TIMOR LESTE'S INITIAL NATIONAL COMMUNICATION

Under United Nations Framework Convention on Climate Change

Timor-Leste's State Secretariat for Environment
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FOREWORD

Timor-Leste is highly vulnerable to natural disasters associated with droughts, floods, landslides and soil erosion resulting from the combination of heavy monsoon rain, steep topography and widespread deforestation. At the same time, the most serious implication of climate change for the country is likely to be an increase in the intensity and frequency of extreme weather events. Responding to such unprecedented needs to adapt to future climatic risks requires special attention from the Government. The Strategic Development Plan of Timor-Leste for 2011-2030 recognizes the importance of climate change adaptation and mitigation in the country and acknowledges the responsibility to ensure that the decisions made today take into consideration the impact of those decisions on future generations. The United Nations Framework Convention on Climate Change (UNFCCC) provides an intergovernmental framework and rules for confronting climate change. Timor-Leste ratified the convention in October 2006 and the Kyoto Protocol to the UNFCCC in October 2008. As a party to the UNFCCC, Timor-Leste has an obligation to report its National Communication to the Conference of the Parties (COP).

Through the support of the Global Environment Facility (GEF), the Australian Agency for International Development (Australian Aid) and the United Nations Development Programme (UNDP), the Initial National Communication (INC) project undertook a number of activities such as a green house gas inventory, a mitigation option analysis, a vulnerability and adaptation assessment and other activities related to education, training and public awareness. The INC report is a result of a participatory process that involved a wide range of stakeholders from government institutions, universities, the private sector and non-governmental organizations in order to capture their inputs and views on climate change in the country. The National Communication processes act as a key instrument to developing climate change adaptation and mitigation strategies, and are a mechanism to enable policy dialogue and to raise public awareness on climate change.

Changes in climate will affect water scarcity, as well as increase the risk of dengue and malaria. Economic losses due to climate change might increase as a result of exacerbated hazard events such as flooding, landslides, storms and drought and potential areas for the establishment of new agriculture will become more limited. These are just some of the INC report's findings.

The INC report also recommends some adaptation actions to be taken to respond to climate risks. Among these recommendations are improving water management including rainfall harvesting, and strengthening the capacity of national and local institutions as well as communities in managing climate risks.

On behalf of the Government, I would like to congratulate all the people and organizations that supported the preparation of the Initial National Communication of Timor-Leste and ensured that the final report truly reflects the position of our nation. The critical task now ahead of us is to continue this important work through the upcoming Second National Communication. In this way we can ensure that we are aware of the environmental changes around us and are capable of adapting to those changes.

Prime Minister of Timor-Leste, Kay Rala Xanana Gusmão

EXECUTIVE SUMMARY

Timor-Leste ratified the United Nations Framework Convention on Climate Change (UNFCCC) in October 2006 and Kyoto Protocol to UNFCCC in October 2008. As a party to UNFCCC, Timor-Leste has an obligation to report its National Communication to the Conference of the Parties (COP). With support from Global Environment Facility (GEF), Australian Aid, and United Nations Development Program (UNDP), Timor-Leste started the development of its Initial National Communication (INC) in 2011. The development of this INC involved a wide range of stakeholders; among them are representatives from local government institutions, academics, private sector and non-governmental organizations (NGO) in order to capture their inputs and views to the national communication. Timor-Leste's INC was prepared in accordance with UNFCCC Reporting guidelines on National Communications.

NATIONAL CIRCUMSTANCES

Timor-Leste occupies the eastern half of the island of Timor and is situated at the eastern end of the Lesser Sunda Islands of the Indonesian archipelago and north west of Australia at a distance of about 500 km. Timor-Leste lies between latitudes 8'15 and 10'30 south, and longitudes 124'50 and 127'30 east and has an area of approximately 14,954 km^2. This includes the main land area of 13,989 km^2, Oecusse enclave of 817 km^2, Atauro Island of 140 km^2 and Jaco Island of 8 km^2. The topography, particularly of the mainland, is comprised of hills and mountain ranges.

The population of Timor-Leste in 2012 was estimated to be 1,210,233 people. The population growth rate is approximately 2.41% per year. Poverty remains a challenge, while unemployment and underemployment are still relatively high. About 41% of the population has a per capita income of less than US $0.88 per day. In addition, household food insecurity is widespread throughout all rural areas. The low input practices of agricultural systems, low crop productivity, unpredictable changes to the annual seasons, characterised by heavy rainfalls and an intense dry season as well as a high rate of population growth are the major contributors to food insecurity in the country.

In 2012, the GDP of Timor-Leste was about US$1,292 million. The highest contributor to the national GDP is the services sector (54.8%) followed by the agriculture sector (27%) and industry (18.1%). Inflation was estimated at 11.8%. The country holds relatively important oil and gas reserves, the revenue from which is the primary source of funding for government expenditure. Oil wealth is estimated at US$24.3 billion or US$22,000 per-capita. Timor-Leste's petroleum fund balance was US$4.2 billion in 2008 and US$5.4 billion in 2009, and in 2010 it reached US$6.9 billion. This figure is projected to rise to above US$14 billion by 2015.

NATIONAL GHG INVENTORY (NATIONAL GREEN HOUSE GAS INVENTORY)

In 2010, total GHG emissions for the three main GHGs (CO_2, CH_4 and N_2O) without land -use, land use -change and forestry (LULUCF) reached 1,277 Gg CO_2-e. With the inclusion of LULUCF, total GHG emissions from Timor-Leste increased to about 1,483 Gg CO_2-e (Table 1). The GHG emissions were distributed unevenly between the three gases, i.e. CO_2 recorded 466.87 Gg CO_2e (31% of total emissions); methane (CH_4) 548.56 Gg CO_2e (37% of total emissions); and nitrous oxide (N_2O) 467.18 Gg CO_2e (32% of total emissions). The main contributors are agriculture, followed by energy, LUCF and waste.

It should be noted that GHG emissions from the energy sector did not include GHG from biomass utilization in household, fossil fuel combustions for the industrial sector, fossil fuel combustions for international aviation, fossil fuel combustion for own use in oil and gas fields, and fugitives from oil and gas fields. These gases are estimated but reported separately from the energy sector. The GHG from oil and gas fields is reported separately from the energy sector due to this facility being under joint operation between Timor-Leste and Australia. Currently there is no agreement regarding GHG emissions. The GHG emission from fossil fuel combustion for the industrial sector did not include NGHGI because the industrial activity practically does not exist and therefore the GHG emission from energy consumed in industrial activity can be neglected. The GHG emission from fossil fuel combustion for marine transportation (international as well as domestic) did not include NGHGI because the data was not available.

Table 1 **Summary of 2010 GHG emission (in Gg CO_2e)**

Sources	CO2	CH4	N2O	Total
Energy	249.48	0.55	0.67	250.70
Agriculture	-	516.35	449.92	966.27
LUCF	206.03	-	-	206.03
Waste	11.36	31.66	16.60	59.62
Total	***466.87***	***548.56***	***467.18***	***1,482.61***
Biomass utilization	770.04	44.70	8.80	823.54
International Bunker for Aviation*	5.92	0.00	0.05	5.97
GHG from oil and gas production	492.58	0.36	0.27	493.21

Notes: GHG emissions from energy used in industry/manufacturing were not included in this INC inventory because there is practically no industry activity in Timor-Leste. GHG from the utilization of solvent and other products are also not covered in this INC inventory because the data was not available. GHG emissions from biomass utilization, international bunker for aviation, and activities in offshore oil and gas production facilities are reported separately from the energy sector. GHG from offshore is under joint operation of Timor-Leste and Australia.

Within the period of 2005-2010, it can be seen that GHG emissions from agriculture and waste sectors were increased significantly. The GHG from LUCF and energy sectors were intended to decrease after 2006 and 2007 respectively. The agricultural and energy sectors remains as the main source of emissions in Timor-Leste during this period, more than 80% of the total country emission.

Table 2 **Emission Trend from the four sectors and other sources (in Gg CO_2-eq)**

Source Categories	2005	2006	2007	2008	2009	2010
Energy	200.20	207.00	313.48	261.50	222.44	250.67
Agriculture	882.69	900.66	956.86	996.75	933.01	966.27
Land-Use Change & Forestry	115.05	1,036.53	734.42	441.48	225.07	206.06
Waste	46.82	52.27	54.06	55.86	57.73	59.62
Total	**1,244.76**	**2,196.46**	**2,058.82**	**1,755.61**	**1,438.25**	**1,482.62**
Biomass utilization	704.80	727.61	750.86	774.59	798.81	823.54
International Bunker for Aviation*	2.17	1.59	3.70	4.88	5.96	5.97
GHG from oil and gas production	544.76	668.06	593.04	624.08	524.27	493.04

Within the four sectors, there are 25 sub-categories of emission sources. Of these 25 sources, only 10 sources are considered as key categories, i.e. emission sources which contribute to 95% of the total national emission as shown in Figure 1. Of the 10 key categories, three sources already contributed to 50% of the total emissions, namely emissions from (i) stationary combustion in offshore oil and gas production facilities (CO_2), (ii) forest and grassland conversion (CO_2), and (iii) from enteric fermentation in domestic livestock (CH_4).

GENERAL DESCRIPTION OF STEPS TAKEN TO IMPLEMENT THE CONVENTION

To meet Timor-Leste's obligation to the convention for communicating its status of GHG emission, mitigation and adaptation actions including constraints, barriers and needs related to financing, technology and capacity building issues, the Government of Timor-Leste assigned the Directorate for International Environmental Affairs and Climate Change (DIEACC) to develop an Initial National Communication. This directorate is under the State Secretariat for the Environment, one of the State Secretaries under the prerogative of the Ministry of Commerce, Industry and Environment (MCIE).

Day to day work on the development of the INC was conducted by the Initial National Communication Team in collaboration with six Thematic Working Groups (TWGs). These TWG were established from various government agencies, academia, civil society organizations and the private sector. The six TWGs are (i) Greenhouse Gas Inventory; (ii) Vulnerability and Adaptation; (iii) Mitigation Options; (iv) Technology Transfer; (v) Research and Systematic Observation; and (vi) Education, Training and Public Awareness Building. Capacity development of the Working Group members and DIEACC should be continuously pursued especially in areas pertaining to GHG inventory development and mainstreaming of climate change considerations in planning and policy making at relevant agencies. For agencies implementing adaptation and mitigation measures, there is also a need to strengthen capacity in monitoring, evaluating and reporting (MER) on program implementation.

The Government of Timor-Leste has proposed one National Adaptation Plan of Action (NAPA) to focus on institutional capacity development. This Action Plan will build on and enhance Timor-Leste's capacity to coordinate/integrate climate change into strategic planning in moving towards sustainable development and poverty reduction. The expected outcome from this NAPA activity is that Timor-Leste will have a 'National Strategy and Action Plan for Low Emissions Climate Resilient Development'.

MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

Due to its geographical location, topography and socioeconomic conditions, Timor-Leste is considered to be one of the top 10 countries most at risk of disaster (9th rank). Together with the other 10 countries, the vulnerability and susceptibility of Timor-Leste is high, with a significant lack of coping capacity and adaptive capacity. Based on the vulnerability assessment at the village (suco) level, there are 61 villages categorized as being vulnerable to very vulnerable to climate change. High levels of exposure and sensitivity and low adaptive capacity characterize the vulnerable and very vulnerable sucos. The level of exposure, sensitivity and adaptive capacity of the sucos are represented by socio economic and biophysical condition. The most vulnerable sucos are mainly located in the western part of the country (Figure 1). These vulnerable and very vulnerable villages will be more seriously affected by the impact of climate change than those less vulnerable. The implementation of adaptation actions should be prioritized in these vulnerable villages.

The occurrence of El Niño and La Niña phenomena which is normally associated with extreme climate events have resulted in serious damage and disasters affecting different socioeconomic sectors of the country. Observations have indicated that El Niño events will become more frequent. Many studies suggest that increasingly high temperatures are exacerbating the extreme regional weather and climate anomalies associated with El Niño (Hansen et al., 2006; Timmerman et al. 1999).

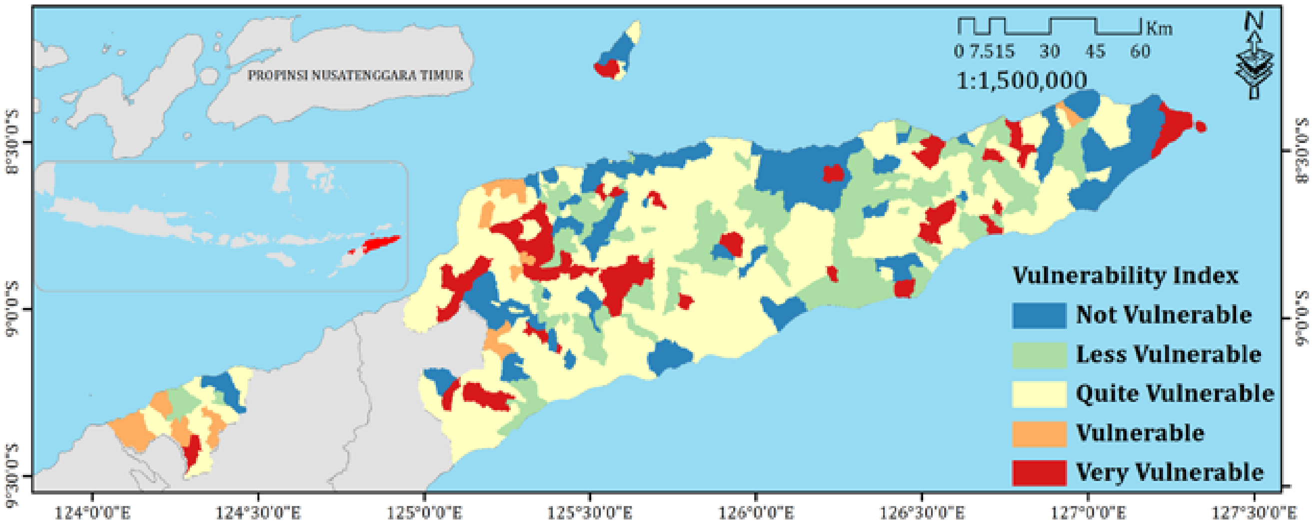


Figure 1 **Categorization of villages at Timor-Leste based on the vulnerability index**

Based on historical climate data and the results of climate scenarios, generated with Regional Climate Model (RCM) using the A1B emission scenario, and with 20 Global Circulation Models (GCMs) using new emission scenarios, Representative Concentration Pathways (RCPs), the following conclusions have been reached:

- In the longer term, annual mean temperature over Timor-Leste has increased consistently with a rate of about 0.016°C per year. It is very likely that temperatures in Timor-Leste will continue to increase. Prior to the 2040s, the mean temperature anomalies in Timor-Leste are expected to increase by up to as much as 1°C for all emission scenarios. Post 2040s, the rate of increase will vary based on different scenarios. For the high emission scenario (RCP8.5) the increase in temperature relative to current conditions may reach 3°C by 2100, while for the low emission scenario (RCP2.6) it may increase by up to 0.5°C.

- Historically, the sea level surrounding the main island of the country has risen at about 5.5 mm/year. Over 100 years, the sea level rise may reach 76 cm. Based on the Pacific Climate Change Science Program (2011); Pacific Ocean acidification has also been increasing in Timor-Leste's waters. It will continue to increase and threaten coral ecosystems.

- Historical data suggests that during the 20th century and early 21st century, there were already some shifts in the peak of the wet season. In the future, the wet season onset may be delayed by about 20 days from the current climate pattern, while dry season onset will be delayed by as much as 11 days depending on the period and emission scenarios. Thus, in some areas the length of the wet season would shorten.

- Extreme rainfall events are projected to become fewer but more intense as a result of decreasing numbers of tropical cyclones albeit with stronger intensity (Pacific Climate Change Science Program 2011).

- Decreases in rainfall are projected in some parts of the country, as well as changes in its seasonal distribution, with respect to the 1981-2010 conditions. For example, the drier area on the northern coast of the country (annual rainfall less than 1000 mm) will expand in the future.

- The water balance suggests that the area with a duration of water deficit period (LDP) of more than 8 months will expand while the area with LDP<5 months will shrink.

The implications of the changes in climate in Timor-Leste include:

- Potential areas for the establishment of new agricultural areas (expansion) will become more limited.

- Increasing cropping intensity will be more difficult without supporting irrigation water. In some areas of the north coast of Timor-Leste, even planting crops once a year is not possible. Changes in climate would result in a reduction of maize yield between 5% and 20% from the current yield depending on climate scenarios. Crop failures due to extreme climate events may also increase.

- Water scarcity will become more serious in the future particularly in those areas with a longer water deficit period.

- Economic loss (damaged vital infrastructure such as offshore oil and gas infrastructure) due to extreme climate events might increase as a result of exacerbated hazard events (flooding, landslides, storms and drought).

- Risk of dengue and malaria may increase in the future, however after 2040 it might decrease.

Some key adaptation actions include:

- Research and development of technologies more adaptive to climate change particularly for key sectors, i.e. agriculture, water resources and coastal/maritime (e.g. development and introduction of varieties resistant to climate stresses, climate proof infrastructure, etc.).

- Improvement of water management including development and utilization of rainfall harvesting technologies particularly in high prone drought areas.

- Protection and rehabilitation of rainfall catchment areas should be accelerated to ensure sustainable water supplies. Priority should be given to watersheds that supply water for agriculture and domestic uses.

- Protection and rehabilitation of mangrove ecosystems in priority areas to protect economic, social and environmental assets against climate risks.

- Strengthening capacity of national and local institutions as well as communities in managing climate risks through the development of an effective climate information system (improving the skills of climate forecasters) including the development of early warning system and decision support system tools for policy makers.

- Development and enhancement of sectoral capacity to coordinate the implementation of adaptation actions and also to integrate climate change into strategic planning in moving towards sustainable development and poverty reduction.

The Government of Timor-Leste has proposed nine programs under the NAPA (National Adaptation Plan of Action-2010) which cover all the above key adaptation actions. The nine programs are as follows:

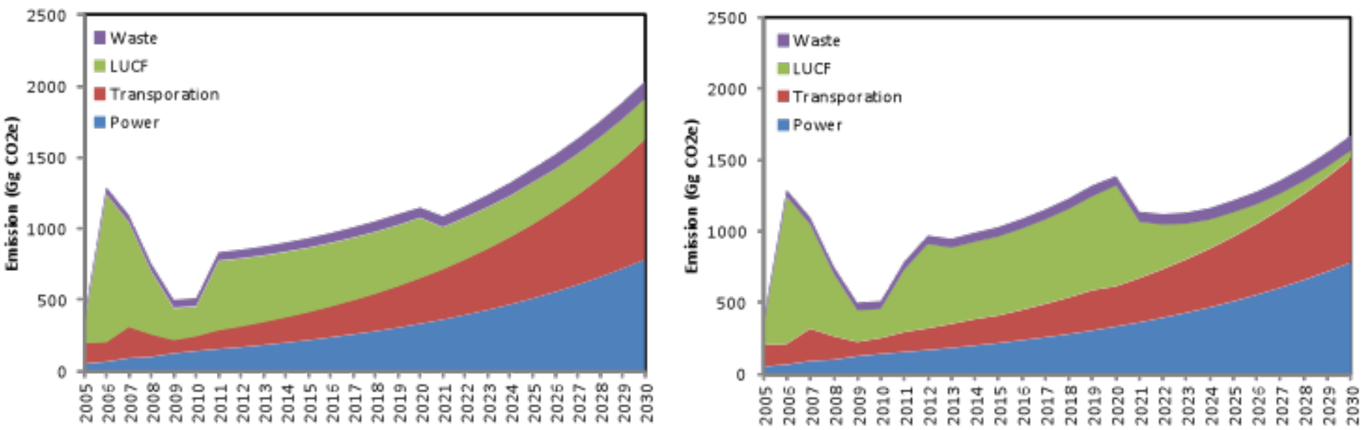
1. Building resilience of rural livelihoods to ensure national food security.
2. Promotion of Integrated Water Resource Management (IWRM) to guarantee water access to people in the context of increasing climate risks.
3. Enhancing capacity of the health sector to anticipate and respond to changes and reduce the vulnerability of populations at risk from expansion of climate related diseases.
4. Improving institutional, human resource and information management capacity in the disaster management sector in relation to climate change induced risks at national, district and community levels.
5. Restoration and conservation of mangrove ecosystems and awareness raising to protect coastal ecosystems exposed to sea level rises.
6. Improved strategic planning, institutional frameworks and methodologies to promote sustainable, integrated livestock production under changing climate conditions.
7. Review and revise legislation, regulations and standards to enhance climate change resilient infrastructure.
8. Support to the ambitious national poverty reduction target (Timor-Leste Strategic Development Plan 2011-2030) in relation to the expected increased storm intensity at sea by improving capacity to forecast and adapt offshore oil and gas infrastructure to withstand strong storms and waves.
9. National Institutional Capacity Development to build and enhance Timor-Leste's capacity to coordinate and integrate climate change into strategic planning in moving towards sustainable development and poverty reduction.

International support is urgently required to implement the above actions.

MEASURES TO MITIGATE CLIMATE CHANGE

Future GHG emissions in Timor-Leste for the four key source categories namely: energy use (electricity), transportation, land use change and forestry, and waste will continue to increase in the absence of mitigation policies. By 2030 the rate of GHG emissions would reach 2,254 Gg CO_2e. With mitigation policies, this rate of emissions could be reduced by about 30% (1,565 Gg CO_2e; Figure 2). Key mitigation measures proposed for these four sectors can be seen in Table 3.

Figure 2 **Projection of GHG emissions under BAU (left) and mitigation scenarios (right).**



Note: From LUCF, there would be a sudden decrease in emissions in 2021 as it is assumed that there would be no development of new agricultural areas after 2020.

Table 3 **Key mitigation measures**

Key Sectors	Mitigation Measures
Power	Potential mitigation actions in the demand side can be achieved through the improvement of energy efficiency (i.e. by implementing cleaner energy and more efficient technologies for end use of energy appliances/technologies such as efficient lamps, renewable based energy technology (biogas, micro hydropower, photovoltaic, wind propelled electric generators, etc.); while in the supply side mitigation can be achieved through efficiency improvement throughout the entire process of electricity generation by utilizing efficient technology and implementing cleaner energy.
Transportation	Potential mitigation actions can be achieved through (a) increasing efficiency of combustion technology by replacing old car with the new car for taxy through incentive or stimulus, (b) increasing energy efficiency by providing public transport (bus or mini/micro bus), (c) providing pedestrian and bicycle lines so that more people want to walk or use bicycle, and (d) replacing oil fuels with gas fuels (LPG, CNG or LGV) in transportation sector through developing the infrastructure for the gas utilization in transport (conversion kits, gas station, gas supply infrastructures, etc.). The utilization of biofuel in this sector cannot be considered since the government of TL does not allow the utilization of the land for biofuel plantation.
Land Use Change and Forestry (LUCF)	Implementation of sink enhancement programs namely (i) Planting of teak, *ai-naa* (rosewood) and sandalwood in managed rotations for shrubland areas (ii) development of agroforestry using candlenut as main crop species in agriculture mixed shrubland areas, and (iii) mangrove restoration on swampy shrubland areas. For the period of 2011-2050, the total area needed for implementation of the program is 57,300 ha consisting of 52,100 ha of shrubland, 400 ha of swampy shrubland, and 4,800 ha of agriculture mixed with shrublands (this is an increase of about 48,500 ha from the baseline).
Waste	Potential measures (started from 2020) for GHG mitigation relevant for these sources are (i) waste composting and 3R (about 10% of waste), (ii) change from open landfill to managed landfill equipped with flaring unit (about 70% of LFG recovery) and leachate treatment; and (iii) reducing open burning until from 41% (2005-2010) to 20% (2020-2030) of the total waste generation.

OTHER INFORMATION

Timor-Leste has carried out various efforts to increase its climate resilience through technology development and implementation adoption, research, education, training, public awareness, and dissemination of information.

In terms of research, producing information and developing know-how, and creating the capacity within the national territory to deal with climate variability and climate change is one of the most important aspects in meeting commitments to the UNFCCC (United Nations Framework Convention on Climate Change). The establishment of national research capacity is also important. At present, two national agencies that work quite actively in conducting climate change research and systematic observation are ALGIS and the National Directorate for Meteorology and Geophysics (NDMG) with support from a number of international agencies such as the Australian Bureau of Meteorology, UNDP etc. However, until now, Timor-Leste has not developed a national research program on climate change. Most of the national and international institutions interviewed agreed that the Government of Timor-Leste needs to develop a national research program on climate change.

The types of research activities being recommended include: assessment of climate change impact on sectors, particularly on agriculture and fisheries, socio-economic impact of climate change, vulnerability assessment at household, community and ecosystem levels, and utilization of local technologies for adaptation and mitigation (Figure 3). Research on the development of systematic observations for ecosystems vulnerable to climate change and for climate change impact on infrastructure also received attention.

In terms of technology, common climate change related technologies implemented by communities with support from the Government of Timor-Leste and NGOs include biogas, organic agriculture, efficient cooking stoves, agro-forestry, and rainfall harvesting. These technologies need further improvement and replication or up scaling. Based on views from a number of institutions, other important technologies needing to be implemented are recycling of agricultural waste and water conservation.

The Government of Timor-Leste has implemented a number of programs for supplying electricity in rural areas through the use of renewable energy, particularly hydropower, solar PV and biogas. Up to 2012, the government had installed pico hydro in three districts supplying electricity for 733 HH; Solar PV about 9,300 units with a total capacity of around 0.465 MW; and biogas energy for 270 HH and 1 school. Development of renewable energy (RE) in Timor-Leste has good potential. Potential emissions reduction from the use of RE which include wind, solar and hydropower energy, might reach 484 million tons of CO_2e with a total mitigation cost of about US$154 million.

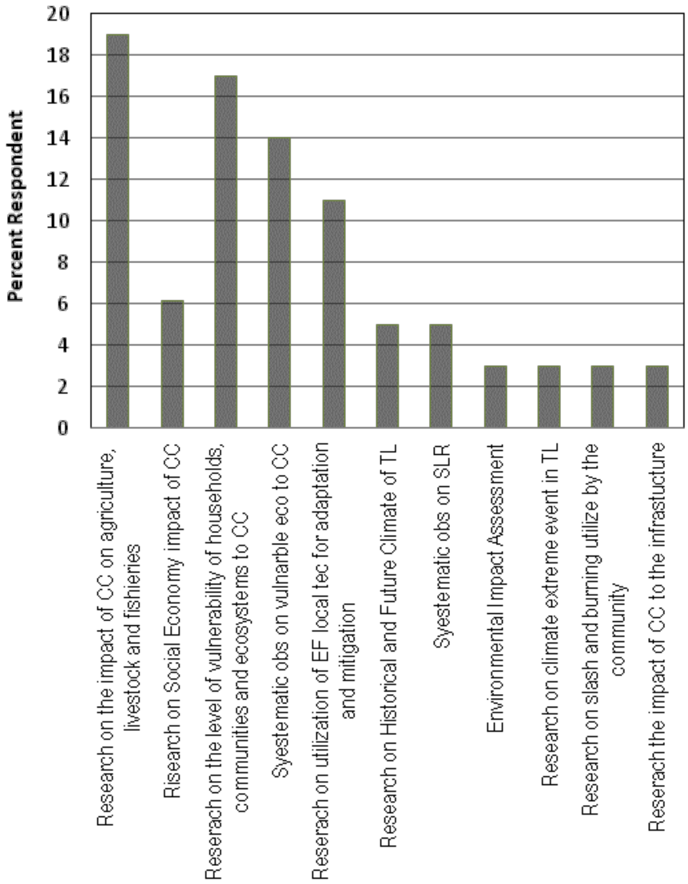


Figure 3 **Recommended climate change research activities from national and international agencies in Timor-Leste.**

Most respondents considered it important to have more pilots in addition to training and comparative studies to enable communities to implement climate change adaptation and mitigation activities. The presence of supporting policies such as providing extension services, establishment of information centres (e.g. agribusiness clinics), providing subsidies and strengthening education and dissemination of information regarding technologies will be a key factor for ensuring the successful implementation of climate change mitigation and adaptation actions.

In terms of Education, Training, and Public Awareness (ETPA), the Government of Timor-Leste in collaboration with UNICEF is developing a curriculum for environment sciences for primary and secondary schools, for training staff at the district level and also a public awareness program. A general introduction about environmental issues (e.g. climate change) will be introduced in primary schools at grade 5 and will be continued through related subjects at higher grades. At present the Government is still in the process of disseminating information on environmental education to all 13 districts. So far there has been implementation in four districts. In addition, the SoSE and international agencies and/or local NGOs have also implemented ETPA on climate change at primary and secondary schools at the district and sub-district levels. However the number of activities being implemented is still very low.

Some of the challenges in developing and implementing the environment curriculum and ETPA in Timor-Leste have been identified. These include (i) lack of funding for environmental education, (ii) lack of trainers and teachers with an environmental background, (iii) lack of awareness of sustainable development considerations in general, (iv) poor access to internet and lack of availability of reliable electricity supply for supporting web-based information on climate change information, awareness raising and education, (v) lack of coordination between donors to utilize available training programs efficiently, and (vi) few available instructional materials, especially those appropriate to the local context.

The development of a good web-based information system has been considered to be important for promoting information sharing of climate change. At present, only a few national institutions have established web-based information systems, while at local institutions there are almost none. Moreover, over 70% of Timorese living in rural areas have very limited access to information and means of communication. However, there is still a strong connection between individuals, communities, the environment, history and cultural traditions. Therefore, ‘adat’ (uma-lisan or clan) leaders can play important roles in the dissemination of information to communities.

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GLOSSARY OF ABBREVIATION

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ADO	Automative Diesel Oil
ANP	Autoridade Nacional do Petróleo
AR5	Fifth Assessment Report
Australian Aid	Australian Agency for International Development
BAU	Bussines As Ussual
BOO	Build Own Operate
CEDAW	Convention on the Elimination of All Forms of Discrimination
CH_4	Methane
CMIP	Climate Model Inter-comparison Project
CNG	Compressed Natural Gas
CNIC	National Centre for Scientific Research
CNRT	The National Reconstruction Party of Timor
CO_2	Carbon Dioxide
COP	Conference of the Parties
CTI	Coral Triangle Initiative
DIEACC	Directorate for International Environmental Affairs and Climate Change
DP	Democratic Party
DSSAT	Decision Support System for Agro-technology Transfer
E4A	Energy for All
EKKN	Elang, Kakatua and Kakatua North
ENSO	El-Nino Southern Oscillation
ESSP	Education Sector Support Project
EST	Environmentally Sound Technology
ETPA	Education, Training, Public Awareness
EWS	Early Warning System
FM	Frenti Mudansa Party
GCMs	Global Climate Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
$GgCO_2e$	Gigaton CO_2 emission
GHG	Green House Gasses
GS	Greater Sunrise
GWP	Global Warming Potential
ICM	Integrated Crop Management
IMOS	Integrated Marine Observing System
INC	Initial National Communication
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Utilizations
IWRM	Integrated Water Resources Management
JPDA	Joint Petroleum Development Area
LFG	Landfill Gas

LGV	Liquefiled Gas for Vechiles
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas
LUCF	Land Use Change and Forestry
LUCF	Land Use Change Forestry
LULUCF	Land Use, Land Use Change and Forestry
MAF	Ministry of Agriculture and Fisheries
MCIE	Ministry of Commerce, Industry and Environment
MJO	Madden-Julian Oscillation
MoF	Ministry of Forestry
MOU	Memorandum of Understanding
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NAPA	National Adaptation Plan of Action
NDF	National Directorate of Forestry
NDMG	National Directorate for Meteorology and Geophysics
NDWCQ	National Directorate of Water Control Quality
NE	Not Estimated
NGHGI	National Greenhouse Gas Inventory
NGO	Non-Governmental Organizations
NO	Not Occurring
PF	Petroleum Fund
PPP	Public Private Partnership
PV	Photo Voltage
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RDF	Refuse Derived Fuel
RE	Renewable Energy
RSO	Research and Systematic Observation
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SEFOPE	Secretary of State for Vocational Training and Employment
SEPI	The Secretary of State for the Promotion of Equality
SISCA	Integrated Community Health Services
SRI	Systems of Rice intensification
SSTA	Sea Surface Temperature Anomalies
TL	Timor-Lorosa'e (Timor-Leste)
TLEA	Timor-Leste Exclusive Area
TLSDP	Timor-Leste Strategic Development Plan
TWG	Thematic Working Group
ULP	Un-Leaded Petrol
UNDP ESCAP	United Nations Development Programme (UNDP) Economic and Social Commission for Asia and the Pacific (ESCAP)
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	The United Nations Children's Fund

UNTL	Universidade Nacional de Timor-Lorosa'e
Urea	Nitrogen synthetic fertilizer
USA	United States of America
USAID	United State Agency for International Development
USD	United State Dollar

1 NATIONAL CIRCUMSTANCES

Photo from UNMIT Photo Library

1.1 GEOGRAPHY AND CLIMATE

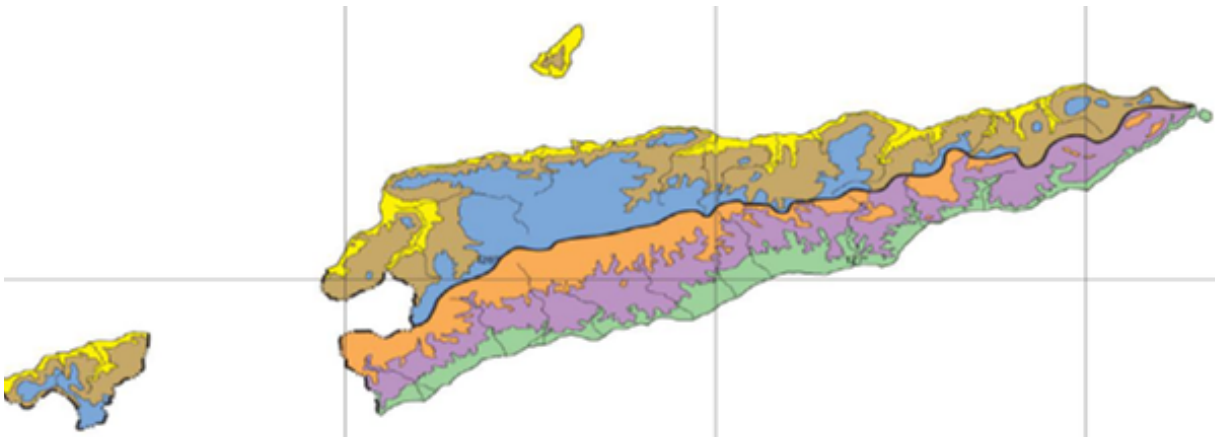
Timor-Leste occupies the eastern half of the island of Timor and is situated at the eastern end of the Lesser Sunda Islands of the Indonesian archipelago and northwest of Australia at a distance of about 500 km. It lies between latitudes 8'15 and 10'30 south, and longitudes 124'50 and 127'30 east (Figure 1-1). The topography is dominated by a massive central mountainous backbone rising to 3000 meters and dissected by deep valleys. On the northern side, the mountains extend almost to the coast, but on the southern part the mountains taper off some distance from the coast, which provides areas of coastal plain (Phillips, 2000). Up to 44% of the area has a slope of 40% (Barnett et al., 2007 cited in Molyneux et al,. 2012).

Based on the nature of the elevation and its orientation north or south of the east–west mountainous spine, the country is categorized into six agro-climatic zones (Figure 1.2; Fox, 2003). Rainfall along the northern coast is very low (<1000 mm/annum), throughout the central and elevated areas is low to moderate (1500-2000 mm/annum), and in high altitude areas which are mostly in the west of the country is relatively high (>2500 mm/annum; Keefer 2000 in Barnett 2003). The monthly rainfall pattern is quite different between northern and southern areas. The northern area has a unimodal rainfall pattern with distinct wet and dry seasons in which the wet season begins around December and ends around March/May. The southern region has a bimodal rainfall pattern, i.e. two rainfall peaks starting in December and again in May (Barnett, 2003). This area has a longer wet season, i.e. between 7 and 9 months.

Figure 1-1 **Map of Timor-Leste**

Rainfall variability in Timor-Leste is strongly influenced by monsoons, El Niño and La Niña, the Indian Ocean, tropical cyclones and the Madden-Julian Oscillation (Da Silva and Moniz, 2011). Extreme heavy rainfall in the wet season, influenced particularly by tropical cyclones, and also by the MJO may result in heavy flooding and landslides (Barnett, 2003). Extreme drought years, commonly associated with El Niño cause serious drought. These two extreme climate events have been reported as causing considerable economic losses as well as having a social and environmental impact.

The mean temperature in the northern coastal zone is 27°C, while the southern coast below 100 m has a mean temperature of 24°C, and the mountain districts with elevations above 500 m have mean temperatures of 21°C. In addition, the cold zone from 1200 m to the highest point has a mean temperature range of 15-21°C (Benevides, 2003). The annual climate is hot with an average temperature of 21°C and 80% humidity.



No	Zone (Percent land area)	Area (%)	Altitude (ma.s.l.)	Annual rainfall (mm)	Months of Rain
1	North Coast Lowlands	10	<100	<1000	4-5
2	Northern Slopes	23	100-500	1000-1500	5-6
3	Northern Uplands	20	>500	> 1500	6-7
4	Southern Uplands	15	>500	>2000	9
5	Southern Slopes	21	100-500	1500-2000	8
6	South Coast Lowland	11	<100	<1500	7-8

Figure 1-2 **Agro-climatic zones of Timor-Leste**

1.2 LAND USE

The total land area of the country is about 14,954 km² (RDTL, 2010). This includes the mainland area of 13,989 km², the Oecusse enclave of 817 km², Atauro Island of 140 km² and Jaco Island of 8 km². Land use and cover assessment conducted in 2010 by the National Directorate of Forestry (NDF) with support from a japanese expert indicated that forest remains the largest land use/cover category in the country, occupying about 60% of the total land area. The second largest is grassland and shrubs occupying about 27% of the total land area. The remaining are bare land, rice field and dry farm covering approximately 3.3%, 2.8% and 1.5% of total land respectively while settlement covers only 0.2% of the total land area (Table 1-1).

Table 1-1 **Land use and land cover of Timor-Leste in 2010**

Category	Land Use/Cover	Area (ha)	Percent
Forest Land	Dense Forest[a]	312,930.67	21.2%
	Sparse Forest[a]	556,199.74	37.7%
	Very Sparse Forest[a]	63,173.45	4.3%
Grassland	Grassland/Shrubs	403,247.22	27.4%
Crop Land	Rice Field	41,387.36	2.8%
	Dry Farm	22,152.57	1.5%
Settlement	Settlement	2,988.57	0.2%
Other Lands	Water Body	22,877.31	1.6%
	Bare Land	48,717.01	3.3%

[a]Dense forest: forests with canopy density more than 60%; Sparse forest:forests with canopy density between 20 – 60%; Very sparse forest: forests with canopy density about 5-20%.

1.3 NATURAL RESOURCES

1.3.1 Mineral Resources

Timor-Leste has many mineral resources. Some of them are economically feasible for exploitation. The most attractive mineral resource is copper and associated gold and silver. Clay minerals in the form of phosphorites, marble and other stone resources also have some commercial interest. The Government of Timor-Leste recently established the Institute for Petroleum and Geology that will play a role in further study and exploration of the mineral potentials of the country (UNDP ESCAP, 2003).

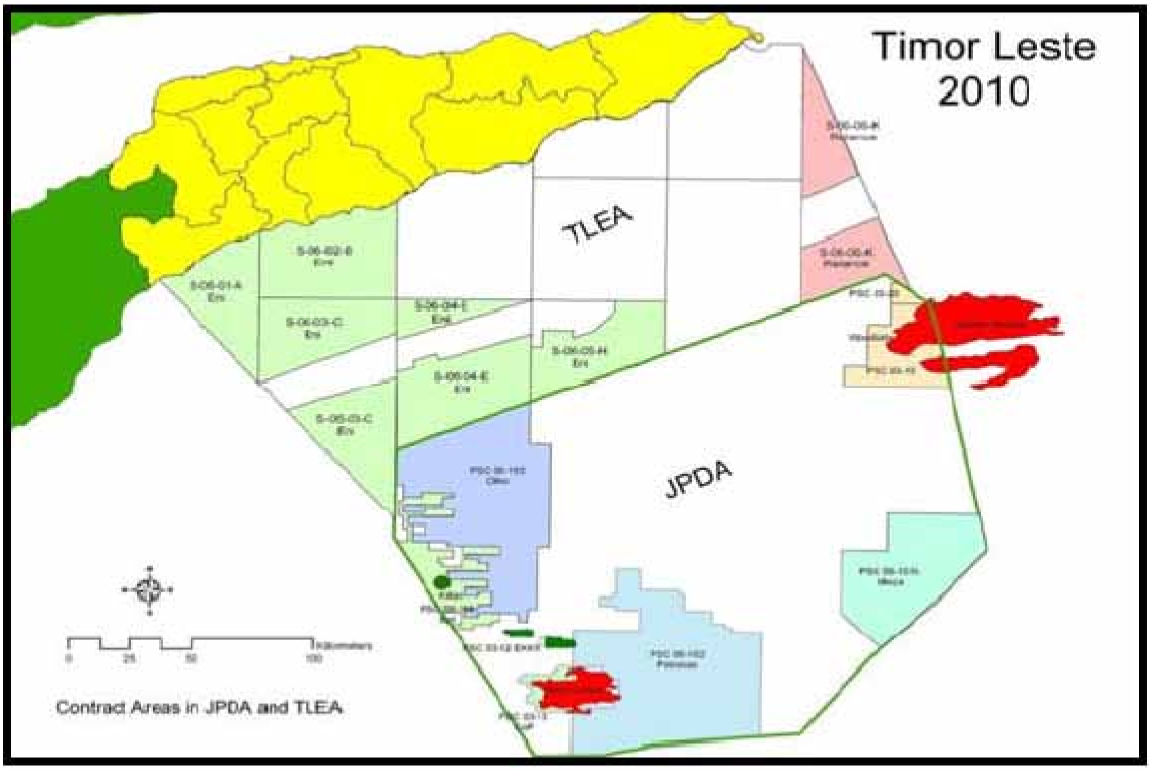


Figure 1-3 **Oil and Gas Field in Timor Sea (Autoridade Nacional do Petroleo, 2011)**

1.3.2 Oil and Gas Reserve

Timor-Leste has oil and natural gas reserves under the Timor Sea. The reserves are divided into two, the Timor-Leste Exclusive Area (TLEA) and the Joint Petroleum Development Area (JPDA) (see figure 1-3). Exploration activities in the JPDA are currently on going and jointly administered by the governments of Timor-Leste and Australia under a profit sharing agreement as specified in the Timor Sea Treaty, which was signed in May 2002.

After signing the Timor Sea Treaty, two production facilities were developed under JDPA: Bayu Undan and Kitan. Bayu Undan has been operating since 2004 while Kitan started production in 2011. An, an oil production facility was operated in the JPDA previously, (1998 to 2007) and those fields were Elang, Kakatua and Kakatua North (EKKN). EKKN was operated with an FPSO (Floating, Production, Storage, Off-loading) system.

Oil production and export during 2006-2012 from these production facilities can be seen in Figure 1-4.

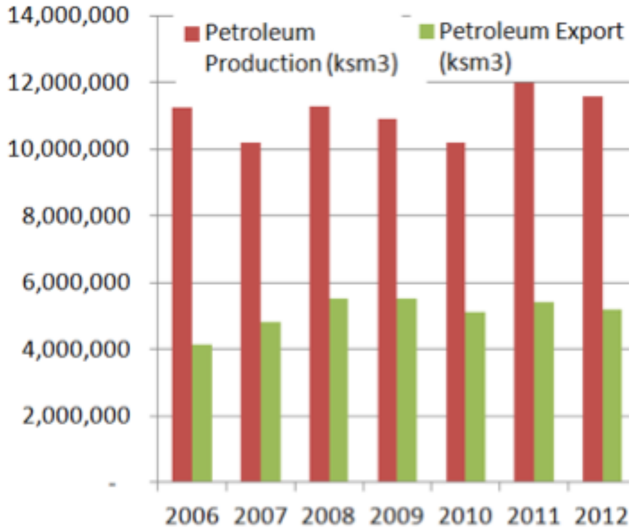


Figure 1-4 **Petroleum Production and Export from JPDA** (ANP, 2013).

Note: Ksm3 = Kilo standard cubic meter. Petroleum production consists of Condensate, LPG and Natural Gas. Only about 50% of Natural Gas is exported to Darwin, hence overall export figure is lower than production figure. Natural gas not exported is being injected back, used as fuel gas or flared and vented.

So far, although no development has taken place in TLEA, oil and gas exploration continues to take place in both the TLEA and JPDA blocks. The Greater Sunrise Field, located on the eastern side of JPDA has been identified to contain large natural gas reserves at approximately 5.1 trillion cubic feet (tcf) and condensate at approximately 226 million barrels[1]. The Greater Sunrise Field is currently awaiting development pending an agreeable solution on the location of downstream industries between the Government of Timor-Leste, the Government of Australia and the private joint venture partners involved.

1.3.3 Coastal and Marine Resources

Timor-Leste has approximately 700 km of coastline (Figure 1-5) and claim on an Exclusive Economic Zone (EEZ) of 200 nautical miles. The country holds many coastal and marine resources including fish, seagrasses, seaweeds, coral reefs, mangrove forests and beaches (Figure 1-6). Timor-Leste's coastal habitats around the country vary from region to region. The coastal areas are characterized by lagoons, fringing coral reefs, seagrass beds and steep cliffs accompanied by adjacent deep-water drop-offs, mangrove stands, beaches and shallow bays. The various coastal habitats influence the abun-

Figure 1-5

Timor-Leste's Coastal areas of about 700 km^2

Photo by Fredrik Stürmer

dance and diversity of local fish stocks with each different habitat contributing to the spawning and recruitment process of inshore and offshore species. About 42% of all the villages in Timor-Leste have a coastal border (McWilliams, 2003), this includes the district of Ambeno (Oecussi) located within West Timor. There are two offshore islands; the island of Atauro, which is part of Dili district and Jáco Island, located off the northern east coast (Kalis, 2010).

Figure 1-6 **One of a species of fish in Timor-Leste**
Photo from UNMIT Photo Library

The coastal zone (and habitats) of Timor-Leste is subject to a high degree of human dependency on resources. To date, almost 560,000 people (approximately two-thirds of the total population) in Timor-Leste live in coastal and lowland areas with an elevation up to 500 m ASL (NSD, 2006). Most fishing activities are limited to low-technology inshore fishing. Mainly women and children collect fish, crabs and molluscs in the intertidal zone at low tide (Sandlund et al., 2001 in Bogss G et al., 2009). During the Indonesian occupation, destructive fishing practices such as the use of dynamite and cyanide were common. Since independence in 1999, they have been used far less commonly (de Carvalho et al., 2007 cited by Bogss G, et al, 2009). The present state of offshore fisheries is unknown, but includes pelagic and demersal stocks. There is some potential for development of offshore fisheries aimed at export markets but a precautionary approach is needed, as there is little information as to the state of the fish stocks or the habitats that support them. The role of coastal habitats in the reproduction of some of the offshore species is still unknown (MAFF, 2004). There were at least 130 fish species from 15 families identified in the northern part of Timor-Leste's marine environment (Cook, 2005).

Timor-Leste is a member of the Coral Triangle Initiative (CTI). The Coral Triangle comprises 76% of coral species in the world, hosts 37% of coral reef fish species, 30% of the world's coral reefs important for fish breeding and growing (especially for tuna species) and has been recognized around the world as a provider of significant economic income for its respective member countries (CTI, 2009; TNC, 2008). The CTI provides for approximately 360 million people who reside in the Coral Triangle.
Over 80% of the coral reefs across the CTI areas are at risk; some fish stocks are depleted and some have already collapsed or are heading toward collapse due to destructive fishing practices, pollution, infrastructure development in coastal areas, over-population, climate change and ocean acidification. These are all problems that Timor-Leste must take into consideration as a CTI member country. This situation needs urgent collaborative action across the region, not only for government but also inclusive of local communities, NGOs, donors, international organizations, private sector, and other stakeholders.

[1]Source: Australian Government, Department of Resources, Energy and Tourism.

1.3.4 Water Resources

Timor-Leste has more than 100 rivers (Figure 1-7). The longest river, the Loes, is only 80 km long, flowing into the sea at Atabae. Given the temporal variation in rainfall and the low capacity of upland areas to hold water, very few rivers flow all year round. There are only eight river channels that have permanent courses of water throughout the year. These include Loes River in Liquisa district, Laclo River in Manatuto district, Sahe River in Manufahi district, Seisal River in Baucau district, Karau Ulun River in Manufahi and Bebui River in Viqueque district. Timor-Leste has only one large lake called Lake Iralalaru, lying on the eastern area of the island covering approximately 22 km^2. Water level in this lake has been observed to vary dramatically over past decades, with great seasonal variations. Initial observations suggest that the primary forests surrounding the lake are a unique ecosystem, which, until now, has been exceptionally well preserved.

