in the Bang Khun Thian area and discovered that productive land areas along the coast has decreased. (Rawadee and Areeya, 2009) ***Structural measures*** - In 1991 the BMA placed rocks along the coast with a total length of 80 m - In 1993 the BMA added more rocks along the coast with a total length of 4,320 m - In 1995 the BMA added extensions to the wall increasing the height and width, resulting in a width of 6 m, height of 2 m, and a total length of 5,020 m; however each year the maintenance	- The coast at Bang Khun Thian has suffered from coastal erosion and it is evident that the rate of erosion is increasing (Ittaro, 2001) - BMA has not yet taken into account in its coastal protection plan the potential impacts due to climate change particularly sea level rise (Rawadee and Areeya, 2009)* - Climate change leads to more frequent and more severe storm that speed up the erosion**	- To develop a plan for prevention and be familiar with early signs of coastal erosion, and increase knowledge of coastal erosion (Ittaro, 2001; Jarupongsakul, 2006; Rawadee and Areeya, 2009) - Cooperation of the national government, local governments and the public is necessary to address the problem of coastal erosion/flooding (Rawadee and Areeya, 2009)* - A thorough study on the impacts of climate change in order for the concerned public agencies to prepare proper solutions to the problem (Rawadee and Areeya, 2009)*

23 Isaraporn Ittaro. (2001). Shoreline Changes at Bang Khun Thian, Master's Thesis, Department of Engineering (Water Resources Engineering), Chulalongkorn University, Graduate School, Bangkok.

24 BMA. (2002). Map of Bangkok. Department of City Planning: Bangkok.

25 Johan C. Winterwerp, William G. Borst, and Mindert B. de Vries. (2005). "Pilot Study on the Erosion and Rehabilitation of a Mangrove Mud Coast" Journal of Coastal Research: Volume 21, Issue 2: 223-230.

26 BMA. (2006). The project on Coastal Erosion Protection: A Case Study of Bang Khun Thain District. Bangkok. Interim Report: Bangkok.

Coastal Erosion in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
- 30 spots along the coast, in the provinces of Samut Sakhon, Samut Prakan, and Bangkok (Bang Khun Thian), suffer from extreme coastal erosion (Jarupongsakul, 2006)[27] - Chulalongkorn University has conducted a research on coastal erosion at the Gulf of Thailand and the Andaman Sea and concluded that there was an 11% erosion in the Gulf of Thailand and 2% erosion in the Andaman Sea where the erosion rate exceeded 5m/year which is an estimate of 156 million US dollars each year (WB, 2006)[28] - The Bang Khun Thian seafront is approximately 5 km long and has extensively suffered erosion damages over the past 28 years, which totals to more than 800 m of land. The coastal erosion of the Bang Khun Thian area are caused by these following points: 1) Use of groundwater and land subsidence 2) Construction of dams at the source of the water 3) The growing and raising of aquatic animals and drilling of wells 4) Destruction of Mangrove forests 5) Coastal current 6) Large waves and seawater levels (BMA, 2014)[29] - The Bang Khun Thian coast has eroded a total of approximately 800-1,000 m with a rate of 1.4-4.5 m/year, the receding shorelines are caused by	for the wall includes repairs and an extension of 2 m to the height; presently the wall is beyond repair and is no longer in use - In 2008 the community in the Bang Khun Thian area built bamboo wave breakers a total length of 900 m - In 2009 the BMA built the 1st length of bamboo wave breakers a total length of 4,190 m - In 2010 the BMA continued on building bamboo wave breakers, the 2nd length being 4,900 m - In 2012 the 3rd installment of the bamboo wave breakers had a length of 4,200 m (BMA, 2014) - From 1991-1996 the BMA constructed wave breakers from stones and used bamboo to support the structure, but this only worked for a short period of time ***Other measures*** - From 2005-2007 the BMA assigned the Department of City Planning to continue the policy to prevent erosion and repair damages caused by coastal erosion in the Bang Khun Thian area in Bangkok		

27 Jarupongsakul T. (2006). Coastal Erosion in Thailand: Causes and Management. Master's Thesis, Department of Geolog, Chulalongkorn University, Graduate School, Bangkok.

28 World Bank. (2006). Thailand Environment Monitor 2006, Bangkok. (เอกสารประกอบ 1.1)

29 BMA. (2014). The project on Coastal Erosion Protection: A Case Study of Bang Khun Thain District. Bangkok. Progress Report, Department of Drainage and Sewerage: Bangkok (ไม่มีรหัสเล่ม)

Coastal Erosion in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
1) decrease in sediments in the Chao Phraya River due to dams that block the sediment flow 2) Large waves that occur during the monsoons 3) Coastal currents 4) The subsidence of the sea floor (BMA, 2014)	○ The temporary solution was to construct wave breakers in 3 different installments (from 2010-2013) ○ The permanent solution was to get advice and consult with building companies (who specialized in building T-Groins) (from 2011-2018) - Other methods used, include giant sandbags, cement stakes were put in place, to use as wave breakers and then car tires were added to the stakes; in Khun Samut Jeen area 49A2 wave breakers were constructed from bamboo, and dikes were installed as well - Conclusion of Solutions: ○ Permanent Measures building T- groin structures to lessen impact of erosion ○ Temporary Measure use bamboo wave breakers to lessen impact of erosion ○ Preliminary Measures re-growing /planting Mangrove trees to us a wave breakers (BMA, 2014)		
Coastal area losing previous stability: - From the analysis of the balance of resources at the coast of Bang Khun Thian area it was discovered that the coast of Bang Khun Thian no longer has its previous stability and resilience and concluded that the erosion rate is 1.4-4.5 m/year (BMA, 2007: p.3-44)[30]	- The 4 main factors to prevent and solve the problem: 1) Not doing anything 2) Evacuation to a safer area or retreat 3) Creating stability and resilience of the shore using non-structural methods 4) Creating stability and resilience of the shore using structural methods (BMA, 2007) - Construction of Bang Khun Thian Coastal	- Within 10 years the remaining mangrove forest will be destroyed leaving the inhabitants of the area to lose >50 m in that time. If nothing is done to prevent the retreat of the shorelines, in 30 years, the shorelines will recede to behind the present day location of the mangrove forest, where the shrimp farms are, and may continue to recede to the Klong Long area. (BMA, 2007: p.3-44)	- Campaign to raise awareness of local citizens especially on the linkage between type of land use and economic activity that will facilitate the implementation of coastal erosion protection plan

Coastal Erosion in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
	Erosion monitoring center** - The most effective structure is the T-Groins and growing mangrove forests in a total area of 550 rai to use as breakers and restore the ecology along the coast (BMA, 2007: p.1-13)		
Coastal fisheries affected - Studies in the area of the local community, in the Chom Thong district in Bangkok, show that households in the provinces of Samut Sakhon and Samut Prakan, which are in the areas affected by the coastal erosion, suffer from the decrease of produce, produced by occupations raising and selling aquatic animals as well as aquaculture farms. (Rawadee and Areeya, 2009) - From the analysis of landmarks in the Bang Khun Thian area, from past to present, the coast has eroded a total of 4-800 m with a rate of 20-25 m/year due to the decrease of collected sediment, the construction of dams, and the rising levels of seawater; this has also affected shrimp and cockel farms of 2 sub-districts (Rawadee and Areeya, 2009)[31]	- Rawadee, J and Areeya, M. (2009) conducted a study with emphasis on the adaptableness behavior of households. - The Bangkok Metropolitan Administration (BMA) is addressing the problem by emphasizing foundations that involve engineering designs or engineering structures** - There are 3 types of strategies 1) Prevention (i.e. building a wave breaker, using a wall of rocks, bamboo dams, and permanent dams) 2) Evacuation 3) Adjusting the elevations of the house. Each household may use more than one strategy and they do not have to be the same strategies. (Rawadee and Areeya, 2009)	- Seawater levels, at the coast of the Gulf of Thailand in the year 2030, will cause risks of two types of disasters which are 1) inundation (permanent flood) 2) extreme flood incidences (episodic extremes) (Rawadee and Areeya, 2009) - Due to low educational attainment and lack of other knowledge skills, farmers could not shift to other occupations (Rawadee and Areeya, 2009)*	- Cooperation of the national government, local governments and the public is necessary to address the problem of coastal erosion/flooding (Rawadee and Areeya, 2009)* - A thorough study on the impacts of climate change in order for the concerned public agencies to prepare proper solutions to the problem (Rawadee and Areeya, 2009)*
Sediment reduction and land subsidence - The decrease of the sedimentary area, ground subsidence, rising seawater levels, crashing waves, storms, and the receding of the coast causes the ground to sink 1 cm each year; which shows definitively that there is coastal erosion at a rate of 5 m/year (Rawadee and Areeya, 2009)	- Rawadee, J and Areeya, M. cited Winterwerp et al., 2005, Jarupongsakul, 2006, and Ittaro, 2001, and conducted a research to understand the reasons for ground subsidence. (Rawade and Areeya, 2009)		- Use technology to keep sediment behind the structure** - Extension of water supply system and define where groundwater drilling and utilization are prohibited**