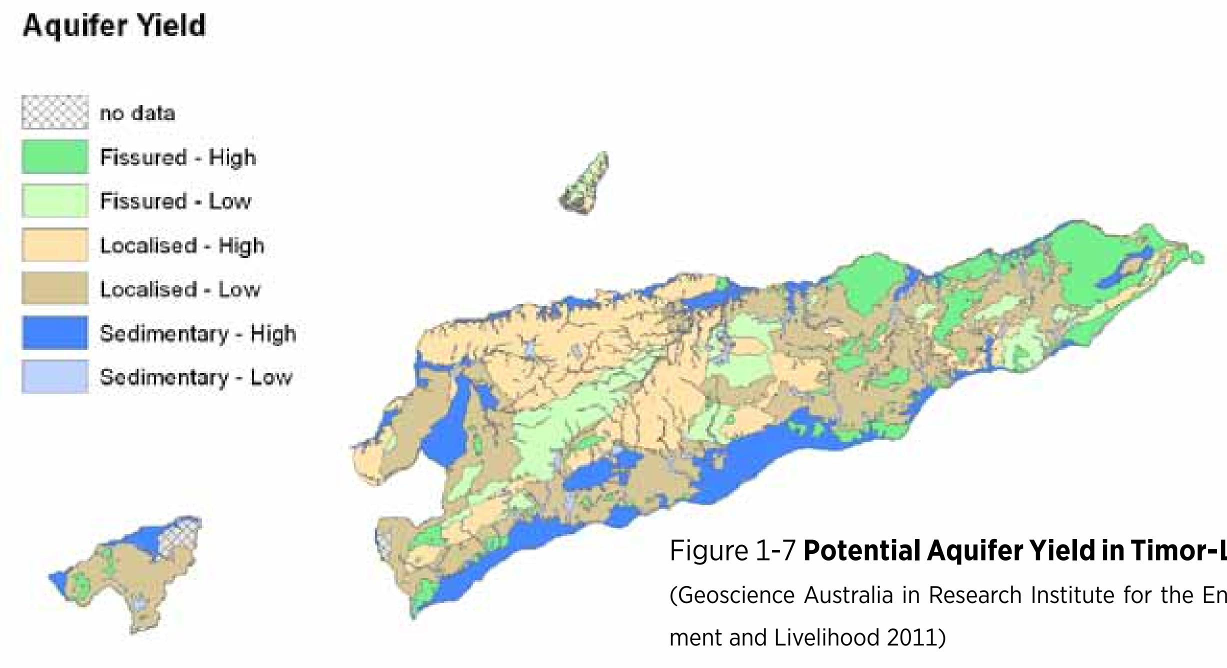


Figure 1-7 **Potential Aquifer Yield in Timor-Leste**
(Geoscience Australia in Research Institute for the Environment and Livelihood 2011)

In Timor-Leste, principal uses of water are agriculture (both irrigated and rain-fed) and domestic consumption. A few sources have been developed into hydropower facilities although high seasonal variability of water availability coupled with challenges related to community-based management models of the facilities has hampered the sustainable utilization of water as an energy source. Groundwater is an important source of water for domestic use across the island, including for upland and urban areas. Areas with higher potential for aquifer yield in Timor-Leste are mostly on the southern coast and the eastern areas of the country with some high potential noted in the northwest inland of the country (Figure 1-8).

1.3.5 Forest Resources

As mentioned above, most of the land in Timor-Leste is still covered with forest ecosystems at different levels of degradation. A study conducted in two districts, Bobonaro and Covalima in 2008 and 2009, found that Timor-Leste´s forests still have an abundance of species (Table 1-2, Pachero Marques (et al.). 2010. . However, most of the forests are heavily degraded as a result of extensive timber and firewood extraction and grazing. It has been recommended that conservation objectives could be best realized through the installation of nurseries and firewood plantations near villages and plantings in pastoral and sparsely forested areas utilizing various species to promote both productivity and diversity. Tree species commonly used for forest regeneration with good regenerative capacity are Eucalyptus alba, Leucaena leucocephala, Pouteria sp., Mallotus philippensis and Schleichera oleosa (Table 1-2).

Forestry Aspect	District of Bobonaro	District of Covalima
Area of primary forest	7%	23%
Area of modified natural forest	87%	64%
Forest area with evidence of fire	22%	18%
Forest areas with evidence of shifting cultivation	32%	24%
Forest areas with evidence of cuts	49%	9%
Forest areas with evidence of grazing	32%	60%
Forest species	> 125 species belonging to 6 families	> 186 species belonging to 7 families
Forest diversity and distribution of species	Most abundant species: *Scheleicheraoleosa* and *Pterocarpusindicus*. Most abundant families were Casuarinaceae, Euphorbiceae, Fabaceae, Malvaceae, Moraceae, Myrtaceae and Rubiaceae. 36 families were observed, 27 were common to both Bobonaro and Covalima.	Most abundant species: *Scheleicheraoleosa* and *Pterocarpusindicus*. Most abundant families were Casuarinaceae, Euphorbiceae, Fabaceae, Malvaceae, Moraceae, Myrtaceae and Rubiaceae. 43 families were observed, 27 were common to both Bobonaro and Covalima.
Forest regeneration	*Eucalyptus alba* and *Leucaenaleucocephala* were observed to have the most regenerative capacity with 501 to 1000 seedlings/ha. Both the above species are the most representative in terms of emergence of poles.	*Leucaenaleucocephala* have the most regenerative capacity with 1000 seedlings/ha. *Pouteria,sp.*, *Mallotusphilippensis* and *Schleicheraoleosa* were observed to have regenerative capacity between 501 to 1000 seedlings/ha. In terms of emergence of poles, all except for *Pouteria sp.* were the most representative.

Table 1-2 **Forest condition in Bobonaro (2008) and Covalima (2009) districts**

1.4 DEMOGRAPHY

The population of Timor-Leste has grown quite quickly over the last 10 years. In 1996, the population of the country was only 0.86 million and in 2012 it reached 1.2 million. The mean annual population growth in this period was about 2.9%. Many East Timorese are actually the descendants of Tetun-Terik speakers, originally inhabitants of the south central part of Timor Island. The rapid growth of population in the country is contributing unemployment. According to government reports, 48% people in the country are literate and as East Timor is slowly becoming a favorite for tourists, the Government expects this may contribute to a permanent solution for the unemployment problem.

1.5 ECONOMIC AND SOCIAL DEVELOPMENT

1.5.1 Economic

Despite being an oil rich country, Timor-Leste is still considered one of the poorest countries in the Asia-Pacific region. Its economic performance since gaining independence from Indonesia in 2002 has been fragile, characterized by slow-moving investment of aid funds and oil revenues. The country is set to benefit from the commercial exploitation of its petroleum and natural gas reserves in the waters southeast of Timor. In June 2005, the National Parliament of Timor-Leste unanimously approved the Petroleum Fund (PF) law following public consultation (IMF, 2009). This PF law was aimed at effectively managing and investing oil revenue in the country's development after exploitation of these resources ends.

The petroleum sector is considered a major source of national income for Timor-Leste. Since 2002, the country is heavily reliant on oil and gas revenue as a main source of funding for government expenditure. Oil and gas contributes about 90% of total budget revenue for the country (IMF, 2011). In addition, oil wealth is estimated at US$24.3 billion or US$22,000 per capita (IMF, 2011). Furthermore, Timor-Leste's petroleum fund balance was US$4.2 billion in 2008 and US$5.4 billion in 2009, and in 2010 this fund has reached US$6.9 billion, and this figure is projected to rise above US$14 billion by 2015 (ADB, 2011). Despite this, poverty is recognized as one of the most crucial problem faced by the country. Available data on poverty in Timor-Leste shows that about half of the population live in poverty (Datt et al., 2008). With regards to non-petroleum GDP for the country, sectors of Industry and Services together with Agriculture including its sub sectors forestry and fishery are the two main sectors that dominate Timor-Leste's economy. The GDP of petroleum and non-petroleum sector as well as total GDP per capita of Timor-Leste from 2005 to 2010 is presented on Table 1-3.

1. Type of GDP	2005	2006	2007	2008	2009	2010
Total GDP (in millions of dollars)	2,510.50	4,065.10	4,034.40	4,521.80	4,206.20	4,140.40
Petroleum Sector (in millions of USD)	1,957.50	3,522.00	3,428.10	3,826.30	3,421.70	3,281.30
Petroleum Sector Growth (%)	77.6%	79.9%	-2.7%	11.6%	-10.6%	-4.1%
Non-Petroleum (in millions of USD)	553	543.1	606.3	695.5	784.6	859.1
Non-Petroleum Sector Growth (%)	6.4%	-1.8%	11.6%	14.7%	12.8%	9.5%
Total GDP per capita (in USD)	2,578.50	4,082.50	3,961.70	4,341.70	3,949.00	3,800.90
Petroleum Sector (in USD)	2,010.50	3,537.10	3,366.30	3,673.90	3,212.50	3,012.30
Non-Petroleum (in USD)	568.00	545.40	595.40	667.80	736.60	788.70

Table 1-3 **GDP of petroleum, non-petroleum sector and per capita of Timor-Leste, 2005-2010**

Ministry of Finance-Microeconomic Framework (GDP-P).TLSDP 2011-2030, Gross Domestic Product (GDP) is defined as the total of value of all goods and services produced with a country in a year.

Non-Petroleum GDP by Sub-Sectors

In terms of share of non-petroleum GDP, sub-sectors such as industry and services and agriculture, forestry and fishery were the dominant sub-sectors that contributed to Timor-Leste's GDP compared to other sectors (Table 1-4). Although agriculture, forestry and fishery were in second position in terms of contribution to GDP, this sector has the potential to be developed as an export commodity in the future.

Table 1-4 **The share of non-petroleum GDP (by sectors) from 2005 to 2010 at constant 2010 prices**

Non-petroleum GDP by sector	2005	2006	2007	2008	2009	2010
	Percentage (%)					
Agriculture, forestry and fishery	28.5	30.5	26.5	24.9	24.0	21.4
Industry and Services	50.7	47.0	51.5	54.9	54.2	56.4
Public administration, defence, education, human health and social work activities	18.1	20.8	20.7	19.9	21.2	21.5

Source: Ministry of Finance, Macroeconomic Framework (GDP-P)

The trend for percentage share of non-petroleum GDP by sub-sectors in 2011 and 2012 shows a similar pattern with the industry and services sector remaining well above the other sectors with 54.2% and 564% respectively in 2009 and 2010. In addition, the percentage of share of non-petroleum GDP for public administration, defence, education, human health and social work activities increased by 1% in 2011 and by 2% in 2012 compared to the year of 2010, which placed this sector in second position for its contribution to the GDP of the country for the period 2011 and 2012, followed by the agriculture, forestry and fisheries sector in third position in the same time period with shares of 20.8% and 20.2% respectively.

1.5.2. Education

Timor-Leste is facing enormous challenges in secondary and higher education. Following the referendum in 1999 there was widespread burning and destruction of property all over the country, and nearly 90% of the schools including Universitas Timor-Timur, which was the only higher education institution at the time, were damaged or destroyed. In 2010, there were 91 secondary schools including general and technical schools registered as public and private, with total student and teacher numbers of 40,781 and 1,696 respectively. (MoE; cited in the SDP 2011-2030). Because of the pressing demand from young people to enter university, the Universidade Naçional de Timor-Lorosa'e (UNTL) was established in 2002. Since then, some other higher education institutions have been established, mainly concentrated in the capital city of Dili including eleven private tertiary education institutions.

Although there has been rapid growth in the establishment of higher education institutions and the number of student enrolments in the country, the quality of these institutions remains an issue. Inadequacy of facilities, lack of human resources, weaknesses in policies as well as the capacity to regulate and control these institutions are considered as obstacles to their development. Currently there is only one public university fully financed by the government, which is UNTL. Within UNTL, there is a National Centre for Scientific Research (CNIC) and through its collaboration with other research institutions both locally and internationally, it is expected that it will play a vital role in contributing to the development of climate change adaptation and mitigation actions for the country in the near future (MoE cited in the Timor-Leste Strategic Development Plan 2011-2030).

1.5.3 Unemployment

While unemployment statistics in a largely agrarian and informal economy are difficult to ascertain, it must be admitted that in a country like Timor-Leste, informal sector activities are essential for income generation, particularly for those living in rural areas. Timor-Leste's Labour Force Survey in 2010 indicated that about 9,000 persons were categorised as unemployed with this number more or less evenly spread between males and females, as well as between urban and rural areas (Table 1-5).

Table 1-5 **Numbers of unemployed, unemployment rate, by sex and locality**

The rate of unemployment as presented in Table 1.5 may be considered very low but it should be noted that in this case employment was defined as a person that did any work at all (paid or unpaid) during the reference week.

Category	Number unemployed	Unemployment rate
Timor Leste	9,000	3.6%
Urban	5,000	6.9%
Rural	4,000	2.2%
Male	5,000	3.1%
Female	4,000	4.6%

Source: TL-LFS, 2010; Unemployment rate is the number of unemployed as a percentage of the labour force

For the time being, private investment, including foreign direct investment into Timor-Leste will remain modest. Timor-Leste's economy is uncompetitive-small and with poor infrastructure, high cost, low labor skills, and impeded by incomplete legal and institutional frameworks.

1.6 SECTORAL CONDITIONS

1.6.1 Energy

The energy system in Timor-Leste comprises energy production activities (supply side) and consumption activities (demand side). The supply side covers the activities of production of crude oil, condensate, and natural gas in oil and gas production facilities and the production of electricity in power generation plants. The demand side covers the activities of fuel combustion in transportation, commercial and residential/household sectors.

1.6.1.1 Supply Side

On the supply side, the GHG inventory includes GHG emissions from fossil fuel combustion activities for own use in oil and gas production facilities, emissions from gas flaring and venting activities in oil and gas production facilities, and fossil fuel combustion activities for generating electricity in the diesel oil based power plants in Timor-Leste.

In the oil and production facility, crude oil and condensate produced by this facility are not used in Timor-Leste. All crude oil and condensate is exported to other countries. Since Timor-Leste does not have its own oil refinery to process these crude oil and condensate products to become petroleum products, the country's consumption of petroleum products is supplied by importing these products from Indonesia, Australia, Singapore, etc. In the production facility, natural gas is also produced in association with the production of crude oil and condensate. The gas is not used for domestic consumption but only for own use in the field. Any unused portion of this gas is flared or vented for safety reasons because there is no consumer demand around the facilities.

In Timor-Leste, oil and gas productions is from JPDA and Greater Sunrise fields that are located in the Timor Sea, in which Australia and Timor-Leste work together to facilitate development of the shared resources. There are currently two operating fields in the JPDA, namely Bayu-Undan (estimated to contain 3.4 TCF of LNG and 110,000 barrels of condensate) and Kitan (commenced production on 10 October 2011 with up to 34.6 million barrels of oil estimated to be recoverable). The Greater Sunrise (GS) gas and condensate fields overlap a combined area of exclusive Australian jurisdiction (79.9 per cent of the fields) and the JPDA (20.1 per cent of the fields). It is estimated that the fields contain 5.1

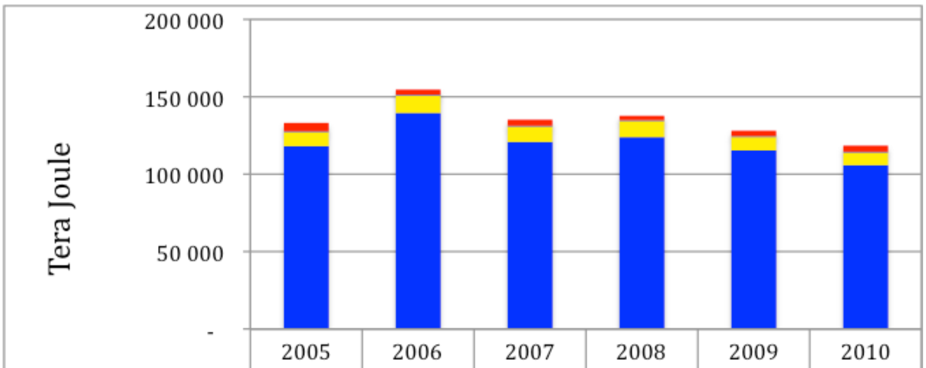
trillion cubic feet of liquefied natural gas (LNG) and 226 million barrels of condensate. The GS field facility is expected to be constructed by 2016. Therefore, the sources of GHG emission from oil and gas production activities in this INC are limited to JDPA operations, for which the ANP (Autoridade Naçional do Petróleo (ANP) or National Petroleum Authority is the Designated Authority that is currently the Timor-Leste offshore regulator. The production and export data for crude oil, and export, own use, venting/flaring data from the JDPA fields (published by ANP) during 2005 – 2010 are presented in Table1-6 (in kTon) and Figure 1-8 (in energy units, TJoule).

Table 1-6 **Oil production, export, own use, venting, and flaring, kTon**

Year	Production	. Export	Stock Change	Fuel gas (own use)	Gas Venting	Gas Flaring
2005	2733	2691	42	202	0.86	109
2006	3228	3199	29	248	0.02	66
2007	2795	2790	5	220	0.26	79
2008	2866	2827	39	232	0.03	55
2009	2669	2656	13	195	0.04	70
2010	2447	2414	34	183	0.14	80

Source: NAPA, 2011

It can be seen from Table 1-6 (in kTon) and Figure 1-8 (in energy unit), that the amount of natural gas being flared is still high. There is room for efficiency through improvements to the operation of oil and gas production facilities so that the amount of gas being flared or vented can be reduced.



	2005	2006	2007	2008	2009	2010
Gas Flaring	5 234	3 190	3 792	2 669	3 366	3 854
Gas Venting	41	1	12	1	2	7
Fuel Gas (Own use)	9 750	11 957	10 614	11 170	9 384	8 825
Crudue Production	118 075	139 494	120 785	123 851	115 316	105 756

Figure 1-8 **Crude oil production, fuel gas (own use), gas venting, and gas flaring (TJoule)**

Source: Estimated from NAPA, 2011 (fuel characteristics referred to IPCC1996 revised GL)

In supplying the total demand for fuels in Timor-Leste, there are several suppliers, presented in Figures 1-9 and 1-10.

In relation to electricity production facilities, power generation plants in Timor-Leste are managed by a national or state owned enterprise/company, EDTL. The power plant systems use fuel oil (diesel oil) as their energy source. EDTL supplies electricity for Dili and districts outside Dili. Table 1.7 presents fuel consumption for EDTL power generation. It can be seen from Table 4.2 that the average specific fuel consumption is between 0.27 – 0.29 litre/kWh. There is room for efficiency because an efficient diesel generation usually consumes around 0.25 litre/kWh.

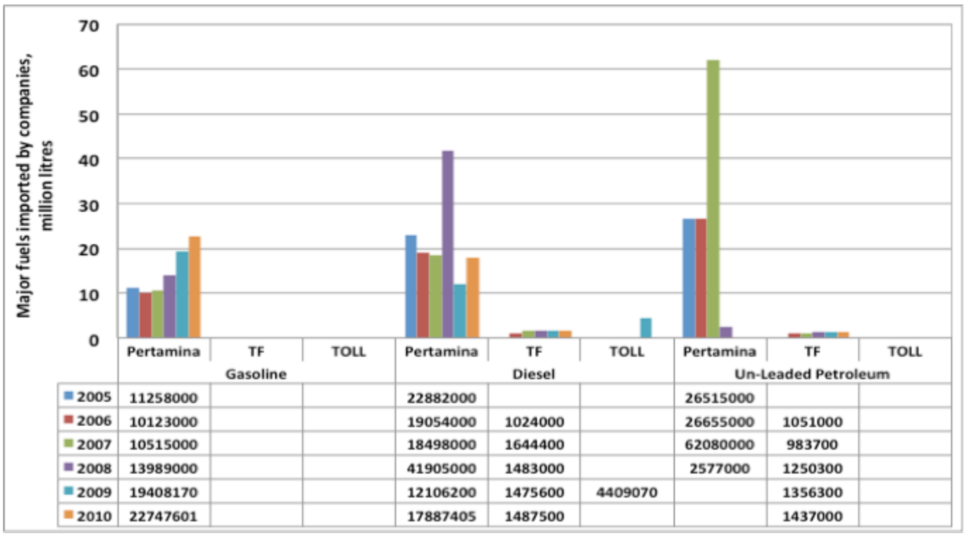


Figure 1-9 **Major fuels importations by companies, MLiter (Customs, 2011)**

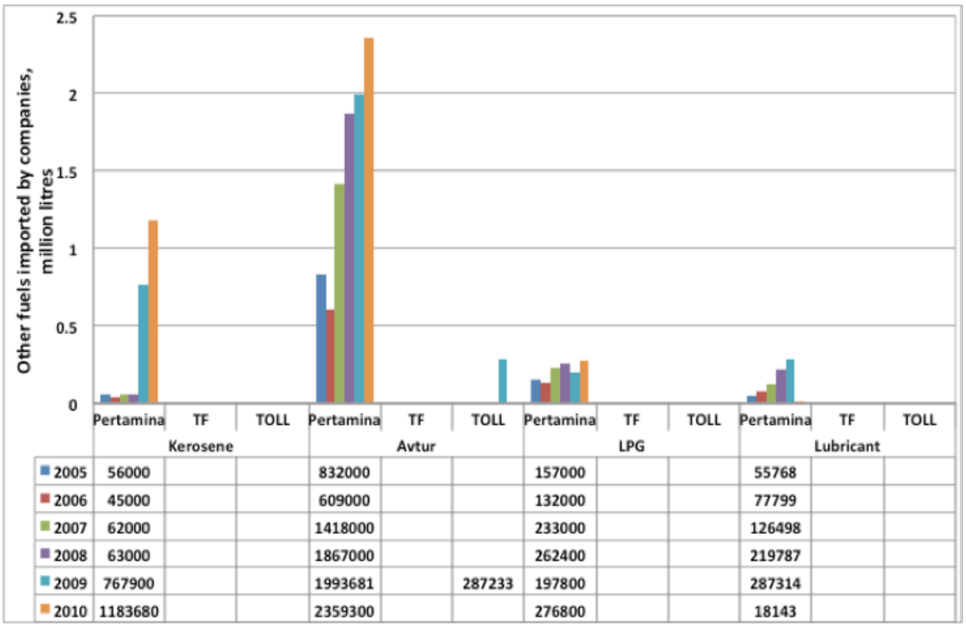


Figure 1-10 **Other fuel imports by companies, MLiter (Customs, 2011)**

Table 1-7 **Electricity generation and fuel consumption by power generation, Kton/year**

Sources: processed from EDTL Data, 2011; data 2012 – 2014 is projection plan

Year	District Electricity		Dili Electricity		TOTAL		
	Electricity Generation kWh	Fuel Consumption kTon	Electricity Generation kWh	Fuel Consumption kTon	Average Specific Consumption Liter/kWh	Electricity Generation kWh	Fuel Consumptio kTon
2005	7,095,110	1.71	55,896,498	13.44	0.27	62,991,608	15.14
2006	9,714,689	2.35	71,958,471	17.43	0.27	81,673,160	19.78
2007	14,972,138	3.84	91,788,978	23.54	0.29	106,761,116	27.38
2008	14,545,793	3.53	110,514,113	26.80	0.27	125,059,906	30.32
2009	23,215,030	5.70	131,700,316	32.35	0.28	154,915,346	38.05
2010	29,560,361	7.66	136,908,654	35.48	0.29	166,469,015	43.14
2011	39,475,770	10.29	140,661,791	36.66	0.29	180,137,561	46.95
2012	53,025,772	13.82	154,727,970	40.33	0.29	207,753,743	54.15
2013	71,226,794	18.56	177,937,166	46.38	0.29	249,163,959	64.94
2014	95,675,290	24.94	204,627,741	53.33	0.29	300,303,030	78.27

Diesel oil utilization in electricity generation can be replaced by zero emission or lower emission fuels, i.e. gas (CNG, LGV, or LPG) and bio-fuel (bio-diesel or SVO (straight vegetable oil). Although there is potential to grow several types of biofuel plantation in Timor-Leste, the Government of Timor-Leste has regulated land in Timor-Leste for food production only and not for biofuel. Therefore, GHG emission reduction potential is in increasing efficiency and fuel oil replacement with gas (LPG, CNG, or LGV). In the future, if the government of Timor-Leste supplies the gas through a gas pipeline from offshore there will be a possibility to provide gas for transportation (CNG or LGV) and also to extract LPG from the gas pipeline for LPG production.

1.6.1.2 Demand Side

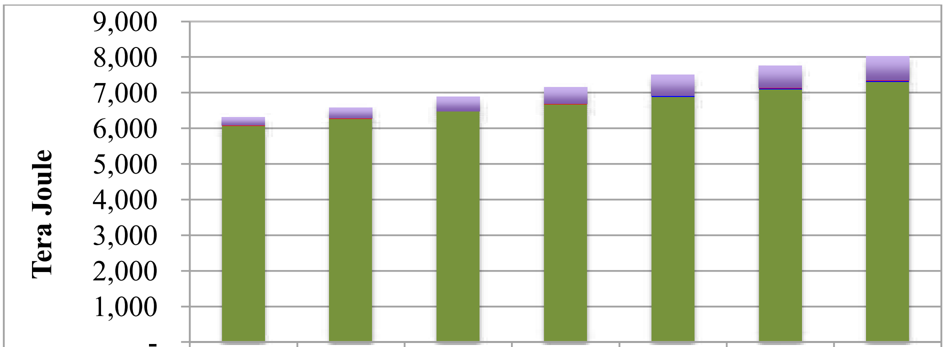
Commercial and Residential Sectors

As discussed previously, fuel consumption in the commercial and residential sectors is too small and the data cannot be separated. As a result, fuel consumption and GHG emissions in these sectors are estimated together. In Timor-Leste, almost 82% of households do not have access to electricity and 98% use firewood as their primary source of energy. Residential and commercial fuel consumption is presented in Table 1-8, Figures 1-12 and 1-13. Figure 1-14 presents the projection of fuel consumption in the residential and commercial.

Table 1-8 **Fuel consumption data in commercial and residential sectors, 2005-2011**

Year	Population	Household	Biomass, Ton	Kerosene, Liter	LPG, kG	Electricity, kWh
2005	983,369	165,308	561,138	56,000	157,000	62,991,608
2006	1,015,187	170,657	579,295	45,000	132,000	81,673,160
2007	1,047,632	176,111	597,809	62,000	233,000	106,761,116
2008	1,080,742	181,677	616,703	63,000	262,400	125,059,906
2009	1,114,534	187,358	635,987	767,900	197,800	154,915,346
2010	1,149,028	193,156	655,668	781,979	276,800	166,469,015
2011	1,184,193	199,068	675,736	796,058	304,540	180,137,561

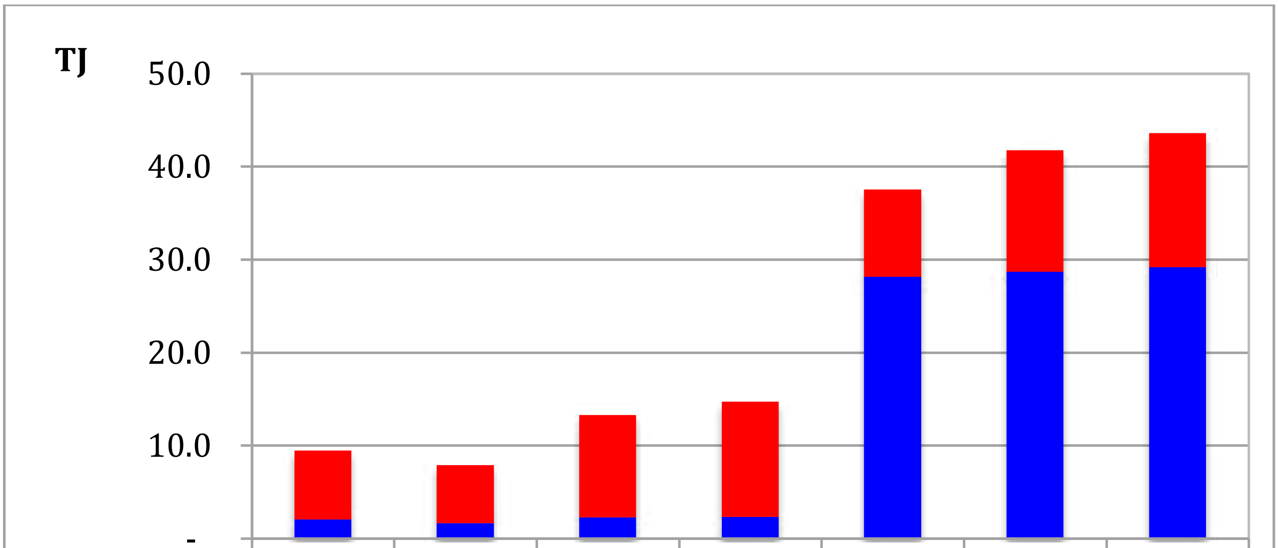
Source: Kerosene and LPG data from PERTAMINA-DILI (2011) and Biomass is estimated using parameter biomass/capita generated from national surveys conducted by the EU.



	2005	2006	2007	2008	2009	2010	2011
Electricity	235.5	305.4	399.2	467.6	579.3	622.5	673.6
LPG	7.4	6.2	11.0	12.4	9.4	13.1	14.4
Kerosene	2.1	1.7	2.3	2.3	28.2	28.7	29.2
Biomasss	6,072	6,268	6,469	6,673	6,882	7,095	7,312

Figure 1-11 **Fuel consumption in residential and commercial sectors (TJoule), 2005–2011**

Source: Kerosene and LPG data from PERTAMINA-DILI (2011) and Biomass is estimated using parameter biomass/capita generated from national surveys conducted by the EU. Figure 1 12 LPG vs kerosene utilization in residential



	2005	2006	2007	2008	2009	2010	2011
LPG	7.4	6.2	11.0	12.4	9.4	13.1	14.4
Kerosene	2.1	1.7	2.3	2.3	28.2	28.7	29.2

Figure 1-12 **LPG vs kerosene utilization in residential and commercial sectors (TJoule)**

Source: Kerosene and LPG data from PERTAMINA-DILI (2011)

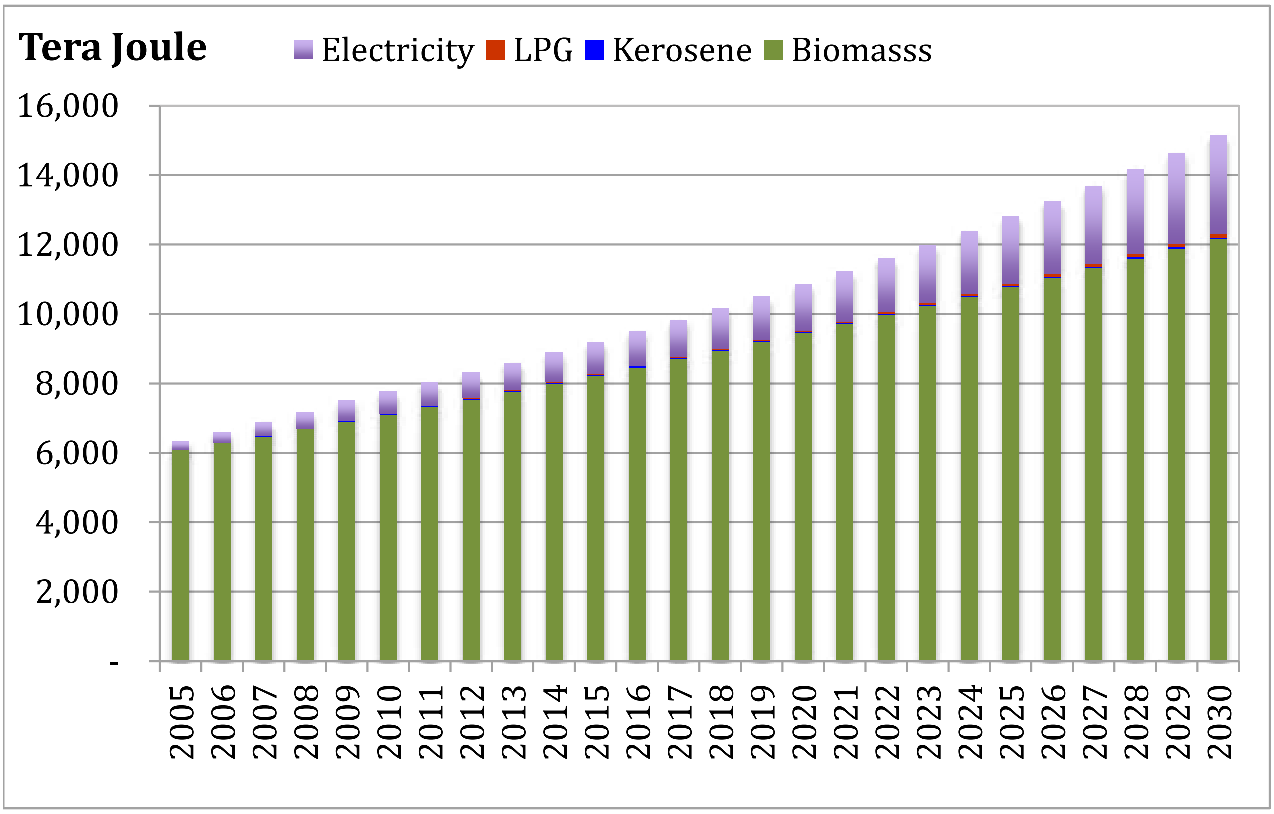


Figure 1-13 **The projection of fuel consumption of residential and commercial (TJoule)**

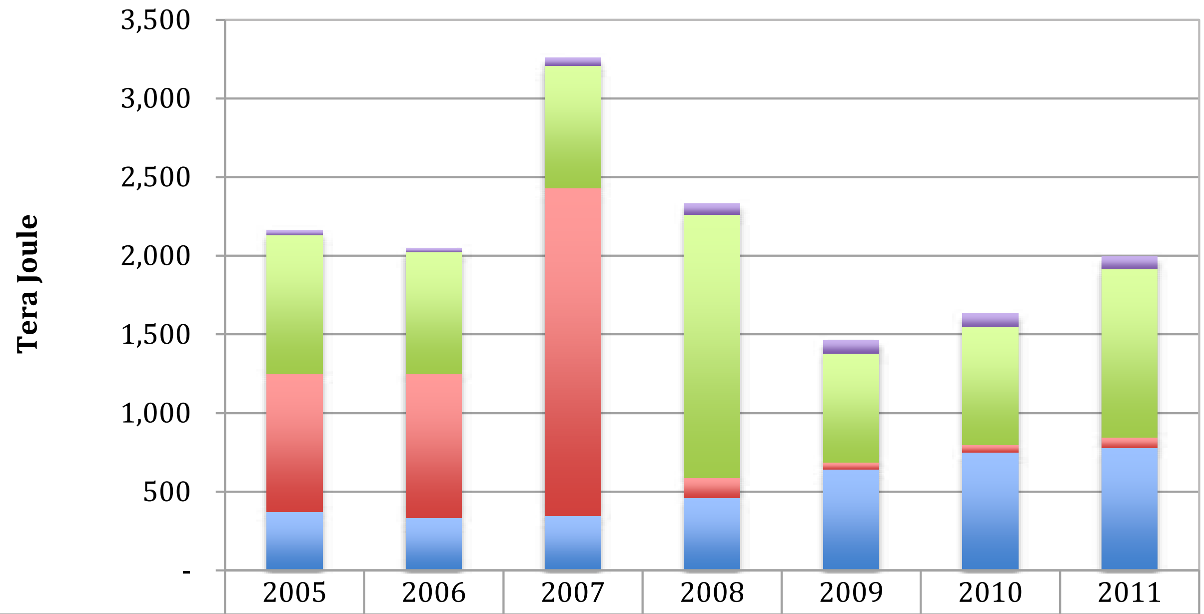
Transportation Sector

The types of fuel used in the transportation sector include gasoline, ULP (un-leaded petrol), and diesel for road transport and aviation and jet-kero for international air transportation. Data on fuel consumption in transport is provided by Pertamina Dili, Tiger Fuel, and TOLL. Table 1-9 and Figure 1-14 present fuel utilization in transportation. The projection of fuel consumption is presented in Figure 1-15. Types of fuels used and their suppliers are presented in Figure 1-16.

Table 1-9 **Fuel consumption in Transportation sector, 2005-2010**

Year	Gasoline, Lt	ULP, Litre		Diesel Oil, Litre			Avtur/Jet-Kero, Litre	
	Pertamina	Pertamina	Tiger Fuel	Pertamina	Tiger Fuel	TOLL	Pertamina	TOLL
2005	11,258,000	26,515,000	-	22,882,000	-	-	832,000	-
2006	10,123,000	26,655,000	1,051,000	19,054,000	1,024,000	-	609,000	-
2007	10,515,000	62,080,000	983,700	18,498,000	1,644,400	-	1,418,000	-
2008	13,989,000	2,577,000	1,250,300	41,905,000	1,483,000	-	1,867,000	-
2009	19,408,170	-	1,356,300	12,106,200	1,475,600	4,409,070	1,993,681	287,233
2010	22,747,601	-	1,437,000	17,887,405	1,487,500	-	2,359,300	-
2011	23,532,090	1,104,000	936,000	27,163,719	600,000	-	2,150,368	-

* ULP = Un-Leaded Petroleum; Jet Kerosene (JET A1/F35) = Avtur (international bunker). Sources: processed from Pertamina Data (2011), TOLL Data, and Tiger Fuel Data.



	2005	2006	2007	2008	2009	2010	2011
Avtur/Jet-Kero	30	22	52	68	83	86	79
Diesel Oil	882	774	777	1,673	694	747	1,071
ULP	875	915	2,082	126	45	47	67
Gasoline	372	334	347	462	641	751	777

Figure 1-14 **Fuel consumptions in Transportation (TJoule)* ULP = Un-Leaded Petroleum; Jet Kerosene (JET A1/F35) = Avtur (international bunker).**

Sources: processed from Pertamina Data (2011), TOLL Data, and Tiger Fuel Data.

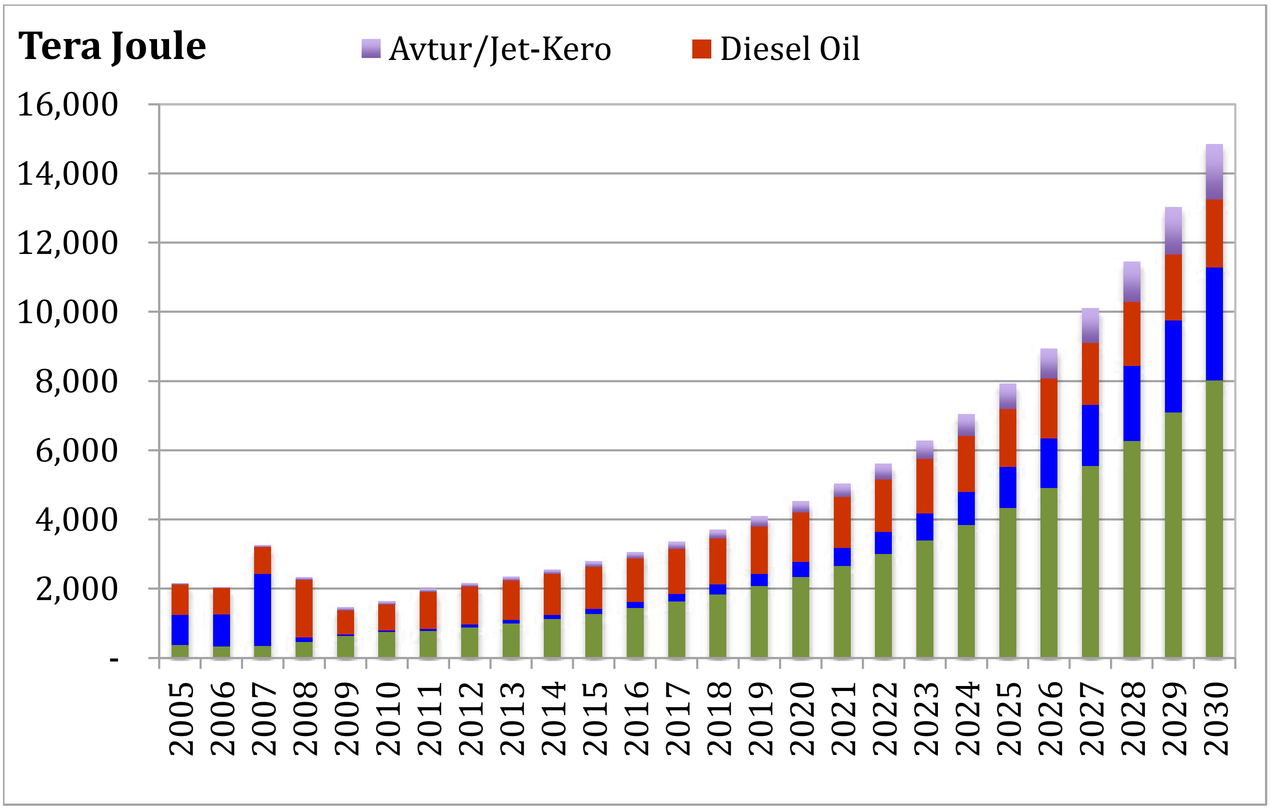


Figure 1-15 **Projection of fuel consumption in transportation sector (TJoule).**

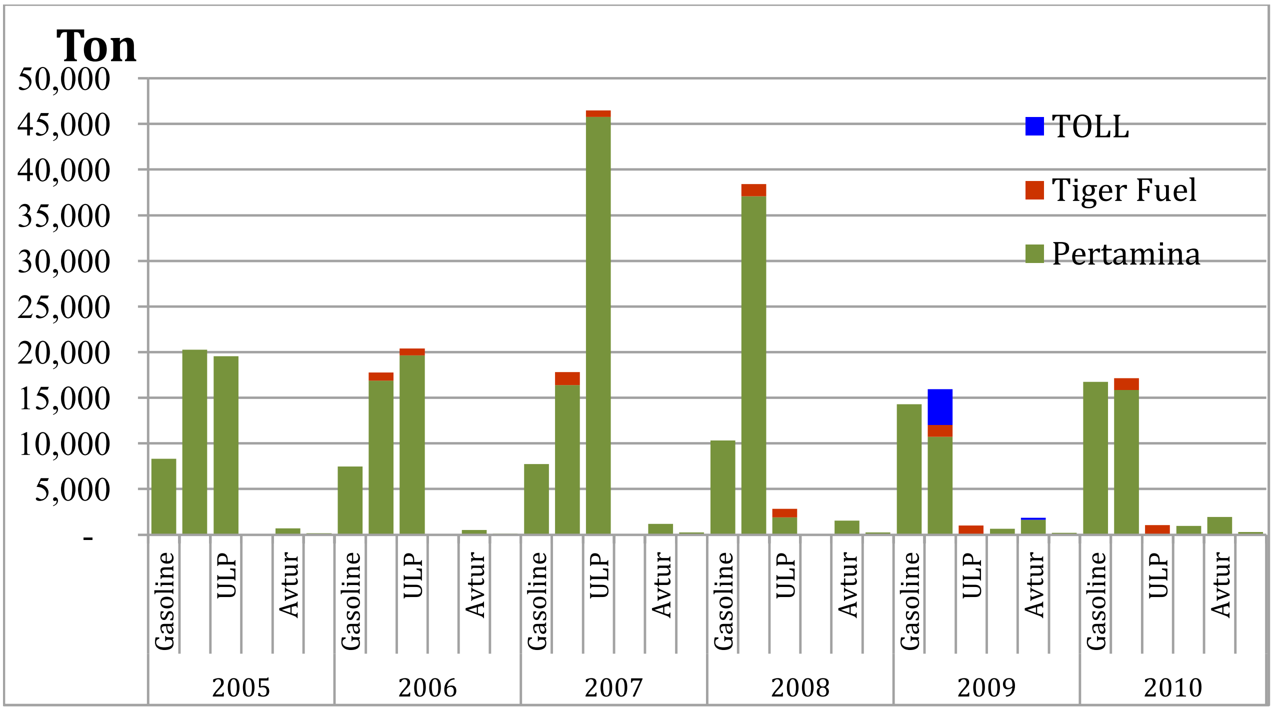


Figure 1-16 **Overall energy/fuel demand by type and supplier (Ton).**

1.6.2 Agriculture

Agriculture dominates economic activities in Timor-Leste (IV Constitutional Government Program, 2007-2012). It is subsistence agriculture with low inputs and outputs. The agriculture sector comprises crops and livestock, fisheries and forestry and employs more than 75% of Timorese people. Staple crops are maize, rice, and cassava with sweet potato, potato, mung bean, peanut and soya bean being widely grown in farmlands on steep slopes. The exception to this is the rice crop, which is mostly found on flat areas or terraces on moderate slopes. Cash tree crops such as coffee, coconut and candlenut are found in certain places in Timor-Leste. For example, coffee plants are found in cool-high elevation areas in some districts such as Ermera, Aileu and Ainaro, while coconut plants are found in the coastal areas of some districts such as Baucau and Viqueque. Numbers of households involved in growing foods and crops for each district based on the 2010 Census are presented in Figure 1-18.

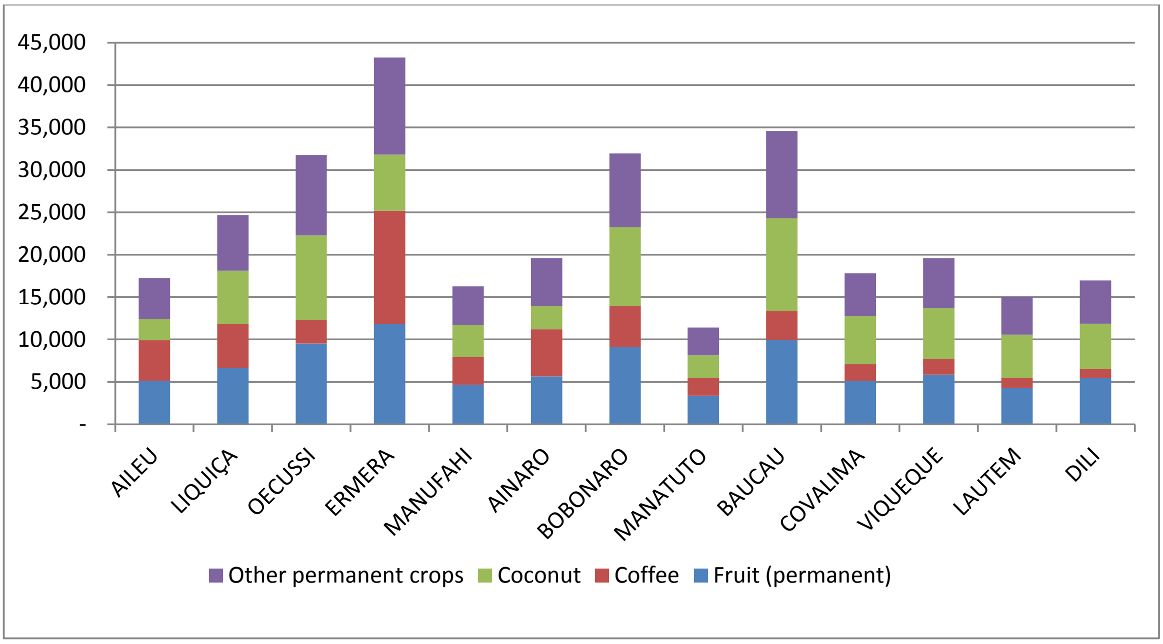


Figure 1-17 **Number of households involved in growing foods and crops for each district based on 2010 census**

Farming in Timor-Leste depends on rainfall events, which is well described by Gusmão (2003). In summary, land preparation takes place during the dry period e.g. from July to November followed by cultivation of maize, cassava, sweet potatoes and grain legume crops in around mid-November when the wet season starts. Maize crops are harvested around February. From February to May, farmers start to prepare paddy fields for rice cultivation. The rice crop is harvested between May and August. Production of crops is very low compared to other countries. For example, rice production in Timor-Leste is less than 2 ton/ha compared to 4.5 ton/ha in Indonesia (IV Constitutional Government Program, 2007-2012). Average maize yield recorded in 2006, 2007 and 2008 were 1.8, 1.6 and 1.7 ton/ha, respectively. These yields are very low compared to hybrid variety yields of 6 ton/ha in irrigated fields in East Java and 5 ton/ha in dry land production in South Selves (Swastika et al. 2004). Low crop yields are considered to be due to low quality of seeds, and low or no inputs of fertilizers (IV Constitutional Government Program, 2007-2012).

Figure 1-18 **Rice field in Timor-Leste**
Photo by UNMIT/Martine Perret

Increased soil erosion as a result of unsustainable land use has resulted in low soil fertility for crop production. Improved farming systems e.g. from Slash and Burn to Slash and Mulch (SoL, 2006) or the use of integrated legume crops or trees (agroforestry systems) would improve soil fertility and also reduce soil erosion and therefore potentially increase crop yields. As low yield also relates to old cultivars, growing new varieties would improve yields. For example, the newly released variety of maize (Suwan 5 [M02]) observed in field trials at Betano, Aileu, Loes and Fatumaka research stations yielded more than 2 ton/ha (SoL annual research report, 2010) which is more than the average described above.

Coffee is the most important of the commercial export tree crops grown in Timor-Leste. A recent estimate showed that more than 57% of the production area (53,816 ha based on 2009 observation) is in Ermera (IV Constitutional Government Program, 2007-2012). Coffee production ranges from 0.23 to 1.4 ton/ha. Annual income from coffee production is up to US$ 200 and this provides 90% of growers' income. The main exporting venue for Timorese coffee production is the United States of America (USA). Net exported weight of coffee was 7.7 ton with a value of US $6,889.00 in 2004 and this increased to 8,328 ton with a value of US$ 12,492,134.00 in 2009. This figure shows that coffee production provides a significant income after oil and gas. The other advantage of growing coffee is that coffee plantations and their shade legume trees e.g. Paraserianthes falcataria (albizzia), Casuarina sp. and Leucaena spp. also play an important role in protecting soil from erosion.

It is predicted that due to global climate change rainfall in Timor-Leste will increase with a high variability. The rainfall intensity will increase, while droughts may be more frequent during the growing season. Increases in air temperature will also have an affect on coffee plantations in Timor-Leste. Coffee plants are very sensitive to high temperatures, thus increases in air temperature will reduce the areas suitable for coffee plantation. For example, coffee plantations at lower elevations in the district of Liquiça would need to move up to higher elevations with subsequent reductions in coffee production. In summary, climate change has direct and indirect affects on crop production and the socioeconomic circumstances of Timor-Leste.

Livestock is one of the most important sources of farmers' income in Timor-Leste, and the contribution of this sector to the country's non-oil GDP is estimated at US$ 4.6 million with an increase of 10.2% annually (MAFF, 2004).

Common livestock found in this country are water buffalo, Bali cattle and dairy cattle, goats, sheep, horses, pigs and chickens. Farmers usually sell their animals to local traders. Other than this, water buffalo, Bali cattle and horses are often used to prepare the soil for rice cultivation. They are also an important source of exchange for cultural events.