[31] Rawadee, J. and Areeya, M. (2009). Adaptation Strategies to Address Coastal Erosion/Flooding: A Case Study of the Communities in Bang Khun Thain District, Bangkok, Thailand, Economy and Environment Program for Southeast Asia, Singapore. [ออนไลน์]. เข้าถึงได้จาก: http://www.eepsea.net/pub/tr/12628446591Rawadee_and_Areeya_-_Coastal_Erosion.pdf (20 เมษายน 2557) (เอกสารประกอบ 5, 8)

Coastal Erosion in Bangkok (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
- Uncontrollable groundwater utilization in the neighboring provinces**			- Cooperation between neighboring provinces to control the use of groundwater**
Mangrove forest decreasing - In the past 30 years the mangrove forest was subjected to severe deforestation and the Bang Khun Thian area has lost a total of 483 ha of mangrove forest. These mangrove forests are the key to lessen the force of impact of storm surges against the coast. The residents of the sub-district of Ban Khun Samut Jeen were forced to evacuate permanently due to coastal erosion. (WWF, 2014)[32] - Mangroves at the shoreline have been fallen by strong waves because their root system does not provide sufficient anchoring anymore (Rawadee and Areeya, 2009)*	- In 1989 the Cabinet resolved to distributing an area of 2,735 rai for mangrove trees from the land reserved for permanent forest and left the BMA in charge of overseeing the prevention of more erosion and conservation of the Mangrove forest (BMA, 2014) - Protection and conservation of the mangrove forests (WWF, 2014)	- In 50 years in the future the seawater levels is predicted to rise, causing erosion at a rate of 15-25 m/year while the intertidal forest is being cut down at an frightening rate, causing a 2,667 km loss of coastal area which damages the perimeter of the province of Bangkok and the tourism industry. (WWF, 2014)	
Sea level rising - The southern coast of Bangkok lies within the 9th and 10th sub-district, in the district of Tha Kham in the Bang Khun Thian area, and suffers from erosion due to seawater (BMA, 2007: p.1-1)[33] - The changing global temperature has caused the average seawater level abruptly increase by 0.09-0.88 m, which causes changes in the delicate state of torrential waves and coastal erosion which effects the coastal ecology, occupations, tourism and the country`s economy. (TGO, 2014)[34]	- Understanding on the side-effects and cause of fluctuations on seawater level and the impact on the country (TGO, 2014)	- There should be changes to adapt and to learn and to know the causes and factor of the rising levels of seawater (WWF, 2014)	

32 WWF International. (2014). Mega-Stress for Mega-Cities: A Climate Vulnerability Ranking of Major Coastal Cities in Asia, Switzerland, 25-26. [ออนไลน์]. เข้าถึงได้จาก: http://awsassets.panda.org/downloads/mega_stress_cities_report.pdf (20 เมษายน 2557) (เอกสารประกอบ 2)

33 BMA. (2007). Protection and Solution of Bang Khun Thain Coastal Erosion in Bangkok Project, The Final. Department of City Planning: Bangkok. (A15)

34 Thailand Greenhouse Gas Management Organization (Public Organization). (2014). ระดับน้ำทะเลผลกระทบในประเทศไทย. [ออนไลน์]. เข้าถึงได้จาก: http://www.tgo.or.th/index.php?option=com_content&view=article&id=71:sea-level&catid=37:effect-of-global-warming-in-thailand&Itemid=59. 21 มิถุนายน 2014 (เอกสารประกอบ 5)

Table 7-3 Water resources, salinization (Present problem – current activities – future problem – required activities)

"*" denotes information extracted by JICA Expert Team

"**" denotes information obtained from Adaptation Task Force

Water resources, salinization (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
Many areas experiencing drought every year - From December to May, of each year, the average temperature of Thailand increases and in April temperatures can reach 40-43 degrees Celsius causing the natural convection to slow down and with combination of little rainfall it results in droughts in some areas including Khan Na Yao District and Hui Khwang District suffers from drought (BMA, 2013: p.94)[35] - Invasion of saline water affects the amount of consumable water and water for agricultural needs. (WWF, 2014)[36] - Poor management of water resource**	- Plans for preparation and mitigation of droughts o Preparation 1.To prepare for and mitigate the impact of droughts; information was gathered to perform a risk analysis to develop procedural guidelines 2. Preparations to increase readiness includes arranging and training of volunteers and readying the community o Response (Management Administration During Emergencies) 1.Setup a control center and proceed according to the developed plans 2.The control center announces news regarding the situation for all citizens 3.Finding and distributing water for consumption 4.Delegating and spreading different groups to help smooth operations o Aftermath (Recovery) 1.Damage assessment and needs assessment 2.Begin rehabilitation of the physical and mental states 3.Begin basic restoration of damages 4.Studying and learning of the incident to collect more information to improve upon (BMA, 2013: p.94-95) - Setting up a system for the prevention and control of flood waters and at the water source install equipment to prevent		- Development of plans and increase in knowledge for prevention (WWF, 2014) - Short run** 1) Soil and water conservation program (use of compost, grow ground-covering plant such as vertiver grass) 2) Drought monitoring and warning system 3) Immediate compensation payment to affected communities - Long run** 1) Develop small scale water reservoir in agricultural land area 2) Accurate warning system so that farmers and communities can plan their type of crop based on water availability 3) Employ appropriate technology: conversion of saline water to freshwater (desalination water) and the

35 BMA. (2010). Bangkok Disaster Prevention and Mitigation Plan During 2010-2014: Bangkok. (A19)

36 WWF International. (2014). Mega-Stress for Mega-Cities: A Climate Vulnerability Ranking of Major Coastal Cities in Asia, Switzerland, 25-26. [ออนไลน์]. เข้าถึงได้จาก: http://awsassets.panda.org/downloads/mega_stress_cities_report.pdf (20 เมษายน 2557) (เอกสารประกอบ 2)

Water resources, salinization (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
	saline water invasions and to help control flood waters (WWF, 2014) - The Thai government has found warehouses, at places with high elevation, to store rice to prepare for severe flooding and subsequent drought to maintain a stable food supply (WWF, 2014) - Setting up training seminars for the community to prepare for emergencies and to increase readiness for severe droughts brought on by rising sea levels and storm surges (WWF, 2014)		use of artificial rain for instance.
Sea level rising causing damages - The changing of the Earth`s temperature has increased the average water level by 0.09-0.88 m since 1993. Researchers have evaluated the factors causing the rising of sea levels and calculated that if the seawater levels rise by approximately 0.5-1 m the coast at the Gulf of Thailand will receive more damages than the coast at the Andaman Sea. The coasts that will receive more damages are in the Bangkok area and areas nearby which include the coast at Rayong, Petchaburi all the way down to Narathiwat (TGO, 2014) - Bangkok lies just 2 m above the current sea level indicating high risk of saltwater intrusion (WWF, 2014) - Saline Water occurs because 1) The rising seawater levels allows the saline water to invade the land	- Research has shed light on the effects and cause of the seawater level in Thailand (TGO, 2014) - Water gate facilities to prevent saltwater intrusion and to help control floodwater (WWF, 2014)	- In the next 50 years the seawater levels will rise by 10-100 cm increasing the saline water invasion into the Chao Phraya River which will cause a decrease in usable water for agriculture and consumption. The severe increase of frequency in saline water invasion and storm surges results in an increase of seawater levels, by 50 cm and 100 cm, and a loss of occupational land which in turn decreases the GDP-Gross Domestic Product. (WWF, 2014) - Saltwater intrusion is also exacerbated by stronger and more frequent sotrm surges (WWF, 2014)*	- There is a need for adaptation and learning of the factors that influence the seawater levels (TGO, 2014) - Protecting existing mangrove forests and restore ones that have been lost due to cutting (WWF, 2014)*