There are indications of an increase in the number of livestock particularly chickens, sheep, goats, cattle and buffalos in 2010 compared to 2004. However, there was a reduction in pigs and horses in the same period of time (Figure 1-20). Despite these signs of increase in the population of livestock in the country, factors such as feed availability and quality, poor feeding systems, unmanaged natural pastures, the use of extensive and traditional rearing systems, the treatment of diseases and health management systems will be challenges for the country to develop its livestock sector in the future.

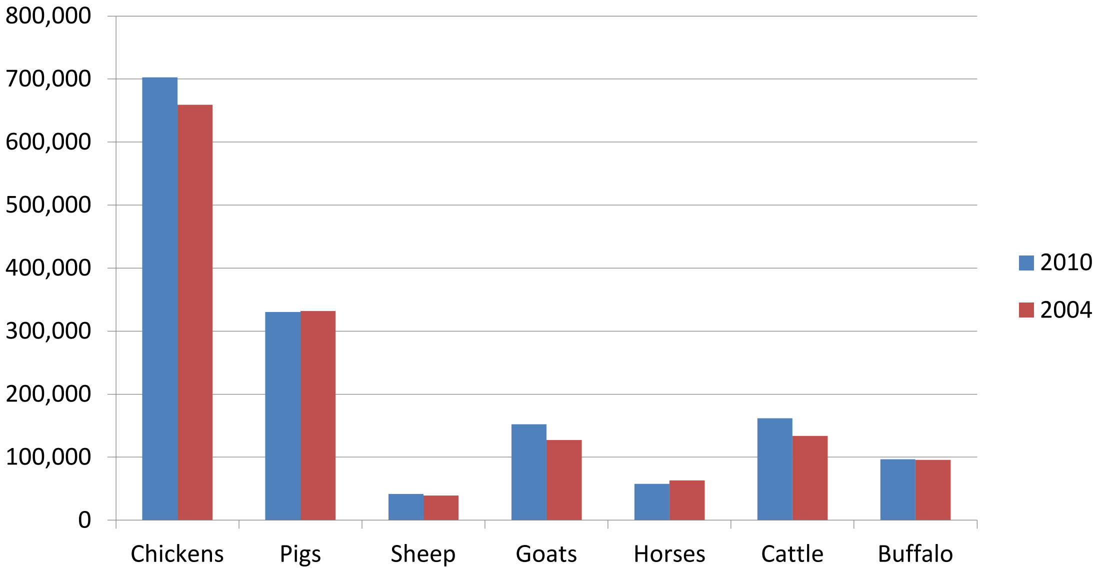


Figure 1-19 **Comparison of census results for reported number of livestock in 2010 Census and 2004 Census**[2]

With regards to the supply of livestock products for the domestic market, it is noted that even though the country actively exports live cattle and buffalo to Indonesia (See Figure 1-20), the sector is still insufficient to supply livestock product, such as milk, meat and eggs for the domestic market. Therefore, importing such products into the country is unavoidable.

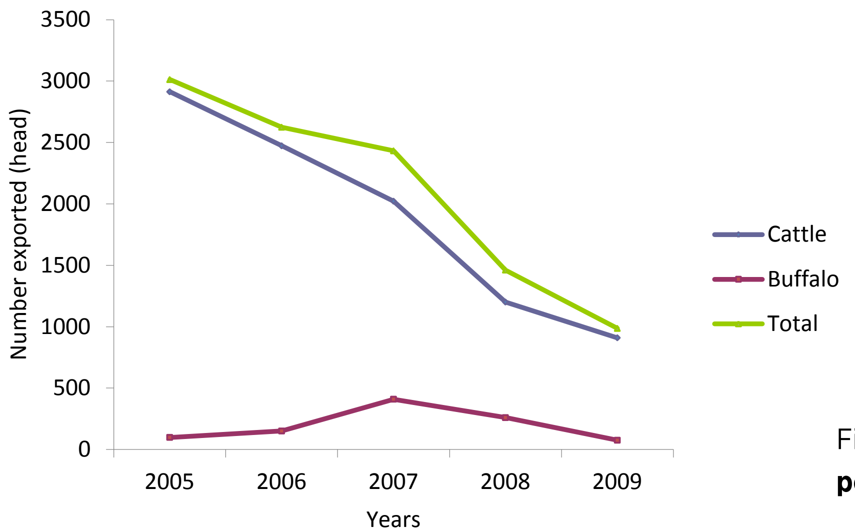


Figure 1-20 **Cattle and Buffalo export to Indonesia from 2005-2009**[3]

[2]Snapshot of Agriculture in Timor-Leste in 2010

[3]Strategic Plan of NDLV 2011-2015

In order to increase meat production (or minimize meat imports), the Australian Centre for International Agricultural Research (ACIAR) has been assisting the Ministry of Agriculture and Fisheries as well as the Faculty of Agriculture, at UNTL to improve livestock production in Timor-Leste.

Figure 1-21 **Bali Cattle on natural pasture in Oecusse, 2008,** Photo by Matias Tavares

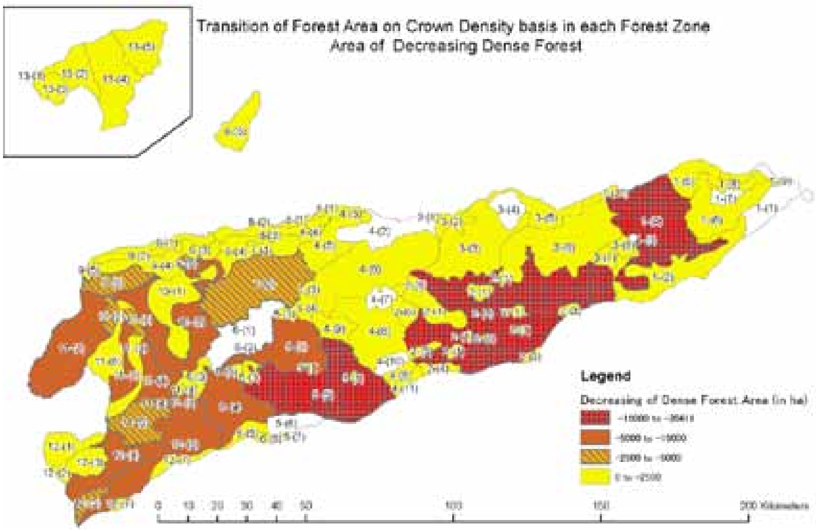


Figure 1-22 **Forest Zones with Significant Deforestation of Dense Forest between 2003 and 2010** (Nippon Koei Co., Ltd, 2010)

1.6.3 Forestry

A recent study from a Japanese team indicated that there has been significant reduction in Timor-Leste's forest cover for the period between 2003 and 2010 where more than 180,000 ha of forest were estimated to have been lost. Deforestation was found to be widespread in all districts for both dense and sparse forests. Reduction in dense forest coverage is especially rampant in Lautem, Viqueque, Bobonaro and Manufahi districts.

Many of the forests in Timor-Leste are thought to have been heavily affected by human intervention and there is a lack of measures to halt and reverse these activities[4]. Recently[5], fragmented forests (mosaic land uses) are observed to be widespread in Viqueque, Baucau, Manufahi, Liquiça and Covalima, most likely a direct result of patch clearing for shifting cultivation.

[4]The two latest inventory studies conducted with the Japanese expert team and the forest inventory study in Bobonaro and Covalima (2008 and 2009) confirmed what has always been thought to be the condition of forests in Timor-Leste.

[5]Based on findings from the Forest Inventory Study conducted by the Japanese team.

1.6.4 Fisheries

The annual potential catch of fish is expected to be about 116,000 tonnes/year, but up until 1988, catches were only 3.5% (3000 tonnes) of this potential (Gutteres, 2003). Further, the economic value of exported fish could be up to US$ 5 million and fishing licenses US$ 15 million, these figures would contribute 5% to the country's GDP.

Despite the country's wealth of coastal and marine resources, limiting factors such as weakness of fisheries legislation and regulations, lack of monitoring systems, and inadequately resourced institutions to control and protect these resources, present challenges for the country to protect and use these resources for the benefits of the people of Timor-Leste. For instance, there was an estimated loss of US$ 36 million per year[6] due to illegal fishing in the country.

1.6.5 Waste

1.6.5.1 Municipal Solid Waste (MSW) Generation and Characteristics

Data on waste generation and characteristics used in estimating the GHG emission level is presented in Table 1-10 and 1-11 respectively. Waste generation quantity used in the GHG emission estimation from MSW management is 0.51 kG/cap/day or 0.186 ton/capita/year.

Table 1-10 **Waste generation data from Timor-Leste and default value of IPCC 2006**

Region	MSW generation rate (t/cap/yr)	Fraction of disposed to SWDS	Fraction of MSW incinerated	Fraction of MSW composted	Fraction of others (unspecified)
Default IPCC 2006 for South East Asia	0.27	0.59	0.09	0.05	0.27
Timor Leste Data (0.51 kG/cap/day)	0.186				

Table 1-11 **Default value of IPCC 2006 for MSW characteristics**

MSW Components	Composition in MSW	DOC content in wet waste	DOC	Dry matter content	Carbon content (% dry weight)	Fossil carbon fraction (% of total carbon)
Paper/ cardboard	12.9%	40.0%	5.2%	90%	46%	1%
Textiles	2.7%	24.0%	0.6%	80%	50%	20%
Food waste	43.5%	15.0%	6.5%	40%	38%	-
Wood waste	9.9%	43.0%	4.3%	85%	50%	-
Garden/park waste	-	20.0%	-	40%	49%	-
Nappies	-	24.0%	-	40%	70%	10%
Rubber/ Leather	0.9%	39.0%	0.4%	84%	67%	20%
Plastic	7.2%	-	0.0%	100%	75%	100%
Metal	3.3%	-	0.0%	100%	n.a	n.a
Glass	4.0%	-	0.0%	100%	n.a	n.a
Other/inert waste	15.6%	0.0%	0.0%	90%	3%	100%

[6]Speech by The Prime Minister and Minister for Defence and Security, Kay Rala Xanana Gusmao at the handover ceremony of the two patrol boats class Jaco, on June 11th 2010

1.6.5.2 Population Distribution and MSW Generation in Timor-Leste

Data on population distribution, MSW generation, and MSW management used in estimating the GHG emission level is presented in Table 1-12, 1-13, and 1-14 respectively.

Table 1-12 **Urban and rural population distributions in Timor-Leste**

Population	Timor Leste	DILI	Other Districts
Urban	30%	82%	15%
Rural	70%	18%	85%

Table 1-13 **Population and MSW generation of Timor-Leste**

Year	Population			MSW Generation			
	Timor Leste	Dili (22% of Population)	Other Districts	Generation (Gg/cap/y)	MSW in Timor Leste (Gg/y)	MSW in Dili Districts (Gg/y)	MSW in Other Districts (Gg/y)
2005	907,311	199,608	707,703	0.000186	169	37	132
2006	937,108	206,164	730,944	0.000186	174	38	136
2007	967,884	212,934	754,949	0.000186	180	40	141
2008	999,670	219,927	779,743	0.000186	186	41	145
2009	1,032,501	227,150	805,350	0.000186	192	42	150
2010	1,066,409	234,610	831,799	0.000186	199	44	155
2020*	1,529,817	305,963	1,223,854	0.000270	413	83	330

*It is assumed that in 2020 the waste generation will be the same with South East Asia (average)

Table 1-14 **MSW management in Timor-Leste**

	Baseline (2005)			
	Fraction of MSW to SWDS	Population	MSW, Ggram	% of Total TL
Dili District	50% urban population	82,160	15.29	
Other districts	7.5% urban population	7,871	1.47	
Rural	none	-	-	
MSW to SWDS		90,030	16.76	9.9%
Composting+3R	0.5% population	4,537	0.84	0.5%
Hospital solid waste Incinerator	35-40 kg/week	-	0.0019	0.001%
MWS open burning	41% population	371,998	69.25	41%
Un-specified		440,747	82.04	49%
TOTAL		**907,311**	**168.90**	**100%**

1.7 POLITICAL SYSTEM

In May 2002 Timor-Leste declared its restoration as a sovereign nation. Prior to this, the country endured 400 years as a Portuguese colony, followed by 24 years of occupation by Indonesia. In 2002 the Constituent Assembly of Timor-Leste approved and decreed the Constitution of the Democratic Republic of Timor-Leste, which provides a semi presidential republic system of government, with the President as the Head of State and the Prime Minister as Head of Government and the National Parliament as the legislative body. The President of the Republic is elected by popular vote for a five-year term. As head of state, the President also presides over the Council of State and the Superior Council of Defence and Security.

The head of the government is the Prime Minister, who is the leader of the majority party or majority coalition in the parliament. Following the election for the legislative assembly, the President appoints the Prime Minister. The government is the executive body of the state and is responsible for the development and implementation of the government program for a five-year term.

Under the Fifth Constitutional Government of Timor-Leste, the executive body of the government is composed of fourteen ministries namely Ministry of Defence and Security; Ministry of State and Foreign Affairs and Cooperation; Ministry of Finance; Ministry of Justice; Ministry of Health; Ministry of Education; Ministry of State Administration; Ministry of Commerce, Industry and Environment; Ministry of Social Solidarity; Ministry of Agriculture and Fisheries; Ministry of Petroleum and Mineral Resources; Ministry of Public Works; Ministry of Transportation and Communications; Ministry of Tourism; and the Ministry of State and of the Presidency of the Council of Ministers; supported by 12 Vice Ministries and 26 Secretaries of State.

In the National Parliament, members are also elected by popular vote to a five year term, and according to the Timor-Leste Constitution as stated in article 3 section 93, “the National Parliament shall be made up of a minimum of 52 and a maximum of 65 members”. This organ deals mainly with legislative supervisory and political decision-making powers. The outcomes of the latest parliamentary election held in May 2012, showed that Congresso Nacional de Reconstrução de Timor-Leste (CNRT) occupied 30 seats, followed by the Frente Revolucionária de Timor-Leste Independente (Fretilin) with 25 seats, and the Partido Democrático (PD) in third position with 8 seats and Frente Mudansa (FM) with two seats.

2 NATIONAL GHG INVENTORY

Photo by UNMIT/Martine Perret

2.1 INTRODUCTION

Timor-Leste National Greenhouse Gas Inventory (NGHGI) includes estimates of emissions by source and sink for the period 2005-2010. The calculations of GHG emissions reported in the Initial National Communication (INC) were made for five of the six emissions categories defined by the Intergovernmental Panel on Climate Change (IPCC), namely Energy, Agriculture, Land Use Change and Forestry and Waste. The missing sector, industrial process and product use (IPPU) was not estimated because there is no industry that generates GHG emissions in Timor-Leste and there is no data/information concerning utilization of product that generates GHG emissions. The NGHGI reports on the three main GHGs included in Appendix A of the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Other gases are also included in the estimation of GHG emissions from energy sector, i.e. precursor gases (NOx, CO, MNVOC, and SO2) such as suggested by revised IPCC 1996 guidelines. The estimation of the emission was done using the revised 1996 IPCC Guideline except for waste sector. Waste sector used the 2006 IPCC Guideline.

2.2 INSTITUTIONAL ARRANGEMENTS FOR THE PREPARATION OF THE GHG INVENTORY

The development of NGHGI (National GHG Inventory) was conducted by a collaboration team comprised of a consultant team and a Working Group (WG) team. The members of the WG are from various government institutions related to energy and mining sector, industry, transportation, waste, agriculture and forestry. The WG was officially recognized through the Environment Minister's Decree and worked under the coordination of the Secretary of State of Environment (Figure 2-1).

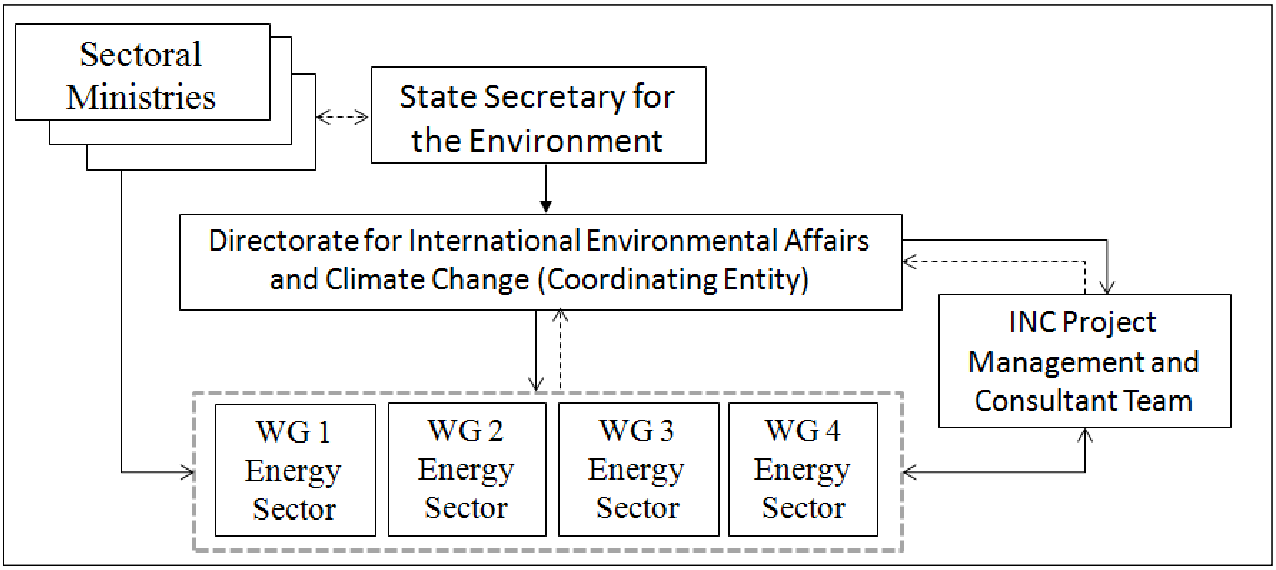


Figure 2-1 **Structure of the institutional arrangements for developing the NGHGI**

2.3 DESCRIPTION OF THE PROCESS OF PREPARING THE GHG INVENTORY

Preparation of the NGHGI was carried out in five phases: (1) beginning, (2) development, (3) sectoral consultation, (4) compiling the report and review and 5) revision, as outlined below:

1. Beginning: In this phase, a meeting of the working group and consultant team was conducted to develop the working group's understanding of the GHG inventory and to discuss the availability of data and the process for collection of the required data for the development of the NGHGI. The consultant, with support from the Inventory Working Group collected activity data from related agencies as well as the emissions/removal factors from various publications and research agencies wherever available. To fill the data gaps, the consultant also conducted surveys, particularly on waste.

2. Development: After activity data and emissions/removal factors were gathered for each emissions category or sector, the data and information obtained were recorded on spread-sheets. Emissions were then estimated and the consultant prepared a report; this included the emissions estimates, as well as the analysis carried out and the sources of information consulted.

3. Verification Workshop. After the NGHGI was completed, the Ministry of Environment called the consultant for a verification meeting. In this workshop, the consultant had discussions with members of the working group to check the estimates, activity data consistency and emissions/removal factors. From this workshop, the working group provided recommendations where some assumptions or activity data used by the consultant need revision.

4. Revision of the GHG Inventory and Final Verification Workshop. Following the results of the Verification Workshop, the consultant undertook revisions of the NGHGI. The results of the revision were presented and discussed again with the working group, and final adjustments and corrections were made to the document for any remaining errors.

5. Dissemination Workshop. The dissemination of final NGHGI to broader audiences was conducted in a National Workshop.

2.4 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES FOR YEAR 2010

In 2010, total GHG emissions for the three main greenhouse gases (CO_2, CH_4 and N_2O) without land use, land use change and forestry (LULUCF) reached 1,277 Gg CO_2-e. With the inclusion of LULUCF, total GHG emissions from Timor-Leste increased to about 1,483 Gg CO_2-e (Table 2-1). GHG emissions (in CO_2 equivalent) were distributed unevenly between the three gases recorded: CO_2 totalled 466.87 Gg, representing 31% of the total emissions; methane (CH_4) totalled 548.56 Gg or 37% of the total emissions; and nitrous oxide (N_2O) totalled 467.18 Gg or 32% of the total emission. The main contributing sectors were agriculture, followed by energy, LUCF and waste (Figure 2-3).

By gases, the main contributor is CH_4 and followed by N_2O and CO_2 (Figure 2-3). Total emission from these three gases in 2010 was 548.56, 467.18 and 466.87 Gg CO_2e respectively. Contribution of CH_4 to the total emission was high as the gas is the main GHG emitted from agriculture sector, the dominant source of Timor-Leste's GHG emission. As shown in Table 2-1 the contribution of this gas to the total emission of the agriculture sector was 53%.

Table 2-1 **Summary of national GHG emissions in year 2010 (in Gg CO_2-e)**

GREENHOUSE GAS SOURCE AND SINK	(Gg CO2e)										
	CO2	CO2	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs	PFCs	SF6
CATEGORIES	Emissions	Removals	Emissions								
Total National Emissions and Removals	**2,093.41**	**358.00**	**593.63**	**476.30**	**3.89**	**66.97**	**5.66**	**2.29**			
1 Energy	**249.48**		**0.55**	**0.67**	**1.38**	**7.16**	**1.36**	**0.40**			
A Fuel Combustion (Sectoral Approach)											
1 Energy Industries											
a. Electricity Generation	137.05		0.12	0.35	0.37	0.03	0.01	0.26			
b. Own use at Oil and Gas Production Facility*	The estimation of GHG emission is reported separately since the GHG potential is under TL and Australia responsibility										
2 Manufacturing Industries and construction	NE		NO	NO	NO	NO	NO	NO			
3 Transport	109.57		0.42	0.31	1.00	7.14	1.35	0.14			
4 Residential/Commercial	2.86		0.01	0.01	-	-	-	-			
5 Other (please specify)	NE		NE	NE	NE	NE	NE	NE			
B Fugitive Emissions from Fuels											
1 Solid Fuels	NO		NO	NO	NO	NO	NO	NO			
2 Oil and Natural Gas	The estimation of GHG emission is reported separately since the GHG potential is under TL and Australia responsibility										
2 Industrial Processes	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
A Mineral Products	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
B Chemical Industry	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
C Metal Production	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
D Other Production	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
E Production of Halocarbons and Sulphur Hexafluoride	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
F Consumption of Halocarbons and Sulphur Hexafluoride	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
G Other (please specify)	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
3 Solvent and Other Product Use	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
4 Agriculture			**516.35**	**449.91**	**0.45**	**24.15**					
A Enteric Fermentation			309.99	NE							
B Manure Management			65.34	195.84							
C Rice Cultivation			121.33	NE							
D Agricultural Soils			NE	250.19							
E Prescribed Burning of Savannas			17.87	3.26	0.38	22.34					
F Field Burning of Agricultural Residues			1.82	0.62	0.07	1.82					
G Other (please specify)			NE	NE	NE	NE					
5 Land-Use Change & Forestry (2)	**564.03**	**358.00**	**NE**	**NE**	**NE**	**NE**	**NO**	**NO**			
A Changes in Forest and Other Woody Biomass Stocks	NE	173.00	NE	NE	NE	NE	**NO**	**NO**			
B Forest and Grassland Conversion	564.03	NE	NE	NE	NE	NE	**NO**	**NO**			
C Abandonment of Managed Lands	NE	NE	NE	NE	NE	NE	**NO**	**NO**			
D CO2 Emissions and Removals from Soil	NE	NE	NE	NE	NE	NE	**NO**	**NO**			
E Other (please specify)	NE	185.00	NE	NE	NE	NE	**NO**	**NO**			
6 Waste	**11.36**		**31.67**	**16.60**	**NE**	**NE**	**-**	**-**			
A Solid Waste Disposal on Land			6.98	NE	NE	NE					
B Wastewater Handling			12.63	12.42	NE	NE					
C Waste Incineration (only clinical waste from hospital)	-		-	-	NE	NE					
D Other (please specify)	11.36		12.06	4.18	NE	NE					
- Open Burning	11.36		11.97	4.08	NE	NE					
- MSW composting in rural area	NE		0.09	0.10	NE	NE					
7 Other (please specify)											
Memo Items :											
International Bunkers	**5.92**		**-**	**0.05**	**0.03**	**0.01**	**-**	**-**			
Aviation	5.92		-	0.05	0.03	0.01	-	-			
Marine	NE		NE	NE	NE	NE	NE	NE			
CO2 Emissions from Biomass (for rural households)	**770.04**		**44.70**	**8.80**	**0.71**	**35.47**	**4.26**	**1.89**			
GHG Emissions from offshore oil and gas production*	**492.58**		0.36	0.27	1.32	0.18	0.04	-			
a. Own use at Oil and Gas Production Facility*	**492.58**		0.19	0.27	1.32	0.18	0.04	-			
b. Fugitive emission from Offshore oil and gas production facility	**NE**		0.17								

Notes: *The offshore oil and gas production facility is under Joint Production of Timor-Leste and Australia but there is no agreement for GHG emission, therefore GHG emissions are reported separately below Memo Items (see No 7 above) although the estimate is under energy sector. ** NE: Not Estimated and NO: Not Occurring. *** Global Warming Potential (GWP) for CH_4 and N_2O used were 21 and 310 respectively. ****Estimation of non-CO_2 (CH_4, N_2O, CO, NOx, NMVOC and SO2) from Biomass (in rural household) is inclusive in energy sector (sectorial approach) and national (Table 2.1). The presented values in the separated Memo Items are solely to reveal the breakdown of CO_2 biomass emission (not accounted in Energy Sector inventory) and non-CO_2 biomass emission (accounted in Energy Sector inventory).

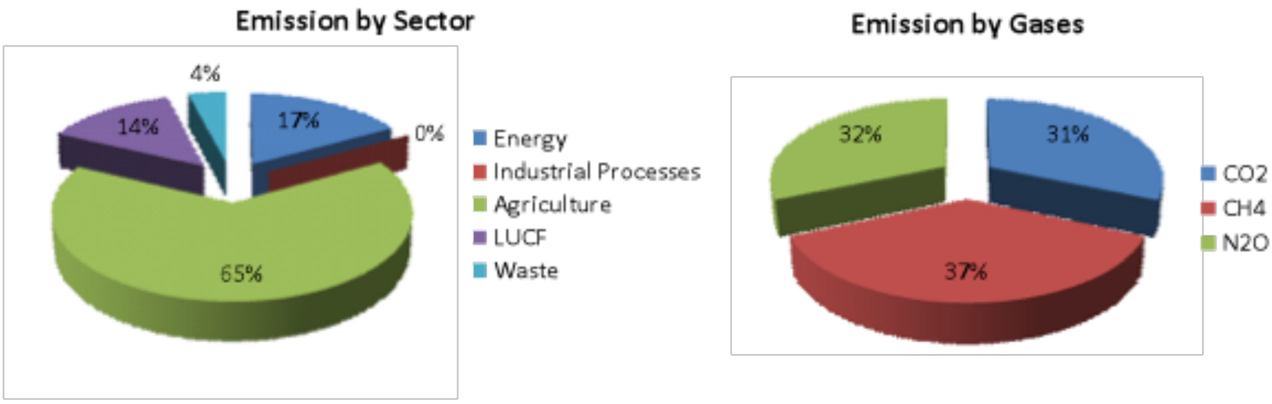


Figure 2-2 **GHG emission estimates by sectors (left) and by gases (right) in 2010**

2.5 SECTORAL EMISSIONS

In the period of 2005-2010, the estimation results of GHG emission levels from all sectors fluctuated, particularly LUCF (Table 2-2 and Figure 2-3). In 2006, GHG emissions, the level of LUCF was the highest. Therefore, the total national GHG emission level of this year was the highest. It was recorded that deforestation was the highest in this year. For other sectors the inter-annual variation of emissions was not as high as LUCF. If the emission from LUCF was excluded, there was an increasing trend in emission at a rate of about 2.6% per year (Figure 2-3).

Table 2-2 **Emission Trend from the four sectors and other sources (in Gg CO_2-eq)**

Source Categories	2005	2006	2007	2008	2009	2010
Energy	200.20	207.00	313.48	261.50	222.44	250.67
Agriculture	882.69	900.66	956.86	996.75	933.01	966.27
Land-Use Change & Forestry	115.05	1,036.53	734.42	441.48	225.07	206.06
Waste	46.82	52.27	54.06	55.86	57.73	59.62
Total	**1,244.76**	**2,196.46**	**2,058.82**	**1,755.61**	**1,438.25**	**1,482.62**
Biomass utilization	704.80	727.61	750.86	774.59	798.81	823.54
International Bunker for Aviation*	2.17	1.59	3.70	4.88	5.96	5.97
GHG from oil and gas production	544.76	668.06	593.04	624.08	524.27	493.04

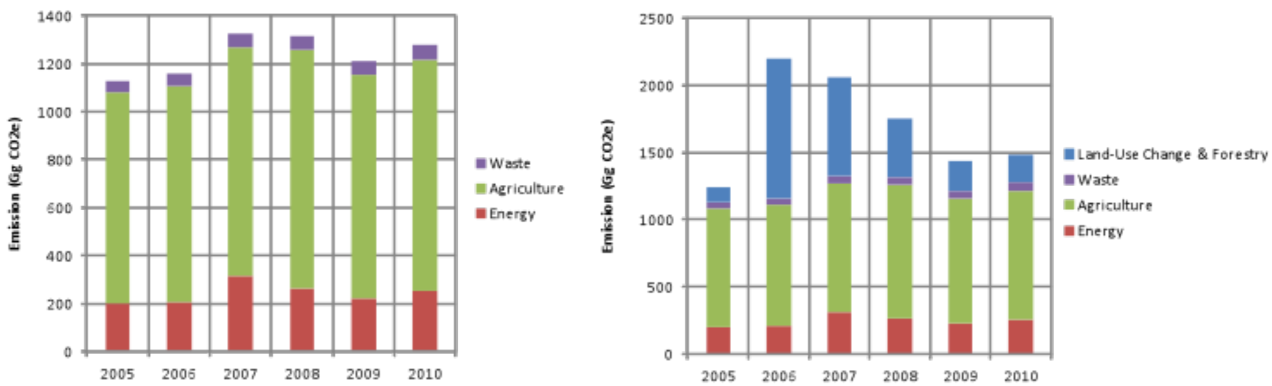


Figure 2-3 **GHG Emission Estimates for 2005-2010 without (left) and with LUCF (right)**

2.5.1 Energy Sector

GHG emissions from energy sector had been estimated using reference (top-down) and sectoral (bottom-up) approaches. Reference approach merely calculates CO_2 emission while sectoral approach includes CH_4, N_2O, and other non-CO_2 (CO, NOx, SO2, NMVOC). The energy sector of Timor-Leste is simple. Types of fossil fuel combusted in this sector are liquid and gas fuel. Liquid fuel comprises gas oil, diesel, and unleaded petroleum for transport, diesel oil for power generation, kerosene for household, and avtur or jet-kero for international aviation. Gas fuel covers LPG for household and natural gas for supplying energy in oil and gas field.

CO_2 Emissions

Estimation results of CO_2 emission levels under reference and sectoral approaches are similar because activity data used for estimating GHG emission levels under both approaches is the same and fugitive emissions does not cover CO_2 but only CH_4 emission from oil and gas field. Figure 2-4 presents CO_2 emissions level estimated under both approaches while Figure 2-5 presents CO_2 emission level for total estimation, without CO_2 from oil and gas field, and CO_2 in the oil and gas field.

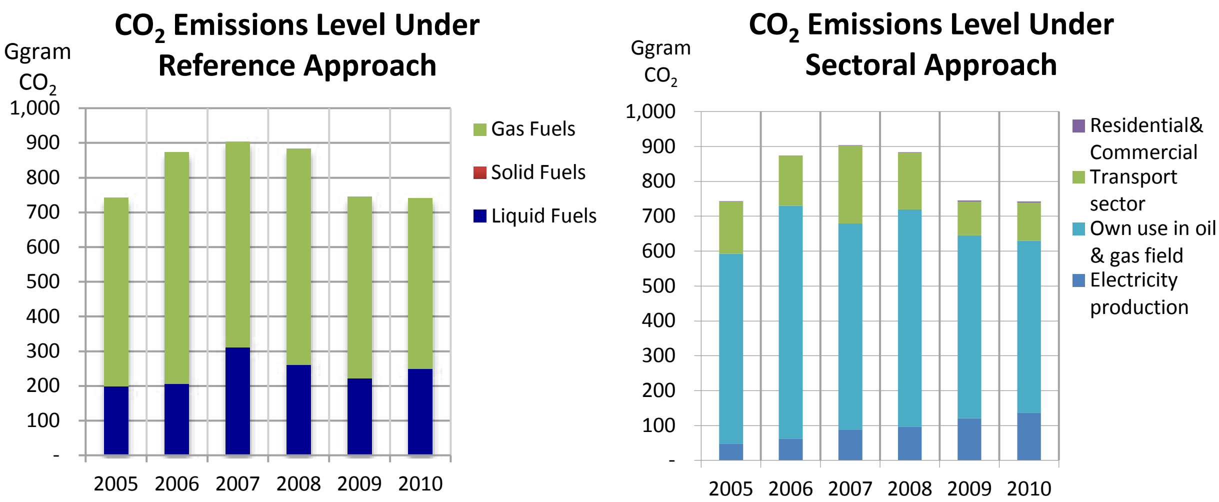
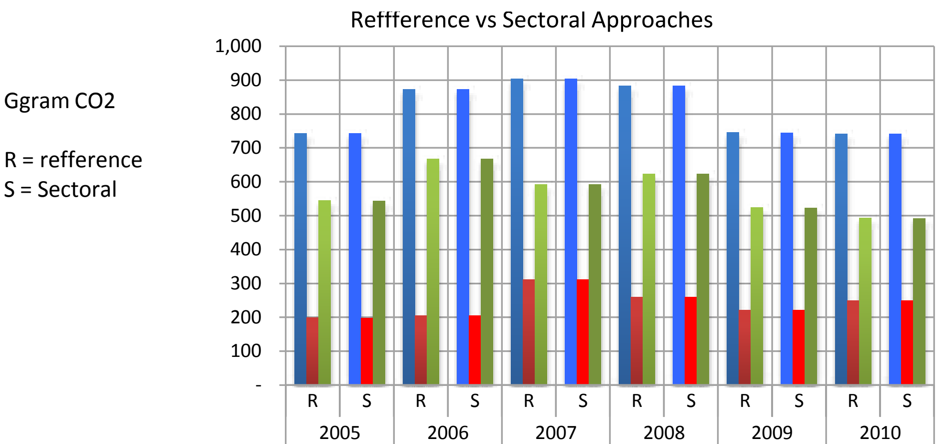


Figure 2-4 **CO_2 emission level under reference (left) and sectoral (right) approaches**

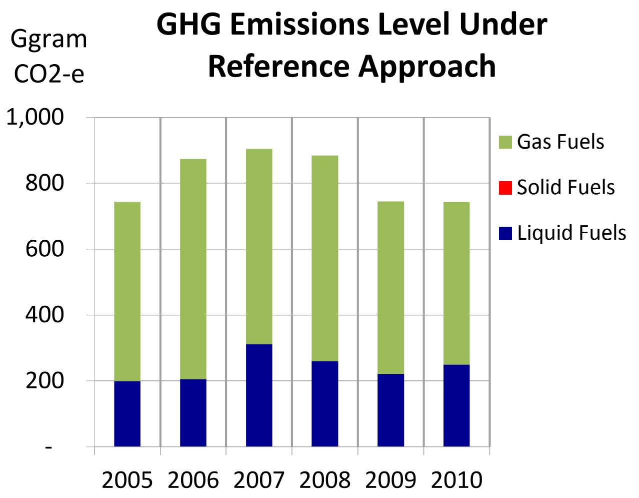


	2005 R	2005 S	2006 R	2006 S	2007 R	2007 S	2008 R	2008 S	2009 R	2009 S	2010 R	2010 S
CO2 Total	743	743	873	873	904	904	884	884	745	745	742	742
CO2 (not include oil&gas sub Sector)	199	199	206	206	311	311	260	260	221	221	249	249
CO2 from Oil&Gas Sub Sector	544	544	667	667	592	592	623	623	524	524	493	493

Figure 2-5 **CO_2 emission level for total estimation, without CO_2 from oil and gas field, and CO_2 in the oil and gas field**

All GHG Emissions (as Ggram CO_2-e)

The estimation results of GHG emissions level (Ggram CO_2-e) during 2005 to 2010 under both reference and sectoral approaches are presented in Figure 2-6. It can be seen that under a sectoral approach, GHG emissions from the combustion of natural gas for supplying energy in the oil and gas facility is the largest contributor (around 70% in average) to the overall energy sector's emissions. However, this oil and gas facility itself is a join operation between Timor-Leste and Australia. Since there is no agreement on GHG emission from this facility, the GHG emissions from this sub-sector was omitted from the total GHG inventory. If the GHG emission from oil and gas subsector (from own use energy and fugitive) is excluded from the total energy sector's emission, then transportation is the largest contributor (61% in average) followed by electricity production (38% in average).



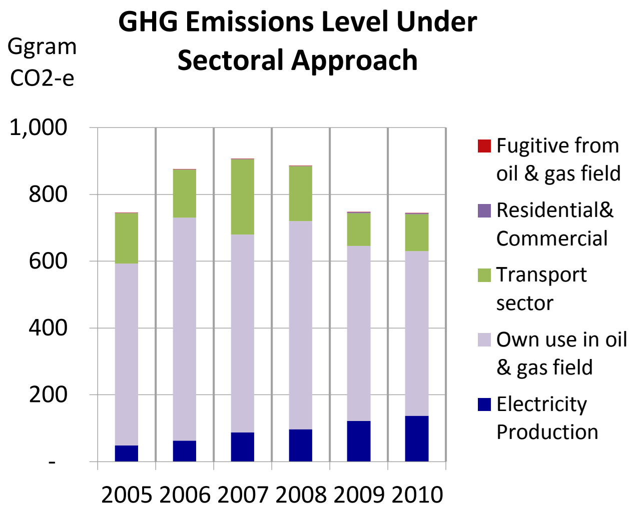
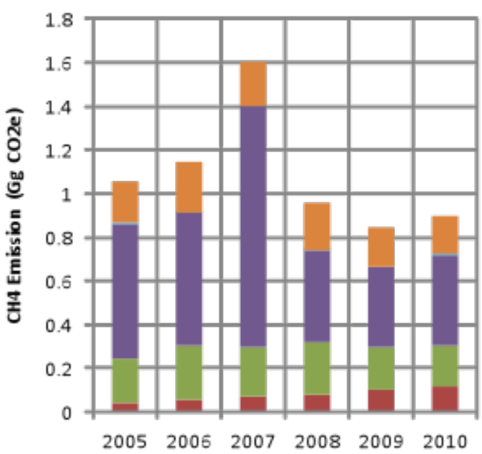


Figure 2-6 **GHG emission level (Ggram CO_2-e) under reference (left) and sectoral (right) approaches**

Non-CO_2e Emissions (CH_4 and N_2O gases)

GHG emission profile of CH_4 and N_2O emissions by sector is quite different from that of CO_2 (Figure 2-7, c.f. Figure 2-4) as the emission factor of these gases are distinct between sectors. Similar to the case of CO_2, a major contributor for CH_4 and N_2O is also transportation sector. N_2O emission from transportation contributes about 62% of total emission while in CH_4 emission transportation accounted for about 86% of total emissions.



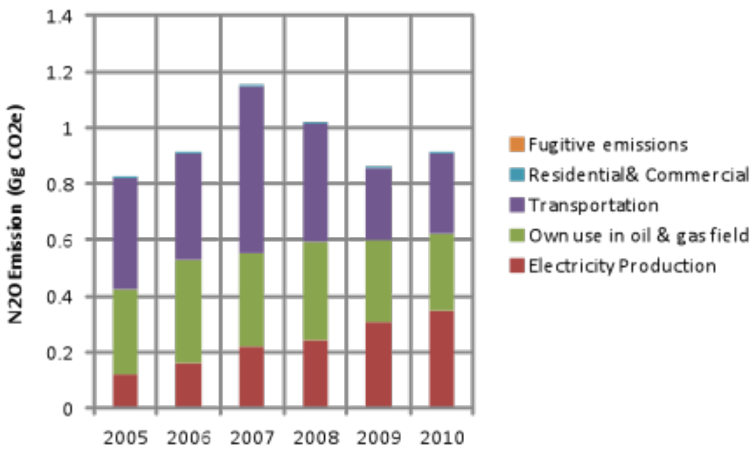


Figure 2-7 **GHG Emission Estimates for CH_4 (left) and N_2O (right)**

Other Non-CO_2e Emissions (Precursor gases)

The GHG inventory of the INC also covers the precursor gases, i.e. CO, NOx, SO2, and NMVOC. The estimates of GHG emission level of these gases are presented in Figure 2-8. Profiles of GHG emission of these precursors between years are quite different. These profiles are influenced by emission factors of each type of non CO_2e gases (CO, SO2, NMVOC NOx) as well as type of fuels used.

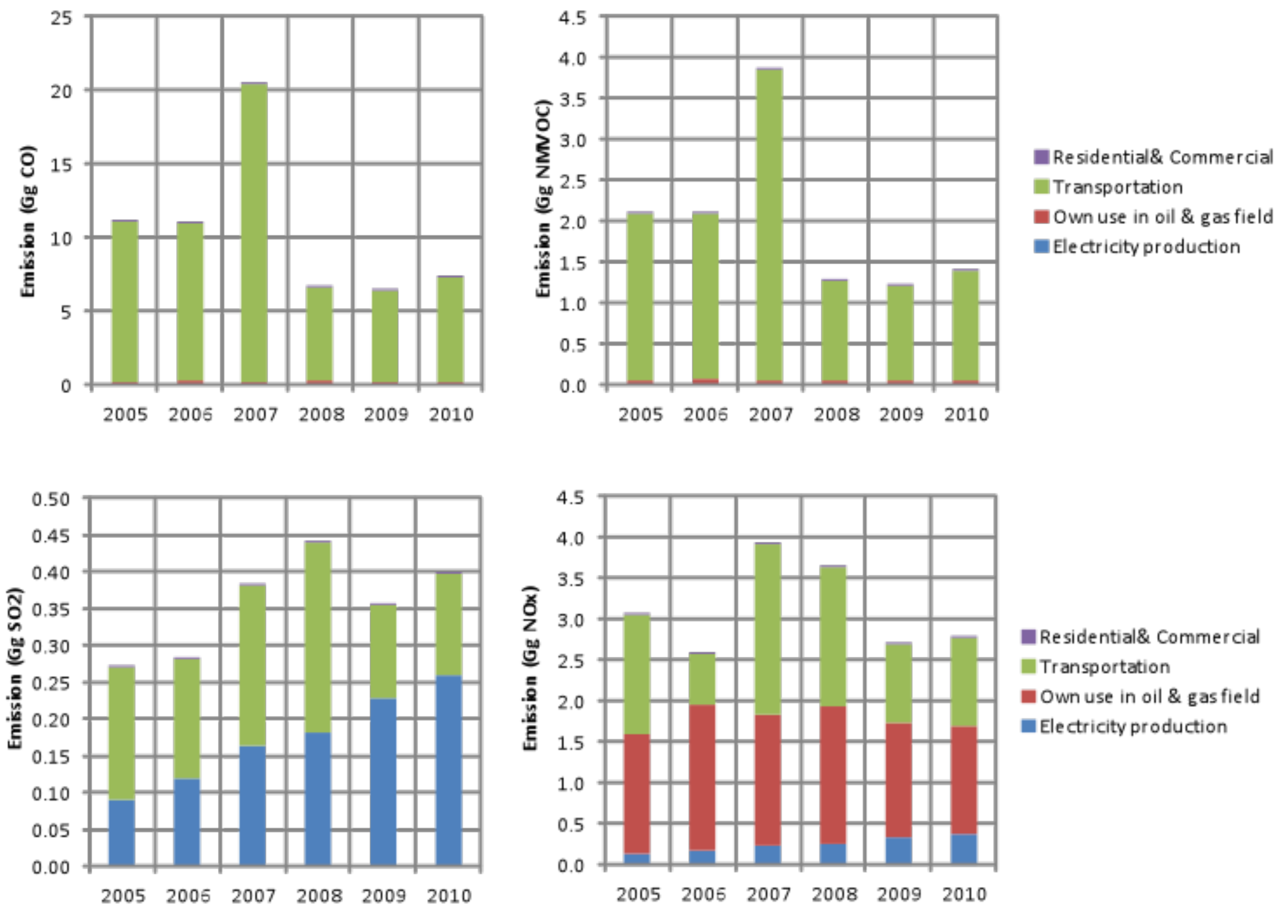


Figure 2-8 **GHG Emission Estimates for CH_4 (left) and N_2O (right)**

2.5.2 Agriculture

The agriculture sector emits significant GHGs. Analysis shows that in 2005, total emissions of the two main GHGs (CH_4 and N_2O) reached 882.69 Gg CO_2e, by 2010 it increased to 966.27Gg CO_2-e (Table 2-3). Methane contributed to approximately 53.44% of the total emissions, while N_2O contributed 46.56%. Figure 2-9 shows the shares of GHG emissions from the agriculture subsectors. The source is mainly enteric fermentation with 32%, followed by manure management with 27%, agriculture soil with 26% and rice cultivation with 13%.

Table 2-3 **GHG emissions from the agriculture sector from 2005 to 2010 by gas**

Gas	2005	2006	2007	2008	2009	2010
CH_4 (Gg)	21.83	22.24	24.39	25.76	22.31	24.59
N_2O (Gg)	1.37	1.40	1.43	1.47	1.50	1.45
Total in CO_2-e	882.69	900.66	956.86	996.75	933.01	966.27

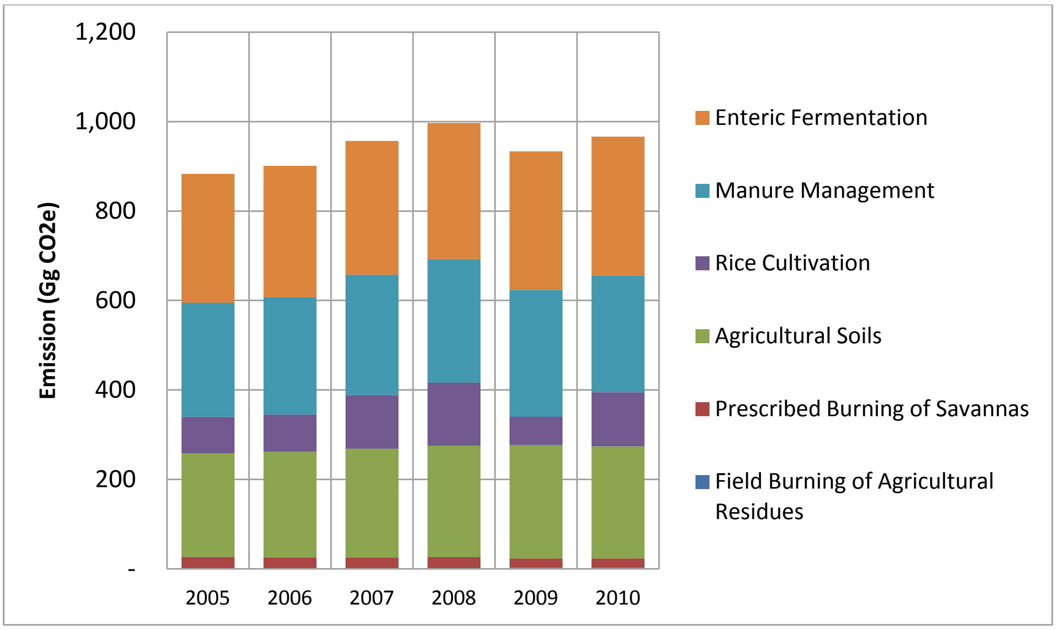


Figure 2-9 **GHG emissions from the agriculture sector from 2005-2010 by source category**

2.5.2.1 Livestock

Emissions from livestock is grouped into two sources, i.e. enteric fermentation and manure management. Both source categories are major contributors of CH_4 emissions in the agriculture sector with a total value of 17.87 Gg. Cattle are the main source of CH_4 emissions from enteric fermentation with 48.18%, followed by buffalo with 35.95%, horses with 7.05%, and goats with 5.16% (Figure 2-10). In 2010, methane emissions from manure management accounted for 3.11 Gg. The main source is swine with 74.34%, followed by buffalo with 9.30% and by horses with 4.09% as depicted in Figure 2-10.

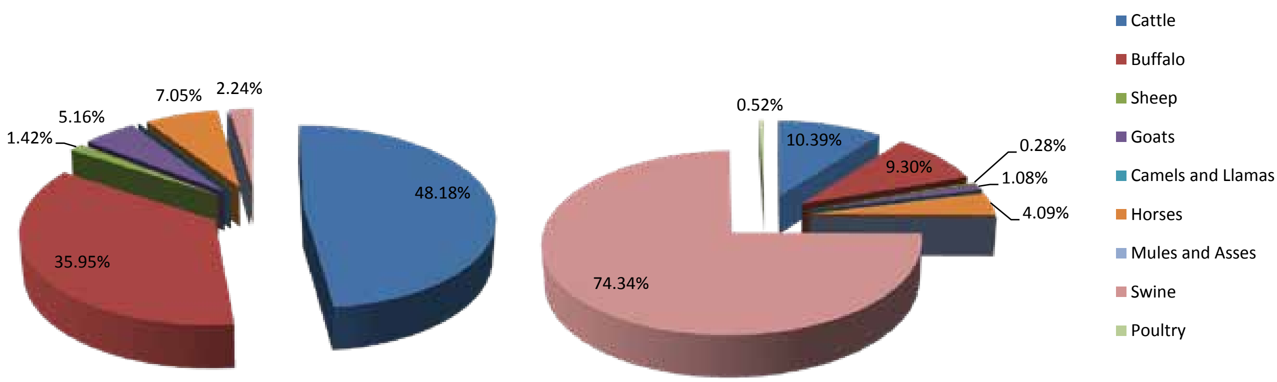


Figure 2-10 **Methane emissions from enteric fermentation (left) and manure management (right) in 2010**

N_2O emissions from manure management in the period 2005 to 2010 are presented in Figure 2-11. The total N_2O emissions from manure management account for 0.61 Gg in 2005 and 0.63 Gg in 2010, in which the main source was solid storage and dry lot (99%).