Water resources, salinization (What? Where? When? Why?)			
Present Problems (Source of information)	**What have you done/are you doing to addressing the problems?**	**Future Problem (Source of information)**	**What Kind of activities will be required additionally?**
2) Pumping up groundwater for use increases the relative seawater levels (TGO, 2014)[37]			

[37] Thailand Greenhouse Gas Management Organization (Public Organization). (2014). ระดับน้ำทะเลผลกระทบในประเทศไทย. [ออนไลน์]. เข้าถึงได้จาก: http://www.tgo.or.th/index.php?option=com_content&view=article&id=71:sea-level&catid=37:effect-of-global-warming-in-thailand&Itemid=59. 21 มิถุนายน 2014 (เอกสารประกอบ 5)

Table 7-4 Flood adaptation measures (time scale of impact, adaptation level, current condition, classification and relationship with other sectors)
(To be examined continuously)

Flood

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
Short term 1-3 years	**Level 1 Prevention**	**Strengthen measures for retention areas e.g., construct and improve temporary retention basins (BMA et al., 2009)**	**N**	**SAF**	**High**			**✔ A=WW**		
		Dredge of drainage channels	**O**	**SA**	**High**	**✔ A=T**				
		Install drainage pumps	**O**	**SA**						
		Improve small scale irrigation facilities e.g., gates, weirs and etc. (NESDB et al., 2013)	**O**	**SA**						
		Construct flood protection system (e.g., pumping station, water gate, flood dyke, tunnel) with proper supporting system such as alternative power sources and transmission lines	**O**	**SA**	**Middle**		**✔ A→E**			
	Level 2 Minimize impacts	**Provide catchment area to store water and reduce volume of flood water flow rate**	**O**	**SAF**						
		Ensure feed for livestock (NESDB et al., 2013)	**N**	**SA**						
		Designate evacuation areas (MOEJ, 2010) with appropriate	**O**	**AF**						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
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Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
		facilities/equipment								
		Develop disaster evacuation plan and revise the plan as necessary	O	SAF						
		Develop emergency preparedness plan	N	SAF						
		Strengthen emergency communications (BMA et al., 2009)	O	SA						
		Promote people's participation to maintain community canal	O	SA	High	✔ A=T				
		Educate/inform citizens on flood related issues e.g., risk of residing in flood prone area, health care during flood, situation of flood	O	SA						
		Establish "Flood Aid Units" which are ready to help promptly and thoroughly		SA						
		Compensate for damaged farmland and properties	O	F						
	Level 3 Change and Reconstruction	Coordinate with government/related organizations/neighboring provinces to develop agreement on flood water management	O	SAF						
		Formulate business continuity plans (MOEJ, 2010)	N	SAF						
		Provide financial support during inundation period	O	AF						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
		(NESDB et al., 2013)								
Midterm 3-5 years	Level 1 Prevention	Continue the implementation according to the plan	O	SAF	High	✔ A=T	✔ A=E	✔ A=WW		
		Promote household level flood protection measures such as flood walls		SA						
		Construct community-based small scale retention pond	N	SAF	Middle			✔ A→ WW		
		Maintain canals/rivers and increase drainage capacity (NESDB et al., 2013) e.g. maintenance of levees and river bank dredging	O	SA	High	✔ A→T				
		Develop Ayutthaya bypass channel regulation	N	SA						
		Operate existing dams effectively and revise dam water management plan as appropriate	O	SA						
		Construct and elevate outer ring road as alternative for transportation during flood	O	SAF	Middle	✔ A=T				
		Provide alternative power source and power transmission lines	N	SAF	Low		✔ A=E			
		Construct flood proof buildings (BMA et al., 2009)	N	AF						
		Effectively utilize existing flood protection facilities and extending their lifetime via regular maintenance	O	SA						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）: Adaptation is needed to implement before implementation of other TF sectors, A=（TF）: Adaptation and other TF sectors can be implemented at the same time , and A←TF）: Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
		(MOEJ, 2008)								
	Level 2 Minimize impacts	Establish flood hazard maps	N	SAF	High				✔ A→G	
		Implement education program to create understanding on flood risk map and to introduce self-flood prevention measure to citizen		S						
		Improve accuracy of weather forecast and upgrade monitoring and warning systems (MOEJ, 2008)	O	SA						
		Develop flood management information system with link to other sectors e.g., planting schedule	N	SAF						
		Establish guidelines for flood control facilities operation	O	SA						
		Enforce law on land use and adopt integrated land use planning e.g., prohibit construction in flood prone area	N	SAF					✔ A→G	
		Implement intervention measure in agricultural sector when appropriate (NESDB et al., 2013)	N	SA						
		Develop emergency preparedness plans (BMA et al., 2009)	N	SAF						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
		Provide more catchment areas	N	SAF						
		Relocate housing in flood prone areas	N	F						
	Level 3 Change and Reconstruction	Utilize urban planning measures	O	SAF		✔ A→T			✔ A→G	
		Conduct research and develop countermeasures technologies (MOEJ, 2010)	O	SAF						
Long term 5-10 years	Level 1 Prevention	Continue the implementation of plans	O	SAF		✔ A=T	✔ A=E	✔ A=WW		
	Level 2 Minimize impacts	Continue the implementation of plans	O	SAF		✔ A=T			✔ A=G	
		Ensure operational guidelines for flood control facilities	N	SA						
		Enforce law on land use and integrated land use planning (BMA et al., 2009)	N	SAF		✔ A→T			✔ A→G	
		Improve flood management information system (NESDB et al., 2013)	N	SA						
		Upgrade monitoring and warning systems (MOEJ, 2008)	N	SA						
	Level 3 Change and Reconstruction	Continue the implementation of plans	O	SAF					✔ A=G	
		Provide government sponsored flood insurance (for areas outside of flood protection facilities) (BMA et al., 2009)	N	F						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW	Green Urban Planning	
		Establish funds and subsidiaries for post disaster restoration (MOEJ, 2008)	**N**	**F**						
		Conduct research and develop countermeasures technologies (MOEJ, 2010)	**O**	**SAF**						

Table 7-5 Coastal erosion adaptation measures (time scale of impact, adaptation level, current condition, classification and relationship with other sectors)

(To be examined continuously)

Coastal erosion

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←（TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
Short term 1-3 years	**Level 1 Prevention**	**Construct temporary coastal area protection fence (Bamboo)**	**C**	**S**	**High**				**✔ A＝G**	
		Integrated disaster prevention system for coastal community - including evacuation road, hazard map and early warning system to sea side and inland areas[6]								
		Improvement of dike system (BMA et al., 2009)	**N**	**SAF**	**Low**				**✔ A＝G**	
	Level 2 Minimize impacts	**Promote people's knowledge on benefits of mangrove forest and its conservation**	**O**	**SAF**	**High**				**✔ A→G**	
		Promote mangrove forest plantation	**O**	**SAF**	**Middle**				**✔ A＝G**	
		Public information campaigns and training exercises (World Bank, 2010)	**O**	**SAF**						
	Level 3	**Set clear goal for coastal**	**O**	**SAF**						

[6] Time scale of impact is from short to midterm plans

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←（TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
	Change and Reconstruction	area protection measures and develop action plan accordingly								
		Set up joint committee of stakeholders to develop the coastal area management master plan by adopting integrated coastal zone management approach (MOEJ, 2008)	N	SAF	Middle				✔ A=G	
Midterm 3-5 years	Level 1 Prevention	Construct permanent coastal erosion defense (Stone dike)	N	SA	High				✔ A=G	
		Integrated disaster prevention system for coastal community - including evacuation road, hazard map and early warning system to sea side and inland areas[7]								
		Maintain and improve coastal area protection facilities (MOEJ, 2008 and MOEJ, 2010)	N	SAF	High				✔ A=G	
		Comprehensive sediment control along rivers and coastal areas (MOEJ, 2008)	N	SAF	Middle			✔ A→WW	✔ A→G	
		Design proper wastewater discharge	N	SA				✔ A→WW		

[7] Time scale of impact is from short to midterm plans

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S: Strengthen existing adaptation measures, A: Acclimatize/accommodate to medium/long term impacts, F: Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←（TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
	Level 2 Minimize impacts	Prohibit and restrict construction in high risk zones (MOEJ, 2008)	N	F						
		Enforce law on land and fisheries and enhance the role of communities in coastal protection tasks	N	SAF						
		Improve coastal ecosystem services to maintain existing capacity in supporting food security	N	A					✔ A=G	
		Rehabilitate mangrove forest along the shoreline of Bang Khun Thian (The World Bank, 2010)	O	SA					✔ A=G	
		Relocate community from high risk zones	N	F						
		Develop integrated land use plan that address land use patterns in area prone to erosion	O	SAF		✔ A→T			✔ A→G	
		Initiate and develop hazard maps	N	SAF					✔ A→G	
		Early warning system (ONEP, 2011), and monitoring system (MOEJ, 2008)	N	SAF						
		Coastal Monitoring Center	O	SA				✔ A→WW		
		Public information campaigns and training	O	SA						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←（TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
		exercises (The World Bank, 2010)								
		Operate harbor/port	N	SA		✔ A=T				
	Level 3 Change and Reconstruction	Implement integrated coastal zone management according to the plan (MOEJ, 2008)	N	SAF				✔ A= WW	✔ A=G	
		Conduct research and develop countermeasure technologies (MOEJ, 2010)	O	SAF						There are studies on coastal erosion protection measures in Thailand, although may not be done by BMA.
Long term 5-10 years	Level 1 Prevention	Implement integrated coastal zone management according to the plan	N	SAF				✔ A= WW	✔ A=G	
	Level 2 Minimize impacts	Implement integrated coastal zone management according to the plan	N	SAF					✔ A=G	
		Monitor ecosystem changes for protection purpose (BMA et al., 2009)	N	SA	Middle				✔ A=G	
		Implement integrated land use plan	O	SAF	High	✔ A=T	✔ A=E	✔ A= WW	✔ A=G	
		Upgrade monitoring system (MOEJ, 2008)	N	SA						
	Level 3 Change and Reconstruction	Implement integrated coastal zone management according to the plan	N	SAF	Middle			✔ A= WW	✔ A=G	
		Conduct research and develop countermeasure	O	SAF						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A→（TF）：Adaptation is needed to implement before implementation of other TF sectors, A=（TF）：Adaptation and other TF sectors can be implemented at the same time , and A←（TF）：Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
		technologies (MOEJ, 2010)								

Table 7-6 Water resources, salinization adaptation measures (time scale of impact, adaptation level, current condition, classification and relationship with other sectors)

(To be examined continuously)

Drought and saltwater intrusion

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A → (TF) : Adaptation is needed to implement before implementation of other TF sectors, A= (TF) : Adaptation and other TF sectors can be implemented at the same time , and A← (TF) : Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
Short term 1-3 years	**Level 1 Prevention**	***The drought cannot be prevented as Bangkok situated at the end of the river area; and Bangkok is dependent on water from the north and weather***								
	Level 2 Minimize impacts	**Expand water supply service area**	**O**	SAF	**High**			✔ A=WW		
		Construct small water reservoirs	**N**	SA						
		Supply water from other sources/areas	**O**	S						
		Promote water conservation measures, use water efficiently	**O**	SAF	**Middle**		✔ A=E	✔ A=WW		
		Develop drought management and emergency preparedness plans and monitoring system	**N**	SAF						
		Strengthen emergency communications (BMA et al., 2009)	**N**	S						
		Public information campaigns and training exercises (The World Bank,	**N**	SAF						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A → (TF) : Adaptation is needed to implement before implementation of other TF sectors, A= (TF) : Adaptation and other TF sectors can be implemented at the same time , and A← (TF) : Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
		2010)								
	Level 3 Change and Reconstruction	Cooperate with government units and concerned agencies to plan for water allocation	O	SA						
Midterm 3-5 years	Level 1 Prevention	-								
	Level 2 Minimize impacts	Implement drought management plan	O	SAF						It is confirmed that there is a work done on drought management plan by Department of Water Resource and other government agencies however, it is more like a general picture and not specific to BMA.
		Drought hazard map	N	AF						
		Implement water and energy conservation measures	O	SAF	High		✔ A=E	✔ A=WW		
		Plant trees (BMA et al., 2000)	O	SAF	Middle				✔ A=G	
		Public information campaigns and training exercises (The World Bank, 2010)	N	SAF						
		Develop warning and monitoring systems (MOEJ, 2008)	N	SAF						
	Level 3 Change and	Implement drought management plan	N	SAF						

Yellow highlight: Adaptation measures selected to prioritize in the Monitoring and Evaluation (M/E) Table
*C: Completed, O: Ongoing, N: Not yet
**S:Strengthen existing adaptation measures, A:Acclimatize/accommodate to medium/long term impacts, F:Fundamental improvement of vulnerability
*** Ranking of priority measure will be conducted continuously with consultation with other Task Forces and involved parties
**** WW: Wastewater, A: Adaptation, T: Transport, E: Energy, W: Waste and wastewater and G: Green urban planning
A → (TF) : Adaptation is needed to implement before implementation of other TF sectors, A= (TF) : Adaptation and other TF sectors can be implemented at the same time , and A← (TF) : Adaptation is needed to implement after implementation of other TF sectors

Time scale of impact	Adaptation level	Adaptation measure	C/O/N*	S/A/F.**	Priority***	Relationship with other TF****				Explanation
						Transport	Energy	Waste and WW***	Green Urban Planning	
	Reconstruction	Conducting research and developing technologies for countermeasures (MOEJ, 2010)	O	SAF						It is confirmed that Department of Water Resource has some works related.
Long term 5-10 years	Level 1 Prevention	-								
	Level 2 Minimize impacts	Implement drought management plans with proper monitoring and warning systems (MOEJ, 2008)	N	SAF						
		Implement integrated land use planning	N	SAF	High	✔ A=T			✔ A=G	
		Implement water and energy conservation measures	N	SAF	High		✔ A=E	✔ A=WW		
		Plant trees		SAF	Middle				✔ A=G	
	Level 3 Change and Reconstruction	Establish funds and subsidies for post-disaster recovery (MOEJ, 2008)	N	F						
		Implement actions as planned	O	SAF						
		Conduct research and develop countermeasures technologies (MOEJ, 2010)	O	SAF						It is confirmed that Department of Water Resource has some works related.