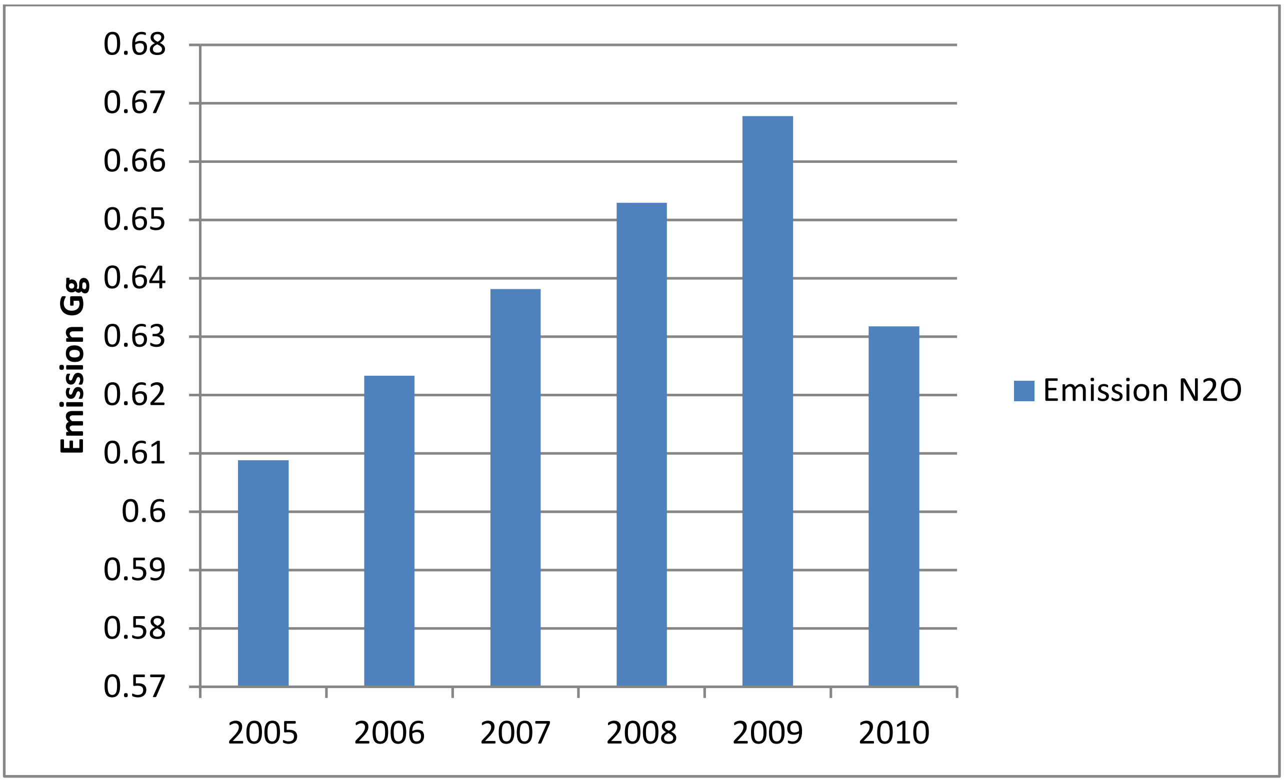


Figure 2-11 **N_2O emissions from manure management**

2.5.2.2 Rice Cultivation

Activity data used to calculate the emissions from rice fields were based on data on the harvested area of rice fields from Reports from the Ministry of Agriculture, Forestry and Fisheries (2011). The harvested area was grouped into two water regimes based on amount of irrigated area and non-irrigated area in 2001, in which the rice fields with irrigation systems was 27% and with no irrigation or rainfed 73% (Table 2-4). Furthermore, the area of each different water regime was adjusted with data from the construction of irrigation systems in Timor-Leste (2004-2010). The harvested area of rice cultivation in Timor-Leste in the period 2005 – 2010 is summarized in Table 2.8. Methane emissions from rice cultivation in 2005 and 2010 were 3.86 Gg and 5.78 Gg, respectively (Figure 2-12). The irrigated rice cultivation's main emission is methane.

Table 2-4 **Harvested area of rice cultivation in 2005-2010 (ha)**

Rice System	2005	2006	2007	2008	2009	2010
Irrigation	9,503	9,854	11,782	17,182	15,576	14,919
Rainfed	23,222	21,532	26,800	27,813	23,422	21,629

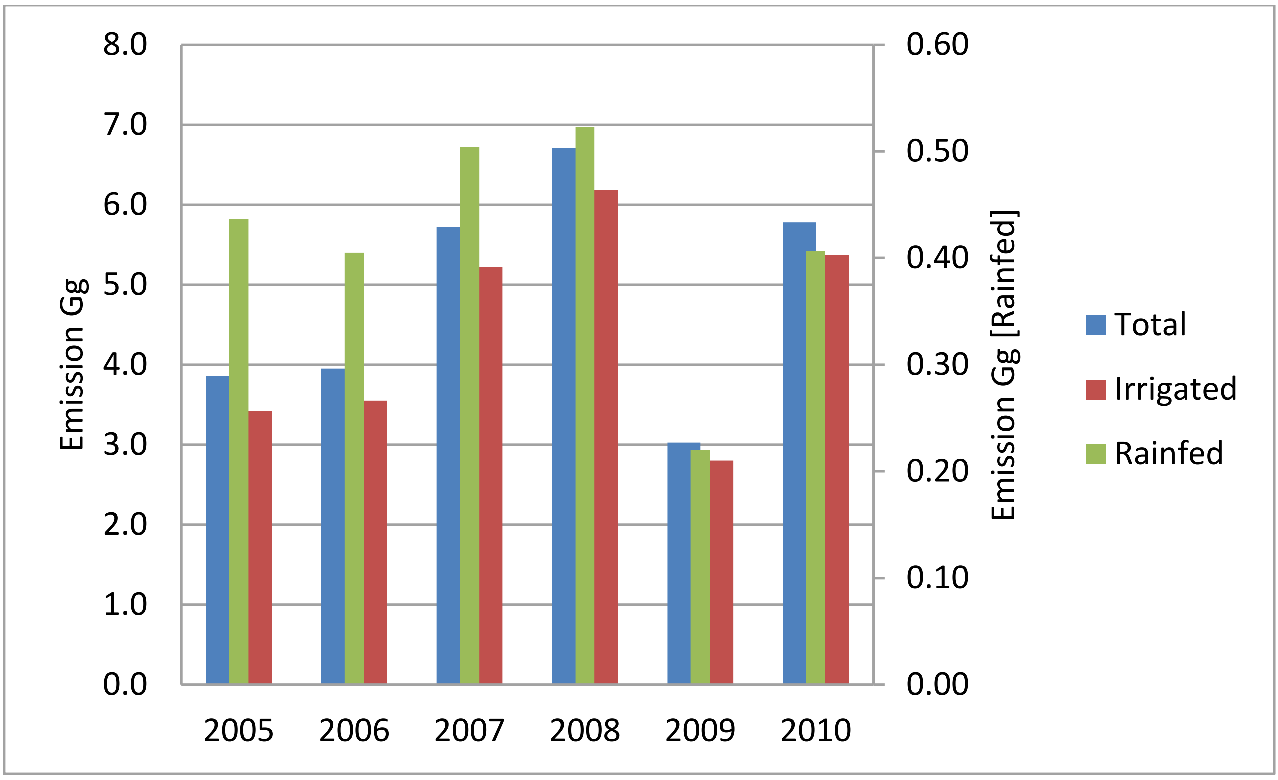


Figure 2-12 **Methane emissions from rice cultivation in 2005-2010**

2.5.2.3 Agricultural Soils

Nitrous oxide emissions from agricultural soil arise from biogenic processes occurring in the soil. The N_2O emissions consist of direct emissions, emissions from grazing animals, and indirect emissions. The activity data required to determine N_2O emissions is the total use of nitrogen synthetic fertilizer (urea) and nitrogen excretion from animal waste management system on pasture range. Total use of urea was estimated based on harvested area and dosage of urea application for rice. Data on dosage of urea application was estimated from field survey. The estimated urea application is summarized in Table 2-5. In 2010, the N20 emission from soils due to urea application was 0.81 Gg, 8% higher than that of 2005 (Figure 2-13).

Table 2-5 **Estimated urea application for rice in 2005-2010**

Activity Data	2005	2006	2007	2008	2009	2010
Harvested Area (ha)	32,725	31,386	38,582	45,635	38,998	36,548
Urea Application (kg)	1,133,732	1,087,344	1,336,643	1,580,989	1,351,055	1,266,177

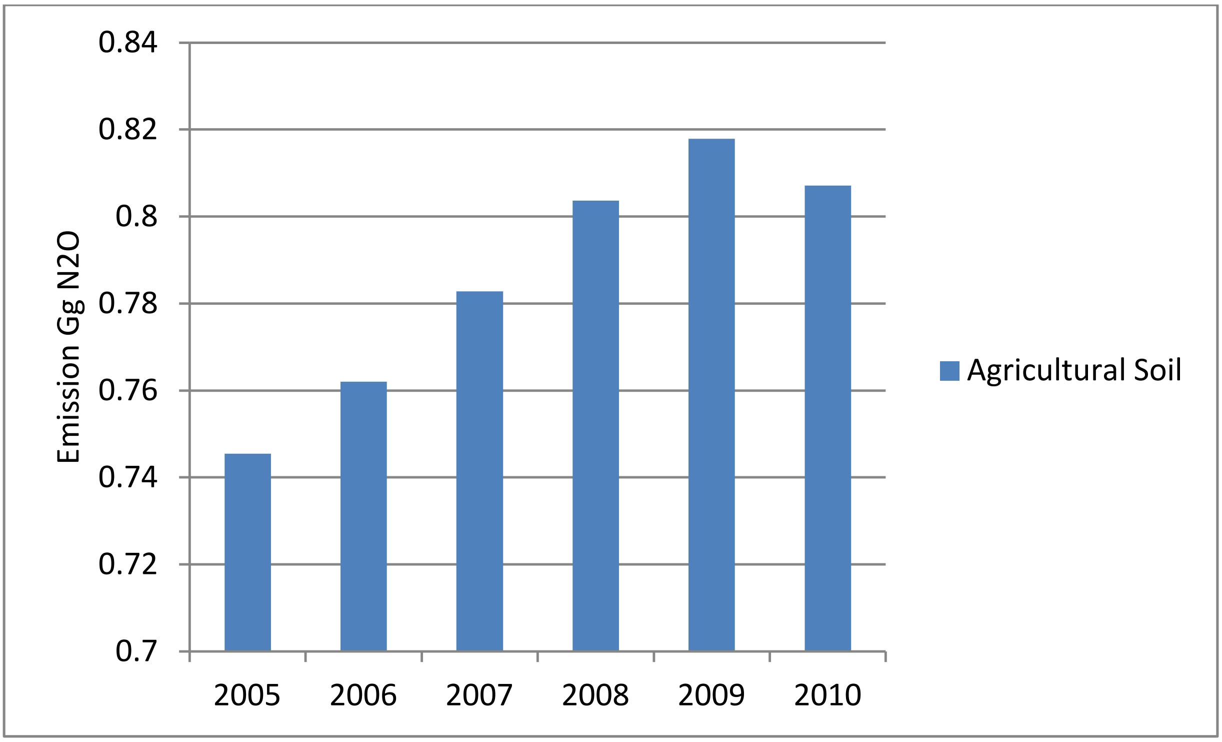


Figure 2-13 **Nitrous oxide emissions from agricultural soil in 2005-2010**

2.5.2.4 Biomass Burning

Non-CO_2 emission from biomass burning was calculated based on burning of savannah and agriculture residues. Savannah is one type of land use where the vegetation is dominated by grasses. Savannah areas requested for calculating biomass burning were sourced from the land cover category of savannah derived from Landsat satellite image (2005-2010). It was assumed that the percentage of area burned is 50%. In 2010, the GHG emissions from savannah burning account for 21 Gg CO_2-e. The main source was CH_4 emissions with 85% followed by N_2O emissions with 15%.

Emissions from agricultural residue burning were estimated from crops residues of rice fields, in which 50% of crops residues in the field may be burned. The activity data used in estimating the non-CO_2 emissions was equal to the activity used for rice cultivation (harvested area). In 2010 methane emission were 0.086 Gg and nitrous oxide emission 0.002 Gg.

2.5.3 Land Use Change and Forestry

The general framework provided by the revised 1996 IPCC Guidelines was used throughout the calculations for this sector. Default values were provided by various tables in the IPCC Reference. Workbook manuals were also used to calculate CO_2 emissions and removal for this sector. Some local values obtained from the Ministry of Forestry and research institutes in Indonesia were applied.

The activity data, area of land remaining in the same category and area of land converted from one category to another, for estimating carbon stock change was gathered from a land cover map generated from interpretation of Landsat satellite images. The classification system of land use used in the image interpretation was sourced from the Indonesian Ministry of Forestry, equivalent to the land use category in Timor-Leste and IPCC 2006 and is summarized in Table 2-6.

Table 2-6 **Land use category**

No	Land use category (Indonesia MoF)	Land use category (TL)	Land use category (IPCC)
1	Primary Dryland Forest	Dense forest	Forest land
2	Secondary Dryland Forest	Dense forest	Forest land
3	Primary Swamp Forest	Dense forest	Forest land
4	Secondary Swamp Forest	Dense forest	Forest land
5	Primary Mangrove Forest	Dense forest	Forest land
6	Secondary Mangrove Forest	Dense forest	Forest land
7	Forest Plantation	Dense forest	Forest land
8	Shrub	Sparse forest	Forest land
9	Swampy shrub	Sparse forest	Forest land
10	Savannah	Grassland	Grass land
11	Agriculture Land	Dry Field / Dry Farm	Crop land
12	Agriculture mixed with Shrub	Very Sparse forest	Crop land
13	Paddy	Paddy field	Crop land
14	Fishpond	Inland water / waterbody	Wet land
15	Settlements	Settlements	Settlement
16	Bare Land	Bare land	Other land
17	Mining	Bare land	Other land
18	Water body	Inland water / waterbody	Wet land
19	Swamp	Sparse forest	Wet land
20	Airport / Harbor	Settlements	Other land

Based on assessment of forest cover changes within land cover maps from 2004 to 2010 the annual loss of forest cover in Timor-Leste is found to be around 2.23% per year. This deforestation rate is slightly higher than the forest cover change assessment by Nippon Koei (2012), where the change from dense forest and sparse forest to other types of land uses was 2.18% per year. Timor-Leste's forest area is composed mainly of dense forest and sparse forest with a total 855,797 ha in 2010. The total emissions resulting from land use change and forestry was 206.1 Gg CO_2 in 2010. This emission is less than the average emissions in previous years (Figure 2-14).

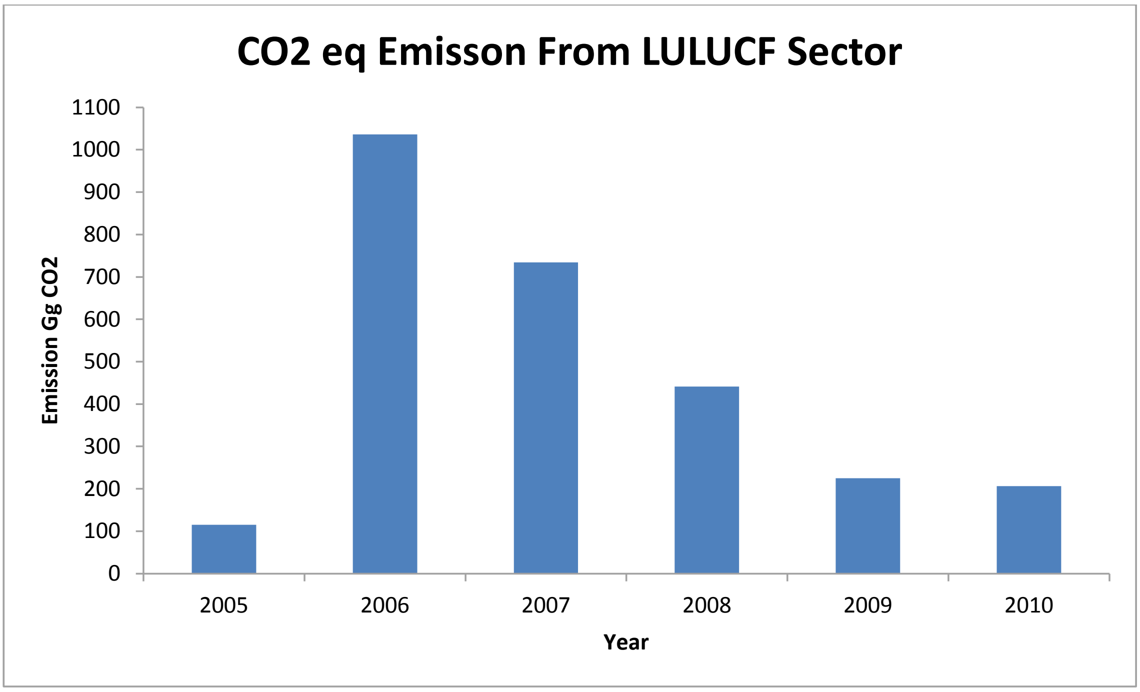


Figure 2-14 **GHG emission from LUCF from 2005 -2010**

By source category, forest and grassland conversion are the main sources of emissions with 564 Gg CO_2, while the total carbon uptake from cropland and change in forest and other woody biomass stocks accounted for 185 Gg and 173 Gg respectively (Figure 2-15).

The category of changes in forest and other woody biomass stocks estimated emissions and removals of CO_2 from decreases or increases in biomass stocks due to regrowth, roundwood removal, fuelwood collection, disturbance, etc. However, the loss of biomass due to wood and fuelwood removals as well as forest disturbances was not estimated since the activity data is not available. Therefore, in 2010 this category was net sink of 173 Gg CO_2.

The category of forest and grassland conversion was calculated based on emissions from land converted to forests and grassland. The non-CO_2 emissions from the burning of biomass was not covered in this category due to lack of availability data, while delayed emissions from decay of biomass in non-forest lands converting to forests under Tier 1 assumes stable or equals to zero. The emission of this category accounts to 564 Gg CO_2 and contributes as main source of emissions.

In the category "other" reported emissions and removals of CO_2 from croplands, land converted to settlements, and wetlands remaining wetlands. The inventory in this category is 185.00 Gg CO_2 (CO_2 removals) in 2010. Meanwhile carbon emission and removal from abandonment of managed lands and soil were not estimated, since the activity data of these categories were not available.

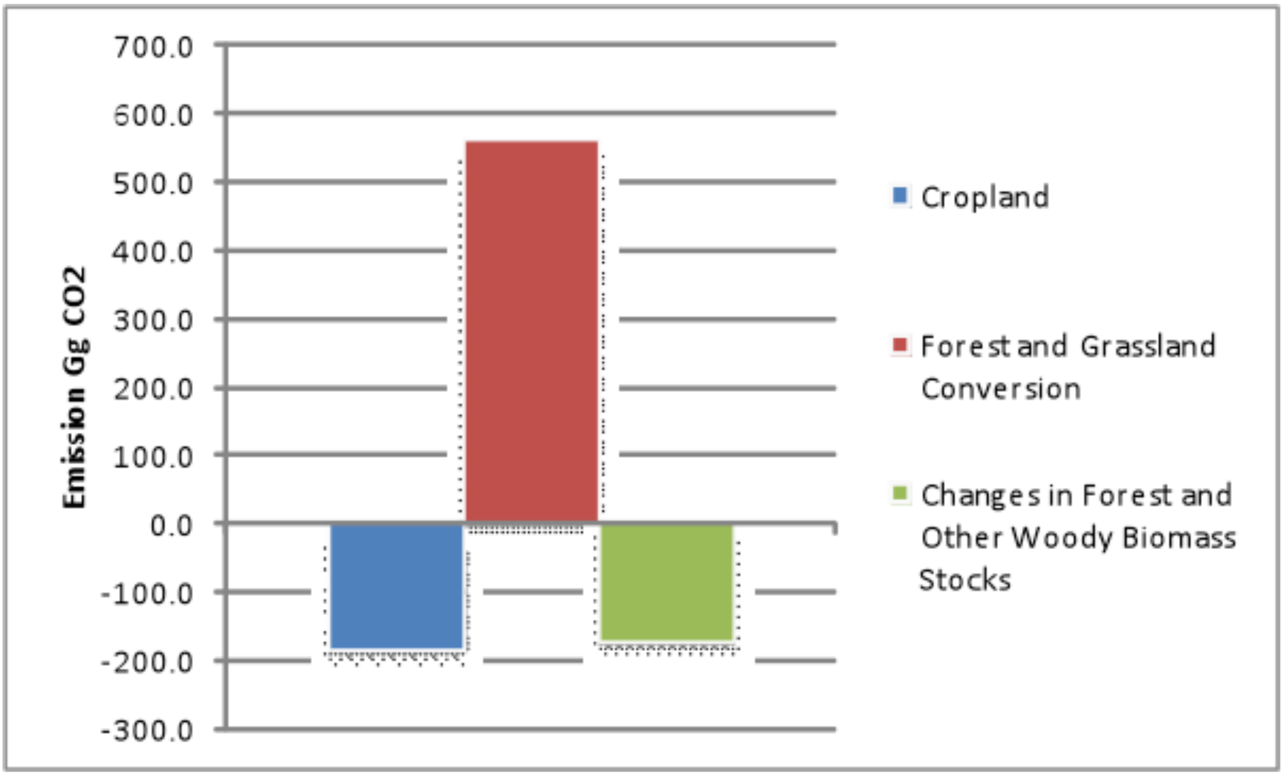


Figure 2-15 **GHG emissions from LUCF sector from 2000-2004 by source/removal category**

2.5.4 Waste

The main source of GHG emissions from the waste sector are Municipal Solid Waste (MSW) dumped in un-managed Solid Waste Disposal Service (SWDS,) MSW open burning, and municipal wastewater treatment. The summary of estimated GHG emissions from domestic waste management and treatment systems of Timor-Leste during 2005 – 2010 is presented in Figure 2-16.

It can be seen from this figure that the main source of GHG emission is from solid waste treatment. The estimation of GHG emission from wastewater treatment of municipal liquid waste only covers collected aerobic wastewater treatment (1% of domestic liquid waste) due to limited data of other uncollected wastewater volume and treatment in household/ community area. Data related to other uncollected wastewater treatment include amount of uncollected wastes that are treated in latrines, septic tanks, anaerobic digestion etc.

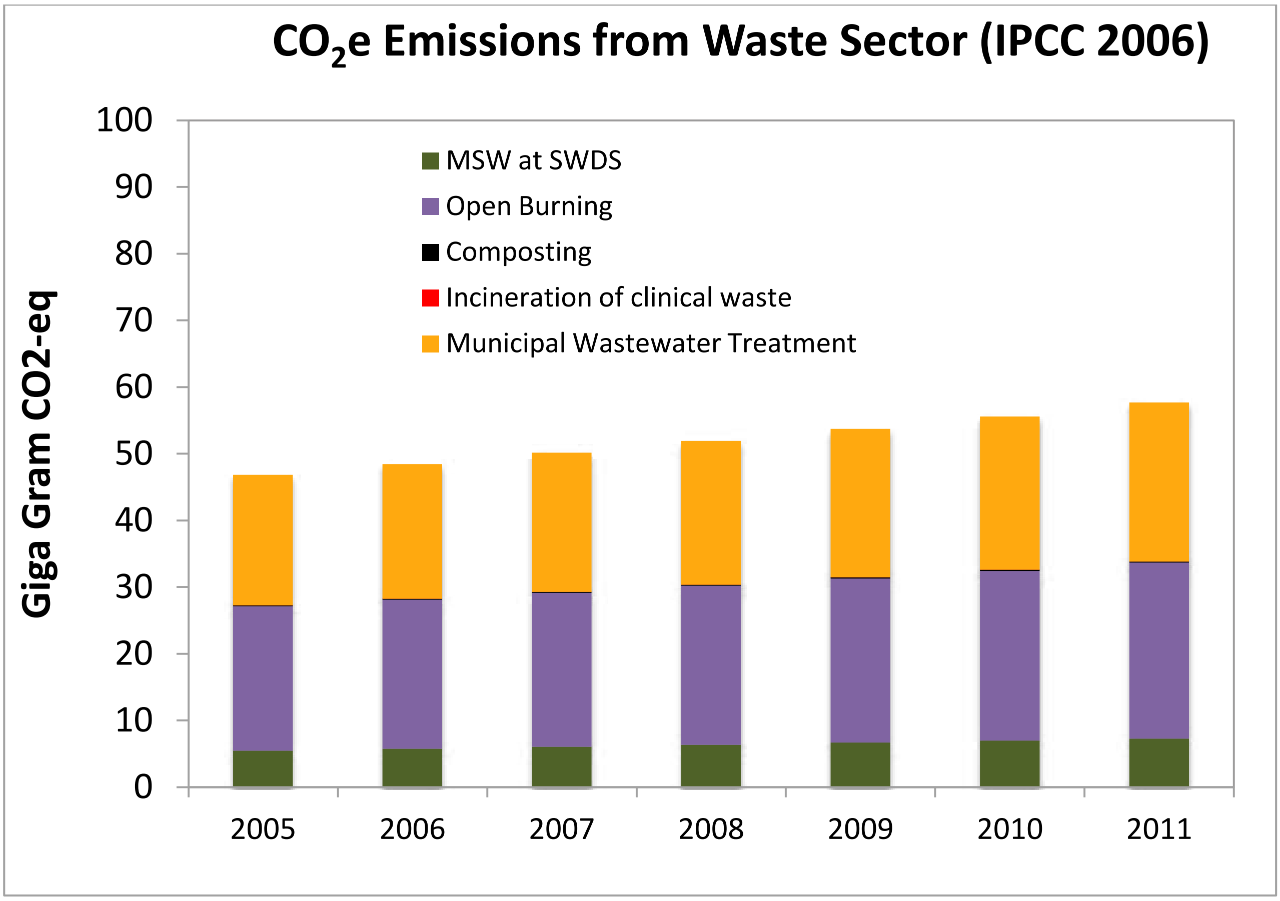


Figure 2-16 **GHG emissions from waste sector in Timor-Leste, 2005 – 2010**

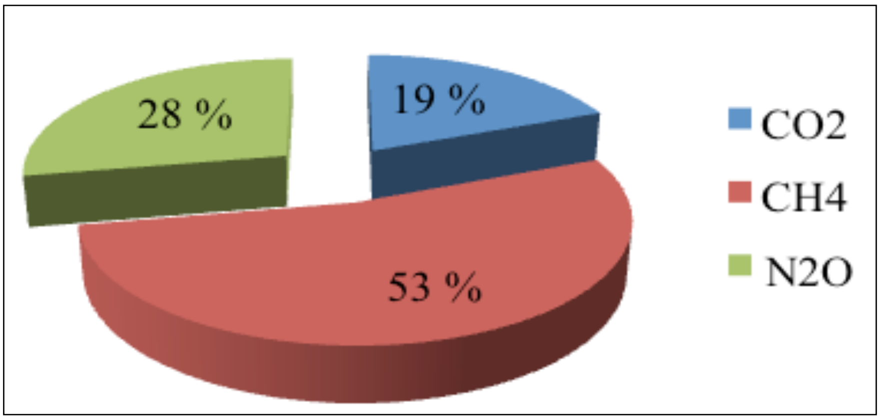


Figure 2-17 **GHG emissions from waste sector by gas**

As seen in Figure 2-17, CH_4 is the main gas generated from waste sector, followed by N_2O and CO_2. Largest contributor of CH_4 emission is the wastewater treatment activity.

2.5.4.1 CH_4 From Open Dumping Activity of Municipal Solid Waste (MSW)

In the INC of Timor-Leste, GHG emission from open dumping activity of MSW is estimated (as Gg CO_2e) under the IPCC revised 1996 and IPCC 2006 (see Figure 2-18). Under the IPCC guidelines, the GHG from open dumping (uncategorized SWDS) only covers CH_4 emission. CO_2 emission is not estimated since the CO_2 is categorized as biogenic in origin that is not covered in the GHG emission inventory of a country. Data used in the estimation of methane emission in SWDS is presented in Table 2-7.

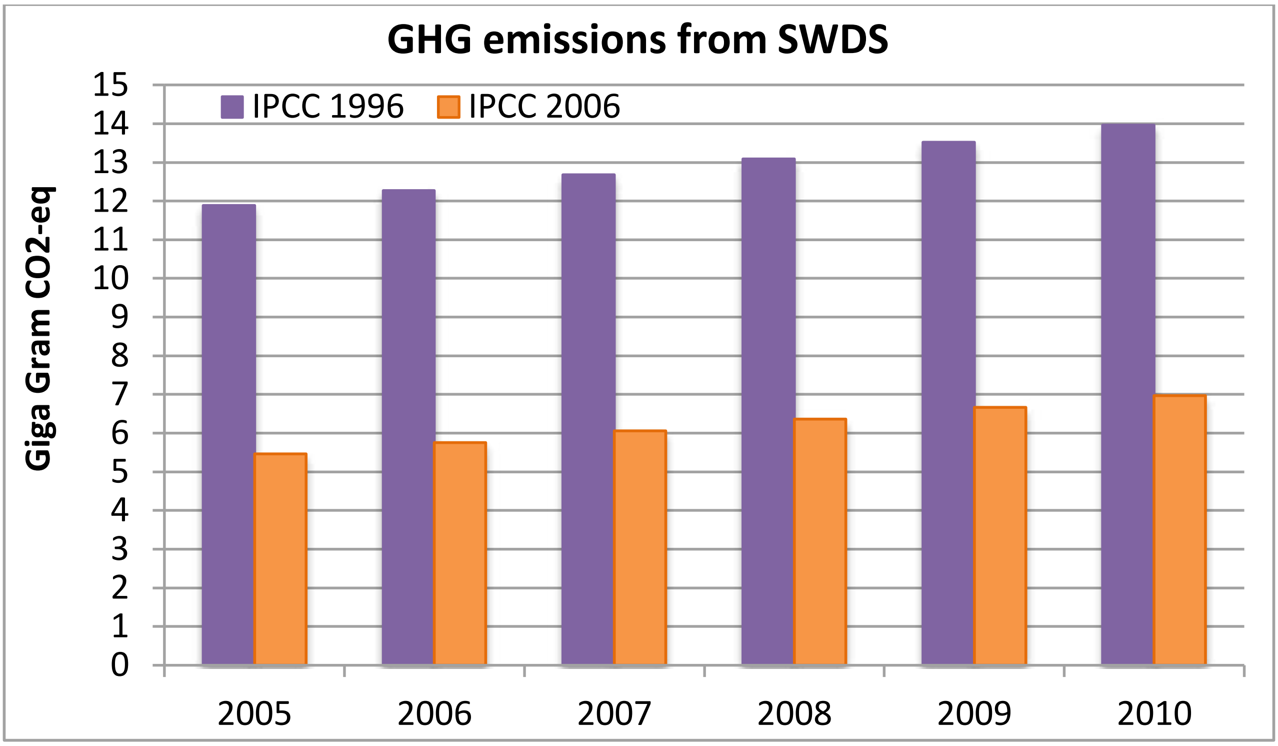


Figure 2-18 **Estimation of GHG from SWDS (IPCC revised 1996 VS IPCC 2006)**

Table 2-7 **Data used in estimate of methane emissions in SWDS**

Year	Number of Population (people)	Total MSW Gg	MSW to SWDS (9.92%) Gg	MCF and k or methane generation rate (1/year)	Other parameter
1990	747,557	139.16	13.81	MCF = 0.6 (default value for uncategorized SWDS) k (1/yr) value used is default value from IPCC 2006, specific for climate dry tropical and for each type of waste (in range of 0.06 - 0.2 yr^{-1})	DOCf (fraction of DOC dissimilated is 0.5 (default value) Fraction of methane (F) in developed gas is 0.5 (default value) Oxidation factor is 0 (assumed there is no oxidation in the land cover of SWDS)
1991	751,089	139.16	13.87		
1992	754,638	139.82	13.94		
1993	758,203	140.48	14.00		
1994	761,785	141.14	14.07		
1995	765,385	141.81	14.14		
1996	769,001	142.48	14.20		
1997	772,634	143.15	14.27		
1998	776,285	143.83	14.34		
1999	779,952	144.51	14.41		
2000	783,638	145.19	14.47		
2001	787,340	146.56	14.54		
2004	952,002	177.22	14.61		
2005	907,311	168.90	17.58		
2006	937,108	174.44	16.76		
2007	967,884	180.17	17.31		
2008	999,670	186.09	17.88		
2009	1,032,501	192.20	18.46		
2010	1,066,409	198.51	19.07		

* The amount of MSW dumped into SWDS is estimated from 1990 (historical data needed for the FOD method at least the past 10 years).

As can be seen in Figure 2-18, there is a difference in GHG emission estimations under both guidelines. The main differences between those estimations are explained as the following discussion.

- Under revised IPCC 1996 guideline, the GHG from waste is estimated using mass balance method. In this method, the degradation of the waste is assumed, not following mechanism of decay reaction, and the GHG generated from the waste is estimated based on the constant amount of waste.

- Under IPCC 2006 guideline, the GHG from waste is assumed using FOD (first order decay) method. In this method, the waste is assumed biologically degraded through first order decay reaction and the GHG generated from the waste is estimated based on amount of waste (exclude degraded waste). The amount of GHG from SWDS has been corrected by the amount of the degraded waste. In addition, the IPCC 2006 guidelines can also be used for estimating GHG emission from open burning, incineration, and composting activities since the revised IPCC 1996 guideline does not provide meth odologies for estimating the GHG emission from those activities.

Therefore, in this INC the IPCC 2006 guideline is used for estimating the GHG emission from MSW at SWDS/landfill and other waste management activities, open burning, clinical waste incineration, and composting.

2.5.4.2 GHG emissions from MSW Open Burning and Composting

Emission from open burning is significant since open burning is common practice in Timor-Leste. It assumed that at least 41% of national population burns MSW. Composting activity is still rare, only 0.5% of total population treat the MSW for compost.

Table 2-8 **Estimate of MSW open burning emissions**

Year	Gg MSW to be Open Burned	Gg CO_2	Gg CH_4	Gg N_2O	Gg CO_2-eq
2005	69.25	8.97	0.45	0.01	21.64
2006	71.52	9.26	0.46	0.01	22.35
2007	73.87	9.57	0.48	0.01	23.09
2008	76.30	9.88	0.50	0.01	23.84
2009	78.80	10.21	0.51	0.01	24.63
2010	81.39	10.54	0.53	0.01	25.44

Table 2-9 **Estimate of MSW composting emissions**

Year	Gg MSW to be composted	Gg CH_4	Gg N_2O	Gg CO_2-eq
2005	0.84	0.0034	0.0003	0.15
2006	0.87	0.0035	0.0003	0.15
2007	0.90	0.0036	0.0003	0.16
2008	0.93	0.0037	0.0003	0.16
2009	0.96	0.0038	0.0003	0.17
2010	0.99	0.0040	0.0003	0.18

2.5.4.3 GHG emissions from Domestic Wastewater Treatment

In the INC of Timor-Leste, GHG emission from domestic wastewater treatment is estimated under the IPCC 2006 as Gg CO_2e. Under the IPCC 2006 guidelines, the estimation of GHG emission from domestic wastewater treatment only covers CH_4 and N_2O (see Figure 2-19).

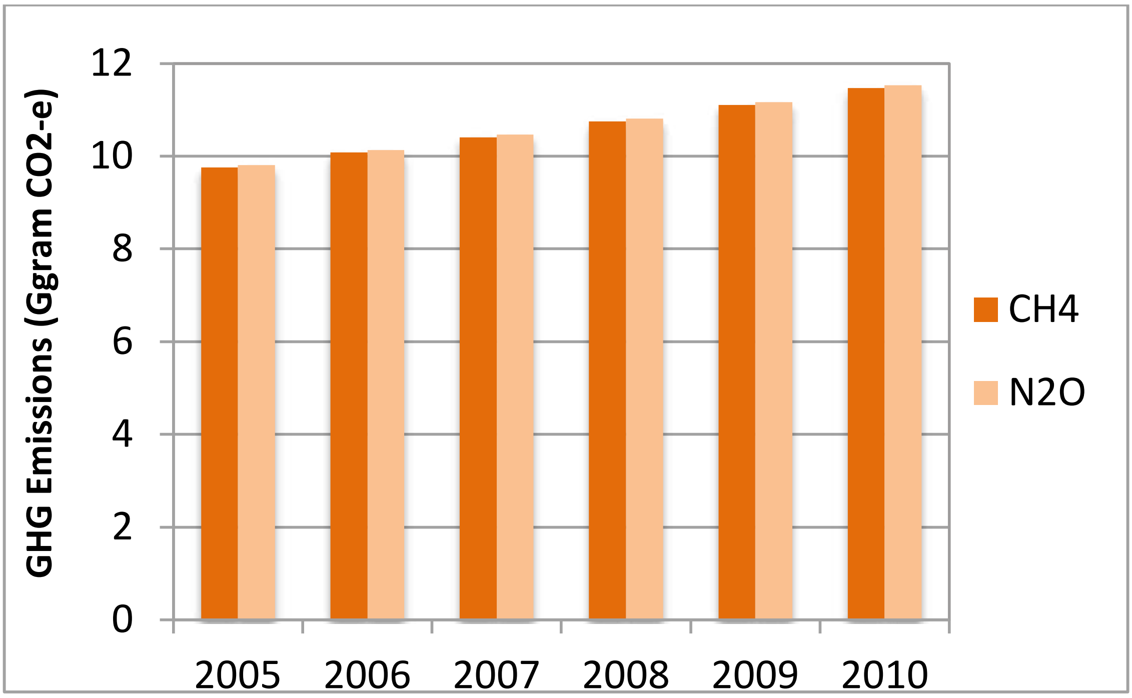


Figure 2-19 **CH_4 and N_2O generated from domestic wastewater treatment and handling**

Due to lack of available data, GHG emissions from wastewater treatment can only capture emissions occurring in Dili district. In Dili, more than 80% of inhabitant live in urban areas whereas in other districts more than 80% of inhabitant live in rural areas. Most inhabitants in Dili use domestic wastewater treatment that falls under the category of pit latrine with slab.

2.5.4.4 GHG emissions from Industrial Wastewater Treatment

The estimation of GHG emissions levels from waste sector referred to IPCC 2006 Guidelines. Since the reporting format of GHG emission inventory was based on revised IPCC 1996 Guidelines, therefore the estimation results (Table 2-10) referred to the format of 1996 IPCC CRF (common reporting format). It can be seen from the table that GHG emissions from industrial wastewater treatment were listed as NO (not occur). The GHG emissions from industrial wastewater were not included in NGHGI because the industrial activity practically does not exist and therefore the GHG emission from industrial wastewater can be neglected and considered as NO (not occur).

Table 2-10 **Estimate Results of Waste Sector Emissions in Year 2010**

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES	Year 2010 (Giga Gram)			
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	CO2-eq
Total Waste	**10.543**	**1.411**	**0.050**	**55.586**
A Solid Waste Disposal on Land	**-**	**0.332**	**-**	**6.975**
1 Managed Waste Disposal on Land	-	-	-	-
2 Unmanaged Waste Disposal Sites	-	-	-	-
3 Other (please specify): uncategorised MCF 0.6	-	0.332	-	6.975
B Wastewater Handling	**-**	**0.546**	**0.037**	**22.997**
1 Industrial Wastewater	**NO**	**NO**	**NO**	**NO**
2 Domestic and Commercial Wastewater	-	0.546	0.037	22.997
3 Other (please specify)	-	-	-	-
C Waste Incineration	**0.001**	**0.000**	**0.000**	**0.001**
1. Clinical Waste Incineration	0.001	0.000	0.000	0.001
D Other (please specify):	**10.542**	**0.533**	**0.013**	**25.612**
1. Open Burning	10.542	0.529	0.012	25.436
2. MSW Composting in rural areas	-	0.004	0.000	0.176

Note: * N.O = Not Occurring

2.6 KEY CATEGORY ANALYSIS

The key category analysis (Tier 1) indicated that there are 10 main sources of emission for Timor-Leste. The three main categories that contribute to more than 50% of the total emissions are from (i) stationary combustion (ii) forest and grassland conversion, and (iii) emission from enteric fermentation (Table 2-11). This analysis suggests that improvement of activity data and emission factors for these key categories is very important to improving the Timor-Leste National GHG Inventory.

Table 2-11 **Key source categories in Timor-Leste**

No	Sector	Source categories	Gas	%
1	LUCF	Forest and Grassland Conversion	CO_2	26%
2	Agriculture	Enteric Fermentation	CH_4	40%
3	Agriculture	Agricultural Soils	N_2O	51%
4	Energy	Fuel Combustion (Sectoral Approach)	CO_2	63%
5	Agriculture	Manure Management	N_2O	72%
6	LUCF	Others	CO_2	80%
7	LUCF	Changes in Forest and Other Woody Biomass Stocks	CO_2	88%
8	Agriculture	Rice Cultivation	CH_4	93%
9	Agriculture	Manure Management	CH_4	96%

Estimates of emissions from these sectors still need refinement especially those that use assumed data such as fertilizer application and rice cultivation as these sources are key categories.

2.7 PLANS FOR IMPROVEMENT

Improvements of the GHG Inventory in the next National Communication will be focused in the following areas:

- Development of local emission factors for key source categories. This will involve UNTL;
- Improvements to the methodology;
- Improvements to the activity data and mechanism for QA/QC; and
- Improvements to the archiving system for the GHG Inventory.

3 GENERAL DESCRIPTION OF STEPS TAKEN OR ENVISAGED TO IMPLEMENT THE CONVENTION

Photo by UNMIT/Martine Perret

3.1 INSTITUTIONAL ARRANGEMENT FOR THE PREPARATION OF NATIONAL COMMUNICATION

The development of the Initial National Communication (INC)'s document was led by the Directorate for International Environmental Affairs and Climate Change (DIEACC) under the State Secretariat for the Environment, one of the State Secretaries under the prerogative of the Ministry of Commerce, Industry and Environment (MCIE). Day to day work on the development of the INC itself was conducted by the INC team in collaboration with Thematic Working Groups (TWG) established from various government agencies, academia, civil society organizations and private sector. Institutional arrangement for the development of the INC is described in Figure 3-1.

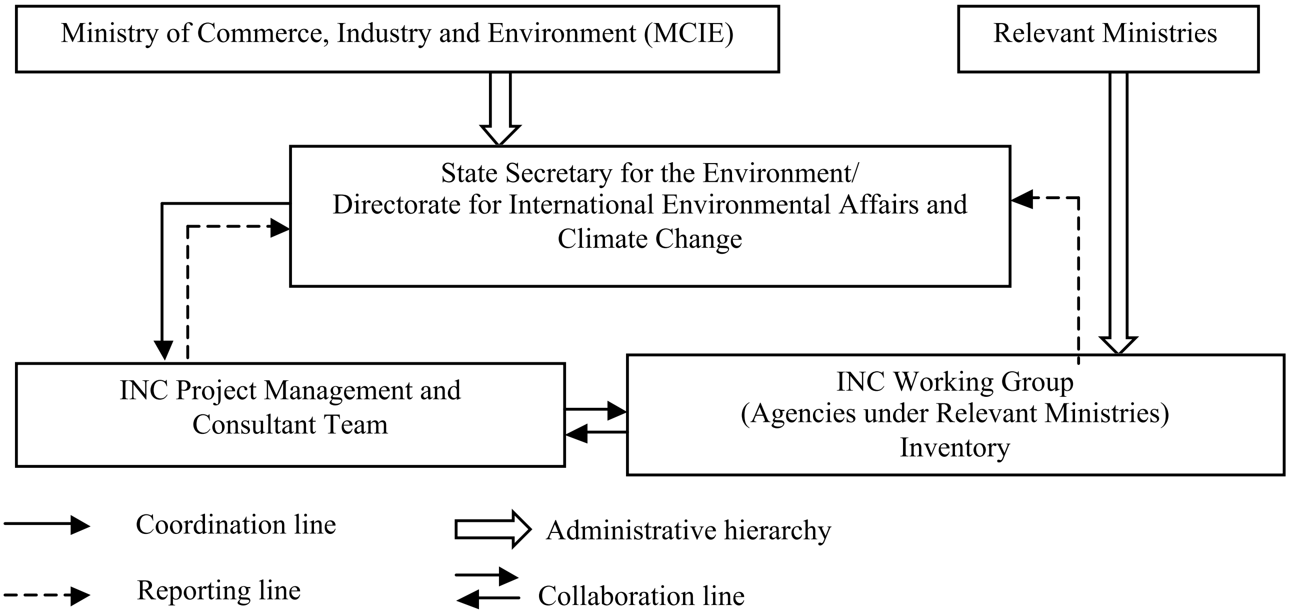


Figure 3-1 **Institutional Arrangement for the Development of INC**

At the beginning of the INC development process, six TWGs were established in accordance with six major themes in the INC report, namely-(i) Greenhouse Gas Inventory TWG; (ii) Vulnerability and Adaptation TWG; (iii) Mitigation Options TWG; (iv) Technology Transfer TWG; (v) Research and Systematic Observation TWG and (vi) Education, Training and Public Awareness Building TWG. Members of the TWGs came from applicable directorates within nine relevant ministries. A list of the government stakeholders, private sector groups, academia and civil society organizations that made up the working group on GHG Inventory is presented in Table 3-1.

Table 3-1 **INC Development Stakeholders**

TYPE	AGENCY	
Government	1	Ministry of Commerce, Industry and Environment – State Secretary for the Environment (Lead Agency and Coordinating Entity)
	2	Ministry of Public Works
	3	Ministry of Transportation and Communication
	4	Ministry of Agriculture and Fishery
	5	Ministry of Petroleum and Mining Resources
	6	Ministry of State Administration
	7	Ministry of Social Solidarity
	8	Ministry of Health
	9	Ministry of Finance
Academia	1	National University of Timor Lorosae
	2	Coffee Institute of Ermera
	3	Da Paz University (UNPAZ)
Private Sector	1	Pertamina
	2	Tiger Fuel
	3	PDL Toll
Civil Society Organization	1	International NGOs: Oxfam, Mercy Corps, Care, CVTL, CRSTL, World Vision
	2	National NGOs: Haburas Foundation, Santalum, Farming Study Group, Halerai, Estrela, Permatil,
Donor/ International Agency	1	World Food Programme
	2	AusAid
	3	Asian Development Bank
	4	Coral Triangle Support Programme (USAID Funded)

Throughout the INC development, the six TWGs have merged into one large working group as many members were actually relevant to more than one working group. Some workshops have also been conducted on subsequent days making it more practical to involve everybody from the beginning to the end. The combined working group has proven to be beneficial to crosscutting issues discussed during the INC events as well.

3.2 PROCESS OF INTEGRATING CLIMATE CHANGE INTO THE NATIONAL DEVELOPMENT PLAN

For future National Communication development, it is recommended that the current ad hoc working group be upgraded into an official working group through recognition by a Ministerial Decree from the Ministry of Commerce, Industry and Environment. An inter-ministerial Memorandum of Understanding (MOU) could also be pursued to ensure a more streamlined data collection, sharing and update of information between the various directorates involved. The State Secretary for the Environment through the DIEACC will continue to play the role of coordinating body and central agency where data and calculation/modelling results are compiled and made public.

Support for capacity development of the working group members and DIEACC should be continuously pursued especially in areas pertaining to GHG Inventory development and mainstreaming of climate change into planning and policy making at relevant agencies. For agencies implementing adaptation and mitigation measures, there is also a need to strengthen capacity in monitoring of project implementation as well as measuring, reporting and verification requirement.

4 MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

Photo by UNMIT/Martine Perret

4.1 INTRODUCTION

Timor-Leste is considered to be vulnerable to the impact of climate change. Many sectors are seriously affected by extreme climate events. Based on data from the last 10 years, climate-related hazards such as floods, droughts, storms, landslides and wildfires have caused major loss of human lives and livelihoods, the destruction of economic and social infrastructure, as well as environmental damage (Figure 4-1). Based on data from the Secretary of State of the Social Assistance and Natural Disasters, the number of hazard events recorded during the period 2001-2011 for strong winds, floods and landslides reached 198, 150 and 38 events respectively. Drought also has serious impacts on communities. The drought event that occurred in 2003 impacted on approximately 8502 households.

Without developing the capacity to manage climate risk, and increasing climate variability in the future, Timor-Leste will be exposed to higher climate risk. Assessment of vulnerability and climate change adaptation is very important to assist sectors in developing strategies to manage climate risk. This Chapter discusses the historical and future climate of Timor-Leste including vulnerability and climate change impact assessment as well as climate change adaptation.