Table 7-7 Monitoring and evaluation table for the stone dike

* DDS: Department of Drainage and Sewerage, BMA: Bangkok Metropolitan Administration, ONEP: Office of Natural Resources and Environmental Policy and Planning, DMCR: Department of Marine and Coastal Resources, MNRE: Ministry of Natural Resources and Environment, BB: Bureau of the Budget and DOE: Department of Education

Title of Project / Action	**Baseline indicator**	**End Project / Action indicator**	**Data / Information**	**Data / Information Provider***	**Reporting cycle**	**Other Remarks**
Coastal Erosion Project 1.1 Constructing permanent coastal erosion defense (Stone dike)	• Feasibility Study (FS) was almost complete (90%)	• FS 100% done	• Final FS Report	• DDS, BMA • Consultant	• Once a year	
	• EIA Approval is in processing	• EIA was approved	• Final EIA Report	• DDS, BMA • ONEP	• Once a year	
	• Detailed Design is 70% complete	• Detailed Design 100% done	• Tender document • Specification • Cost Estimation • Detailed Design	• DDS, BMA	• Once a year	
	• Budgetary approved in National Government (NG) Plan but BMA can get after EIA was approved	• Earn budget	• National Erosion Master Plan	• Department of Budget, BMA • DMCR, MNRE • BB, NG	• Once a year	
	• Construction not yet done	• Construction of Center and Stone Dike 100% (5.2 km)	• Construction Report (Length, wide and height of dike)	• DDS,BMA • Construction Company	• Once a year	
	• Sedimentation will not be increased or reduced more	• Sedimentation will be increased (7.3 – 43.8 cm/year up to the area)	• Thickness of sedimentation	• DDS,BMA	• Once in 6 months	
	• Mangroves areas will not be increased or reduced more	• Mangrove areas will be increased	• Areas of mangrove	• DOE , BMA	• Once in 6 months	

Table 7-8 Monitoring and evaluation table for Coastal Monitoring Center

* DDS: Department of Drainage and Sewerage, BMA: Bangkok Metropolitan Administration, ONEP: Office of Natural Resources and Environmental Policy and Planning, DMCR: Department of Marine and Coastal Resources, MNRE: Ministry of Natural Resources and Environment, BB: Bureau of the Budget and DOE: Department of Education

Title of Project / Action	**Baseline indicator**	**End Project / Action indicator**	**Data / Information**	**Data / Information provider***	**Reporting cycle**	**Other Remarks**
Coastal Erosion Project 1.2 Coastal Monitoring Center (CMC)	• FS was almost complete (90%)	• FS 100% done	• Final FS Report	• DDS, BMA • Consultant	• Once a year	
	• EIA App. is in processing	• EIA was app.	• Final EIA Report	• DDS, BMA • ONEP	• Once a year	
	• Detailed Design (DD) is 70% complete	• DD100% done	• Tender doc. • Specification • Cost Estimation. • DD	• DDS, BMA	• Once a year	
	• Budgetary approval in National Government (NG) Plan but BMA can get after EIA was approved	• Earn budget	• National Erosion Master Plan	• DDS, Department of Budget, BMA • DMCR, MOE • BB, NG	• Once a year	
	• Construction not yet done	• 100% CMC Constructed	• Construction Report	• DDS,BMA • Construction Company	• Once a year	
	• CMC is not constructed	• Coastal engineering. data (erosion, sedimentation, wind & wave speed) • No. of visitors • No. of educational activities for local people • Increase of local activities	• Erosion rate • Erosion length • Mangrove area • No. of visitors • No. activities	• DDS, BMA • DOE., BMA • DMCR, MNRE • Social Development Department	• Once in 6 months • Once in 4 years	

Table 7-9 Monitoring and evaluation table for flood hazard map

* DDS: Department of Drainage and Sewerage, BMA: Bangkok Metropolitan Administration, RID: Royal Irrigation Department, TMD: Thailand Meteorological Department, and DPMD: Disaster Prevention and Mitigation Department

Title of Project / Action	Baseline indicator	End Project / Action indicator	Data / Information	Data / Information Provider*	Reporting cycle	Other Remarks
Floods Establish Flood Hazard Map (FHM)	• Planning Process	• Planed	• GIS Map • High Spot Map • Risk Area Map	• DDS, Fire and Rescue Department., BMA • RID • TMD • DPMD	• Once a year	
	• Budget not yet approved	• Budget app.	• Budgetary Report	• DDS, BMA • Budget Department ,BMA	• Once a year	
	• Consultant not yet employed	• Consultant has been employed	• TOR • Proposal • Contract • Consultant Report	• DDS, BMA	• Once a year	
	• FHM not yet done	• FHM ,100% done (1,569 km2)	• Consultant Report	• DDS, Fire and Rescue Dept., , Public Works Department and District Office, BMA • IRD • TMD • DPMD	• Once a year	
	• Flood warning system is not established • Damage cost by flood will not be decreased or increased	• Operation of flood warning system • Utilization for the flood action plan • Reduction of damage cost by flood	• Area covered by the Map • No. of population covered by the Map • High risk areas (e.g. industrial zones, schools) • No. Bangkok Build. • Existing flood protection infra. • Damage cost by flood		• Review and update of the Map: Once in 3 years • Utilization of the Map: When a flood damage occurs	

Table 7-10 Monitoring and evaluation table for drought hazard map

** DDS: Department of Drainage and Sewerage, BMA: Bangkok Metropolitan Administration, RID: Royal Irrigation Department, TMD: Thailand Meteorological Department, and DPMD: Disaster Prevention and Mitigation Department

Title of Project / Action	**Baseline indicator**	**End Project / Action indicator**	**Data / Information**	**Data / Information Provider***	**Reporting cycle**	**Other Remarks**
Drought Drought Hazard Map (DHM)	• Planning Process	• Planed	• GIS Map • High Spot Map • Risk Area Map	• DDS, Fire and Rescue Department., BMA • RID • TMD • DPMD	• Once a year	
	• Budget not yet app.	• Budget app.	• Budgetary Report	• DDS, BMA • Budget Department, BMA	• Once a year	
	• Consultant not yet employed	• Consultant has been employed	• TOR • Proposal • Contract • Consultant Report	• DDS, BMA	• Once a year	
	• DHM not yet done	• DHM,100% done (1,569 km2)	• Consultant Report	• BMA (Drainage and Sewerage Department, Fire and Rescue Department) • IRD • TMD • DPMD	• Once a year	
	• Drought warning system is not established • Damage cost by drought will not be decreased or increased	• Operation of drought warning system • Utilization for the drought action plan • Reduction of damage cost by drought	• Area covered by the Map • No. of population covered by the Map • High risk areas (e.g. farm lands, water reservoirs) • No. Bangkok Build. • Existing drought protection infra. • Damage cost by drought		• Once in 3 years	

8. Implementation

8-1 Institutional Arrangement

In order to implement and monitor and evaluate the progress of the Bangkok Master Plan on Climate Change, the Institutional Arrangement will be set up consisting of (1) Steering Committee, (2) the Working Group, (3) Task Forces, (4) BMA Secretariat, (5) External Partners, as described in the below chart