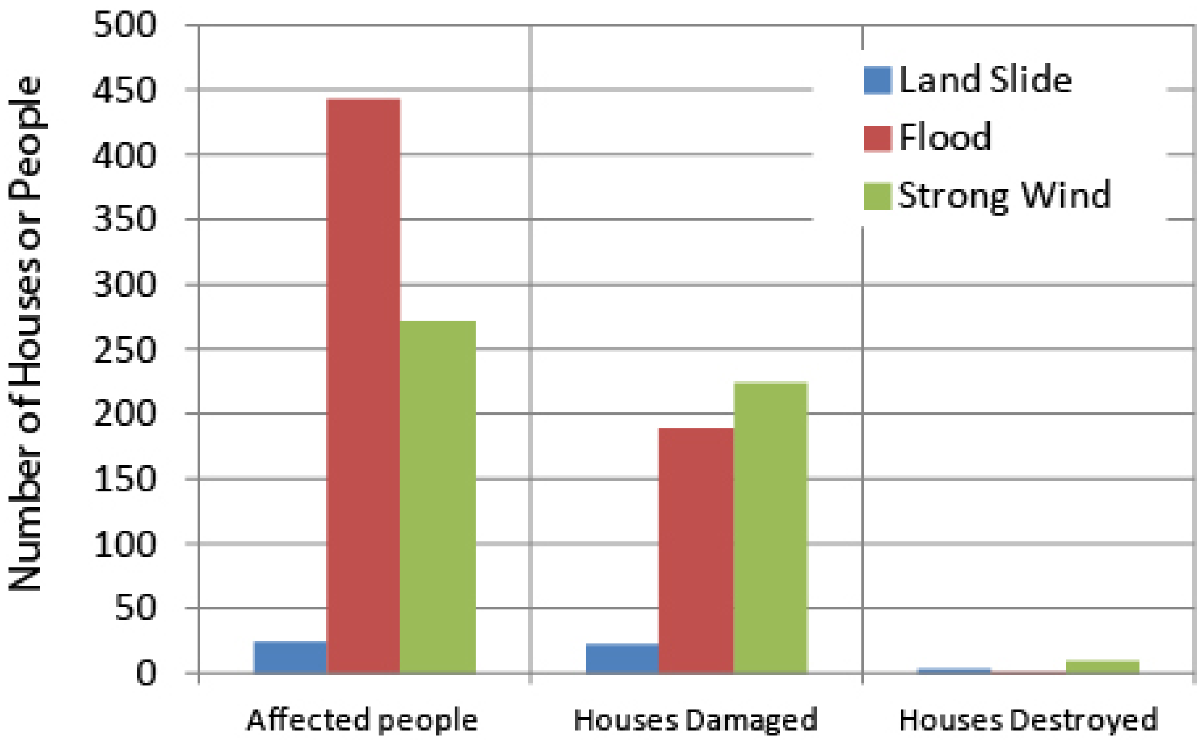


Figure 4-1 **Annual average of number of households or houses impacted by the three main climatic hazards in Timor-Leste (2001-2010)**

Source: Analyzed from hazards data of the Secretary of State of the Social Assistance and Natural Disasters

4.2 HISTORICAL CLIMATE CHANGE

Timor-Leste is one of several countries located in the Maritime Continent region and part of the Pacific small island countries. Based on historical rainfall and temperature record, the region is divided into three different climatic zones, i.e. (i) north coast region, characterized by average mean temperature of more than 24 0C, annual rainfall amount less than 1500 mm, with a dry season lasting for around five months; (ii) mountainous region, characterized by average mean temperature less than 24 0C, annual rainfall amount more than 1500 mm and dry season lasting for four months; and (iii) South coast region, characterized by average mean temperature more than 24 0C, annual rainfall amount of about 2500 mm, and dry season lasting for only three months (Kirono 2010).

4.3 TEMPERATURE

The climatology of monthly mean temperatures in Timor-Leste varies across different areas (Figure 4-2). Based on the climatology of mean temperatures of 11 climate stations located in different altitudes, the highest monthly mean temperature generally occurs during the peak of the rainy season when the optimum solar radiation occurs and there is intensive heating the surface. During the wet season, the mean temperature ranges from around 20°C to 30°C. During the dry season, the temperatures are lower, ranging from 16°C to 27°C.

In general, the country has experienced an increase of mean annual temperatures with an annual rate of increase of 0.016°C per year. Within the last decade, there has been a decreasing trend in the annual mean temperature of about -0.026°C per year (Figure 4-3). However, this downward trend could be related to the pause in global surface temperature rise due to the substantial role of decadal variability in the Pacific (Met-Office 2013). Meehl et al. (2011) suggested that the pause might also relate to the capacity of the deep ocean below 300 m in absorbing heat during the recent cooling periods. However, in the long term the effect of increasing greenhouse gases in the atmosphere in causing global warming is apparent (Figure 4-3).

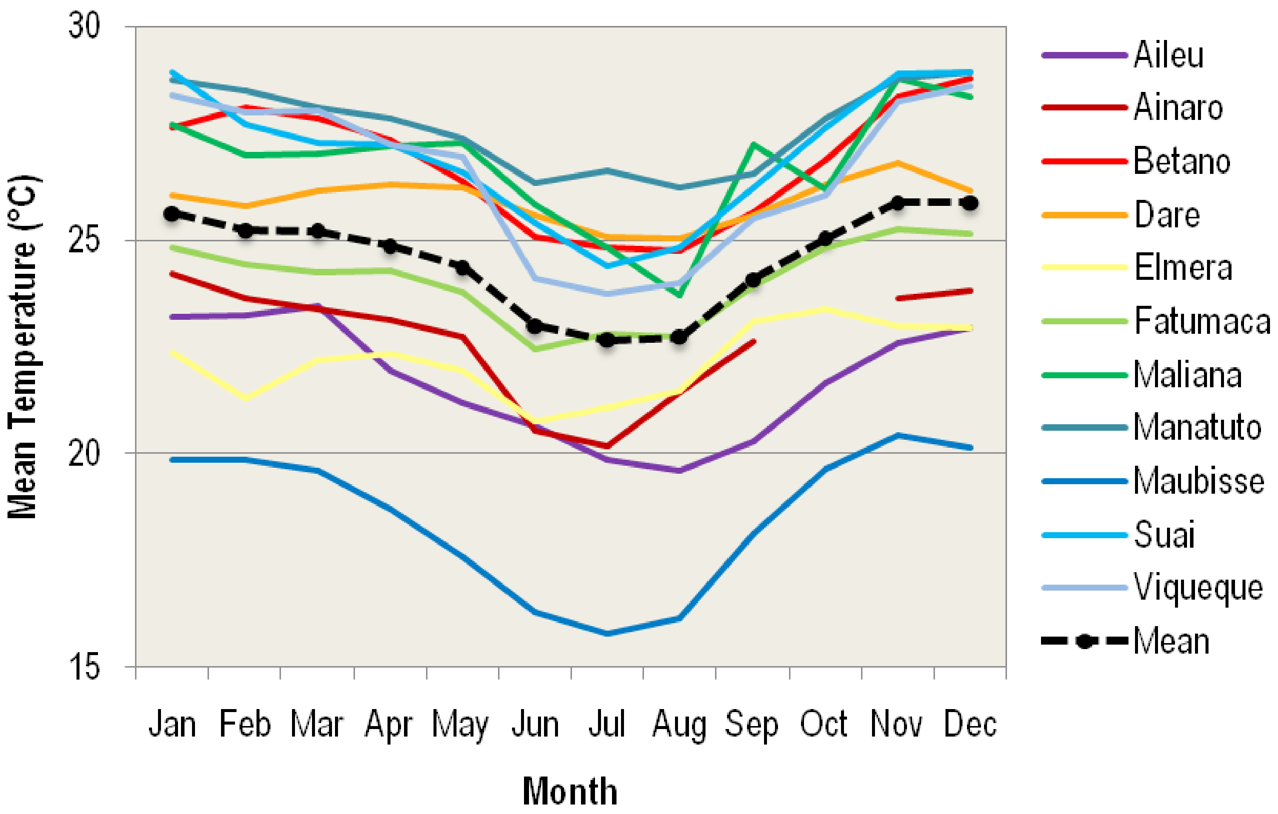


Figure 4-2 **Monthly mean temperature climatology in 11 climate stations in Timor-Leste. Black-dashed line is the mean values of all stations**

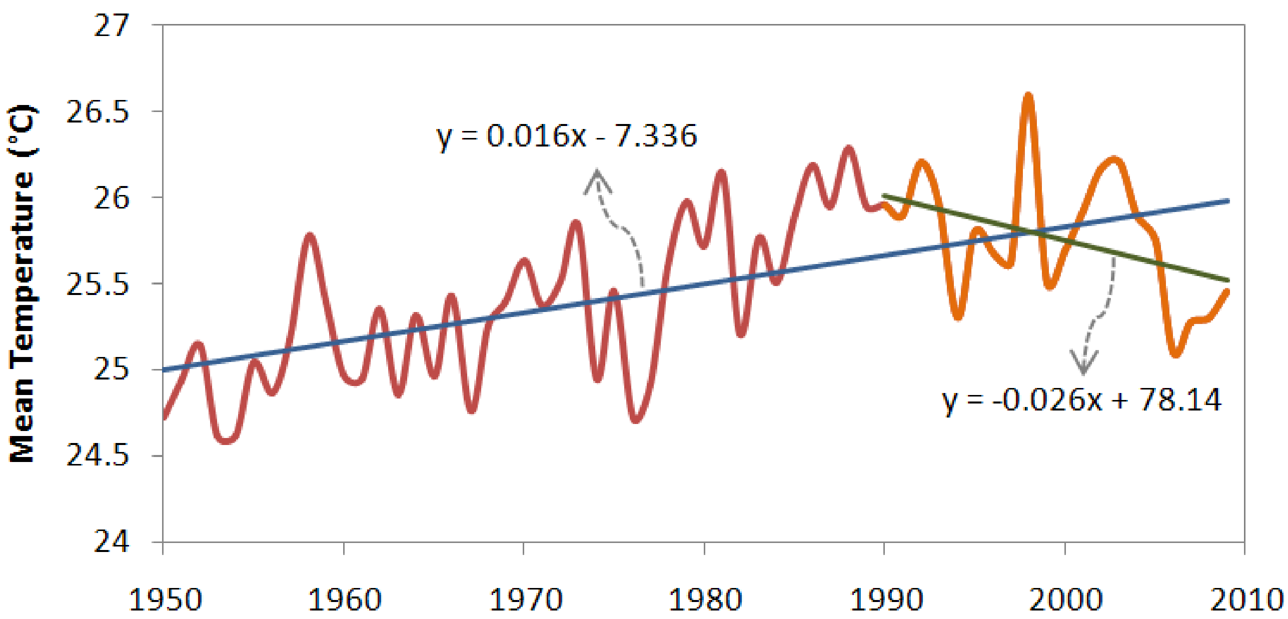


Figure 4-3 **Trend of annual mean temperature over Timor Leste based on CRU TS3.1 dataset**

4.4 RAINFALL

4.4.1 Rainfall Pattern and Climatology

In general, the rainfall pattern in Timor-Leste is strongly characterized by the Australian Monsoons. The peak of the rainy seasons usually occurs in January or February around 250 mm in average, and the dry seasons appear in July to October with the lowest rainfall average around 25 mm (Figure 4-4).

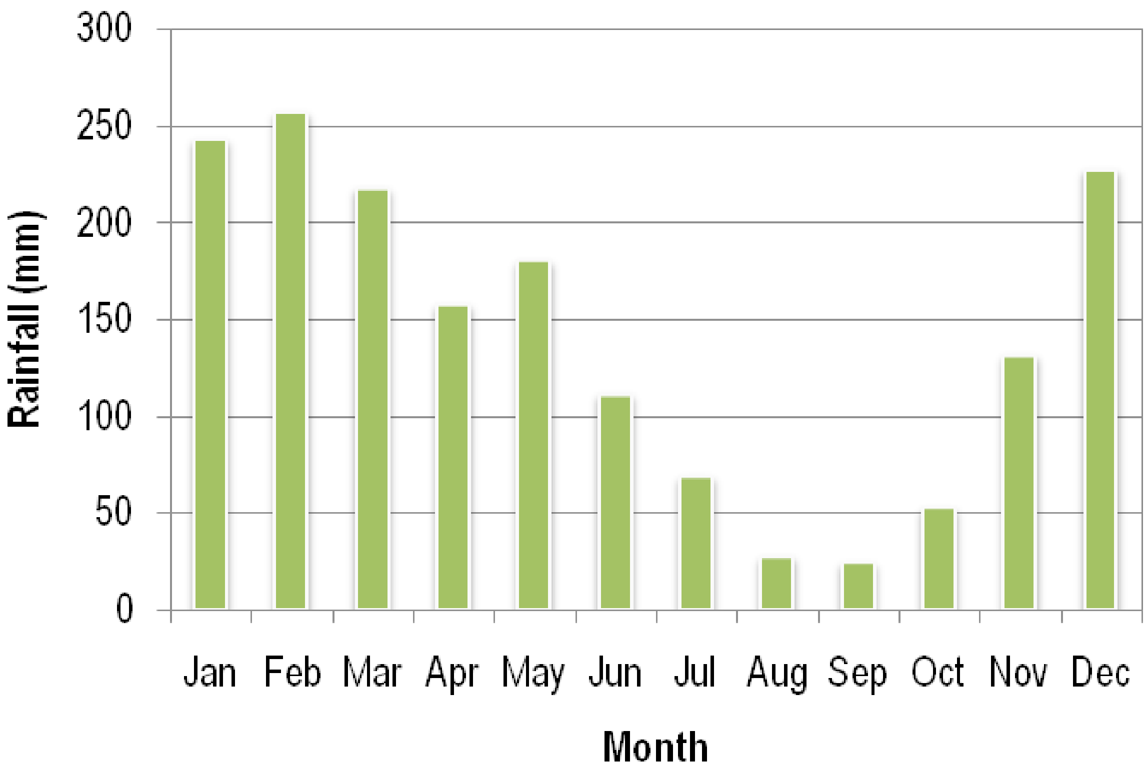


Figure 4-4 **Monthly rainfall climatology in Timor-Leste based on the average of rainfall climatology in 36 rain gauge stations in Timor-Leste**

Rainfall patterns in Timor-Leste vary from the driest area in the northeastern part to wetter areas in the western part of the country. There are five dominant rainfall types found in the country based on the PCA-cluster analysis of monthly rainfall climatology (Figure 4-5). The differences between these types are mostly found in the amount of their wet season rainfall. The Type 1 rainfall region represents areas in the western part of the country with the highest rainfall during wet season, especially in February and March, reaching around 400 mm in average.

The Type 2 rainfall region is also located in the western part adjacent to the Type 1 location. In the Type 2 region, the characteristic Monsoonal rainfall is dominant with the rainfall peak reaching around 275 mm, especially in December, January and February. The Type 3 rainfall region has a peak rainfall around 225 mm and is found adjacent to the north coast region, running from the west to the east of the main region as well as in the separated region in the west. The southwestern part of the country also has the same Type 3 characteristic. The Type 4 rainfall region is located mainly in the centre of the country with a rainfall peak lower than the previous types, i.e. around 175 mm. The north coast region is predominantly characterized by Type 5 rainfall. It has the lowest rainfall compared to the other four rainfall types. The peak of wet season rainfall in a Type 5 area is not more than 150 mm.

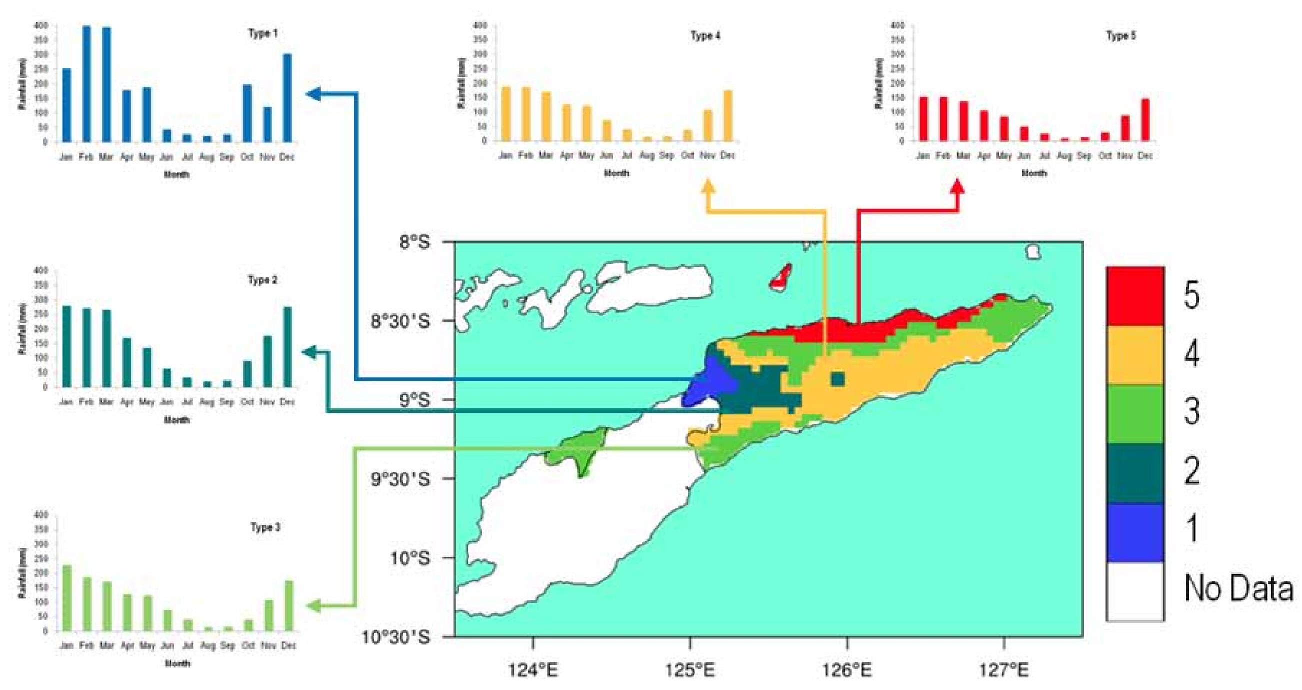


Figure 4-5 **Patterns of monthly rainfall climatology in Timor-Leste based on cluster analysis**

4.4.2 Rainfall Trends

Long-term rainfall variability in Timor-Leste contributes to the change in rainfall climatology over different periods. This is shown by the comparison of the monthly rainfall climatology in different 30-year periods with ten year intervals (Figure 4-6). The changes of rainfall climatology are mostly apparent in December, January, March and May, indicating an increase of rainfall during the rainy season. In contrast, there are no considerable changes found in the dry season, particularly in July, August and September.

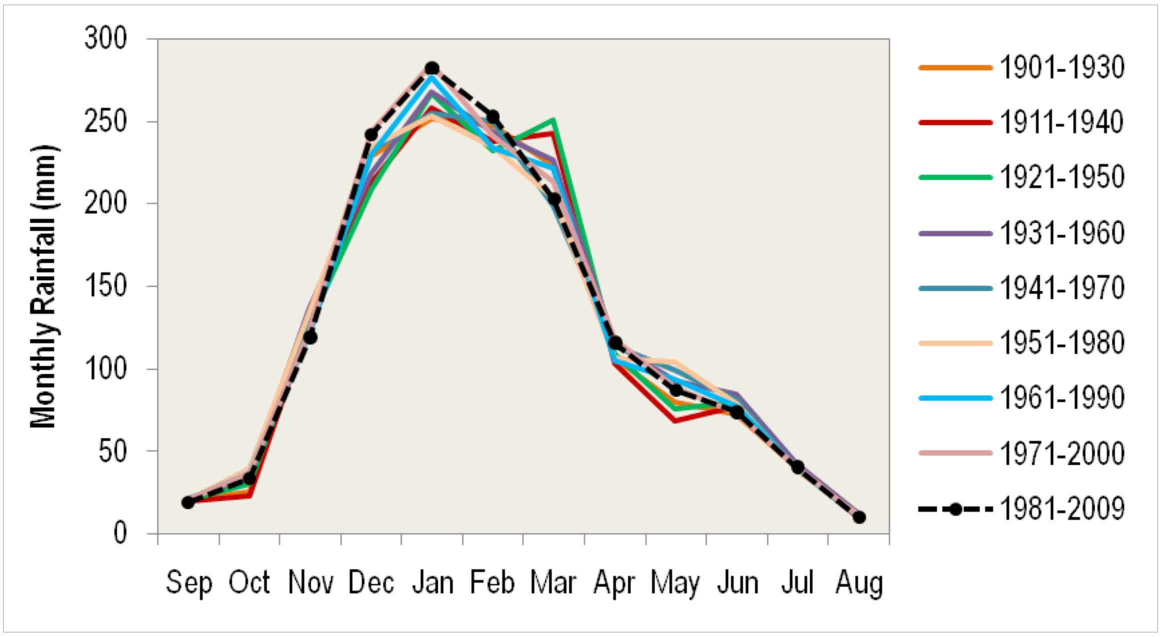


Figure 4-6 **Comparisons of seasonal cycles of rainfall in Timor-Leste calculated from every 30-years monthly rainfall climatology with 10-years interval based on CRU TS3.1 dataset.**

Timor-Leste experienced rainfall changes during the 20th century and in the beginning of the 21st century. The rate of decadal trend of annual rainfall climatology in Timor-Leste is estimated at around 6.4 mm/decade (Figure 4-7). The rates of decadal rainfall trends are different for each season (Figure 4-8). A consistently increasing trend is found only in DJF season with the rate around 7.156 mm/decade. A similarly increasing trend of decadal rainfall is also found in SON with a rate of 0.4 mm/decade, but with the tendency of a downward trend after 1951-1980 climatology (see Figure 4-8). In contrast, the downward trends of decadal rainfall are shown in MAM and JJA seasons. These long-term downward trends are mostly due to dominant decrease of rainfall within the last few decades in those two seasons.

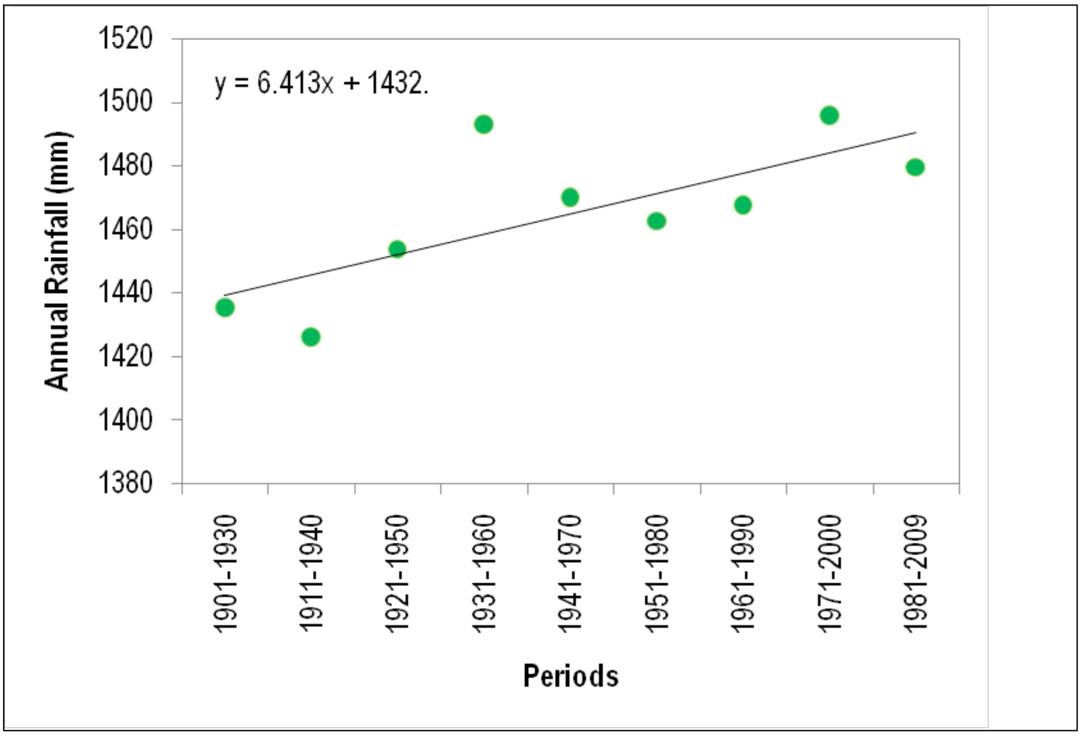


Figure 4-7 **Decadal trend of mean annual rainfall over Timor-Leste based on CRU TS3.1**

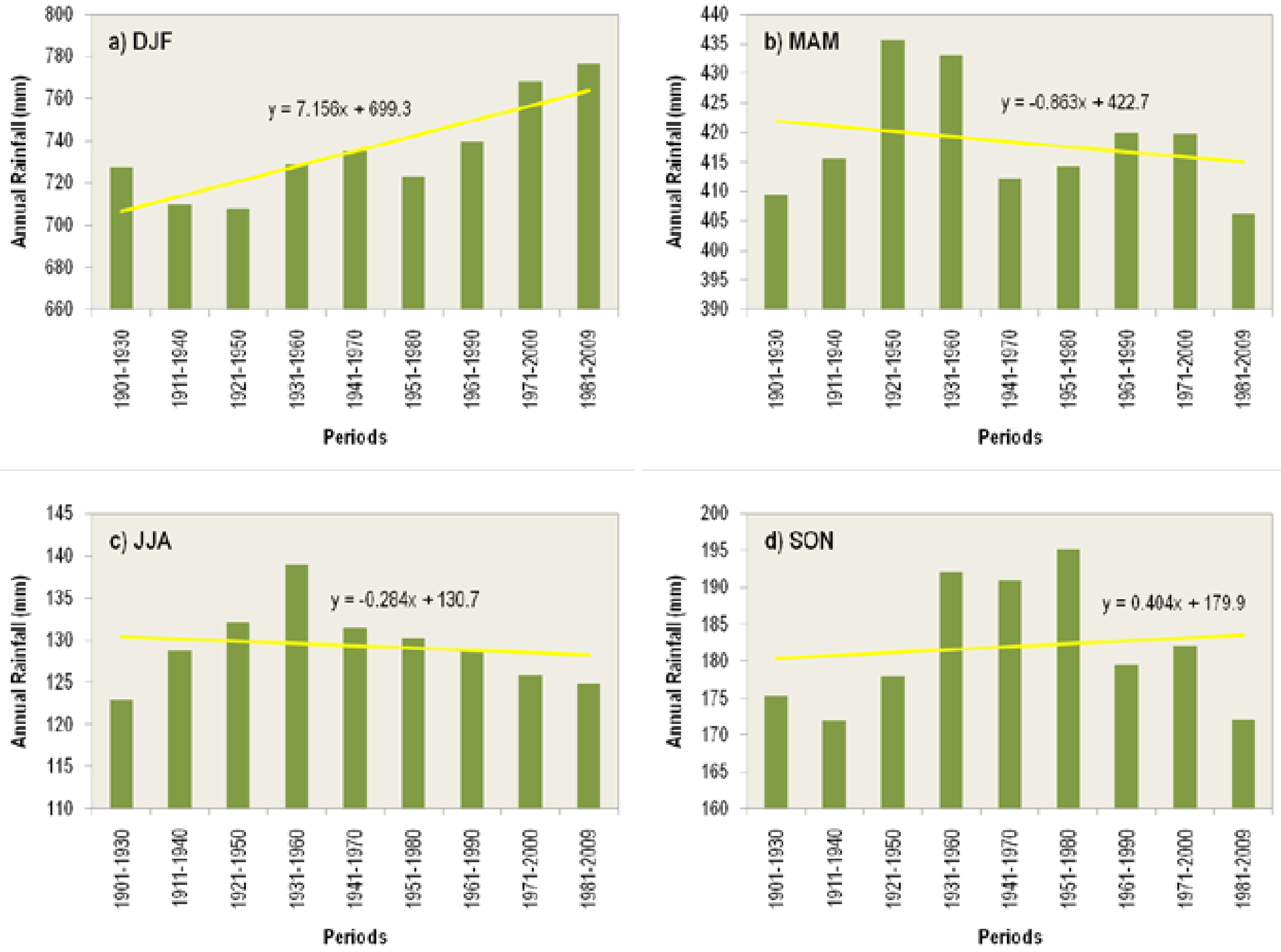


Figure 4-8 **Time series of seasonal rainfall over Timor-Leste taken from CRU TS3.1 (1901-2009 periods)**

4.4.3 Rainfall Variability

The annual rainfall amounts in Timor-Leste are also different each year and show a strong inter-annual variability associated with annual increases or decreases in rainfall that link to possible extreme climate events such as drought and flood. The considerable signs of rainfall variability with very little long-term trends are shown in the seasonal rainfall time series in Figure 4-9.

Many studies have shown that the El-Nino Southern Oscillation (ENSO) could significantly affect rainfall variability in the Maritime Continent region (Aldrian; Susanto 2003; Aldrian et al. 2003; Boer; Faqih 2004; Faqih 2010; Hendon 2003). Similar to many countries within the region, rainfall variability in Timor-Leste is also strongly affected by ENSO. Figure 4.10 shows the spatial correlations between sea surface temperature anomalies (SSTa) in the Indo-Pacific region with the area-averaged rainfall anomalies in the country based on different time lags. Consistent negative correlations at different time lags are found in the central tropical Pacific, indicating considerable influence of ENSO to the rainfall variability in Timor-Leste. The ENSO signal impacting rainfall variability could be identified from the previous 3 months of SSTA data in the central Tropical Pacific, providing potential uses of SSTA data for seasonal climate predictions. Based on the same figure, it is suggested that rainfall variability in the region is not strongly influenced by the climate drivers in the Indian Ocean, especially the Indian Ocean Dipole (IOD) event since the correlations for the SSTA in the western and eastern parts of the Indian Ocean with rainfall anomalies are not significant.

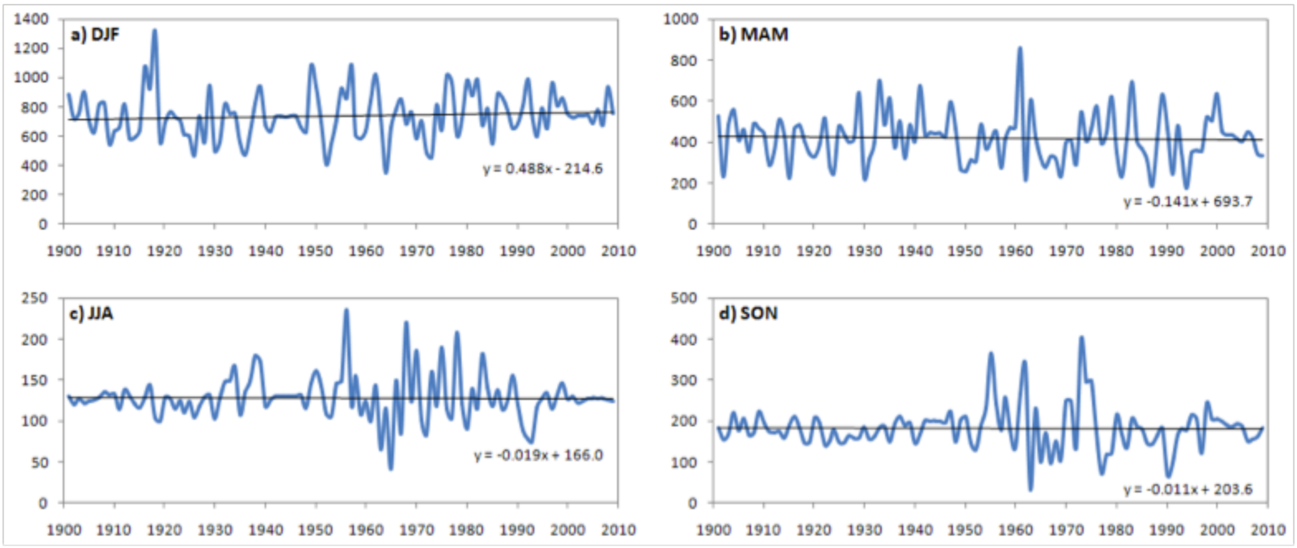


Figure 4-9 **Time series of seasonal rainfall over Timor-Leste taken from CRU TS3.1 (1901-2009 periods)**

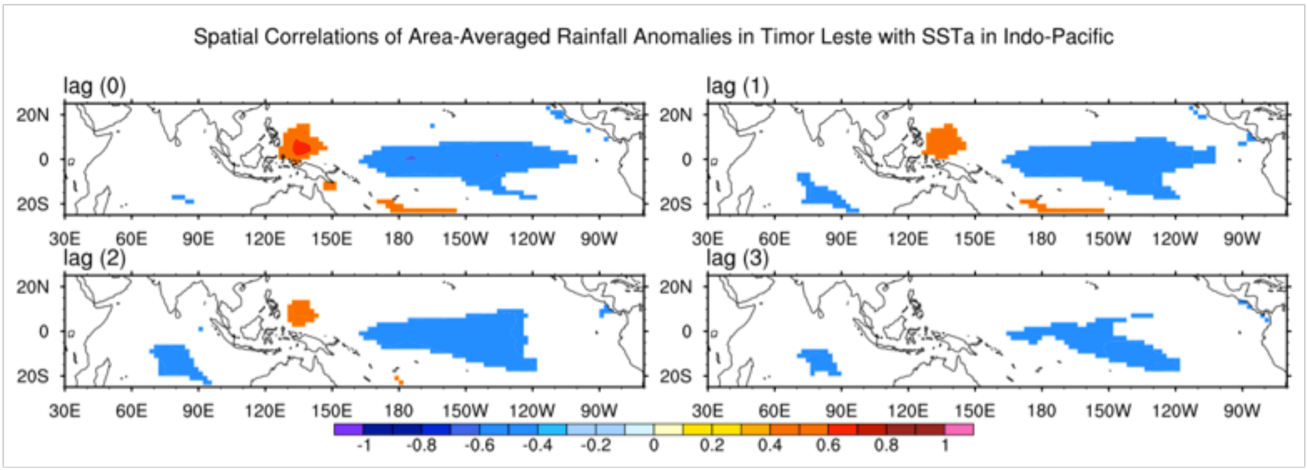
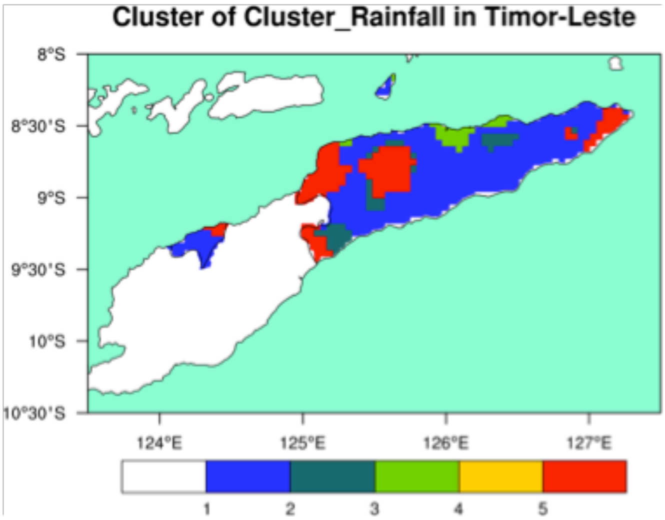


Figure 4-10 **Spatial correlations of area-averaged monthly rainfall anomalies in Timor-Leste with sea surface temperature anomalies in the Indo-Pacific region**

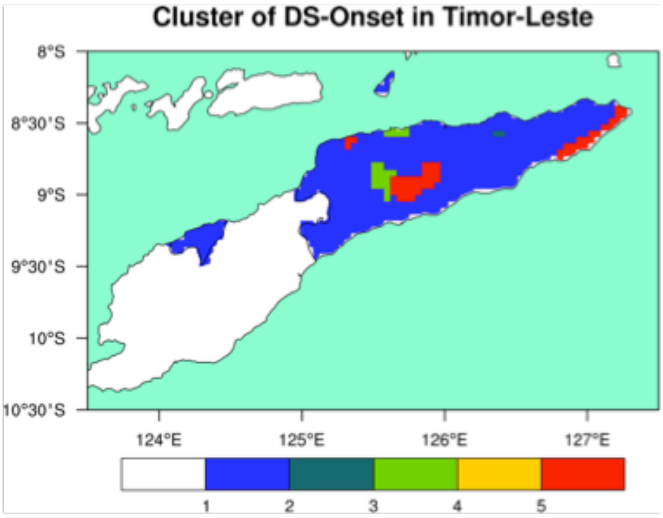
4.4.4 Onset, End and Length of the Seasons

The season onsets are important especially for agricultural and water resource management. The onset of the wet season in Timor-Leste usually occurs in early November to early December with different timing across different regions. The advance or delay of the onset could reach around 15 days in respect of the mean onset date. Figure 4-11 shows the spatial pattern for the average timing of the wet season onset across different areas in Timor-Leste. The usual timing for the onset of the dry season is early to mid-April each year. However, due to the impact of climate drivers affecting climate variability, the onset could shift earlier or later with standard deviations up to 28 days from the mean onset date (Figure 4-12).



Wet Season Onsets				
Cluster Region	Distribution Parameters			Onset Date
	Shape	Scale	Location	
1	-0.679	14	306	2 Nov ± 14 days
2	-0.624	7	318	14 Nov ± 7 days
3	-0.377	15	324	20 Nov ± 15 days
4	-0.631	4	328	24 Nov ± 4 days
5	-0.315	4	337	3 Dec ± 4 days

Figure 4-11 **Patterns of onset of the rainy seasons in Timor-Leste based on the result of cluster analysis. The onsets were calculated by using corrected TRMM data within 1998-2012 periods**



Dry Season Onsets				
Cluster Region	Distribution Parameters			Onset Date
	Shape	Scale	Location	
1	-0.028	19	93	3 Apr ± 19 days
2	-0.152	11	93	3 Apr ± 11 days
3	-0.033	17	100	10 Apr ± 17 days
4	-0.371	10	104	14 Apr ± 10 days
5	-0.206	28	104	14 Apr ± 28 days

Figure 4-12 **Patterns for the end of the rainy seasons in Timor-Leste based on the result of cluster analysis. The cessation time of the wet seasons were calculated by using corrected TRMM data within 1998-2012 periods.**

The variability of the onset of both dry and wet seasons are clearly shown in the time series plot (Figure 4-12). The onset of the dry and wet seasons in Timor-Leste are analyzed using gridded observed data from Aphrodite Dataset (Yatagai et al. 2012). The methodology for these calculations follows the onset definition used by Liebmann et al. (2007). The length of both dry and wet seasons can also be seen from Figure 4-13 based on the combination of the onset of those two seasons.

The onset of the dry and wet seasons in Timor-Leste indicates strong variability with a relatively slow rate of decreasing trends, i.e between -0.15 and -0.17 days per year for the dry and wet season, respectively. The strong variability is consistent with the period of climate events, especially ENSO, as shown from the strong deviations during the El Niño and La Niña year. The onset of the wet season tends to delay (advance) during a strong El Niño (La Niña) year. This occurs similarly for the end of the wet season (the dry season onset), but with some exceptions, depending on the El Niño (La Nina) intensity and duration. For example, the end of the wet season came earlier in 1982 at the beginning of El Niño event which was followed by the delay of onset within the same year. Meanwhile, in the 1972/73 El Niño event, the dry season onset came earlier in 1974 not long after the delay of the onset in 1973. The differences in the responses of the onset and end of the rainy season to ENSO behavior may influence the length of the wet season in the country. As a result, the relationship between the length of the wet season and ENSO is potentially lower than the relationship of onset and end of the wet season with ENSO.

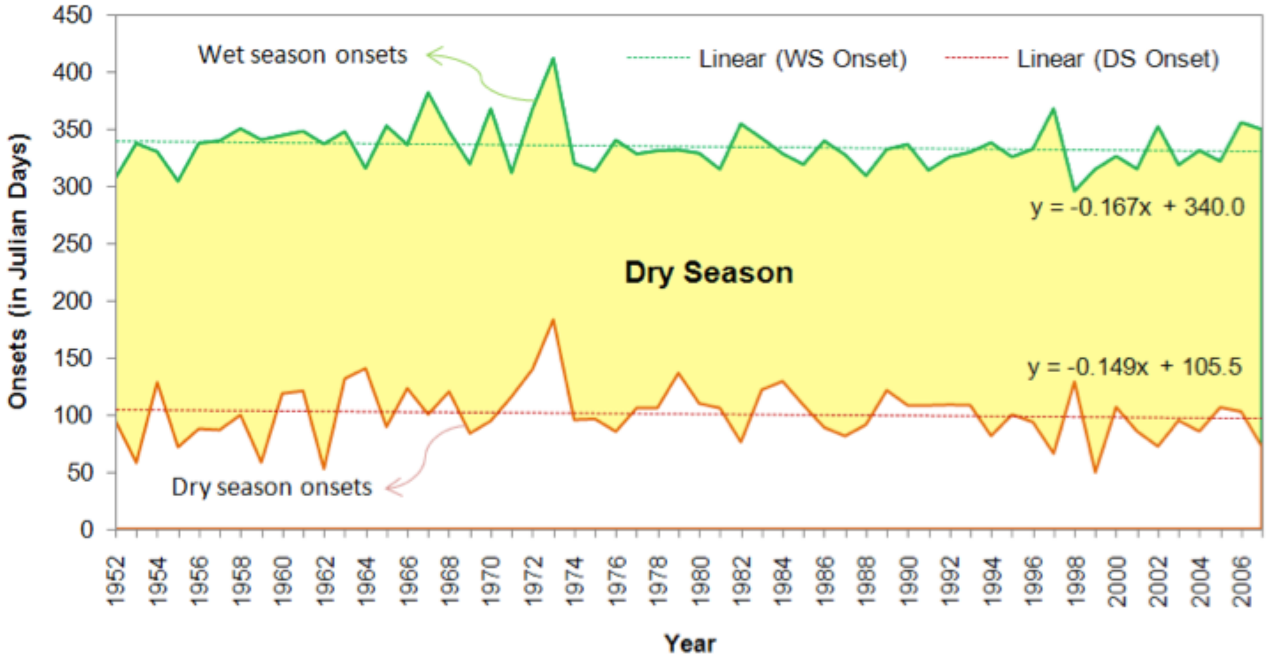


Figure 4-13 **Variability and trend of onset and end of the wet season over Timor-Leste (area-averaged) during 1951-2007 periods. Calculations are based on the methodology used by Liebmann et al. (2007). Daily rainfall data from Aphrodite was used for calculating the onset and end of the wet season and red dash-line is the end of Julian day (365) and the value beyond this red dash-line represents the Julian day of the following year.**

Variability of onset and end of the wet season within the Maritime Continent region, including Timor-Leste, is strongly affected by climate drivers in the Indo-Pacific region, especially ENSO. Since ENSO is the representation of climate phenomenon as a result of coupled air-sea interactions, it is acceptable and common to select one of many atmospheric and ocean variables in order to measure and identify ENSO behavior. A common variable used as an indicator of ENSO is sea surface temperature anomalies (SSTA).

Figure 4-14 performs the correlations between SSTA and onset of the wet season (left figures), end of the wet season (or onset of the dry season; middle figures) and the length of the wet season (right figures) in Timor-Leste. The maps are created separately for five different months of SSTA as predictors, i.e. June, July, August, September and October. It is shown that the onset is strongly correlated with SSTA both in local (negative correlations) and in remote areas in the central tropical Pacific Ocean (positive correlations). Negative correlations over the local sea indicate that warm (cold) SSTA in the local area may increase (decrease) the heat flux transferred to the atmosphere through evaporations associated with more (less) intense convections that could bring advance (delay) of the wet season onset in the country. In contrast, positive correlations found in the central Tropical Pacific Region lead to an indication where warm (cold) SSTA in the region associated with the El-Niño (La-Niña) event is associated with the onset of the dry and wet seasons.

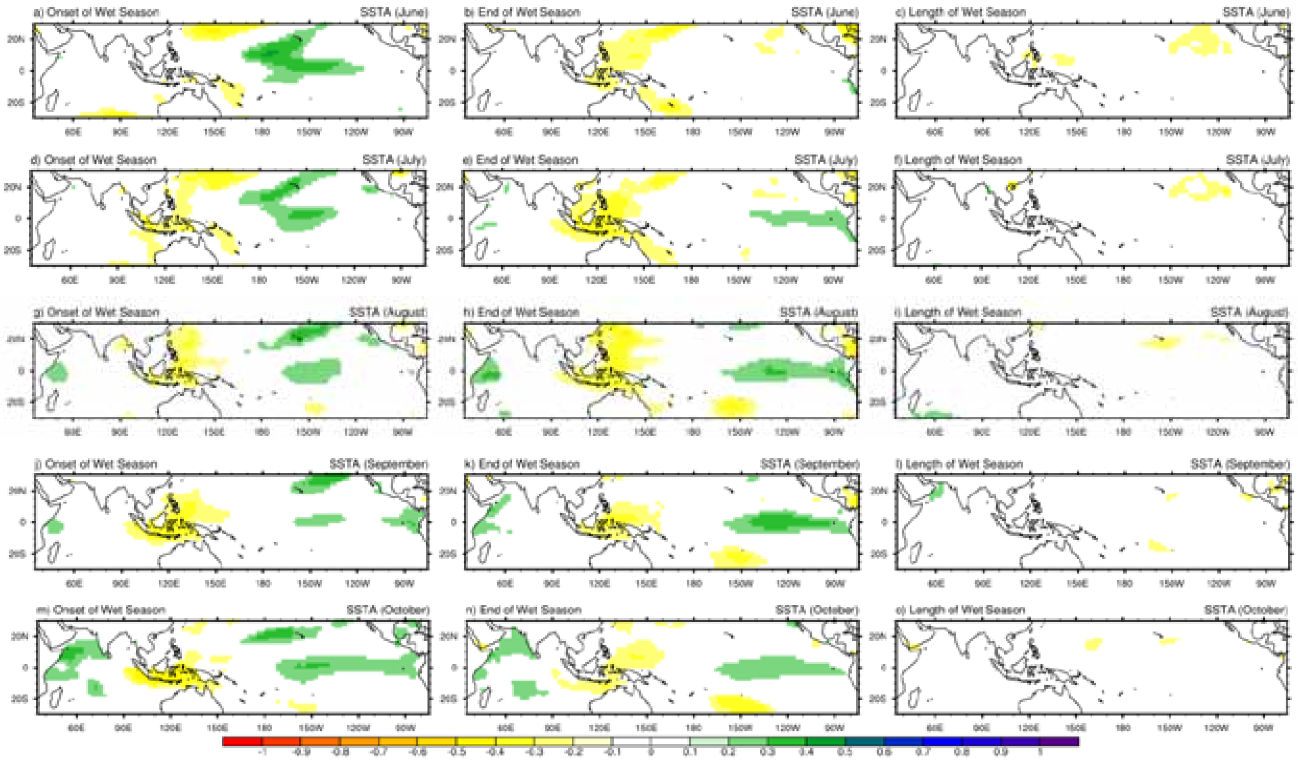


Figure 4-14 **Spatial correlations of onset, end and length of wet seasons in Timor-Leste with SSTA in Indo-Pacific in a-c) June, d-f) July, g-i) August, j-l) September, and m-o) October**

The areas of local SSTA that are significantly correlated with the onset are clearly shown in July and areas with significant correlations extend to August, September and October. This is in contrast with the correlations with SSTA in remote areas over the central tropical Pacific Ocean, where the most significant correlations are found in June and become weaker in the following months, i.e. July, August and September. The correlations become higher again for SSTA in October but with significant correlations in areas that shift from the central to the eastern part of the Tropical Pacific Oceans. Based on this finding, it can be concluded that the length of the wet season are not significantly correlated with the SSTA in the Tropical Pacific Oceans but that the onset is significantly correlated.

4.5 SEA LEVEL RISE

Based on the trends of sea level obtained from satellite altimetry data (referred to as multi-mission, see Figure 4-15), there were increasing trends of sea level rise surrounding Timor-Leste. The rate of SLR was found to be higher in the south coast (≥5.5 mm/year) than in the north (<5.5 mm/year) (Figure 4-15; left). On average, the rate of sea level rise surrounding the main island of the country based on multi-mission satellite altimetry is around 5.5 mm/year. Assuming that this rate is linearly consistent to the future (2010-2100), the sea level in the region is projected to increase around 50 mm by 2100 (Figure 4-15; right).

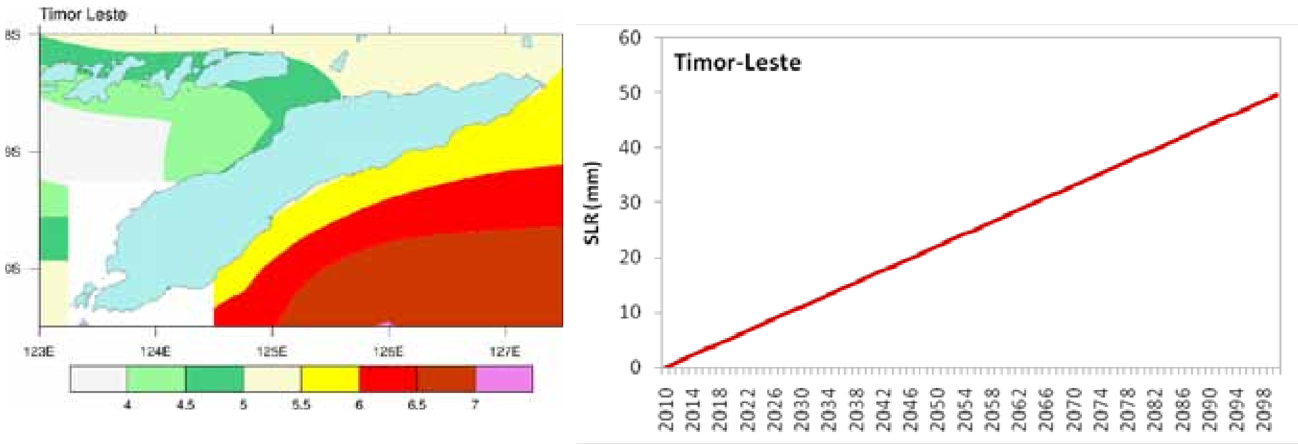


Figure 4-15 **Trend of mean sea level rise from observed multi-mission satellite altimetry during October 1992 – November 2009 (units in mm/year; left), and projected increase of sea level based in the future based on the average of current trends (units in mm; right).**

Source:http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea level/altimetry-data-and-images/index.html)

4.6 FUTURE CLIMATE CHANGE

The study of climate change in the country has been performed in several studies (Barnett et al., 2003; Barnett et al., 2007; Katzfey et al., 2010; Mol, 2010). Barnett et al. (2003) summarized future climate projections in the country by using nine GCMs of the IPCC's Third Assessment Report (TAR). The study projected that mean temperature in the country will increase around 0.3-1.2 0C by 2030 and around 0.8-3.6 0C by 2070. It is also expected that the wet season rainfall in November-April will slightly increase or decrease by 2030 (± 8%) and will increase to 20% by 2070. This is in contrast with the rainfall change in May-July (the second wet season for the southern part of Timor-Leste and the beginning of the dry season in the north) that shows a considerable decrease reaching 30% by 2030 and continuing to decrease to 80% by 2070. Similar rainfall changes are expected to occur during August-October (Figure 4-16).