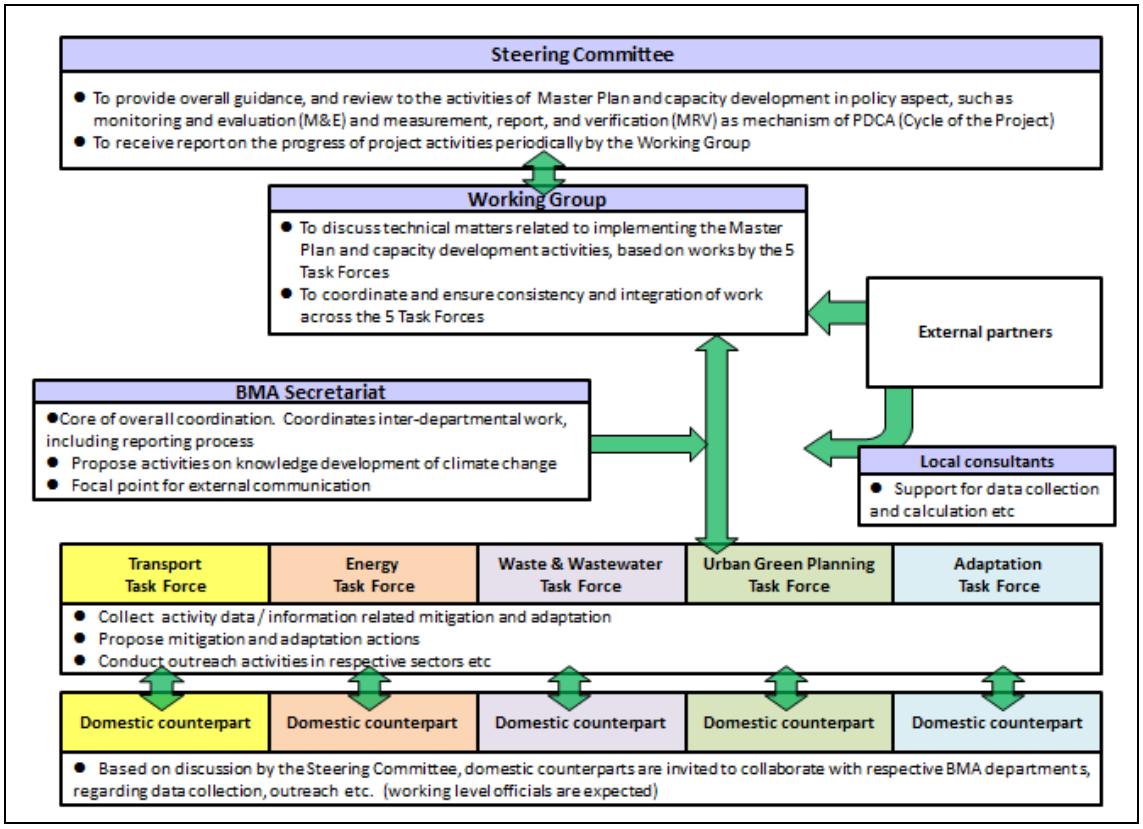

Figure 8-1 Institutional arrangement for the implementation of the Bangkok Master Plan on Climate Change 2013-2023

For enhancing the institutional capacity to mainstream climate change concern and implement the Master Plan, BMA will consider strengthening of their administrative structure, such as establishing division officially in charge of climate change and global environmental affairs.

(1) Steering Committee

- The Steering Committee(SC) is a forum to provide overall guidance and review to the progress of activities of the Master Plan and capacity development in policy aspect
- The SC supervise the conduct of monitoring and evaluation (M&E) and measurement, report, and verification (MRV) as mechanism of PDCA (Cycle of the Project), based on reports

received from the Working Group on the progress of project activities periodically.

- It is expected the SC meets annually for the above mentioned purpose, unless otherwise required.

(2) Working Group

- The Working Group(WG) discusses technical matters related to implementing the Master Plan and capacity development activities, based on works by the 5 Task Forces
- The WS coordinates and ensures consistency and integration of work across the 5 Task Forces, including the approaches to the implementation and M&E of the activities under the Master Plan.
- It is expected the WS meets every 6 months for the above mentioned purpose, unless otherwise required.

(3) Task Forces

- Task Forces (TF) are established by sector to deal with actual implementation work of activities under the Master Plan. Sectoral TFs are to implement and propose new activities on mitigation and adaptation, as well as other related activities.
- The TFs collect activity data / information related mitigation and adaptation for the use of M&E and MRV.
- The TF conducts outreach activities in respective sectors etc., in partnership with citizens, the private sectors, academia, NGOs, and other key stakeholders, as appropriate.

(4) BMA Secretariat

- BMA Secretariat is set within the Department of Environment in order to play a core role of overall coordination for inter-departmental work, including implementation and reporting work.
- BMA Secretariat also proposes activities on actions necessary and useful for the implementation of the Master Plan, and for further strengthen and enhance BMA's action strategically. Such actions may include, strengthening knowledge development of climate change, organizing internal and external events, and others.
- BMA Secretariat functions as the focal point for BMA for external communication

(5) External Partners

- External partners are invited to cooperate with BMA in effective implementation of the Master Plan through contribution of their available resources. External partners may include other local governments, development partners, which have experiences and knowledge of working on local governments' actions on climate change.

(6) Others

- It is important that BMA should plan and implement overall actions as well as mitigation and adaptation as well as other relevant activities in cooperation with stakeholders such as citizens, the private sectors, academia, NGOs, and other.

8-2 Roadmap and milestones

The Bangkok Mater Plan on Climate Change expects key mile stones during the implementation. The drafting of the Master Plan was conducted from March 2013 through July 2015, supported by the JICA Technical Cooperation Project on Bangkok Master Plan on Climate Change2013-2023. During the same period, especially in early and middle of 2015, preliminary implementation activities were started. Upon the completion and approval of the Master Plan by the BMA Governor, the full implementation is expected to be completed by the end of the fiscal year 2023.

In order to keep the right track of the implementation, and provide useful feedback of lesson learned, the regular monitoring and evaluation (M&E) is conducted. Also for more substantial improvement of the situation, such as addition of sectors, strengthening of the institutional arrangement, the 5 year comprehensive review will be conducted. The first comprehensive review will be conducted in the year 2018, for the period of 2013 through 2017, and the final comprehensive review is conducted in 2024, that covers not only the period of 2018 through 2023, but also the whole implementation period. Also regular and comprehensive M&E will be information resources of proposal for enhancement of work. Other than these continuous efforts to conduct capacity development of BMA officials and its stakeholders should be done. For the implementation of the Master Plan, a further detailed implementation plan will be developed.

Table 8-1 Roadmap and milestones

		2013	2014	2015	2016	2017	2018	2019	2020	2022	2023	2024
1	Drafting the MP			Governors' Approval								
2	Preliminary implementation											
3	Full implementation											
4	Regular M&E											
5	Comprehensive review											
6	Proposals of enhancement											
7	Other (e.g. capacity development)											

8-3 Roles of BMA Departments

(1) Individual projects

(a) Task Forces/Sectoral Departments

Mitigation and adaptation, as well as other related actions (projects) under the Bangkok Master Plan on Climate Change are planned, budgeted, implemented by the authority and responsibility of the respective BMA Departments, which belong to the sectoral Task Forces. Also, the Task Forces, and related sectoral departments conduct monitoring and evaluation of individual projects, and produce reports to be submitted to the Working Group.

(b) Overall coordination of the implementation and M&E

The BMA Secretariat will take the role of providing facilitation and advises on planning, budgeting, and implementing, and monitoring and evaluating individual projects. As to the overall coordination of implementation and M&E, the BMA Secretariat will play the central role for supporting the Steering Committee and the Working Group to conduct necessary work.

For all of these works to be done in an appropriate manner, the Task Forces should make an annual work plan in the beginning of the fiscal year.

Table 8-2 Role of the Task Forces/Departments and the BMA Secretariat

Parties involved	Planning	Budget	Implementation	Monitoring	Reporting	Other remark
Task Forces/ Depts.	• Design Project Plan	• Mobilize budget from Dept. or from other resources	• Conduct physical implementation	**[Individual projects]** • Elaborate monitoring plan (in a template) • Monitor the progress • Measure GHG emission reductions • Provide feedback to further implementation	• Report the progress made by projects (orally and in a common reporting format/every 6 months and annual)	• **Implementation may be regarded actions recognized in KPI.**
BMA Secretariat	• Facilitate and advise on designing	• Facilitate and advise on budget as appropriate	• Facilitate and advise on implementation as appropriate	**[Individual projects]** • Facilitate and advise on monitoring as appropriate **[Overall Progress]** • Monitor overall progress, such as targets, budget spent, etc.	• Produce record of the Working Group and the Steering Committee • Compile information and consolidate reports	• **These actions are currently proposed to be a part of in future KPI .**

9. Monitoring and Evaluation (M&E) and MRV

9-1 Objective and purpose of the M&E and MRV

Monitoring and evaluation (M&E) is a tool for supporting the effective implementation of the Master Plan, by efficient input of resources. For this purpose, Monitoring is done through systematic and routine collection of information from projects to learn from experiences to improve practices and activities in the future; to have internal and external accountability of the resources used and the results obtained; to take informed decisions on the future of the initiative; to promote empowerment of beneficiaries of the initiative. And evaluation is done through assessing, as systematically and objectively as possible, ongoing and completed project and actions

Measurement, report, and verification (MRV) may be regarded as one type or variation of M&E. Like M&E applied in many different areas, contents and targets of MRV may vary from policy to project-level, or national to local government levels. However, it may be recognized that MRV may often imply involvement of quantitative indicators or metrics, such as tCO_2-eq for assessment of GHG.

9-2 Procedures of M&E

The Master Plan expects the following procedure through the established institutional arrangement.

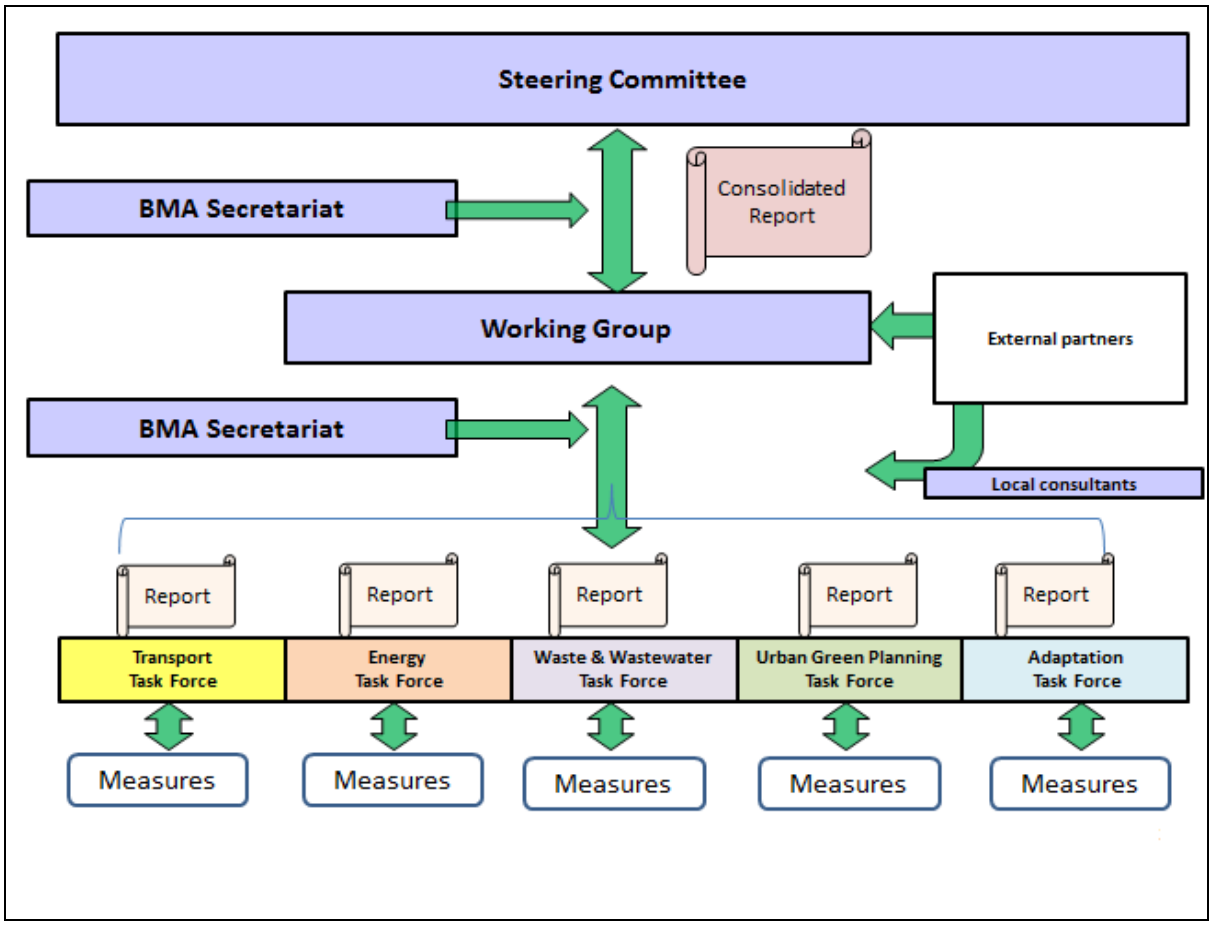

Figure 9-1 Monitoring and evaluation through the Institutional Arrangement

(1) Reports of TFs on the implementation for projects/activities to the Working Group

As shown in the Chart X above, progress of the implementation of projects are reported by the Task Forces. The information contained in the report is to clarify the status of projects, providing items;

Mitigation Projects

(a)Baseline indicator of project and End of project/action indicator for M&E

Baseline indicator is to indicate the status of respective steps of project. For example, in a project to build and operate monorail to induce modal shift, currently the status of the project is that "a feasibility study was almost completed (90%)". In this case, to complete the feasibility study (100%) is the action by the Transport Task Force and the Department of Transport. And as a result of the action, the DOT will make a proposal to the BMA Governor and the BMA Council, which is clarified in in the End of project/action indicators, and the actions should move on to next step (budgetary arrangement).

(b) Baseline indicator of project and End of project/action indicator for MRV

As to MRV, the status is show with or without project/actions, the reduction of GHG is specified. In case of the blow project, before introducing the monorail, GHG reduction is not available, and by introducing the monorail, GHG reduction occur. While this is a qualitative statement, since it is important to provide quantified information, data and calculation methodologies are also provided in the format.

Adaptation Projects and other actions

Likewise mitigation projects, the progress of efforts is to be assessed by baseline indicator of project and End of project/action indicator for M&E. However, it not possible to quantify the results and effectiveness of adaptation work, in a way that mitigation project indicates with GHG emission. In this regard, adaptation projects are monitored and evaluated in the below template, which corresponds only to the M&E of the template for the mitigation.

All these reports are submitted by the Task Force to the Working Group (through the BMA Secretariat) every 6 months, to provide information resources for Working Group session for twice a year. For respective measures, specific action plans or project documents will be prepared, and M&E and MRV will also be further elaborated, based on the framework consideration provided as below, and the main document.

Table 9-1 Common template for M&E of mitigation projects

M&E/MRV		Baseline indicator	End of Project/Action indicator	Data/Information	Data/Information Provider	Reporting cycle	Other remark
M&E	M&E of activities	• A feasibility study was almost completed (90%)	• With the feasibility proposal to the Governor, and BMA Council for budget	• FS Report	• DOT		
		• Budgetary arrangement is not yet decided.	• Budgetary arrangement is decide.	• BMA council decision (Budget xxx Bath)	• BMA council, DOT, DOB		
		• Tender is not yet done	• Tender				
		• Construction is not yet done.	• Construction 3 monorail lines are build and operate				
		• There is no Monorail yet.					
	MRV of GHG emissions	• GHG reduction from modal shift is not yet in place	• GHG reduction from modal shift is in place	• Number of passenger of the MRT in year y (passenger/y) • Average trip distance of the passenger of the MRT in year y (km) • Electricity consumption of MRT (MWh/year) • Share of passengers that would have taken transport mode i (%) • CO2 emission factor of transport mode i (gCO2/km) • Average occupancy rate of transport mode i (passenger/vehicle)	• MRT company • MRT company • MRT company • BMA (Interview survey) • PCD or other agencies • BMA (Ex-ante measurement)	• Annually • Annually • Annually • every 2-3 years • not monitor • once before project start	

Table 9-2 Common template for M&E of adaptation projects

M&E/MRV		Baseline indicator	End of Project/Action indicator	Data/Information	Data/Information Provider	Reporting cycle	Other remark
M&E	M&E of activities	• A feasibility study was almost completed (90%)	• With the feasibility proposal to the Governor, and BMA Council for budget	• FS Report	• XXX		
		• Budgetary arrangement is not yet decided.	• Budgetary arrangement is decide.	• BMA council decision (Budget xxx Bath)	• BMA council, XXX		
		• Tender is not yet done	• Tender				
		• Construction is not yet done.	• Construction sea walls				
		• There is no sea walls					

(2) Reports of Working Group to the Steering Committee

Based on discussion at the Working Group, as well as TF reports submitted, the BMA Secretariat will produce reports for the discussion at the Steering Committee. In earlier stage of M&E, the BMA Secretariat may produce simple compilation report, which only compiles information from TF report, but to increase the effectiveness of M&E, the Steering Committee may consider that information should be consolidated and synthesized with analysis. For this, discussion on approaches and methodologies are necessary, and this may be dealt with in future.