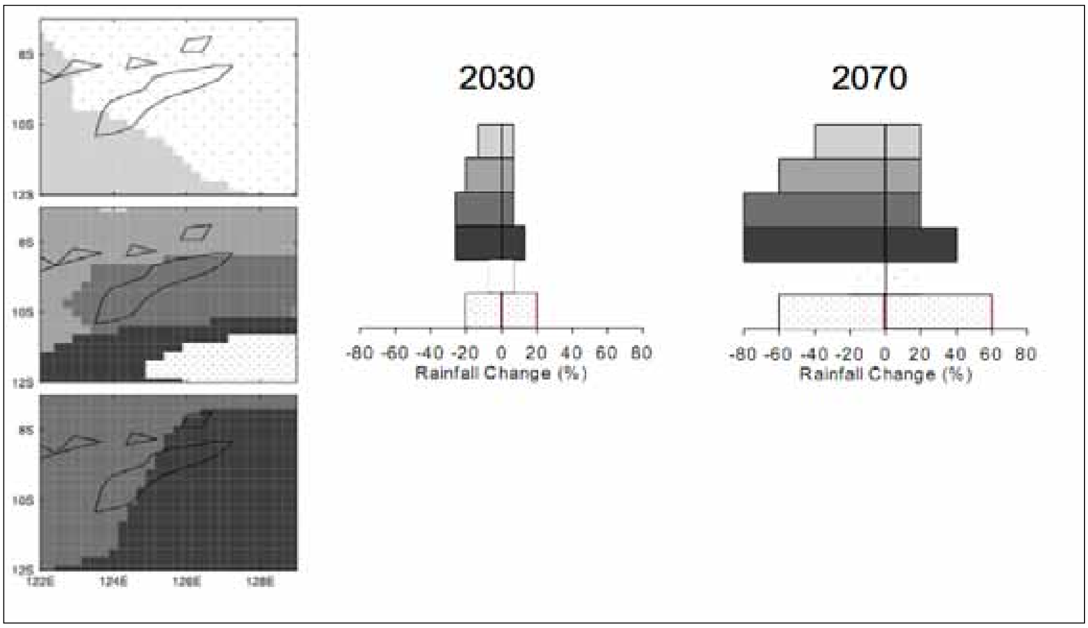


Figure 4-16 **Rainfall change in Timor-Leste for November-April (top), May-July (middle), a nd August-October (bottom).** (Source: Barnett et al. 2003)

Another climate change study was conducted by Katzfey et al. (2010). Although this study was specifically intended for Indonesia, some of the results can be used to show climate changes in Timor-Leste. The study was based on dynamical downscaling using CSIRO CCAM with the output of six GCMs. The simulations were performed with 60 km x 60 km grid resolution for selected periods between 1971 -2000 for baseline periods, and two periods for future projections under the SRES A2 scenario, i.e. 2041-2060 and 2081-2100. The study projected that the maximum and minimum temperature will increase from 1 to 2°C and 1 to 1.5°C in 2081-2100 respective to the 1971-2000 baseline. The annual rainfall is expected to decrease around 0.1 to 1 mm/day, with the most considerable decrease projected for March-April-May (MAM). In addition, MoI (2010) recently conducted another climate change study for the country. This study utilized 17 GCMs outputs divided into three future periods in 2020, 2050 and 2080 with relative baseline periods in 1961-1990. The result of analysis suggests that the mean temperature is expected to increase by around 0.8°C by 2020, 1.5°C by 2050 and 2.2°C by 2080. Meanwhile, rainfall is projected to change with a 2% increase in the average by 2020, 4% by 2050 and 6% by 2080.

The different climate change studies discussed above have provided some insights into future climate changes in Timor-Leste. Nevertheless, for the purpose of the First National Communication (INC), more detailed studies need to be conducted in order to better understand the future climate change projections for the country. It will also be necessary to conduct an updated study by using new climate change scenarios in order to get a better sense of the most recent climate change projections. In this document, we present the study of future climate change over Timor-Leste based on the output of Global Climate Models (GCMs) of the Climate Model Inter-comparison Project 3 (CMIP3) and the new CMIP5 data. The CMIP3 data is used for regional climate model simulations based on the SRES A1B scenario. The CMIP5 data is used for updating current climate change scenarios for the country. The CMIP5 data uses the new climate change scenarios, named the Representative Concentration Pathways (RCP) scenarios developed for the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC AR5).

In SRES scenarios, mitigation policy is not taken into account. The projection of emissions is merely based on the set of assumptions in which the future GHG emission depends on (i) changes in development direction from an only economic orientation to a more environmental orientation and (ii) changes in regional/global cooperation from independence to greater dependence. The high emissions scenario (SRES-A2) is expected to occur if the development orientation is focused more on economic growth without considering the environment and if collaboration across nations is low causing slow diffusion of technology. The low emissions scenario (SRES-B1) is expected to occur if development orientation is not only focused on economic growth but also on environmental protection and if collaboration across nations is high facilitating rapid diffusion of technologies across nations. One of the emissions scenarios between low and high is SRES A1B.

The global target is to stabilize the concentration of GHG in the atmosphere at a level in which the global temperature will not increase more than 2°C by 2050 from the current temperature. Findings from IPCC suggest that any increase in global temperature beyond 2°C will result in unmanageable climate change. Therefore, IPCC developed new emissions scenarios called RCP (Representative Concentration Pathways) where the emissions scenarios were developed based on the target GHG concentration level in the atmosphere.

There are four RCP scenarios namely RCP2.6, RCP4.5, RCP6.5 and RCP8.5 (Moss et al., 2008). The ideal target is scenario RCP2.6 in which mitigation is targeted to limit GHG emissions so that the peak will be at 490 ppm before 2100 and then decline. Under this scenario, the probability of global temperature to increase beyond 2°C will be less than 50%. However, considering the capacities of various nations, this target may not be achievable and the pledge may follow RCP4.5 (650 ppm CO_2e at stabilization after 2100). Without any serious mitigation effort, the future emissions may follow RCP 6.5 (850 ppm CO_2e at stabilization after 2100) or RCP8.5 (1,370 ppm CO_2e in 2100).

4.7 PROJECTIONS OF IPCC AR4 CMIP3 MODELS WITH SRES SCENARIOS

4.7.1 Temperature

The changes in temperature in the future were assessed for Timor-Leste based on the output of Regional Climate Model 3 (RegCM3) by comparing the mean temperature difference in the future (2041-60 and 2061-80 periods) based on their departure from the current baseline (1981-2000 period). The projection is based on the SRES A1B scenario. It was clearly shown that mean temperatures are expected to increase in the future. This is consistent with future projections of mean temperatures for other countries as indicated in many studies. The mean temperatures during the 2041-60 and 2061-2080 periods are expected to increase from the current temperature between 1.5°C and 1.8°C and between 2.1°C and 2.7°C respectively.

4.7.2 Rainfall

In the future, the rainfall in Timor-Leste is expected to change. Figure 4-17 demonstrates the change of seasonal rainfall in the future respective to the 20th century baseline for the country. The analyses performed in these figures are based on the output of RegCM3 simulations under the SRES A1B scenario. The seasonal rainfall climatology in Timor-Leste is expected to increase in some or all parts of the country especially from wet to dry seasons (DJF, MAM and JJA). The most considerable increase is expected to occur in JJA during the 2041-60 period. During the transition period, the seasonal rainfall climatology in SON is predicted to be drier than the historical baseline, especially in the 2061-80 period. In general the seasonal rainfall climatology in the region will be much wetter during 2041-60 than 2061-80 periods.

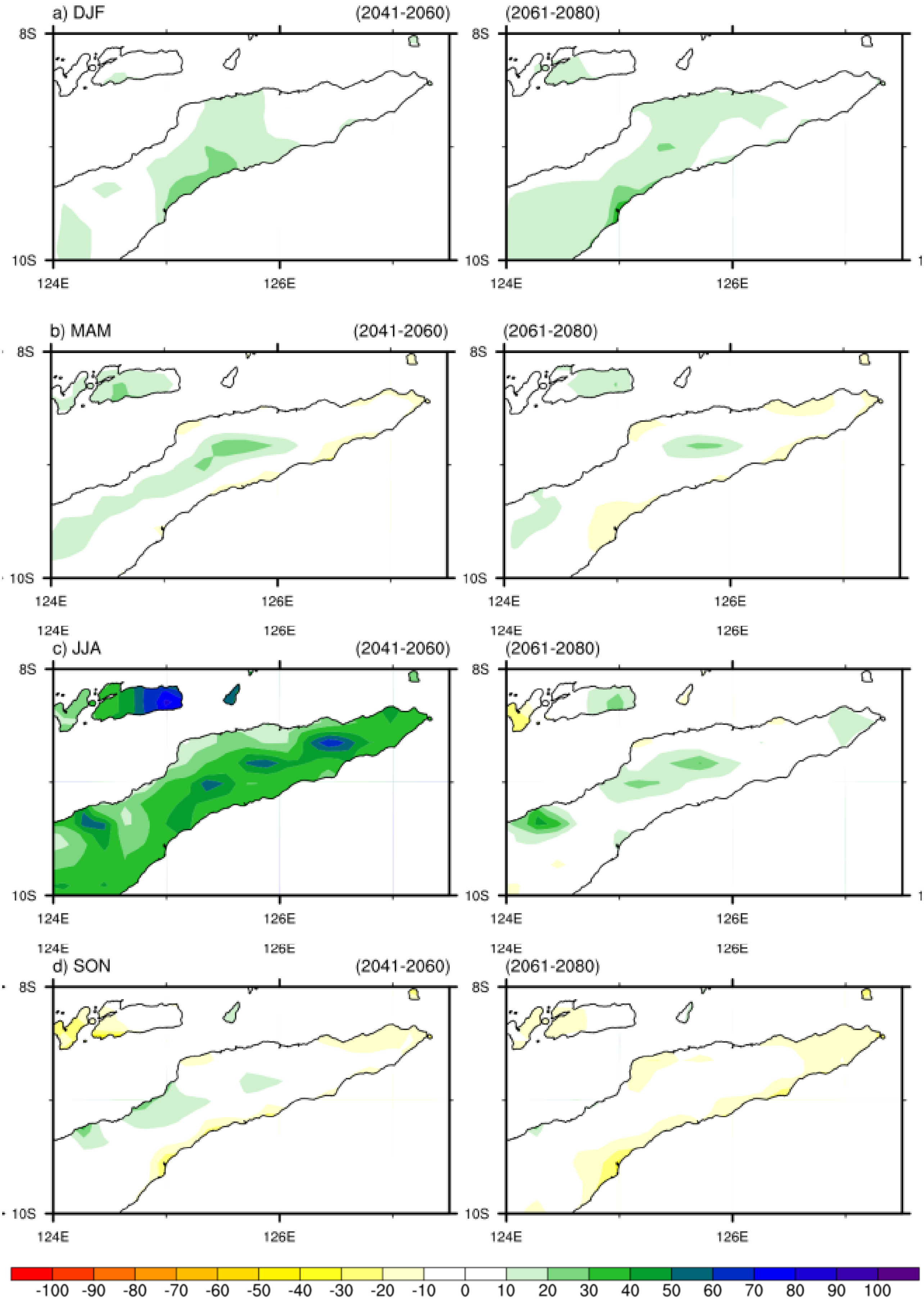


Figure 4-17 **Seasonal rainfall differences in Timor-Leste based on the output of RCM projected for 2050 (mean value of 2041-2060 periods) and 2070 (mean value of 2061-2080 periods) relative to the 1981-2000 baseline (in %).**

In addition to the analysis of seasonal rainfall projections from RegCM3, we compare the patterns of seasonal rainfall differences simulated by RegCM3 with the map of proportion stating the agreement of GCMs in projecting the change of seasonal rainfall in the future. This analysis only compares the projection results under SRES A1B scenario (Figure 4-18) since only the RegCM3 model is simulated under this scenario. The seasonal rainfall difference is stated as a percentage (%) and is calculated by subtracting the seasonal climatology of future rainfall projection from the current baseline, and by dividing the result with the baseline in order to define the change in percentage. The proportion maps of GCMs are calculated by identifying the ratio of GCMs that have similar agreements in projecting the change of seasonal rainfall climatology in the future. The range of proportion values is from 0 to 1. The higher (lower) the value indicates that more (less) GCMs agree with the increase of seasonal rainfall climatology in the future. If the value is in the middle of the range (0.5), it indicates that half of the models agree with the increase of seasonal rainfall, while the other half of the models agree with the decrease. This may also indicate that there might be no change of seasonal rainfall in the future.

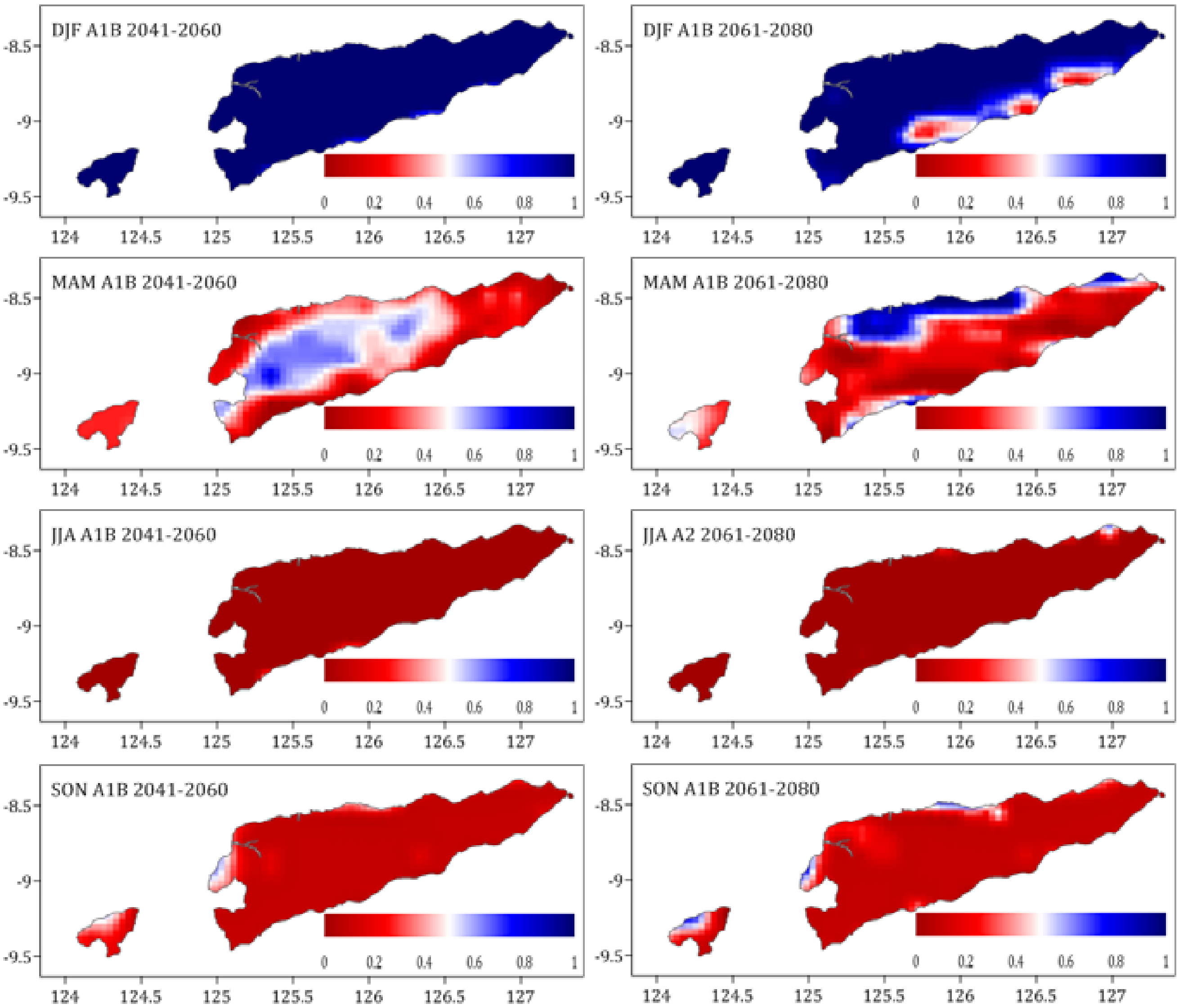


Figure 4-18 **Seasonal rainfall differences in Timor-Leste based on GCM ensembles under the SRES A1B scenario projected for 2050 (mean value of 2041-2060 periods) and 2070 (mean value of 2061-2080 periods) relative to the 1981-2000 baseline (in %)**

The GCMs proportion in projecting the rainfall change in Timor-Leste seems to be inconsistent with the patterns of seasonal rainfall differences projected by RegCM3. The ensemble model only shows similar agreement with the RegCM3 patterns during MAM in 2041-60 and SON in both 2041-60 and 2061-80 periods. The GCM ensemble projections under different scenarios, i.e. SRES A2 and B1, can be seen in Figure 4-19 and 4-20, respectively.

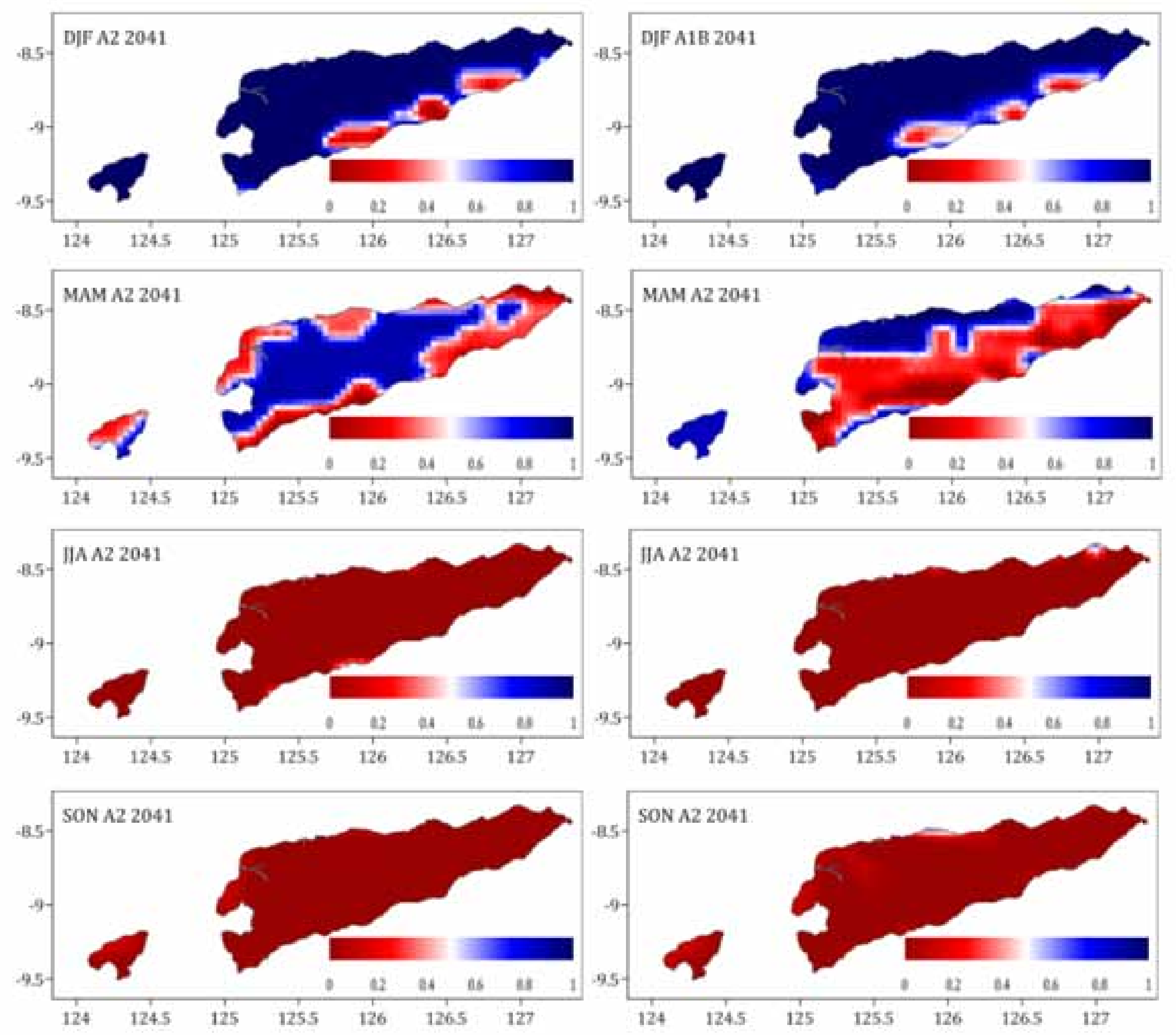


Figure 4-19 **Seasonal rainfall differences in Timor-Leste based on GCM ensembles under the SRES A2 scenario projected for 2050 (mean value of 2041-2060 periods) and 2070 (mean value of 2061-2080 periods) relative to the 1981-2000 baseline (%)**

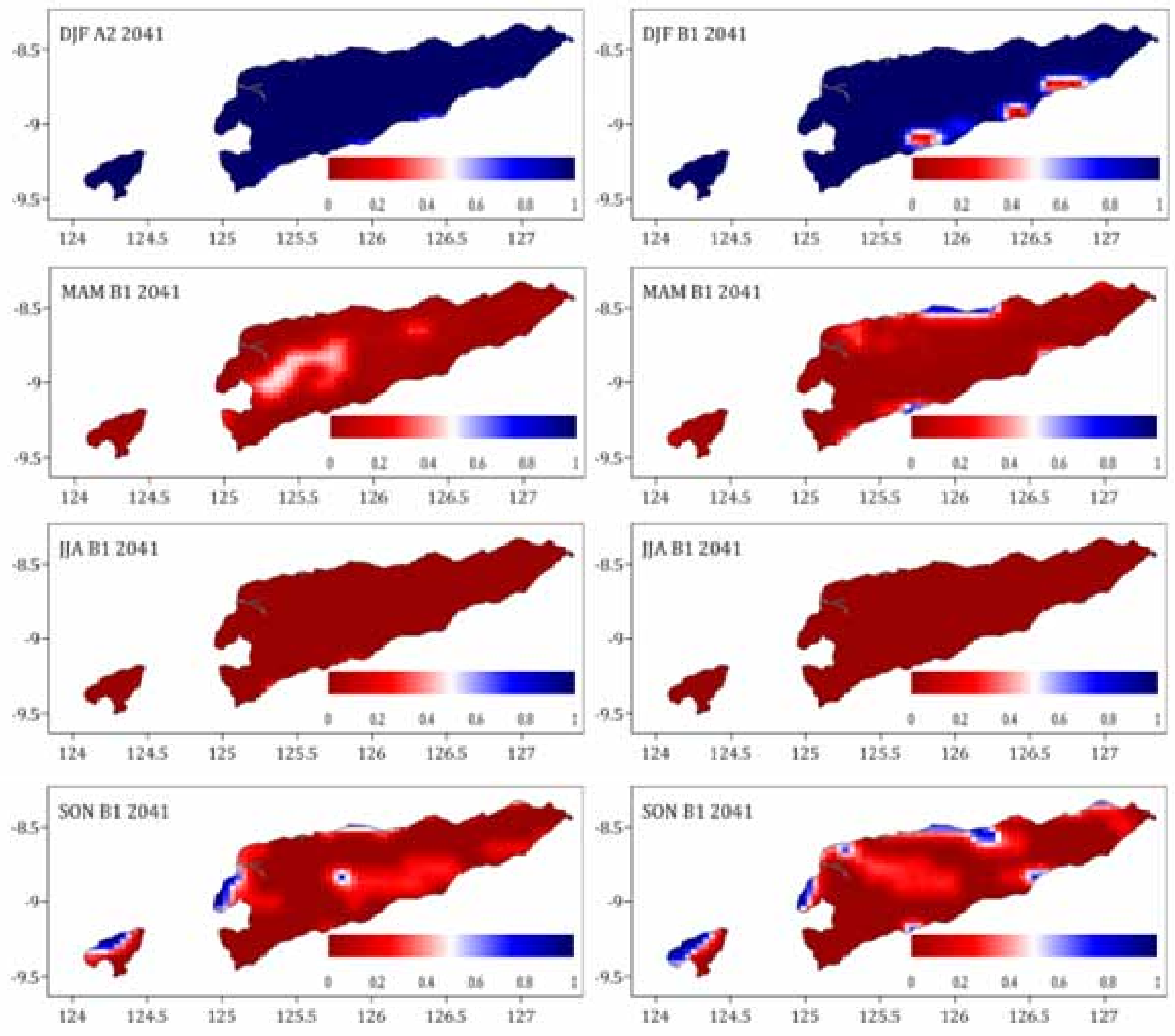


Figure 4-20 **Seasonal rainfall differences in Timor-Leste based on GCM ensembles under SRES B1 scenario projected for 2050 (mean value of 2041-2060 periods) and 2070 (mean value of 2061-2080 periods) relative to the 1981-2000 baseline (%).**

4.7.3 Sea Level Rise

Previously, the future SLR projection was calculated by using the trend of observed historical altimetry data. In this subsection, the resultant trend from multi-mission satellite data is combined with the future projections of six GCMs data and their ensemble (2010-2100 period) under the SRES A1B scenario. In average, the sea level surrounding Timor-Leste is expected to increase around 0.76 meters by 2100 (Table 4-1).

Table 4-1 **Sea level trends and projected SLR increase based on the multi-mission satellite combined with projected global mean sea level from six GCMs and their ensemble (2010-2100 period)**

Sources	SLR Rate (mm/year)	Projected SLR (m)
Multi-Mission Satellite Altimetry	5.5	0.50
+ mri_cgcm	6.8	0.62
+ cgcm_t47	8.1	0.73
+ giss_er	9.9	0.90
+ miroc_hi	9.4	0.85
+ miroc_med	8.7	0.79
+ miub_echo	7.6	0.69
+ GCM Ensembles	8.4	0.76

4.8 PROJECTIONS OF IPCC AR5 CMIP5 MODELS WITH RCP SCENARIOS

4.8.1 Temperature

The area averaged monthly mean temperature anomalies calculated from the multi-model ensemble of CMIP5 GCMs with four RCP scenarios as well as from CMIP3 GCMs with the SRES A1B scenario are shown in Figure 4-21. From these projections, it is found that there are no significant differences in the range of the trends prior to year 2035. The mean increase of temperature for Timor-Leste to 2035 is expected not to exceed 1 °C. The projection shows that the difference in the increase of mean temperature trends across different scenarios will be more considerable after the year 2035. The increase in the temperature anomalies will range from 0.5°C to around 3.5°C by 2100 based on the lowest range scenario (RCP2.6) into the highest range scenario (RCP8.5), respectively. For the SRES A1B scenario, the increase of mean temperature will be around 2°C by 2100 from the current baseline. This value is in between of RCP6.0 and RCP8.5.

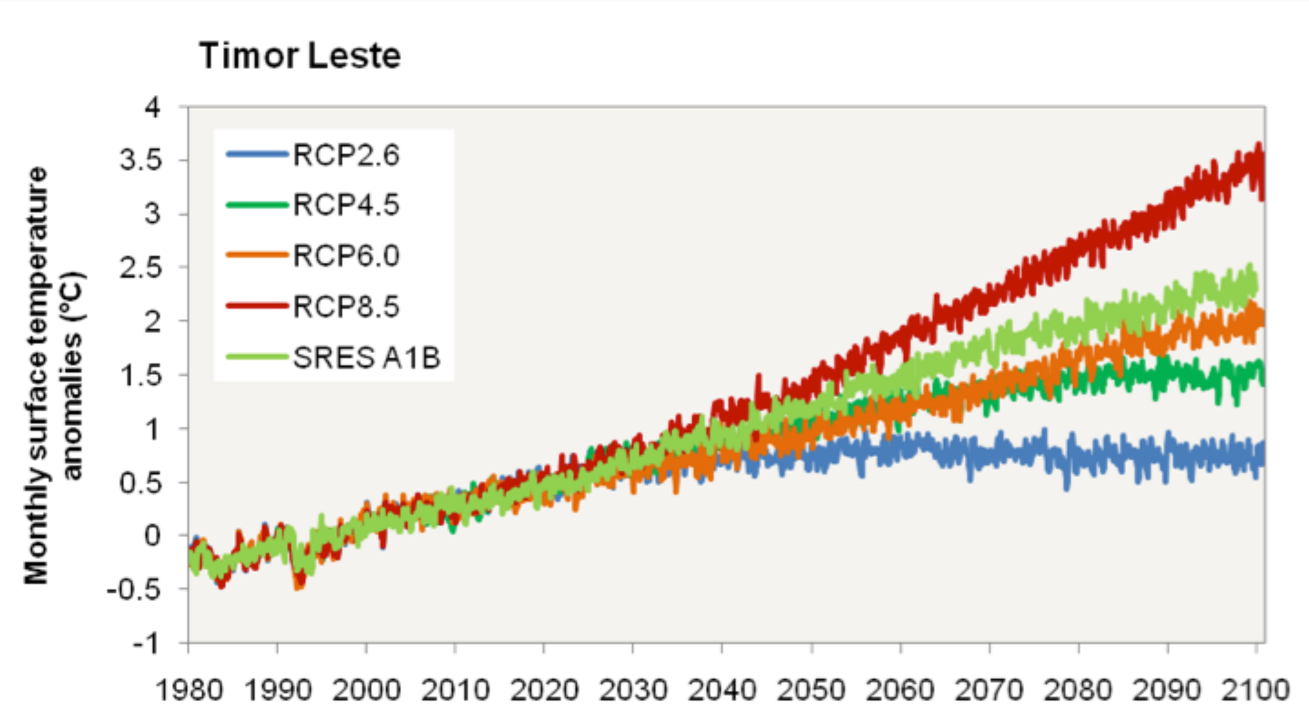


Figure 4-21 **Projections of monthly mean temperature anomalies in Timor-Leste based on the multi-model ensemble mean under four RCP scenarios and SRES A1B scenario.**

4.8.2 Rainfall

Changes of Rainfall Types

The spatial patterns of rainfall in Timor-Leste are expected to change in the future. This is shown by the changes in the total area of each rainfall type as shown in Figure 4-22 and 4-23 (see Figure 4-4 as reference for rainfall types). Consistent decreases are found at all periods in the RCP2.6 scenario for total rainfall area in Type 1, 2 and 4, with the decrease reaching 10% of the current total area. Similar consistent decreases for the same rainfall types are also found in the RCP6.0 scenario but only during the 2041-2070 and 2071-2100 periods with the decreases less than 8%. The decreases of total area having Type 1, 2 and 4 rainfall regions contribute to the increase of total area having Type 3 and 5 rainfall regions.

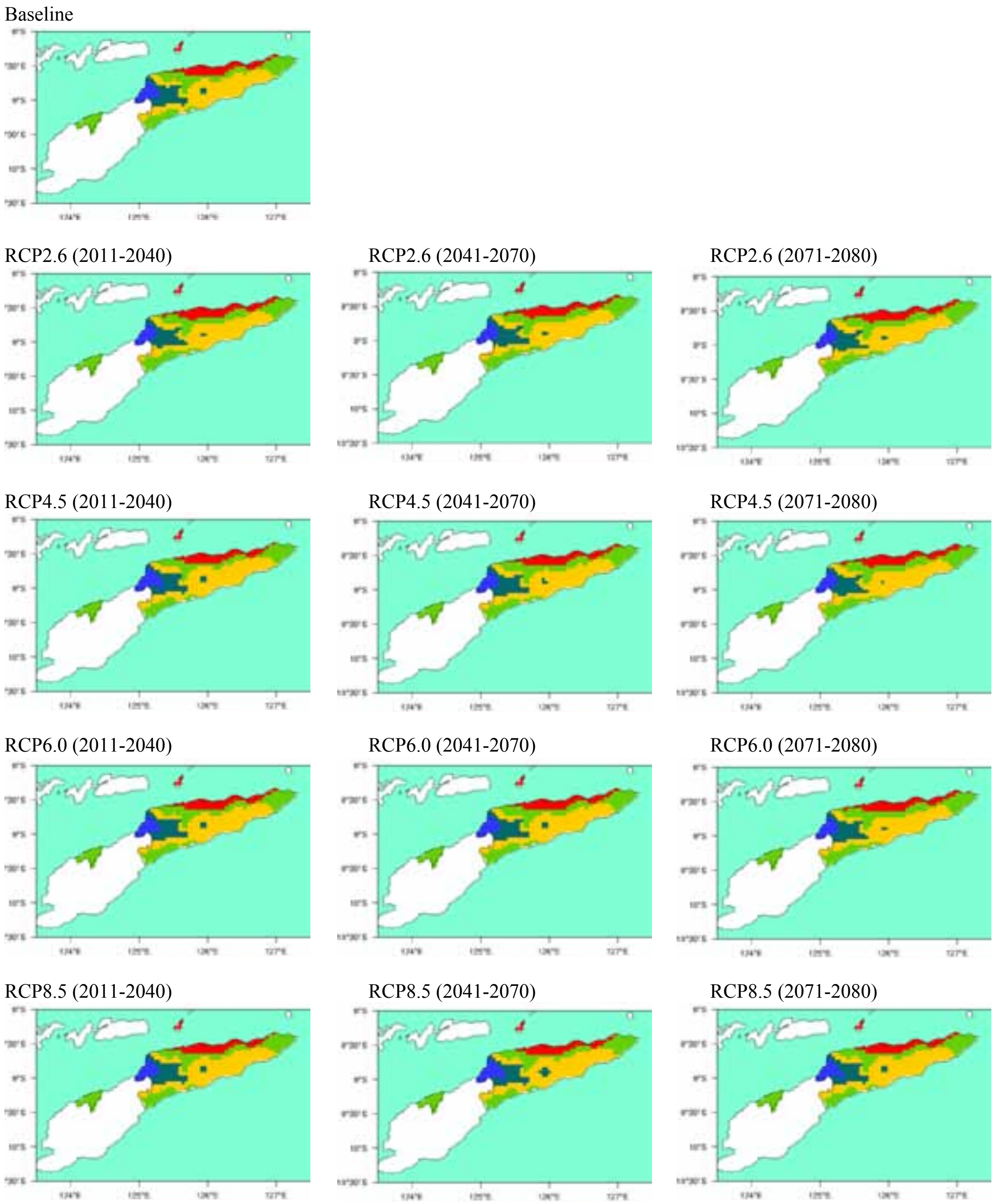


Figure 4-22 **Changes in the spatial patterns of rainfall types in Timor-Leste based on the 20 GCMs multi-model ensemble projection under four RCP scenarios at three different future periods, i.e. in 2011-2040, 2041-2070 and 2071-2100**

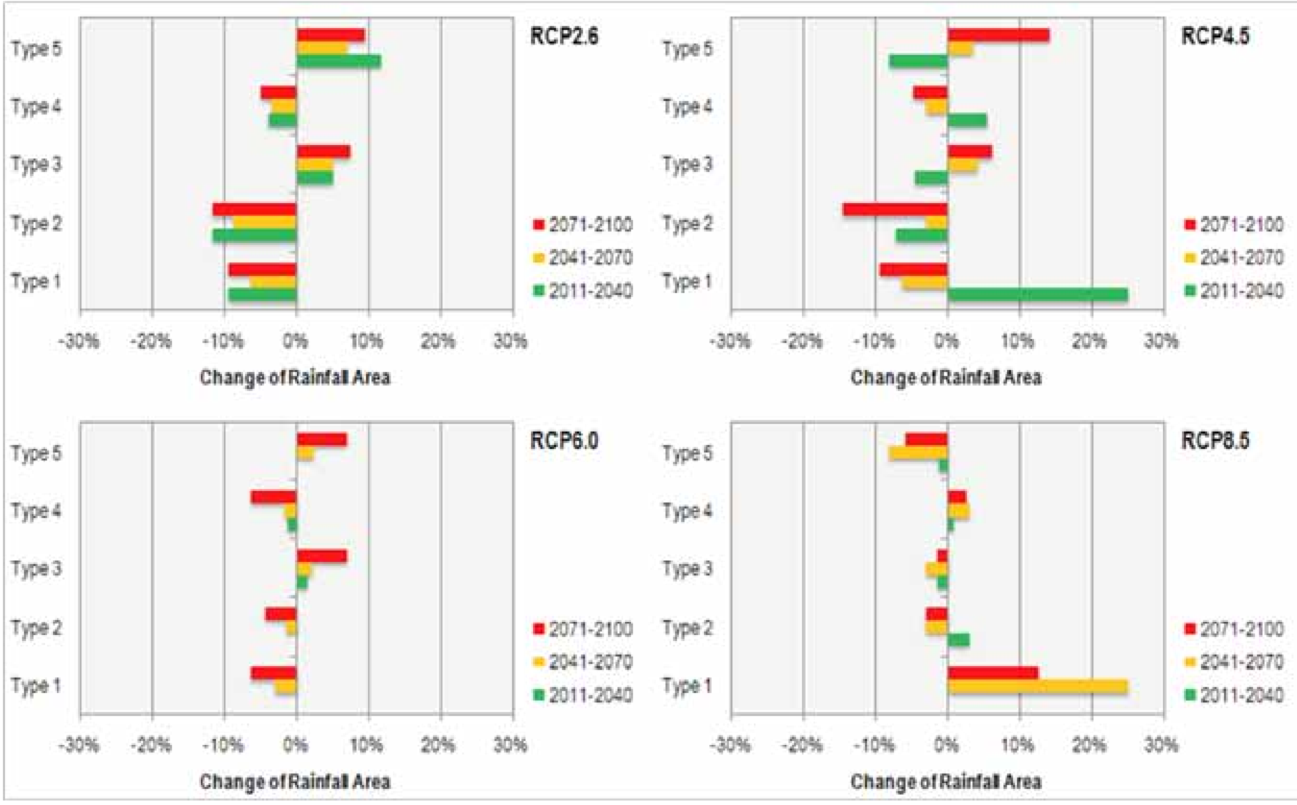


Figure 4-23 **Projected changes of total area at different rainfall types**

In the RCP4.5 scenario, the changes of total rainfall area across different rainfall types are varied at different periods. The highest increase is found in the Type 1 rainfall region during the period 2011-2040, reaching a more than 20% increase. Such an increase contributes to the decrease of areas having Type 2, 3 and 5 rainfall.

Changes of Monthly and Seasonal Rainfall Climatology

Timor-Leste is projected to experience some changes in monthly and seasonal rainfall climatology in the future, as has already happened in the past (see Figure 4-5 and 4-7). Unlike the change of monthly rainfall climatology in the past where the changes were mostly found in the wet season, the future projections indicate that the change of rainfall will be expected to occur in the dry season and the transition of the season, especially from July to October in the 2011-2040 and 2071-2100 periods. The rainfall increases during those months may reach more than 10% of the current rainfall baseline. In 2041-2070, more rainfall is expected during transition periods in March, April and May, as well as in September. Meanwhile, rainfall is projected to decrease in June and July during that period (Figure 4-24).

Based on the consensus of 20 CMIP5 GCMs, it can be seen that in 2011-2040 and 2041-2070 under RCP2.6 scenario, the models agree that the wet season rainfall in the DJF season is expected to decrease compared to the current baseline. Within the same scenario, the models agree that there will be an increase in MAM rainfall, especially during the 2041-2070 and 2071-2100 periods. For the JJA and SON periods, there is only around 0.5% probability that rainfall will increase in all periods, except for the SON rainfall in 2041-2070 where most models agree that the season will experience a rainfall decrease (Figure 4-25).

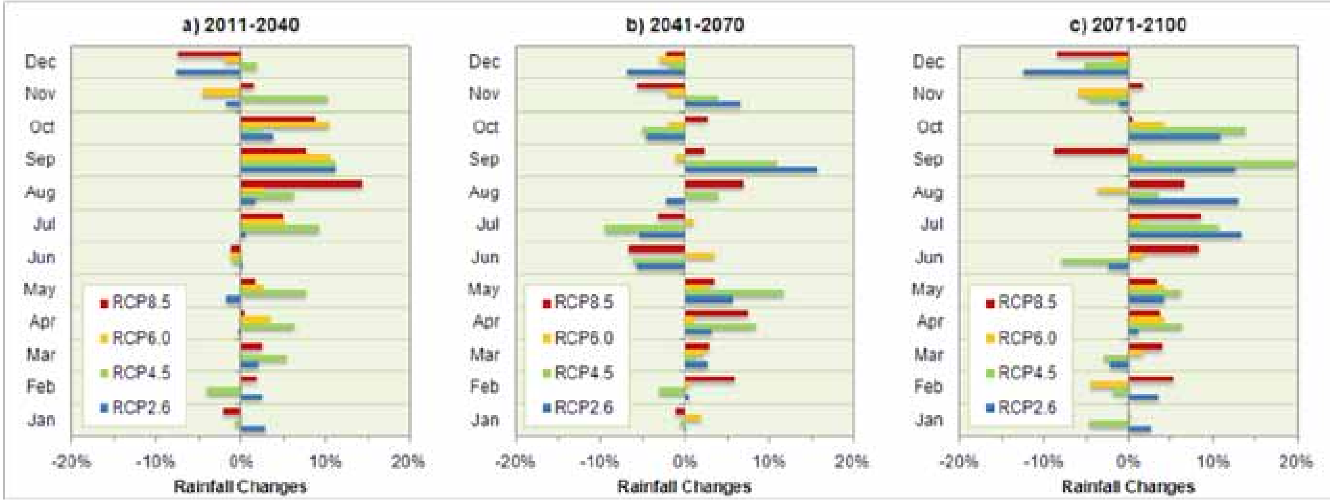


Figure 4-24 **Changes of monthly rainfall climatology in Timor-Leste as projected by the median of 20 CMIP5 GCMs based on four RCP scenarios**

Under the RCP4.5 scenario, different projections' results on future rainfall are shown (Figure 4-26). Unlike the RCP2.6 scenario, dry season rainfall under the RCP4.5 scenario is expected to increase in the future, especially during the 2011-2040 and 2041-2070 periods. Nevertheless, a similar projection result is found for SON rainfall in 2041-2070 with the RCP6.0 scenario (Figure 4-27), where most models agree that the season will experience a rainfall decrease over some areas in the country. Especially for this season and time periods, most models under the RCP6.0 scenario project an increase of rainfall. Under the highest range scenario (RCP8.5; Figure 4-28), the models mainly show a nearly fifty-fifty change of agreement, indicating a very low consensus in projecting future seasonal rainfall in Timor-Leste. This is similarly found in other RCP scenarios. The only clear agreement of the model is the consensus in projecting an increase of future rainfall in Timor-Leste under the RCP8.5 for the MAM season during the 2011-2040 and 2041-2070 periods.

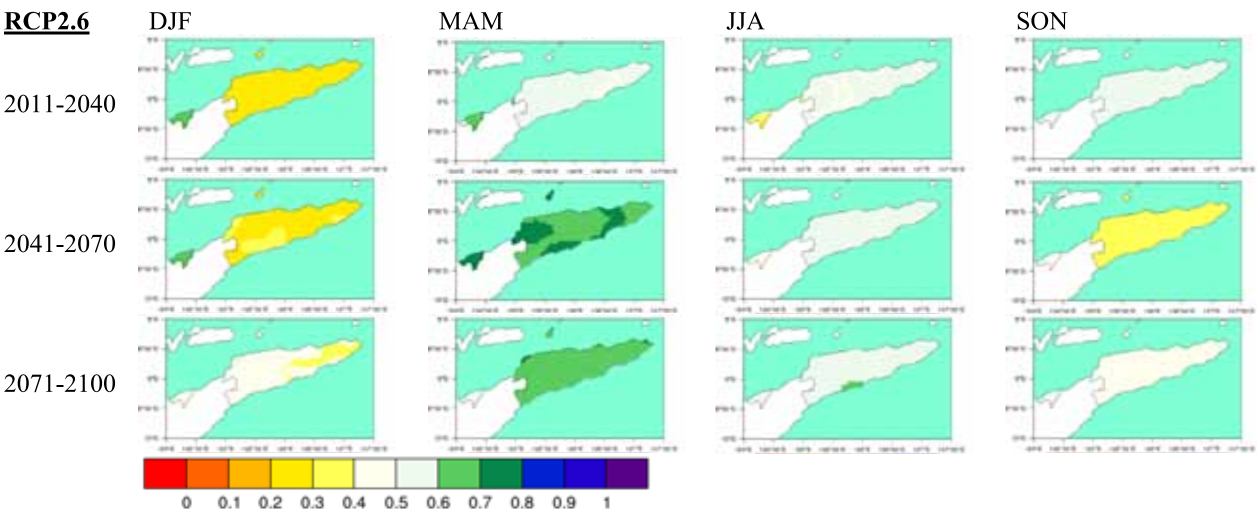


Figure 4-25 **Level of probability of 20 CMIP5 GCM models under the RCP2.6 scenario in projecting seasonal rainfall increases in Timor-Leste**

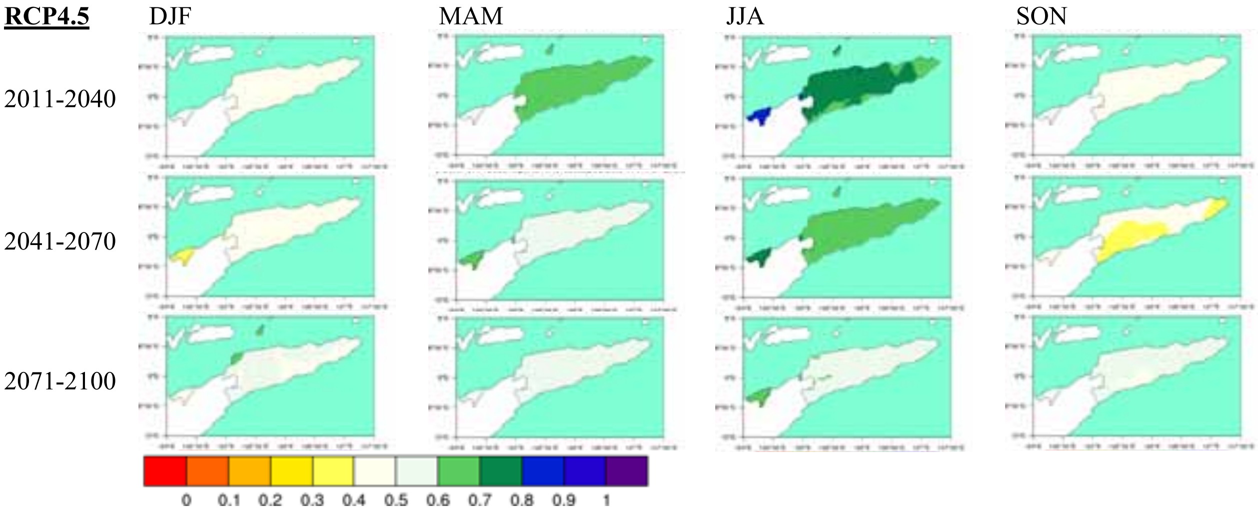


Figure 4-26 **Level of probability of 20 CMIP5 GCM models under the RCP4.5 scenario in projecting seasonal rainfall increases in Timor-Leste**

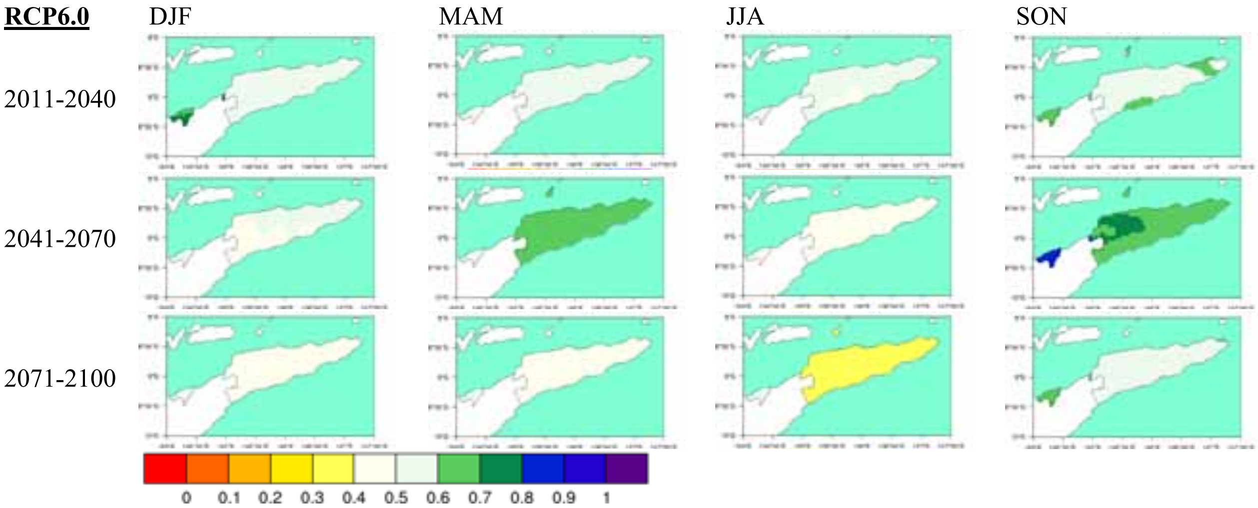


Figure 4-27 **Level of probability of 20 CMIP5 GCM models under the RCP6.0 scenario in projecting seasonal rainfall increases in Timor-Leste**

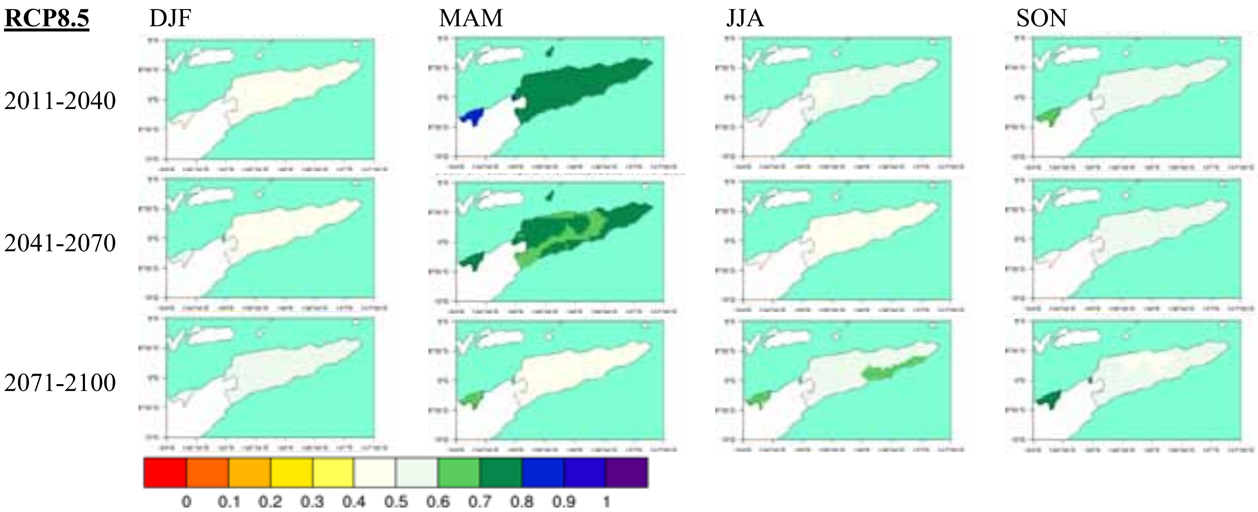


Figure 4-28 **Level of probability of 20 CMIP5 GCM models under RCP8.5 scenario in projecting seasonal rainfall increases in Timor-Leste**

Changes of the Dry and Wet Season Onsets

Based on the projections of the future onset of the dry and wet season using statistical downscaling methods, Timor-Leste is projected to experience some changes to the average timing of the seasonal onset in the future. Figure 4-29 indicates that most of the timing of the dry season onset in the country will be shifted. In the current period, most of the regions in Timor-Leste experience the dry season onset in early April with variability of around 19 days. In the future, some of the country will have delays until mid-April with an average variability that could reach around 28 days of advance and delays of the onset due to climate factors driving rainfall variability. The changes of the timing of dry season onsets will vary, depending on future periods and scenarios.