10. Capacity-building and outreach

(1) Capacity building and outreach for BMA Officials (Individual level)

Capacity building and outreach for BMA Officials play a critical role to maintain and strengthen the basis of implementing the Master Plan. For this reason, BMA should positively utilize internal and external opportunities for capacity building. Through the implementation of the Master Plan, BMA will consider how to mainstream climate change into their policy and administrative work and take appropriate measures for them.

(2) Capacity-building of the institution of BMA (Institutional level)

Institutional capacity-building is vital to steady and sound implementation of the Master Plan. Based on the institutional arrangement created in the earlier stage, it is expected that capacity to mainstream climate change issues within the BMA operation, smooth internal communications and coordination, and systems for M&E and MRV should be strengthened.

(3) Capacity-building and outreach for relevant stakeholders (Society level)

It is also important that BMA should conduct and promote capacity-building and outreach for relevant stakeholders, as a part of the implementation of the Master Plan. In conducting such activities, it is important to explore collaborators in the government, civil society, and the private sector, including academia, NGOs, international organizations and other stakeholders, drawing experiences from other local governments, such as the City of Yokohama.

(4) Inter-city cooperation among ASEAN cities

As a leading mega city in Southeast Asia, BMA will cooperate with other ASEAN cities by sharing and transferring its knowledge and experiences of preparing and implementing the Master Plan. Such cooperation should also be participated by partners such as the City of Yokohama or other cities and urban development partners.

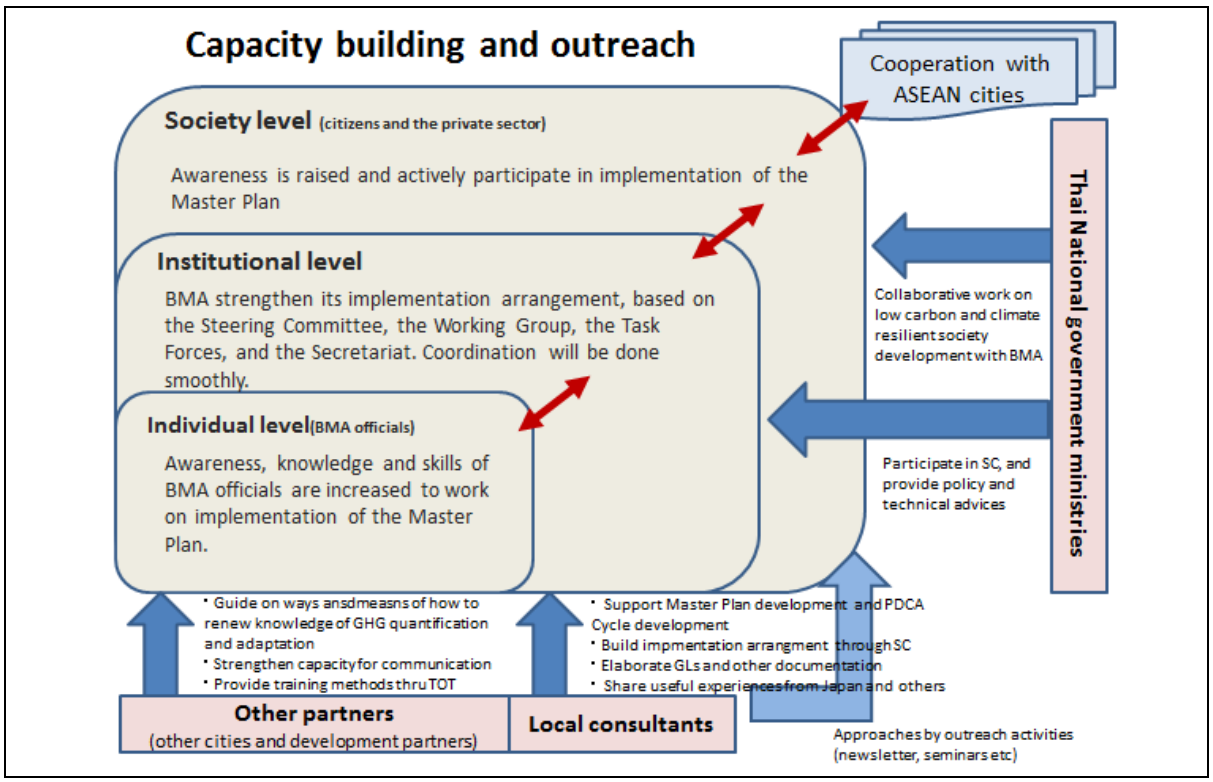

Figure 10-1Capacity building and outreach

Abbreviations

[Thai organizations]
BMA = Bangkok and Metropolitan Administration
BMTA = Bangkok Mass Transit Authority
DPW = Department of Public Works
DOE = Department of Environment
DOEd = Department of Education
DDS = Department of Drainage and Sewerage

MoEn = Ministry of Energy
DEDE = Department of Alternative Energy Development and Efficiency
DOEB = Department of Energy Business
EGAT = Electricity Generating Authority of Thailand
EPPO = Energy Policy and Planning Office
ERC = The Energy Regulatory Commission Office

MNRE = Ministry of Natural Resources and Environment
ONEP = Office of Natural Resources and Environment Policy and Planning
PCD = Pollution Control Department
TGO = Thailand Greenhouse Gas Management Organization (Public Organization)

MOT = Ministry of Transport

DOH = Department of Highway
DLT = Department of Land Transport
MRTA = Mass Rapid Transit Authority
OTP = Office of Transport and Traffic Policy and Planning
SRT = State Railway of Thailand
TMD = Thailand Meteorological Department

Other organizations
ASA = The Association of Siamese Architects Under Royal Patronage
DDPM = Department of Disaster Prevention and Mitigation
EIT = The Engineering Institute of Thailand
EXAT= Expressway Authority of Thailand
FTI = The Federation of Thai Industries
KT = Krungthep Thanakom Co., Ltd.
MEA = Metropolitan Electricity Authority
MoE = Ministry of Education
MRTA = Mass Rapid Transit Authority of Thailand
NESDB = National Economic and Social Development Board
RID = Royal Irrigation Department
RTP = The Royal Thai Police
TCC = The Thai Chamber of Commerce
TGBI = The Green Building Institute
TISI = Thai Industrial Standards Institute

[Climate change-related matters]
BAU = Business-as-Usual
CDM = Clean Development Mechanism
GHG = Greenhouse Gas
IPCC = Intergovernmental Panel on Climate Change
JCM = Joint Crediting Mechanism
MRV = Measurement, Reporting, and Verification
M&E = Monitoring and Evaluation
NAMAs= Nationally Appropriate Mitigation Actions
UNFCCC = United Nations Framework Convention for Climate Change

[Others]
AEDP = Alternative Energy Development Plan
ART = Airport Rail Link
BAF = Biotope Area Factor
BMR = Bangkok Metropolitan Region
BOD = Biochemical oxygen demand
BRT = Bus Rapid Transit
BTS = Bangkok Mass Transit System
CASBEE = Comprehensive Assessment System for Built Environment Efficiency
CBD = Central Business District
EEDP = Energy Efficiency Development Plan
EF = Emission Factor
ESCO = Energy Service Company
EST Master Plan = Environmentally Sustainable Transport Master Plan
FAO = Food and Agriculture Organization
FOD = First Order Decay
HSD = High Speed Diesel
INDC = Intended Nationally Determined Contributions
LEED = Leadership in Energy and Environmental Design
LEV = Low Emission Vehicles
LRT = Light-Rail Transit
MRT = Mass Rapid Transit
NESDP = National Economic and Social Development Plan
NGV = Natural Gas Vehicle
PDCA = Plan-Do-Check-Act
SRT = State Railway of Thailand
WWF = World Wide Fund for Nature
WWTP = Wastewater Treatment Plant