Unlike the changes of the means and variability of the dry season onset, the changes to the wet season onsets in Timor-Leste are expected to be consistent across different periods and scenarios (Figure 4-30). The projections show that the wet season onsets will shift from early to end of November in most of the regions, with some regions shifting to mid November. Although there is a consistent shift especially from early November (Region 1) to end of November (Region 4), the variability of future timing of the wet season onsets will be smaller as indicated by smaller standard deviations from 14 to only 4 days. The changes in the characteristics of the dry and wet season onsets will slightly influence several important sectors in the country, especially the agriculture and water resource sectors.

Baseline

Cluster Region		Distribution Parameters			Onset Date
		Shape	Scale	Location	
	1	-0.028	19	93	3 Apr ± 19 days
	2	-0.152	11	93	3 Apr ± 11 days
	3	-0.033	17	100	10 Apr ± 17 days
	4	-0.371	10	104	14 Apr ± 10 days
	5	-0.206	28	104	14 Apr ± 28 days

Dry Season Onsets

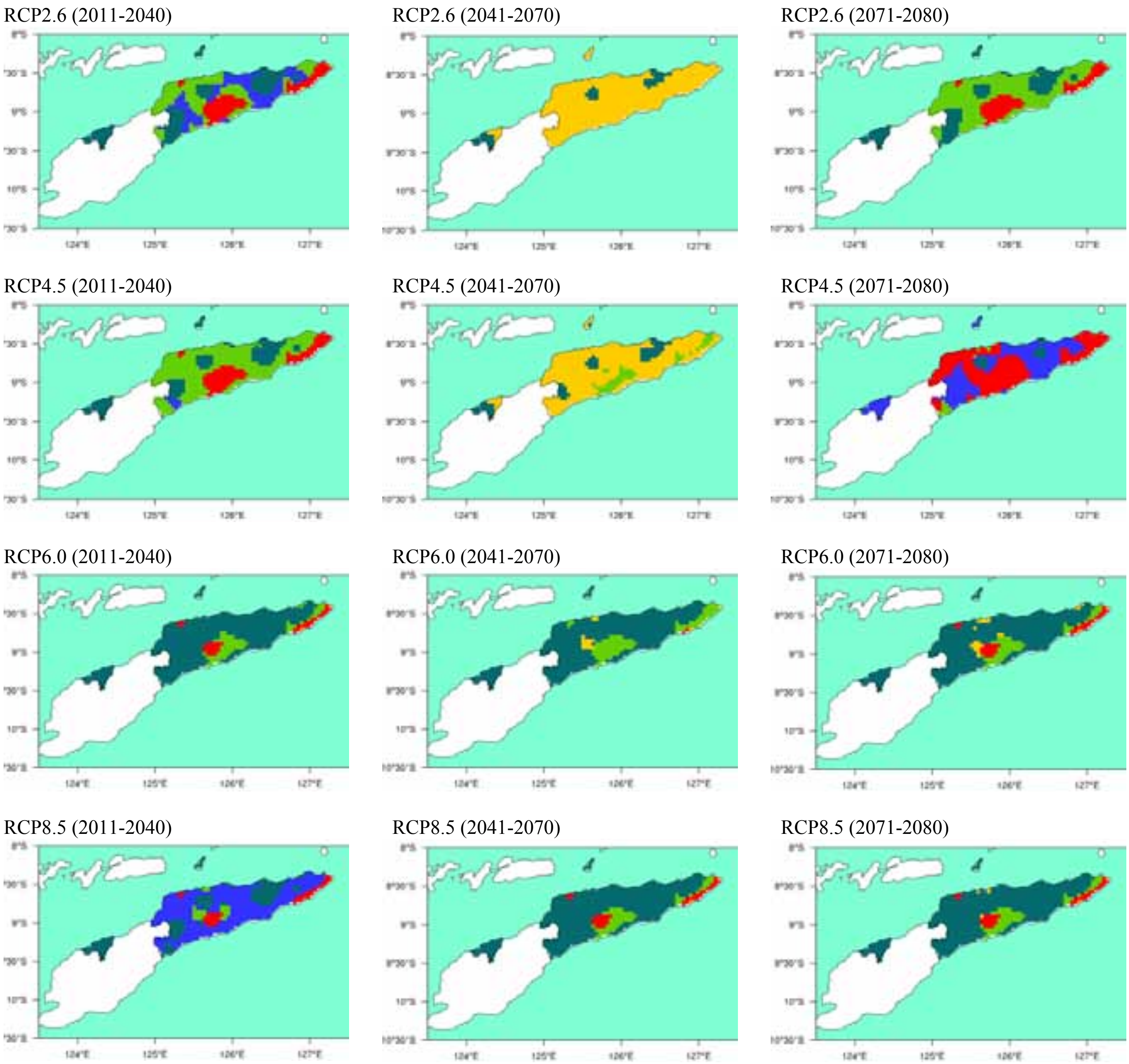
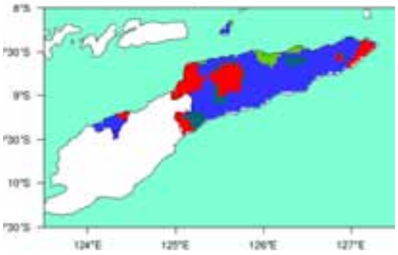


Figure 4-29 **Projected changes of dry season onsets from 20 GCMs CMIP5 in Timor-Leste compared to the current baseline**

Baseline



Cluster Region	Distribution Parameters			Onset Date
	Shape	Scale	Location	
1 (blue)	-0.679	14	306	2 Nov ± 14 days
2 (teal)	-0.624	7	318	14 Nov ± 7 days
3 (light green)	-0.377	15	324	20 Nov ± 15 days
4 (orange)	-0.631	4	328	24 Nov ± 4 days
5 (red)	-0.315	4	337	3 Dec ± 4 days

Wet Season Onsets

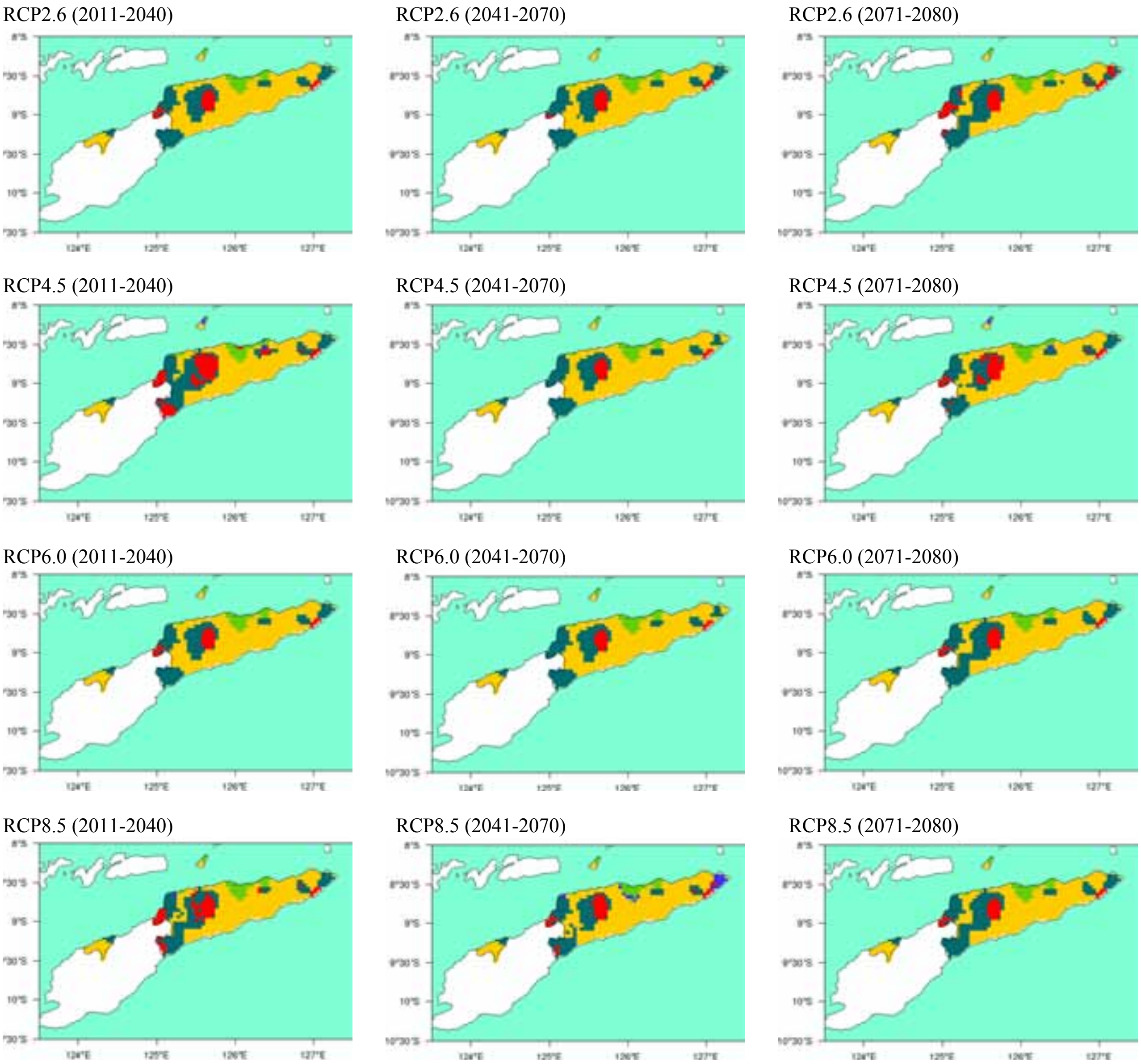


Figure 4-30 **Projected changes of wet season onsets from 20 GCMs CMIP5 in Timor-Leste compared to the current baseline**

4.9 VULNERABILITY ASSESSMENT

At present Timor-Leste is considered one of the top 10 countries in the world in terms of their vulnerability to the impact of climate change (UNU-EHS, 2011). Timor-Leste, the three island nations of Vanuatu, Tonga and the Solomon Islands, together with Philippines, Bangladesh, Cambodia, Guatemala, Costa Rica, and El Salvador have the highest world risk index (Figure 4-31 left). The risk index was calculated by combining exposure to natural hazards with the vulnerability of a society, which in turn combines its susceptibility and its coping and adaptive capacities. Factors that contribute to Timor-Leste's high risk index are mainly high exposure to hazards, and relatively high vulnerability and susceptibility and lack of coping capacity and adaptive capacity (Figure 4-31 right).

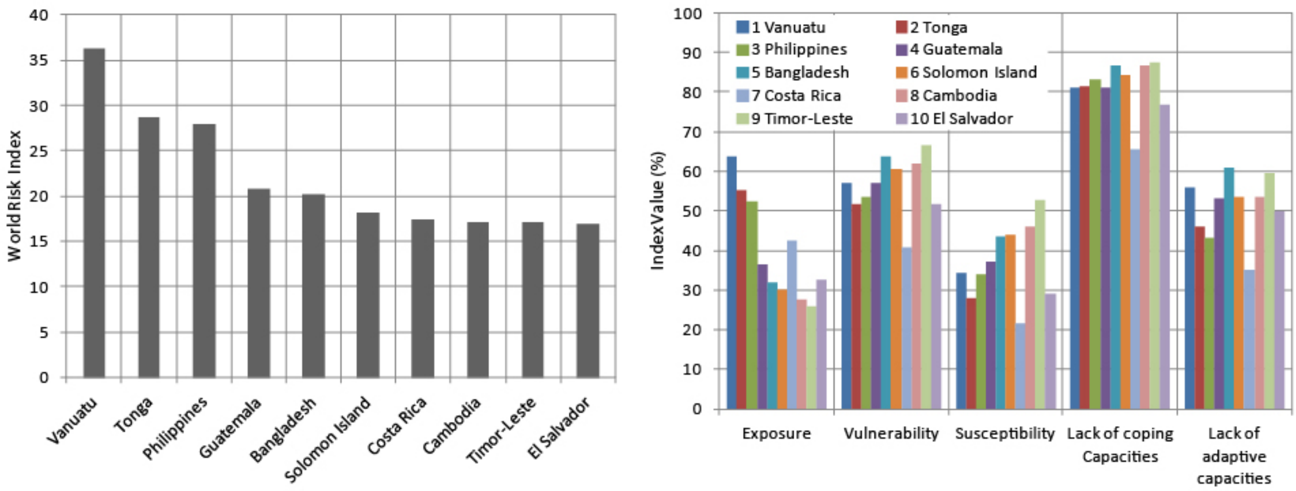


Figure 4-31 **World Risk Index of the top ten countries (left) and factors causing the countries to be high risk (right)**

The INC undertook further vulnerability assessment at the village ('suco') level by adopting the IPCC approach (IPCC 2001 and 2007) where vulnerability is measured using three dimensions, namely level of exposure, level of sensitivity and adaptive capacity. Vulnerability is defined as: 'the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity'. (IPCC 2001, 2007)

Exposure is the degree, duration and/or extent to which the system is in contact with, or subject to, the perturbation (Adger 2006 and Kasperson et al. 2005 in Gallopin 2006). Sensitivity is internal to the system and is determined by the human and environmental conditions. Adaptive capacity is defined as the 'ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences' (IPCC 2007). Thus a system which has a high level of exposure and sensitivity with low adaptive capacity will be considered as a most vulnerable system while those with a low level of exposure and sentivity with high adaptive capacity will be considered as less vulnerable.

Using biophysical, social and economic indicators to represent the exposure, sensitivity and adaptive capacity, sucos in Timor-Leste can be grouped into five categories. Sucos with high levels of exposure and sensitivity and low adaptive capacity are considered the most vulnerable, while those with low levels of exposure and sensitivity and high adaptive capacity are not. Sucos with low exposure, sensitivity and adaptive capacity are considered as vulnerable, those with high exposure, sensitivity but high adaptive capacity are less vulnerable, and those with medium level of exposure, sensitivity and adaptive capacity are considered as quite vulnerable.

Based on biophysical, social and economic data of 2010, 44.7% of the sucos in Timor-Leste could be categorized as quite vulnerable, 2.9 % vulnerable and 11.5 % very vulnerable. Thus only 18.6% sucos were less or not vulnerable. The vulnerable sucos are mostly located in the western part of the country (Figure 4-32). The impact of climate change is expected to be high in the vulnerable sucos and therefore, these sucos should be the highest priority for the implementation of adaptation actions. Improving the capacity of the sucos to manage climate risk in key sectors such as agriculture and water is very important as part of the effort to reduce their vulnerability. The inability of sucos to manage the impact of climate change on these key sectors will cause them to become more vulnerable. For example, losses in agricultural production due to climate change will increase poverty within the sucos and this in turn will contribute to an increase in their vulnerability. Therefore, assessment of climate change impact on key sectors sector is crucial to assist in identifying adaptation options.

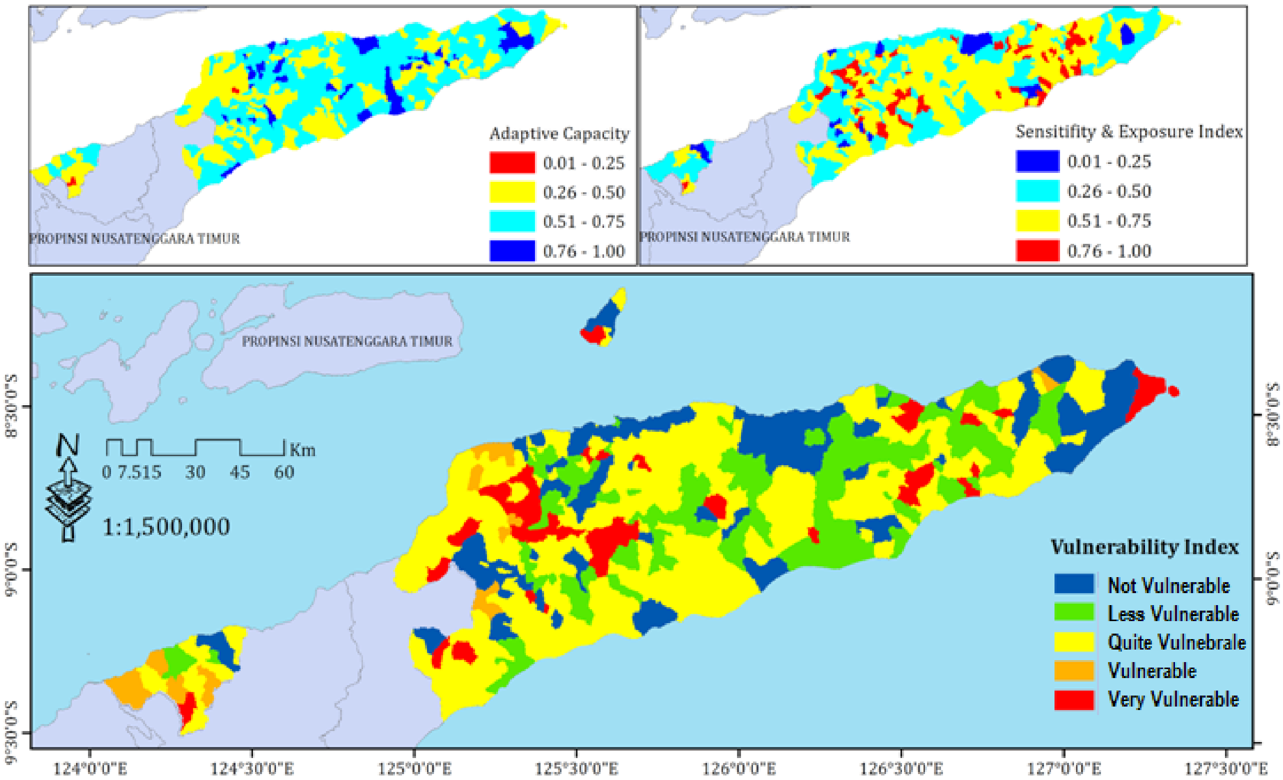


Figure 4-32 **Vulnerability index of Timor-Leste by Villages or "Suco" in 2010**

4.10 CLIMATE CHANGE IMPACTS ASSESSMENT

Increases in global temperatures and the resultant changes to global climate will affect many sectors. Changes in rainfall, onset of seasons, sea level rise, increasing intensity and frequency of extreme climate events as discussed above will have serious implications for agriculture, forestry, water resources, coastal area activities etc. The INC assessed the potential impact of climate change on three main sectors: agriculture, water resources and health. For other sectors, the INC assessed climate change impact based on available studies.

4.10.1 Agriculture

Increasing frequency and intensity of extreme climate events will cause reductions in agricultural production. The agriculture sector is likely to be the most adversely affected by climate change. Increases in frequency and intensity of extreme weather events such as cyclones under a warming atmosphere will also cause significant losses in agricultural production. Reductions in agricultural production start with less resilient crops such as annual crops and then ultimately affect perennial crops such as coconuts etc. In the INC, the assessment of climate change on the agriculture sector focused only on maize as it is the main food crop in Timor-Leste. The assessment used a dynamic-crop simulation model, DSSAT (Decision Support System for Agro-technology Transfer). The analysis was done in eight locations.

Results of the analysis suggest that this crop can produce good yields if it is planted in the wet season. Planting outside the wet season results in very low yields. The optimum planting time is in December and January. If irrigation water is available the optimum planting time is between July-October. Under future climate scenarios (SRESA1B for period 2041-2060 and 2061-2080), this optimum planting time may not change (Figure 4-33), however future yields may be lower than current yields (Figure 4-34). The impact of climate change on yields of maize ranged between 5% and 20%. It is suggested that the impact of climate change could be reduced if irrigation facilities are provided, particularly for the period 2061-2080, but not for the period 2041-2060. Different responses of the crop to irrigation application at these two time periods may be due to different levels of temperature increase. The temperature increase in 2061-2080 will be higher than 2041-2060, and irrigation application might reduce the heat and water stress to the crop.

It should be noted that loss of crop production due to increases in extreme climate events was not calculated in this study. Crop damage due to extreme events may be severe. In Timor-Leste, extreme climate events are normally associated with ENSO events (see Section 4.4.1.3). During El Nino, less rain falls and the dry season is longer leading to a decrease in rainfall of around 20%. During La Nina, more rain falls and the wet season can be quite long leading to an increase in rainfall of around 20%. The increase in rainfall during La-Nina may increase crop loss due to the increase of flood risk. During El Nino, the crop may be exposed to higher drought risk, particularly at the early stage and/or at the later stage of the crop development as rainy season may start late and end earlier. During El Nino, farmers often suffer from 'false rains' in which isolated rainfall events around the expected onset date do not signal the sustained onset of the monsoon. Such false starts can cause multiple failures, with farmers sometimes planting up to four times in a season (Moron et al., 2009).

Changes in behaviour of the ENSO due to global warming may affect the pattern of extreme climate events. Over recent years, it is quite clear that El Niño events have become more frequent as the global temperature anomalies associated with each El Niño continue to increase (Hansen et al., 2006). The extreme regional weather and climate anomalies associated with El Niño are likely being exacerbated by increasingly higher temperatures.

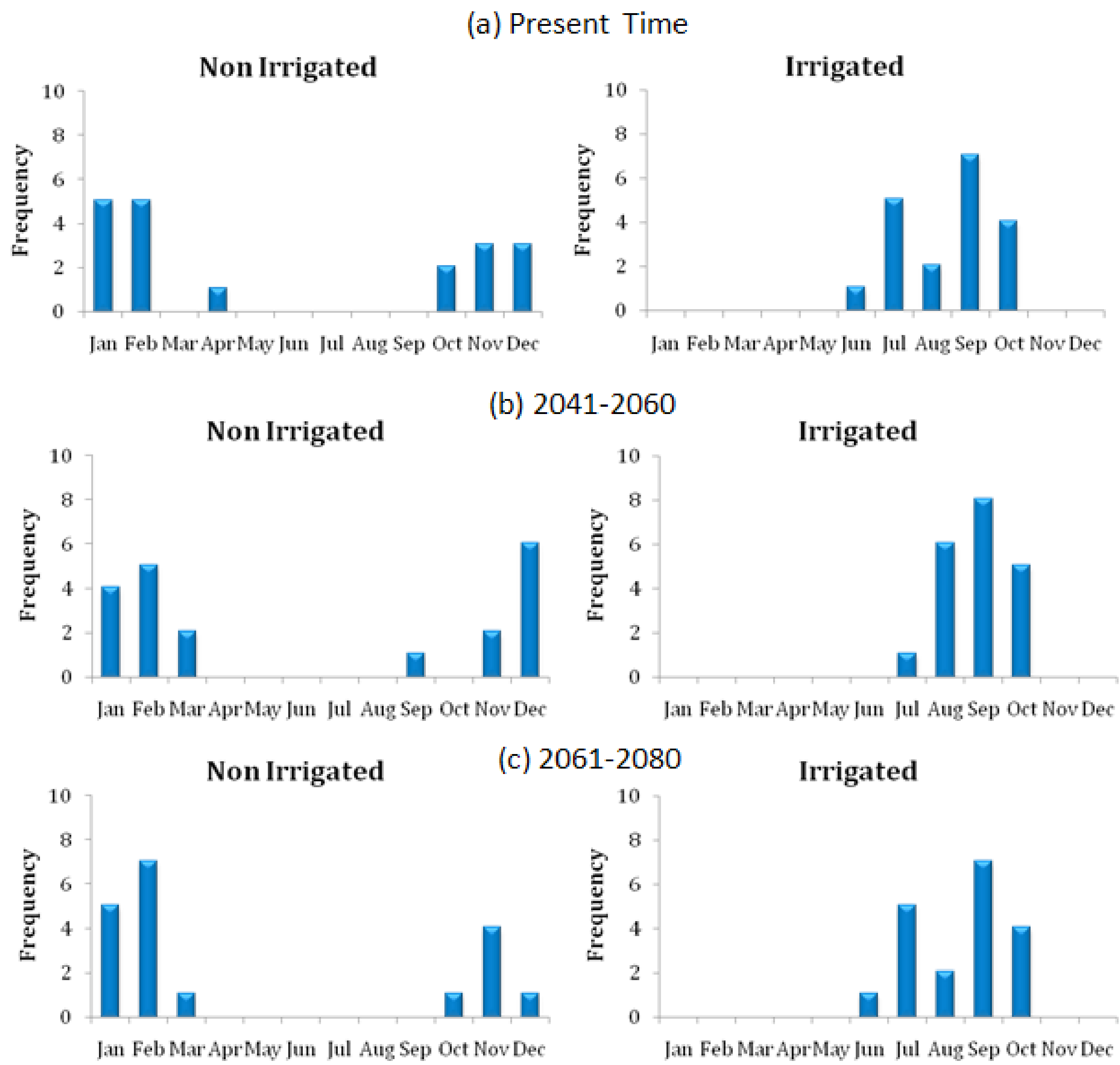


Figure 4-33 **Number of years of the 20 years simulation that give the highest yield for each planting month for irrigated and non-irrigated maize at present climate (a) and future climate periods (b) 2041-2060 and (c) 2061-2080**

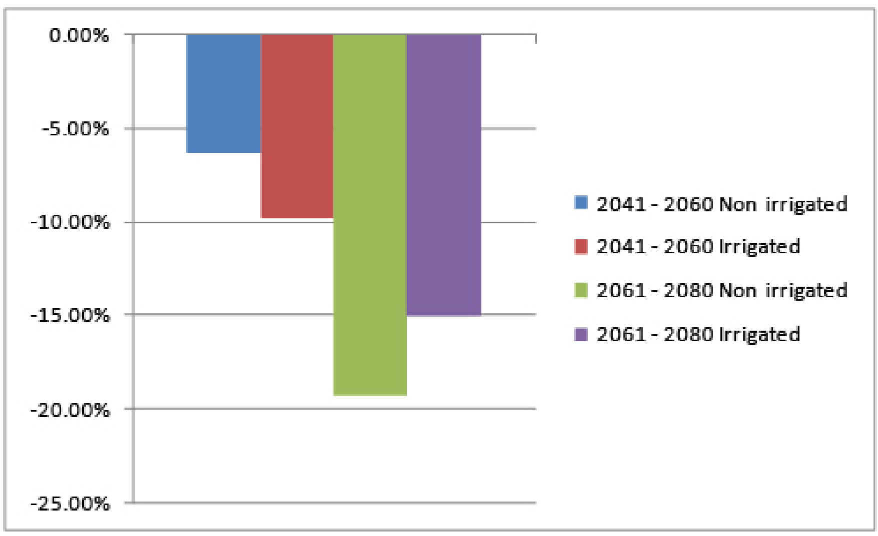


Figure 4-34 **Changes in mean crop yield due to climate change in Timor-Leste**

4.10.2 Water Resources

Changes in rainfall will affect the soil water balance of Timor-Leste. Soil water balance shows the soil water pattern and periods of water surplus and deficit. This is useful to indicate which parts of Timor-Leste will be exposed to higher drought and/or flood risks in the future due to climate change. Thus, it can provide guidance as to which regions in Timor-Leste should be prioritized for the development of irrigation projects to manage the increasing drought risk, and reservoir/dam developments for hydropower and flood management. The INC assessed the impact of climate change on water balance using the book-keeping method of Thornthwaite and Mather (1955). The data used for this analysis were the median rainfall and temperature of the GCMs defined in the previous section. The models were run under four RCP scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) and three time periods were used (2011-2040, 2041-2070, and 2071-2100). The grids of the GCM were clustered based on the pattern of monthly soil water content (SWC) using K-means clustering (Jang et al., 1997).

Results from the analysis suggest that the pattern of monthly soil water content for Timor-Leste can be grouped into five patterns (Figure 4-35). The region with the shortest dry period is in the southern part of the country (blue), while that with the longest is the northern part with a dry period equal to or greater than 10 months. In this area, growth is difficult for trees and crops due to lack of water. Referring to the land cover map of Timor-Leste, this finding is consistent with land cover conditions. The land cover type in those areas with the longest dry period is mostly bare land (Figure 4-35, c.f Figure 4-36). Those with the shortest dry period are covered by dense forest.

Due to changes in the rainfall pattern, future soil water balance patterns may change from their current conditions. Under the four emissions scenarios, it is suggested that the area with a deficit period of more than 10 months duration will expand as the emissions scenarios move from RCP2.6 to RCP8.5 (Figure 4-37). Expansion of areas with a deficit period of more than 10 months duration due to climate change will limit the expansion of agriculture areas in the future. The need to use rainfall harvesting and water conservation technologies for managing water deficit and drought will become more urgent in the future. Increasing cropping intensity will be more difficult without support from irrigation water.

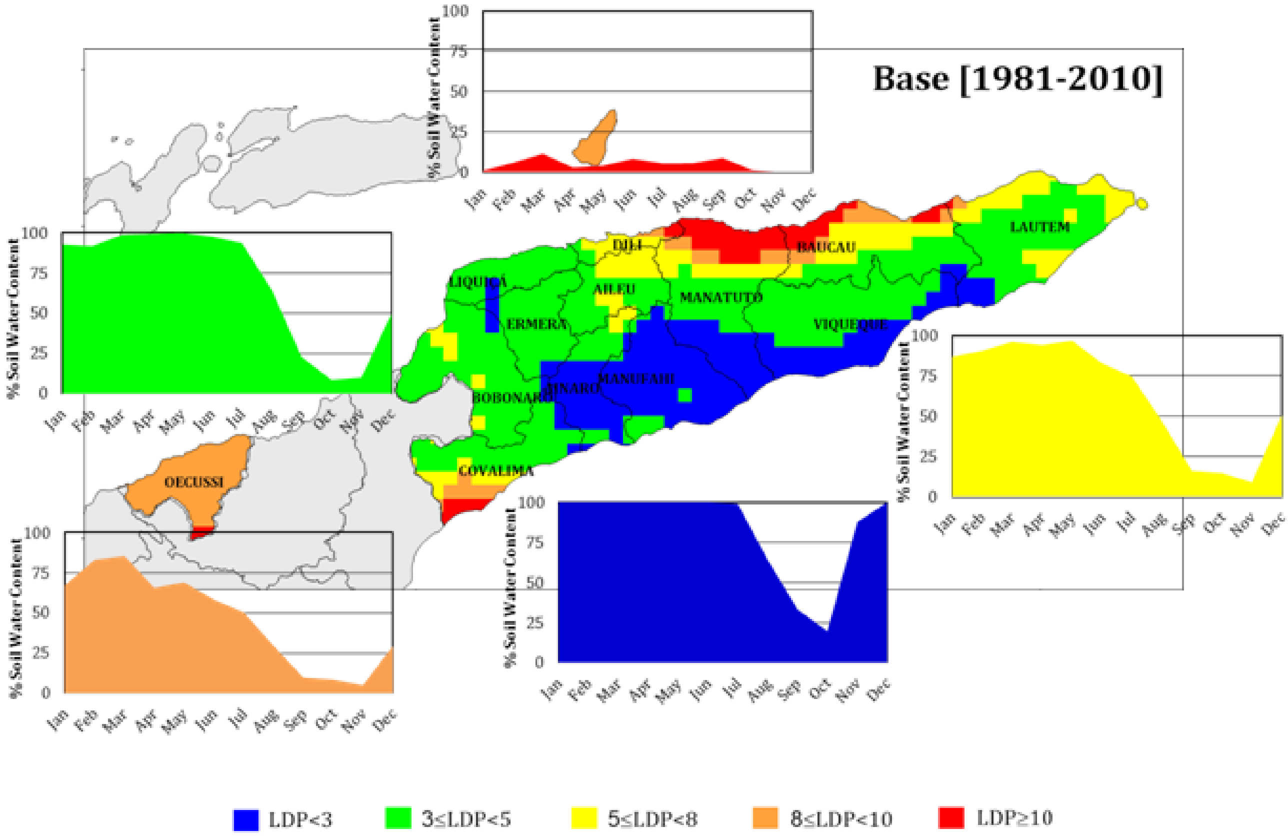


Figure 4-35 **Classification of Timor-Leste according to the monthly pattern of Soil Water Content**

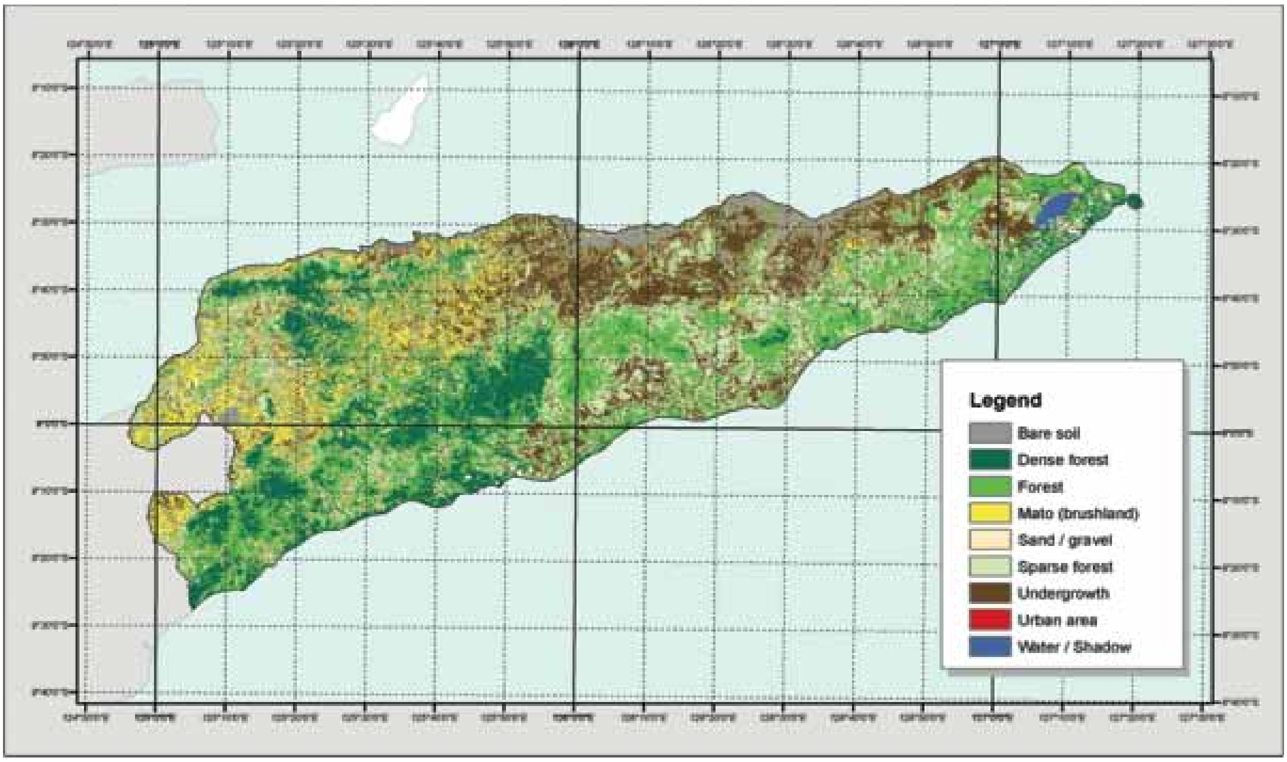


Figure 4-36 **Land cover of Timor-Leste in 2010**

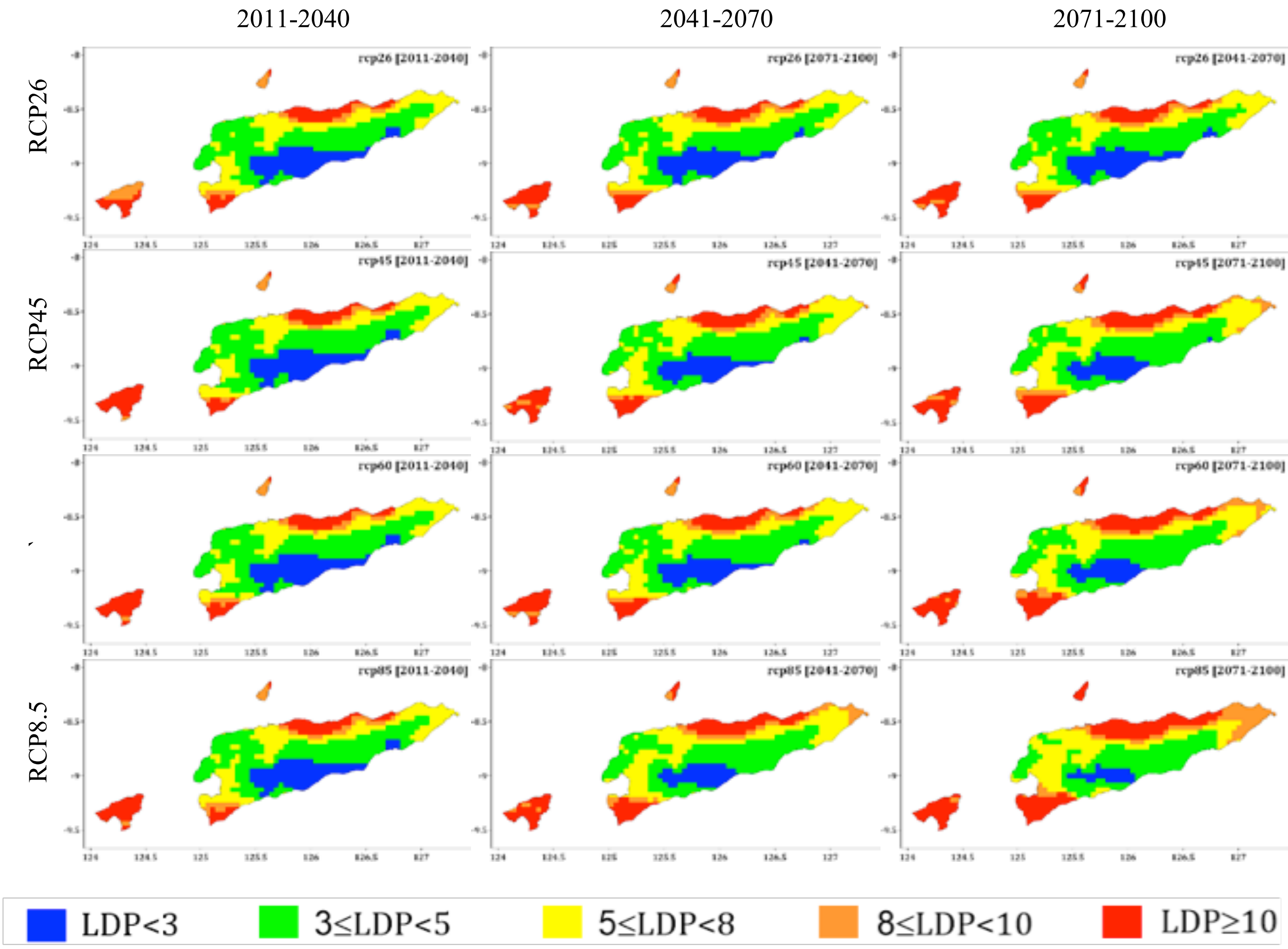


Figure 4-37 **Impact of climate change on length of deficit periods in Timor-Leste (in month)**

The significant change in soil water regimes due to changes in rainfall (Figure 4-37) and increases in temperature also pose a serious threat to the forest sector. Future expansion of drier areas into current forest lands will reduce overall forest productivity and may also increase exposure to higher fire risks. Changes in land use will cause further deterioration as livestock activities are introduced and expanded. All of this may result in processes such as fragmentation, loss of regenerative capacity, dispersion, loss of key species, change in the abundance of species, introduction of alien plants, proneness to plagues, etc., and deficiencies in environmental services. Given this condition, a more effective strategy is required for forest rehabilitation and protection. Special emphasis on climate change should be made when establishing any land use plans.

4.10.3 Health

Direct impacts of climate change on human health include exposure to thermal extremes and damage to public health infrastructure, increased frequency of physiological disorder and injuries, due to the increase in frequency and/or intensity of extreme weather events. Indirect impacts include disturbances to ecological systems that result in changes to the geographical range and incidence of vector-borne diseases, infectious diseases, malnutrition and hunger that in turn disturb child growth and development. Sea level rises may also force population displacement and cause damage to infrastructure which will lead to increased susceptibility to infectious diseases and psychological disorders. Many infectious diseases such as malaria, dengue fever, diarrhoea and other water and food borne diseases are found to be susceptible to climate change (Martens et al. 1995). Increasing temperatures may create more favourable conditions for vectors' development. Precipitation is another important factor that influences insect growth rates, especially mosquitoes and black flies because many of these species breed in the residual water that remains after flooding during the wet season. However, heavy rainfall may wash vector larvae away or kill them directly.

In Timor-Leste malaria is still ranked among the leading causes of mortality and morbidity. Dengue is also quite serious but not as bad as malaria. This study assessed the potential impact of climate change on the risk of malaria and dengue. The level of risk is defined by the incidence rate and transmission risk. The incidence rate is classified into five categories, 1-5. Locations that have an incidence rate of more than the lowest four quintiles of the incidence rate across all sites are categorized as sites with the highest incidence rate (score equal to 5). Transmission risk is determined by climate factors namely temperature and rainfall. The transmission risk will change when there are changes to temperature and rainfall. The formula for estimating the transmission risk follows Reiter (2001; see Appendix 1).

Categorization of locations based on transmission risk also consists of five categories defined similarly to incidence rate. Using a risk matrix, we can determine the level of risk of any site to malaria and dengue (Table 4-2). Thus the level of climate risk for malaria and dengue would be considered very-very high (VVH) if both the incidence rate and the transmission risk of the districts are equal to 5.

The results of the analysis indicate that sucos located in Manatuto district are all considered to have high risk of dengue (Figure 4-38). Under the emissions scenarios RCP2.6 to RCP8.0, the risk of dengue may increase in the future (Figure 4-39). The worst conditions will occur under the emissions scenario of the RCP8.0. For malaria, the districts with highest risk under the current climate are Viqueque and Lautem (Figure 4-40). In the future the number of districts with a high malaria risk will also increase (Figure 4-41). The worst conditions will also occur when emissions follow the RCP8.0 scenario.

Table 4-2 **Matrix of climate risk for Malaria and Dengue Fever**

Transmission risk Incidence Rate	5	4	3	2	1
5	VVH	VH	H	H-M	M
4	VH	H	H-M	M	M-L
3	H	H-M	M	M-L	L
2	H-M	M	M-L	L	VL
1	M	M-L	L	VL	VVL

Incident Rate [/1000]		Risk Transmition 5	4	3	2	1
5	IR≥0.134	V V H	V H	H	H-M	M
4	0.134≤IR<0.089	V H	H	H-M	M	M-L
3	0.089≤IR<0.044	H	H-M	M	M-L	L
2	0.044≤IR<0	H-M	M	M-L	L	V L
1	IR≤0	M	M-L	L	V L	V V L

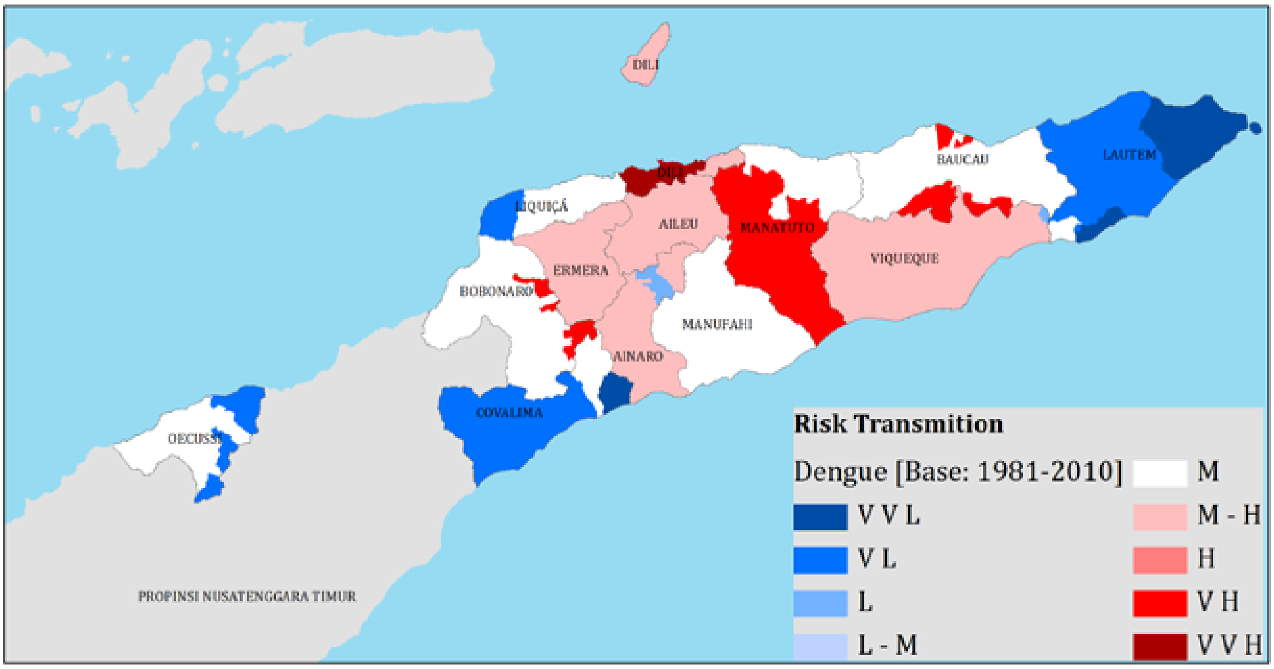


Figure 4-38 **Level of risk for dengue fever in Timor-Leste under current climate conditions**

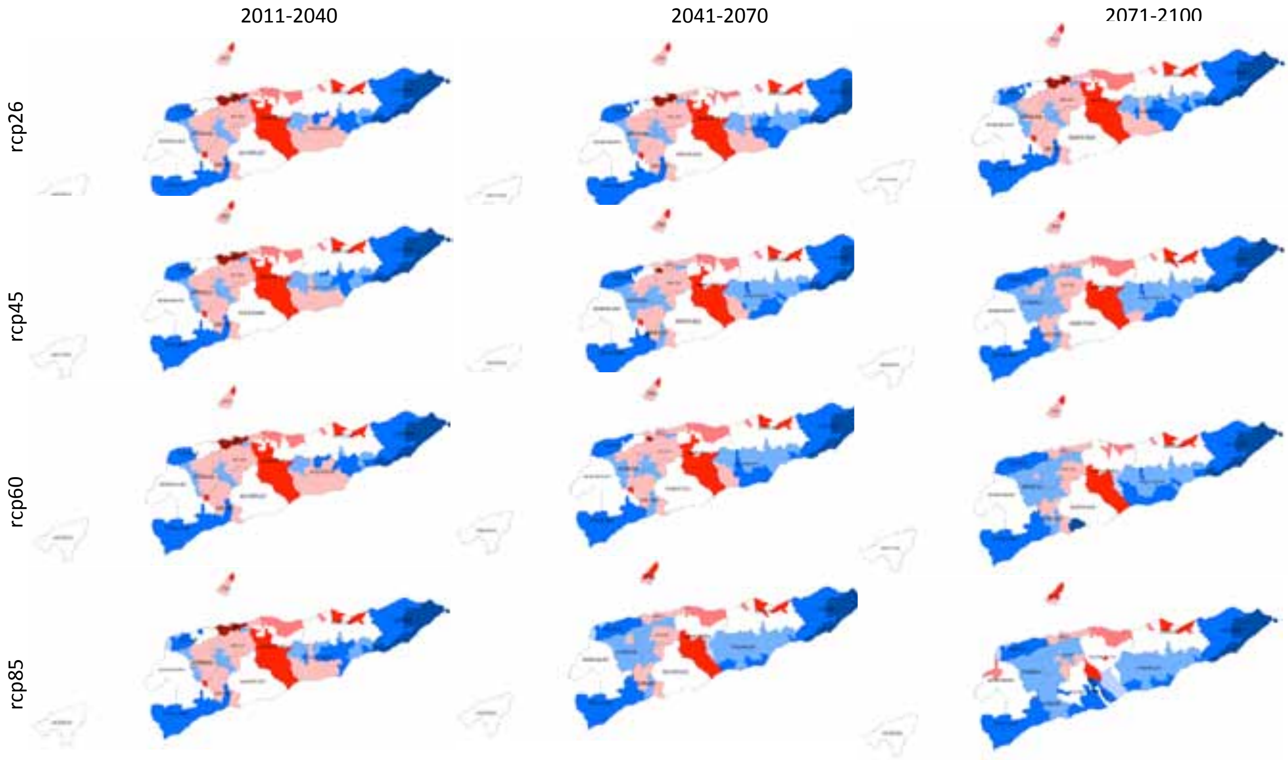
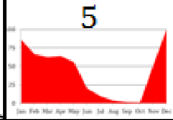
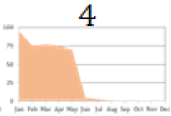
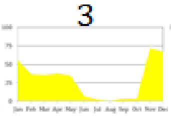
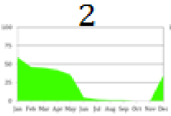
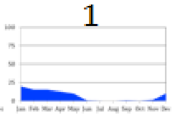


Figure 4-39 **Level of risk for dengue in Timor-Leste under future climate**

Incident Rate [/1000] \ Risk Transmition		5 	4 	3 	2 	1 
5	IR≥0.134	V V H	V H	H	H-M	M
4	0.134≤IR<0.089	V H	H	H-M	M	M-L
3	0.089≤IR<0.044	H	H-M	M	M-L	L
2	0.044≤IR<0	H-M	M	M-L	L	V L
1	IR≤0	M	M-L	L	V L	V V L

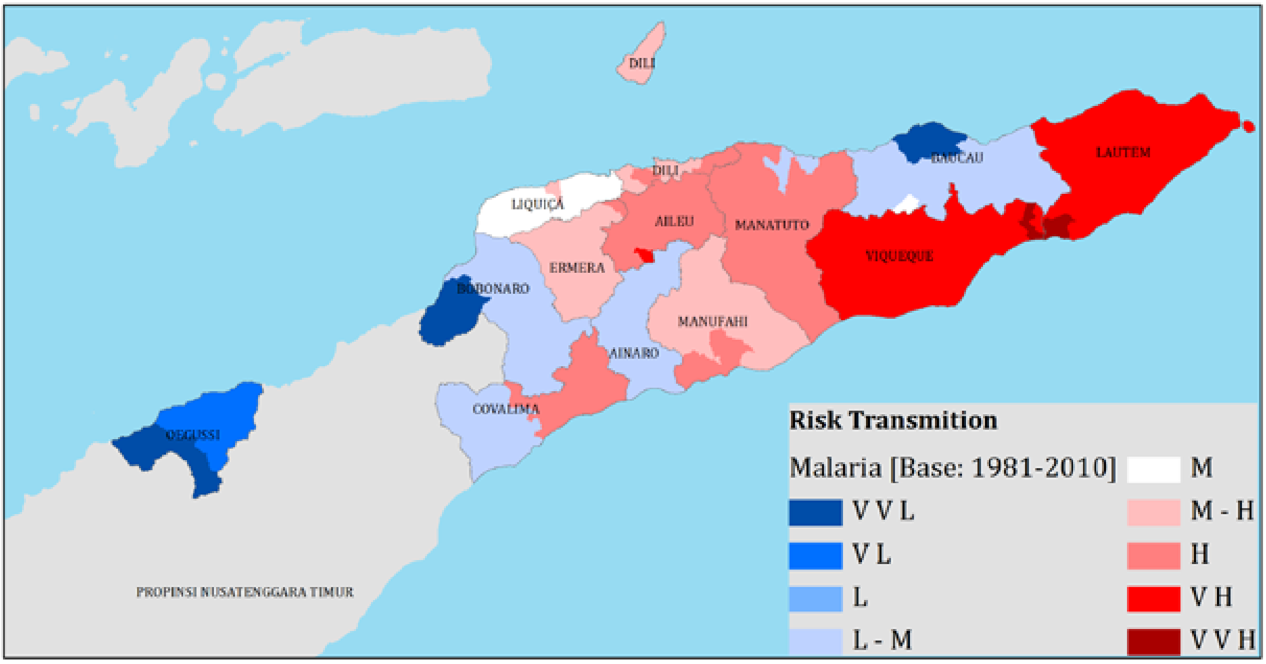


Figure 4-40 **Level of risk for Malaria in Timor-Leste under current climate conditions**

4.10.4 Coastal and Marine

Timor-Leste has a long coastal area, extending over 700 km and including unique resources both on land and in the sea. Marine and coastal areas provide habitat for mangroves, coral reefs and sea grasses. There may be in excess of 500 species of coral occurring in Timor-Leste waters (Veron et al, 2000). A significant part of this ecosystem is at present in pristine condition. This resource may provide a significant contribution to economic development, if it is utilized in a non-destructive and well-planned manner. Economic interests relating to the coastal zone, particularly oil exploration and tourism can pose significant threats to this resource.

The magnitude of the impact of climate change on the coastal and marine sectors of Timor-Leste is still unknown. Many people believe that climate change will have a serious impact on this sector. The primary concern in relation to the coastal zone is the combination of more frequent and intense storms and a potential rapid rise in sea level. These events are identified as having the most adverse effects (Ministry for Economy and Development and UNDP, 2010). Some of the expected impact of climate change on this sector is presented in Table 4-3.

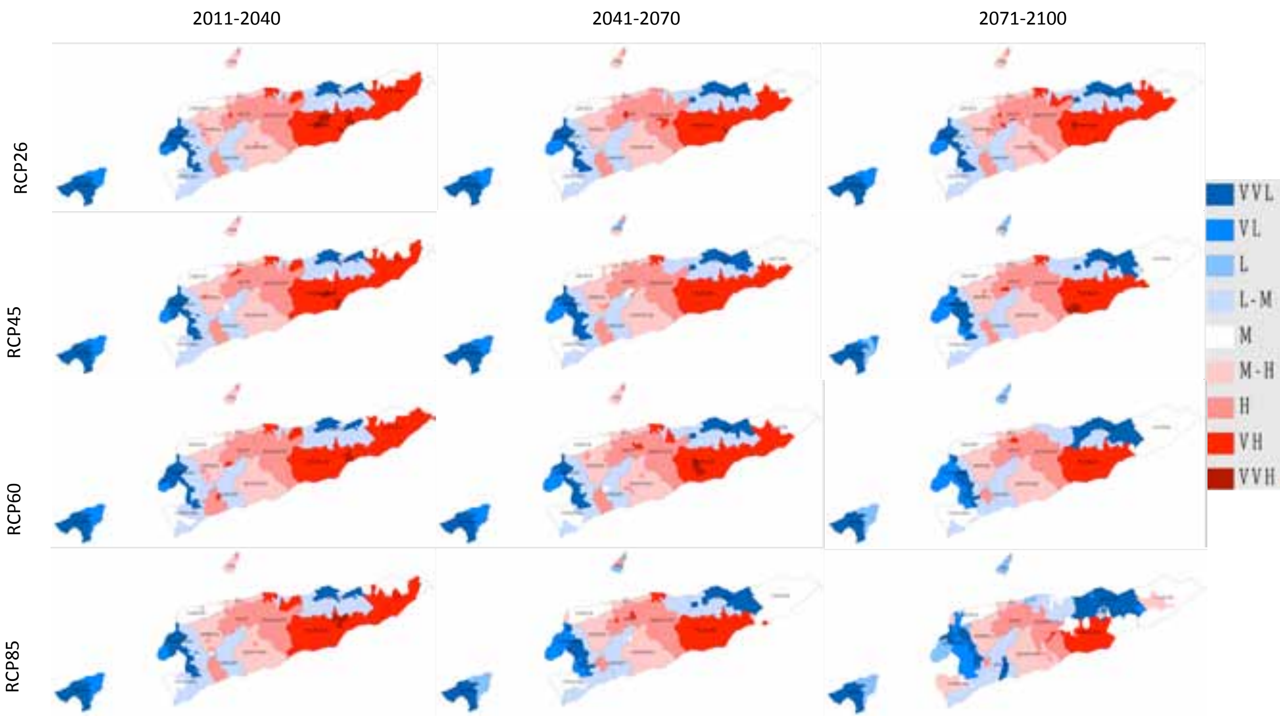


Figure 4-41 **Level of risk for Malaria in Timor-Leste under future climate**

Table 4-3 **Potential impact of climate change on coastal and marine resources of Timor-Leste (Ministry for Economy and Development and UNDP, 2010)**

Climate change related phenomena and events	Climate change impacts
Increased air temperature	• Migration/displacement of fish to locations with more suitable environmental conditions. • Loss or destruction of coastal vegetation, species and habitats. • Loss of health, diversity and productivity of inshore marine systems and fisheries.
Changes in rainfall patterns and intensity	• Increased sedimentation reducing aquatic reproduction, productivity, habitat area and causing local extinctions due to increasing flood frequency and intensity. • Destruction of freshwater and shallow marine habitats and species by increased river flows, run-off, flooding and sedimentation. • Smothering of sea-bed habitats by siltation. • Damage to coastal saline habitats including wetlands and mangroves due to flooding.
More intense storm activity	• Reduced health, diversity and productivity of coastal and inshore marine ecosystems and species. • Loss or destruction of coastal vegetation, species and habitats. • Physical damage to coral reefs and mangroves by strong wave action. • Increased erosion of beaches, shorelines and coastal land, loss of breeding and nesting habitats. • Damaged vital infrastructure such as offshore oil and gas infrastructure
Rise in shallow seawater temperatures, rise in sea level and seawater acidification	• Loss or destruction of coastal vegetation, species and habitats. • Reduced health, diversity and productivity of *offshore marine ecosystems, fisheries and marine mega fauna.* • Reduced survival of many species due to loss of plankton productivity (base of food chains). • Impacts on reproduction and survival of young. • Stalinization of soil, freshwater, coastal lands, infrastructure and agriculture by seawater intrusion. • Reduced health and survival of many marine species due to increased acidity of seawater.

The above assessment shows that climate change will have a serious impact on many sectors in Timor-Leste. Agriculture production is likely to be affected by the increase in temperature and change of rainfall pattern. Crop loss due to extreme climate events may be more often and the expansion of agricultural areas would be confined due to the expansion of drier areas. Risk to health may also increase. Coastal and marine sectors will also be seriously affected. Developing the capacity to adapt the potential impact of climate change in the various sectors is very important.

4.11 CLIMATE CHANGE ADAPTATION

Climate change will have serious impact on many sectors in Timor-Leste as described above. Development of climate change adaptation action plans is urgently needed. A number of prioritized adaptation actions that should be implemented to increase Timor-Leste's climate resilience include:

- Strengthening the capacity of national and local institutions as well as communities in managing climate risk through the development of effective climate information systems (improving skills for climate forecasting) including the development of early warning systems and decision support system tools for policy makers.
- Improvement of water management including development and utilization of rainfall harvesting technologies particularly in high prone drought areas.
- Protection and rehabilitation of rainfall catchment areas should be accelerated to ensure sustainable water supply. Priority should be given to watersheds that supply water for agriculture and domestic purposes.
- Research and development of technologies more adaptive to climate change particularly for key sectors, i.e. agriculture, water resource and coastal/marine (e.g. development and introduction of plant/crop varieties resistant to climate stresses, climate proof infrastructure etc.).
- Protection and rehabilitation of mangrove ecosystems in priority areas to protect economic, social and environmental assets against climate risks.
- Development and enhancement of sectoral capacity to coordinate the implementation of adaptation actions and also to integrate climate change into strategic planning oriented towards sustainable development and poverty reduction.

Some of the climate change adaptation activities that have been implemented in Timor-Leste by the Government in the three main sectors are described below.

4.11.1 Agriculture Sector

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has been actively promoting new genotypes of maize and rice Noi Mutin, Sele and Nakroma which have higher yields compared to local varieties (up to 40%). Through collaboration with international development agencies such as GIZ, the MAFF has also been active in promoting and introducing the new crop management system called Integrated Crop Management (ICM) and Systems of Rice Intensification (SRI) to farmers across the territory. These new crop management systems have a yield advantage over traditional systems with an average of 1.5 ton/ha. These crop management systems require less water in comparison with traditional systems. Even though farm demonstration trials have been implemented, no comprehensive information is available on the rate of adoption by farmers for the varieties and techniques mentioned. The latest survey conducted by FAO in 2013 showed that around 25% of farmers in the country have utilized introduced varieties of maize; Bisma, Noi Mutin and Sele while 75% of farmers are still using local varieties (interview with Mr. Ximenes, FAO food security program manager, August, 2013).

With support from other international development agencies operating in Timor-Leste, MAFF implemented other activities that are believed to play a critical role in addressing climate change in the agriculture sector. Some of these activities include (i) recruitment of village based extension workers, (ii) development and rehabilitation of irrigation systems, (iii) improving seed storage and post harvest management, (iv) improving crop management systems, (v) production and distribution of climate (rainfall and temperature) and soil maps (soil pH, soil texture, soil mineral deficiencies), and (vi) research regarding new varieties of main crops with high yields and climate resilience.

4.11.2 Water Sector

In terms of adaptation programs in the water sector, there has not been much activity undertaken compared to the agriculture sector even though these two sectors are closely related. It is impossible to develop the agriculture sector without having sufficient water. Some adaption actions in the water sector have long been practiced by Timorese communities, including: rain water harvesting, hand carrying spring water and use of bamboo to channel water from the mountain springs. One of the important adaptation measures that will enable the country to respond to the impact of climate variability and climate change as considered by the National Directorate of Water Control Quality (NDWCQ) is watershed management. Financial aspects are considered as the main constraints for the adoption of watershed management strategies.

Apart from the above activities, the government of Timor-Leste through the NDWCQ in collaboration with international development agencies have conducted studies such as an assessment of the vulnerability of groundwater resources to climate change, and also produced a hydro-geological map of Timor-Leste. This directorate has also drafted a water resource policy and law to be taken to the Council of Ministers for approval. The draft of the water resource law consists of the following elements: protection of water resources, right to take and use water, access to water sources, licensing and registration, flood protection, safety and contingency planning, compliance and emergency, inspection and monitoring, financial provisions, water management groups and users associations, cross-border water resources, offences, sanctions and remedies as well as transitional and final dispositions.

The draft water resources policy covers the role of State and relevant authorities, customary and traditional practices, development of specific types of water resources, regulation and licensing of water resource development, coordination arrangements, cross-border water resources, water conservation, protection of ecosystems and prevention of contamination of water resources. The final section of the draft focuses on water resource disasters. In addition, the National Directorate of Forestry (NDF) has also taken serious steps towards conserving forests that can be seen to directly contribute positively to water source conservation. From 2014 to 2023, the NDF has targeted the conservation of 228,174.57 ha of dense forest, which accounts for 73% of the total dense forest area and has a plan to rehabilitate 278,999.90 ha of sparse forest that accounts for 50% of the total sparse forest area in the country. While these programs are potentially a part of adaptation measures for responding to the impact of climate variability and climate change to water sector, they are not explicitly defined as measures to address the impact of climate change.

4.11.3 Health Sector

One of the major adaptation programs undertaken by the Ministry of Health to overcome and/or reduce the incidence of malaria in the country is the introduction of Rapid Diagnostic Test kits, an improved surveillance system and the distribution of long lasting insecticide treated nets to the highest risk areas. Nearly half (46%) of Timorese households own at least one mosquito net, and 42% of these nets are insecticide treated nets. The programs conducted have proved to be effective in reducing the incidence of malaria in the country. The incidence of malaria in 2009 was 120 per 1000 population, and the number of malaria cases decreased by 34% in 2008 compared to 2007 (Ministry of Health-Strategic Plan 2011-2013).

The main strategies highlighted by the Ministry of Health to reduce morbidity and mortality caused by malaria include: i) improving case management through early detection of infection and delivery of effective anti-malarial therapies; ii) application of integrated vector management systems; iii) epidemic preparedness and outbreak responses; iv) enabling and promoting research for improved policy formulation (Ministry of Health-Strategic Plan 2011-2013). In addition, the rapid establishment of Integrated Community Health Services (SISCa) at the village level is improving health service delivery for communities in remote areas while at the same time SISCa plays a very important role in disseminating information regarding environmental health issues. Records from the Ministry of Health show that up to December 2010 as many as 475 SISCa posts had been established across the country (Health Statistics Report, 2010).

To further enhance the capacity of Timor-Leste in addressing climate change impacts, the Government has proposed nine priority programs under the NAPA (National Adaptation Plan of Action-2010). These nine programs cover all of the key adaptation actions defined above (Table 4-4). To implement these programs Timor-Leste will require funding of about $US 21.3 million. The duration of implementation would range from 2-5 years.

Table 4-4 **Prioritized adaptation program proposed under NAPA**

Project No	Title	Adaptation Actions and Expected Long-Term Outcomes
1	Building resilience of rural livelihoods to enhance national food security	Actions: Reforestation of degraded lands in high risk areas (hill sites, roads and riverbanks) to prevent landslides and provide sustainable fuel wood sources. Demonstration, through localised interventions, of sustainable land management measures (reduce erosion, increase soil fertility, reduce crop losses, reduce burning) to increase resilience to climate risks. Demonstration measures to diversify rural household income, including agro-forestry based livelihoods models Outcome: Farmer organisations and other rural stakeholders able to develop and apply adaptive practices to enhance agricultural productivity and promote economic diversification in rural livelihoods Estimated Cost: 3.6 million USD
2	Promotion of Integrated Water Resource Management (IWRM) to guarantee water access to people in the context of increasing climate risks	Actions: Create and enhance household and village based water harvesting models (capture and storage) and water distribution systems. Physical protection of critical water sources (springs, streams, wells, etc) to provide safe water supply during extreme climate extreme events. Capacity development for ongoing monitoring and maintenance of village and household level water supply systems. Outcome: Improved access to safe water and sanitation under the conditions of changing climate by adoption of new technologies and participatory water management at household and village levels Estimated Cost: 3.7 million USD
3	Enhancing capacity of health sector to anticipate and respond to changes and reduce vulnerability of the population at risk from expansion of climate related disease	Actions: Integration of climate related health concerns into the SISCa programme 6 steps community health process. Strengthening early warning systems (EWS) and public health preparedness at the community level in relation to airborne, waterborne, and vector borne diseases and epidemics with disease and nutrition status surveillance. Targeted disease prevention measures piloted at community level to promote awareness and understanding. Outcome: Improved community awareness and understanding and preparedness regarding health related climate risks Estimated Cost: 1.7 million USD
4	Improving institutional, human resource capacity & information management in the disaster sector in relation to climate change induced risks at national, district and community levels	Actions: Identification, field demonstration and appraisal of targeted climate risk reduction measures: (i) improved settlement construction, (ii) livelihoods protection, (iii) physical infrastructure, and (iv) improved land and water management practices. Training programme for district and community level professionals to support strengthened planning competencies for climate risk reduction. Outcome: District planners and communities aware of and putting into practice improved and cost effective climate-related disaster prevention measures through local level demonstration Estimated Cost: 2.6 million USD

5	Restoration and conservation of mangrove ecosystems and awareness raising to protect coastal ecosystems exposed to sea level rise	Actions: Develop national program of protection and rehabilitation of mangrove ecosystems in priority areas to protect economic, social and environmental assets against climate risks (involving all stakeholders including local communities, private sector and government). Promotion of measures to diversify household incomes in coastal areas to reduce pressure on vital and protected ecosystems. High priority is development of fuel wood lots; incentives-based approach to include development of alternative livelihood activities including small business approach, including nature-based tourism Outcomes: Healthy mangrove ecosystems functioning to protect coastal zone resources in areas of high risk of impacts from climate change with local communities able to identify and implement appropriate and cost effective coastal protection measures which also promote income diversification. Estimated Cost: 3.0 million USD
6	Improved strategic planning, institutional frameworks and methodologies to promote sustainable, integrated livestock production under climate change conditions	Actions: Development, demonstration and implementation of small scale integrated, intensive animal agribusiness management systems (with links to agroforestry, sustainable energy, waste management, health and disease control) to reduce climate risks and improve productivity, breeding, health and disease control, improved marketing and development of secondary processing and marketing). Improved biosecurity measures at the farm/household level through improved veterinary service delivery and establishment of a self-monitoring early warning system with livestock owners at the farm and neighborhood level Outcome: Resilience of livestock management systems to climate risks strengthened through applied and field tested measures supporting households in at least 7 districts Estimated Cost: 2.3 million USD
7	Review and revise legislation, regulations and standards to enhance climate change resilient infrastructure	Actions: Review existing practices based on field investigation and document current standards and failure rates in the existing infrastructure stock. Implement pilot projects in at least 6 districts to field test and develop new resilient building methods and standards (cyclone proofing, slope stabilisation, flood risk construction standards). Document best practices for national review and consultations and adjustment of existing infrastructure codes and standards, and identify entry point for the review of other key sectoral legislation (water and agriculture) Outcome: Improved understanding of cost effective methods to climate proof critical infrastructure based on physical demonstration in key sectors (roads, bridges, housing, water supply schemes) Estimated Cost: 2.0 million USD

8	Support to the ambitious national poverty reduction target (Timor Leste Strategic Development Plan 2011-2030) in relation to the expected increased storm intensity at sea by improving capacity to forecast and adapt offshore oil and gas infrastructure to withstand strong storms and waves	Actions: Review of current national government and relevant international regulations and standards for the construction, operation and maintenance of offshore and onshore oil and gas installations. Review of existing risk assessment, risk management and contingency measures in relation to additional risks from storms, high winds and wave action. Identification of planning, management and technical measures to strengthen the resilience of key policies and regulations. Outcomes: Policies, regulations and standards governing the oil and gas sector (both onshore and offshore) fully integrate climate risk factors Estimated Cost: 1.1 million USD
9	National institutional capacity development to build and enhance Timor Leste's capacity to coordinate/integrate climate change into strategic planning in moving towards sustainable development and poverty reduction	Actions: Establishment of a Climate Change Unit with necessary staffing and budget to engage in and support national policy development and programming activities. Assessment of staff numbers and skills including a training needs assessment and training plan based on current and expected future work responsibilities. Promotion of sub-national capacity development for improved adaptation planning and implementation. Capacity development support for key non-state actors in climate resilient development planning (national NGOs and research / educational institutions). Outcomes: National Climate Change Institution effectively coordinating both state and non-state actors in addressing climate risks to human development requirements in a coherent and organised manner Estimated Cost: 1.3 million USD

5 MEASURES TO MITIGATE CLIMATE CHANGE

Photo by UNMIT/Martine Perret

5.1 INTRODUCTION

As discussed in Section 2.5, the main sources of emissions from Timor-Leste come from 9 source categories. These key source categories (from the highest to the lowest) are: (i) CO_2 Forest and Grassland Conversion, (ii) CH_4 Emissions from Enteric Fermentation in Domestic Livestock, (iii) N_2O (Direct and Indirect) Emissions from Agricultural Soils, (iv) CO_2 Emissions from Stationary Combustion, (v) N_2O Emissions from Manure Management, (vi) CO_2 Other (LULUCF), (vii) CO_2 Changes in Forest and Other Woody Biomass Stocks, (viii) CH_4 Emissions from Rice Production and (ix) CH_4 Emissions from Manure Management.

The Government of Timor-Leste has identified a number of potential measures for mitigating climate change for each sector (Table 5-1). The forestry, agriculture and energy sectors can play a significant role to mitigate climate change. In 2010, about 35.8% of the total land area of the country was covered by shrubs (about 535 thousand ha), and most of this land could be targeted for establishment of productive forest. For the energy sector, renewable energy such as hydropower, solar photovoltaic (PV), and biogas from manure also have potential as alternative sources of energy to reduce the use of fossil-fuel based energy production. Although GHG emission from waste is not a key source, there are some potential mitigation actions of this sector such listed in Table 5.1.

Table 5-1 **Potential Mitigation Option**

Sector	Potential Mitigation
Energy	a. Higher efficiency and less carbon emissions from power generation (pico/micro-hydro), biogas, solar PV, wind power, natural gas power generation, etc.); b. Higher efficiency technology in end user (efficient lamps, efficient electric motors, etc) c. Increasing combustion efficiency in transportation sector by replacing old cars with the new cars for taxis through incentives or stimuli, increasing energy efficiency by providing public transport (bus or mini/micro bus), providing pedestrian and bicycle lanes so that more people are inclined to walk or use a bicycle. Replacing oil fuels with gas fuels (LPG, CNG or LGV) in transportation through developing infrastructure for gas utilization in transport (conversion kits, gas station, gas supply infrastructures, etc.).
Agriculture (Livestock)	Biogas and composting
Agriculture	Reducing slash and burn practices by introducing permanent agriculture with improved management practices
Forestry	Development of agro forestry and community forestry on degraded land
Waste	a. Reducing unspecified treatment of MSW by increasing the amount of MSW brought to landfill will increase GHG emission from SWDS, therefore this action must be supported by development of managed landfill equipped with LFG (landfill gas) recovery system for flaring or utilization; b. Reducing open burning through composting and 3R will significantly decrease GHG emissions from open burning c. Improving technology of old incinerators (for clinical waste from the hospital) will increase combustion efficiency and therefore GHG emissions can be reduced by around 5%.

Note: This mitigation options were determined base on key category analysis and inputs from INC Working Group as well as government programs.

5.2 ASSESSMENT OF MITIGATION POTENTIAL FOR ENERGY SECTOR

Based on national circumstances, as one of the non-Annex I Parties, Timor-Leste is encouraged to use whatever methods are available and appropriate in order to formulate and prioritize programs containing measures to mitigate climate change; this should be done within the framework of sustainable development objectives and in line with prioritized development programs.

5.2.1 Mitigation Potential for Energy Sector

Note: These mitigation options were determined based on key category analysis and inputs from the INC Working Group as well as government programs.

5.2.1.1 Transportation Sector

In the transportation sector, GHG emissions are mainly generated from fuel combustion activities, which are dominated by gasoline and diesel oil. The utilization of jet/kerosene in Timor-Leste is only for international air transportation since there is no domestic air transport in Timor-Leste. International air transport is not included in the GHG inventory and mitigation action plans of Timor-Leste. Therefore, potential mitigation actions in the country can be achieved by increasing efficiency in car combustion technology, increasing efficiency through mass transport facilities (bus), and the replacement of fossil fuels (gasoline or diesel oil) with zero or less emission energy, i.e. natural gas based fuels (CNG, LPG, or LGV), electric cars, or biofuels (bio-diesel, bio-ethanol, etc.).

The possibilities of CNG, LPG or LGV utilization in the transportation sector can be implemented if the government develops infrastructure for natural gas pipelines and gas station distribution. The utilization of electric cars in Timor-Leste would be difficult. The implementation of this program will face difficulties in supplying electricity since the main source of fuel for electricity generation is diesel oil that has to be imported.

Another possibility is the replacement of fossil fuels in transportation from 5 – 20%, in which biodiesel in ADO (automotive diesel oil) is around 5-10% (B5 or B10) and bioethanol in gasoline is 10 – 20% (E-10 or E20). However this potential will face a major barrier in the supply of biofuels in Timor-Leste since current regulations regarding land use only allow land utilization for food production and not for biofuel production.

Therefore the estimation of GHG emissions reduction potential is estimated from mitigation activities that are in-line with the government's policies and/or regulations, namely:

- Increasing efficiency of combustion technology by replacing old cars with the new cars for taxis through incentives or stimuli.
- Increasing energy efficiency by providing public transport (bus or mini/micro bus).
- Providing pedestrian and bicycle lanes so that more people will want to walk or ride.
- Replacing oil fuels with gas fuels (LPG, CNG or LGV) in the transportation sector through developing the infrastructure for this gas utilization in transport (conversion kits, gas stations, gas supply infrastructure, etc.).

Table 5-2 presents the projection of energy consumption in the transportation sector under the BaU (baseline) scenario and the mitigation scenario while the GHG emissions under both scenarios are presented in Figure 5-1 and 5-2.

Table 5-2 **GHG emission reduction potential in transportation under mitigation scenario**

Year	Mitigation Projection, TJoule										
	BaU					Mitigation					
	Gaso-line	ULP	Diesel Oil	Avtur/ Jet-Kero	Total	Gaso-line	ULP	Diesel Oil	Gas	Avtur/ Jet-Kero	TOTAL
2005	372	875	882	30	2,160	372	875	882	-	30	2,160
2006	334	915	774	22	2,046	334	915	774	-	22	2,046
2007	347	2,082	777	52	3,258	347	2,082	777	-	52	3,258
2008	462	126	1,673	68	2,330	462	126	1,673	-	68	2,330
2009	641	45	694	83	1,463	641	45	694	-	83	1,463
2010	751	47	747	86	1,632	751	47	747	-	86	1,632
2011	777	67	1,071	79	1,994	777	67	1,071	-	79	1,994
2012	856	83	1,330	76	2,345	856	83	1,330	-	81	2,350
2013	942	101	1,652	74	2,770	942	101	1,652	-	84	2,780
2014	1,037	124	2,053	72	3,286	1,037	124	2,053	-	87	3,301
2015	1,142	152	2,550	70	3,914	1,085	145	2,422	-	90	3,742
2016	1,258	187	3,168	68	4,680	1,195	178	3,009	-	93	4,475
2017	1,385	229	3,935	66	5,615	1,316	218	3,738	-	96	5,368
2018	1,525	281	4,888	64	6,758	1,449	267	4,644	-	100	6,459
2019	1,679	345	6,072	62	8,158	1,595	327	5,769	-	103	7,795
2020	1,849	423	7,543	60	9,876	1,566	279	6,808	103	107	8,862
2021	2,036	518	9,371	59	11,984	1,722	353	8,457	115	110	10,758
2022	2,242	636	11,641	57	14,576	1,893	444	10,506	130	114	13,088
2023	2,469	780	14,461	55	17,765	2,081	557	13,051	147	118	15,955
2024	2,718	956	17,965	54	21,693	2,287	697	16,213	166	122	19,486
2025	2,993	1,173	22,317	52	26,535	2,513	871	20,141	188	126	23,839
2026	3,296	1,439	27,723	51	32,508	2,761	1,085	25,020	214	131	29,210
2027	3,629	1,764	34,440	49	39,882	3,032	1,349	31,082	243	135	35,841
2028	3,996	2,164	42,783	48	48,991	3,329	1,675	38,612	278	140	44,033
2029	4,400	2,654	53,148	46	60,248	3,653	2,077	47,966	318	144	54,158
2030	4,845	3,254	66,023	45	74,168	4,007	2,572	59,586	366	149	66,680

Note: There might be small different between the sum of the mitigation potential and the figures the column 'Total'.

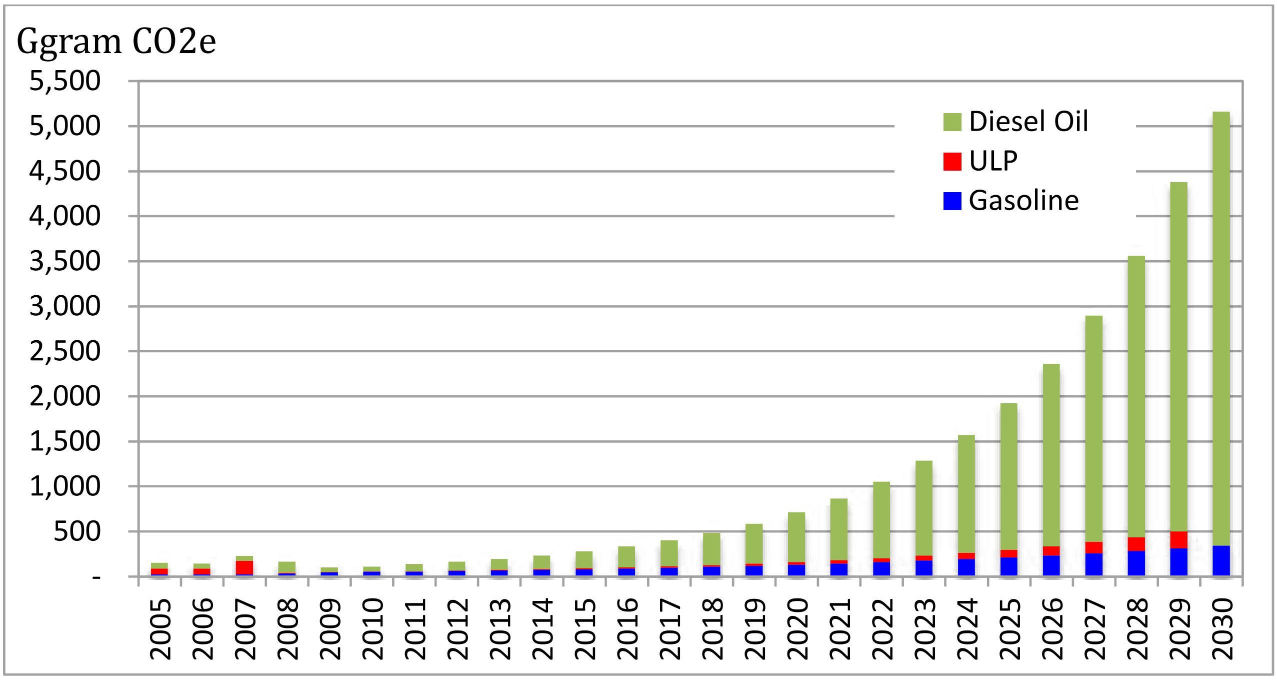


Figure 5-1 **GHG emissions projection under the BAU (baseline) scenario in the transportation sector**

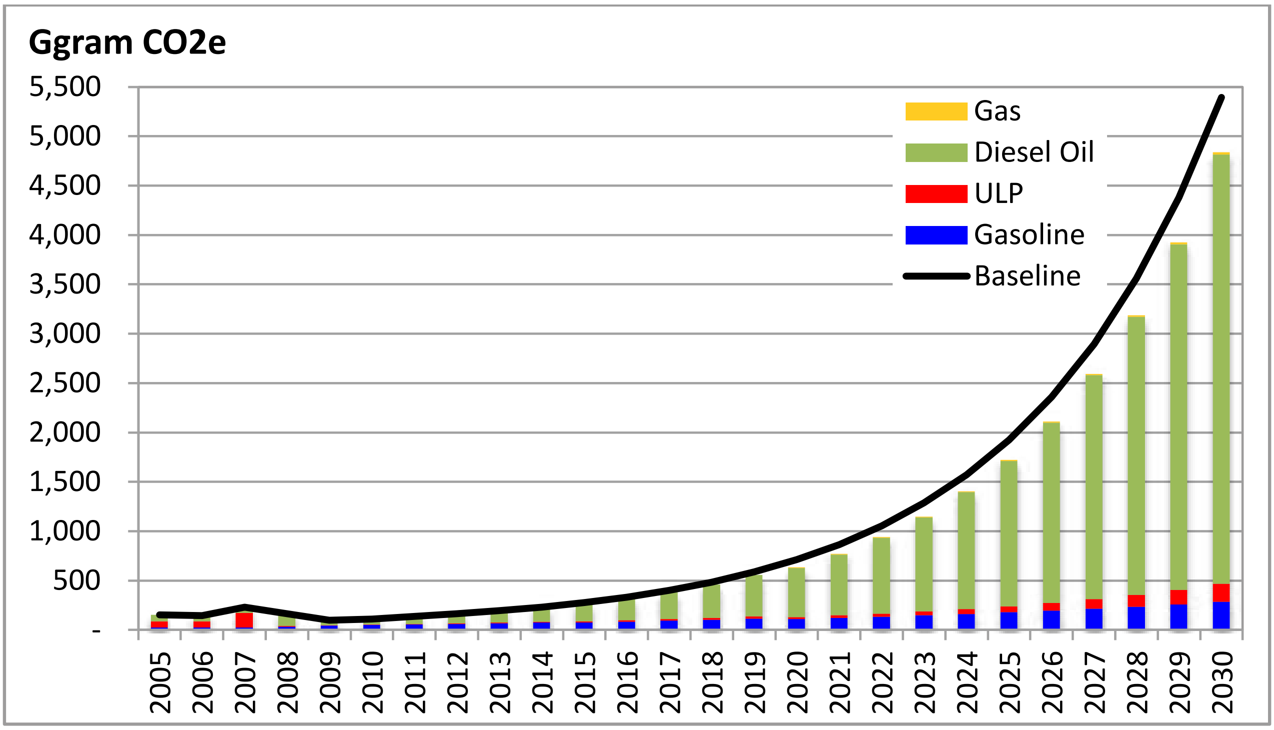


Figure 5-2 **GHG emissions projection under mitigation scenario in transportation sector**

5.2.2.2 Power Sector

On the demand side, energy efficiency can be improved by implementing cleaner energy and more efficient technologies for end use of energy appliances/technologies, i.e. higher efficiency technology (efficient lamps), renewable based energy technology (biogas, micro hydropower, solar photovoltaic home system, wind propelled electric generators, etc.).

On the supply side, energy efficiency can be improved throughout the entire process of electricity generation by utilizing more efficient technology and implementing cleaner energy. Table 5-3 presents electricity generation and fuel consumption in the generation of power. It can be seen that average specific fuel consumption is between 0.27 – 0.29 litre/kWh. There is room for increasing efficiency, because an efficient diesel engine consumes around 0.25 litre/kWh. The GHG emissions reduction potential from this action is presented in Table 5-4.

Table 5-3 **Electricity generation and fuel consumption by power generation, kTon/year**

Year	District Electricity		Dili Electricity		TOTAL		
	Electricity Generation kWh	Fuel Consumption kTon	Electricity Generation kWh	Fuel Consumption kTon	Average Specific Consumption Liter/kWh	Electricity Generation kWh	Fuel Consumption kTon
2005	7,095,110	1.71	55,896,498	13.44	0.27	62,991,608	15.14
2006	9,714,689	2.35	71,958,471	17.43	0.27	81,673,160	19.78
2007	14,972,138	3.84	91,788,978	23.54	0.29	106,761,116	27.38
2008	14,545,793	3.53	110,514,113	26.80	0.27	125,059,906	30.32
2009	23,215,030	5.70	131,700,316	32.35	0.28	154,915,346	38.05
2010	29,560,361	7.66	136,908,654	35.48	0.29	166,469,015	43.14
2011	39,475,770	10.29	140,661,791	36.66	0.29	180,137,561	46.95
2012	53,025,772	13.82	154,727,970	40.33	0.29	207,753,743	54.15
2013	71,226,794	18.56	177,937,166	46.38	0.29	249,163,959	64.94
2014	95,675,290	24.94	204,627,741	53.33	0.29	300,303,030	78.27

Sources: processed from EDTL Data, 2011; data 2012 – 2014 is projected plan

In addition, diesel fuels for power generation could be replaced by biomass based power generation. There are potential sources of biomass in Timor-Leste, i.e. agricultural waste and municipal solid waste (MSW). However, there is no plan to utilize MSW to generate electricity. Another possibility is the replacement of diesel oil with a low emission fuel, such as natural gas. Similar to the utilization of this gas in the transport sector, this possibility can be considered if the government of Timor-Leste plans to develop gas pipeline infrastructure from oil and gas production facilities (offshore) to the power plants.

According to the ADB study in the Power Sector Development Plan for Timor-Leste (2004), the target growth rate for power generation (in terms of MW) in Timor-Leste during 2004 until 2025 is around 8%, in which the growth rate is 9% (in terms of MWh). The development of power generation at this growth rate is aimed to achieve the target of an electrification ratio in Timor-Leste of 80% in 2025. The projection of power generation and GHG emissions from power generation in Timor-Leste was estimated using this growth rate. Table 5-4 and Figure 5-3 show GHG emissions reduction potential projection for the electricity sector.

Table 5-4 **GHG emission reduction projection potential from the electricity sector**

Year	Generation, kWh					GHG Emission, kTon CO2e		
	Diesel Generation	Micro-hydro	Wind	Solar PV	Biomass/ natural gas	Baseline	Mitigation	Reduction Potential
2005	62,991,608					49	49	-
2006	81,673,160					63	63	-
2007	106,761,116					88	88	-
2008	125,059,906					97	97	-
2009	154,915,346					122	122	-
2010	166,469,015					138	138	-
2011	181,451,227					152	152	-
2012	197,781,837					165	165	-
2013	215,582,203					180	180	-
2014	234,984,601					197	197	-
2015	165,931,209	89,700,000	356,006	146,000		214	139	75
2016	188,983,198	89,700,000	356,006	146,000		234	158	75
2017	214,109,866	89,700,000	356,006	146,000		255	179	75
2018	241,497,935	89,700,000	356,006	146,000		277	202	75
2019	271,350,930	89,700,000	356,006	146,000		302	227	75
2020	288,696,159	89,700,000	356,006	146,000	15,194,535	330	206	124
2021	322,391,085	89,700,000	356,006	146,000	16,967,952	359	230	129
2022	359,118,554	89,700,000	356,006	146,000	18,900,977	392	256	135
2023	399,151,496	89,700,000	356,006	146,000	21,007,973	427	285	142
2024	442,787,402	89,700,000	356,006	146,000	23,304,600	465	316	149
2025	490,350,540	89,700,000	356,006	146,000	25,807,923	507	350	157
2026	542,194,360	89,700,000	356,006	146,000	28,536,545	553	387	166
2027	598,704,124	89,700,000	356,006	146,000	31,510,743	603	428	175
2028	660,299,766	89,700,000	356,006	146,000	34,752,619	657	472	185
2029	727,439,017	89,700,000	356,006	146,000	38,286,264	716	519	197
2030	800,620,800	89,700,000	356,006	146,000	42,137,937	780	572	209

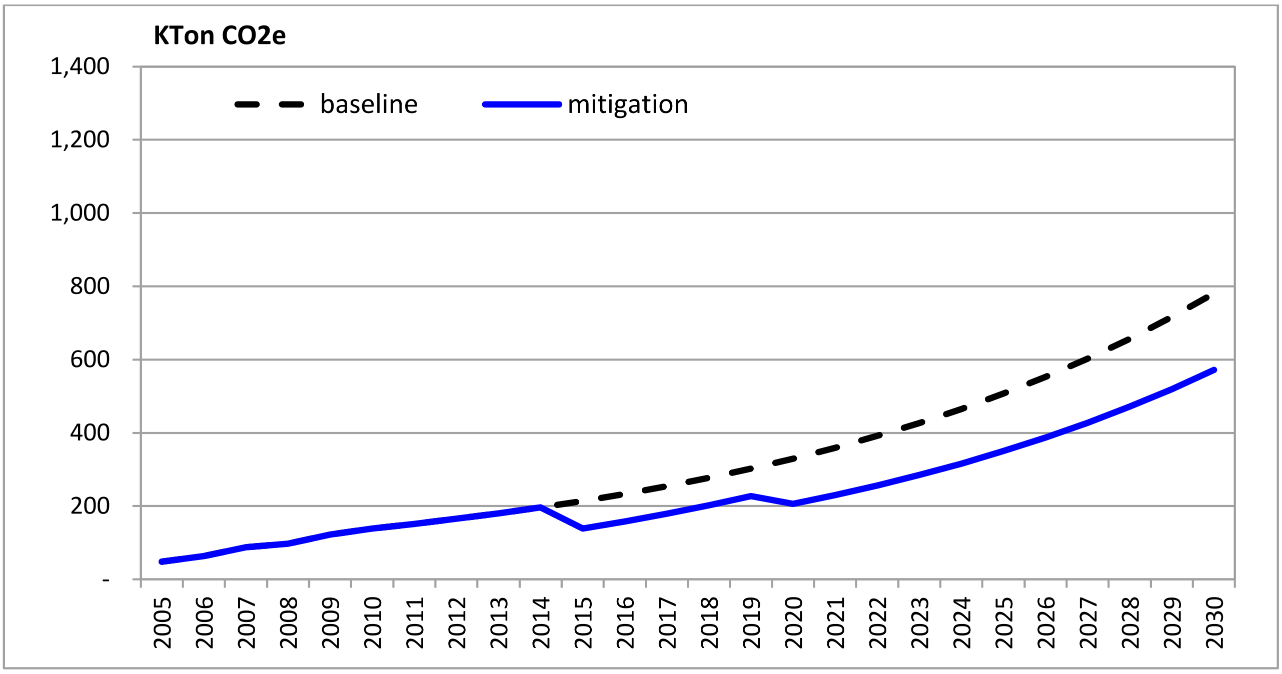


Figure 5-3 **Projection of GHG emissions from power generation for baseline and mitigation scenario**

GHG emission from power generation for the baseline and mitigation scenarios is estimated according to the specific energy consumption of each scenario such as presented in Table 5-5. The supply mix of power generation is presented in Figure 5-4.

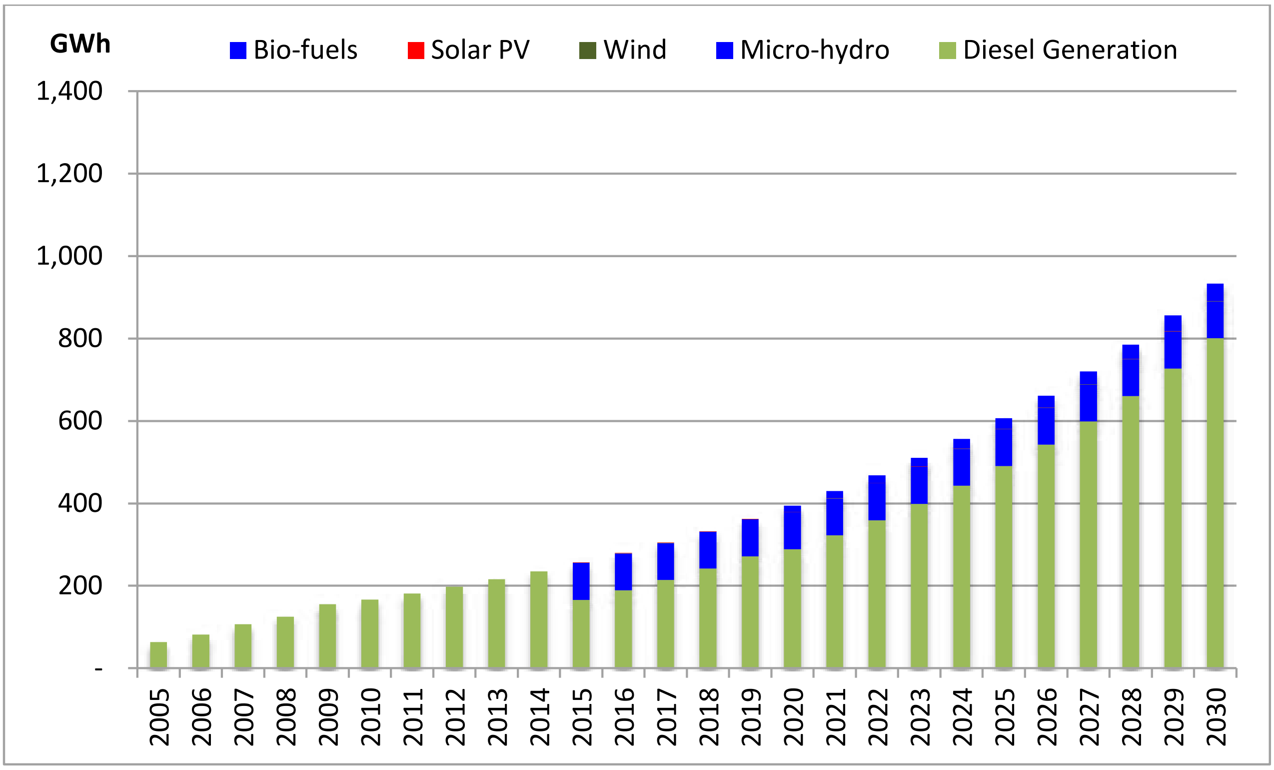


Figure 5-4 **Energy supply mix of the power generation under mitigation scenario**

Table 5-5 **Fuel Specific Consumption of power generation plants in Timor-Leste**

Year	Baseline Scenario, Lt/kWh		Mitigation Scenario, Lt/kWh	
	District Electricity Generation	EDTL, Dili	District Electricity Generation	EDTL, Dili
2005	0.27	0.27	0.27	0.27
2006	0.27	0.27	0.27	0.27
2007	0.29	0.29	0.29	0.29
2008	0.27	0.27	0.27	0.27
2009	0.28	0.28	0.28	0.28
2010	0.29	0.29	0.29	0.29
2011	0.29	0.29	0.29	0.29
2012	0.29	0.29	0.29	0.29
2013	0.29	0.29	0.29	0.29
2014	0.29	0.29	0.29	0.29
2015	0.29	0.29	0.29	0.29
2016	0.29	0.29	0.29	0.29
2017	0.29	0.29	0.29	0.29
2018	0.29	0.29	0.29	0.29
2019	0.29	0.29	0.29	0.29
2020	0.29	0.29	0.25	0.25
2021	0.29	0.29	0.25	0.25
2022	0.29	0.29	0.25	0.25
2023	0.29	0.29	0.25	0.25
2024	0.29	0.29	0.25	0.25
2025	0.29	0.29	0.25	0.25
2026	0.29	0.29	0.25	0.25
2027	0.29	0.29	0.25	0.25
2028	0.29	0.29	0.25	0.25
2029	0.29	0.29	0.25	0.25
2030	0.29	0.29	0.25	0.25

5.2.2 Mitigation Plan for Energy Sector

5.2.2.1 Greenhouse Gas Emissions Reduction Plan in Energy Activity

In the energy development plan for Timor-Leste, renewable energy technology is to be deployed for electricity generation plants and the rural energy sector (Table 5-6). The development of renewable energy in Timor-Leste started in 2005 with the establishment of biogas generation units in rural areas and solar home systems in 2008. In the future, a national program named E4A (Energy for All) will implement several renewable energy programs from 2013-2017, particularly for the electricity generation plant and household/residential energy sectors. Table 5-7 and 5-8 present the milestones of the development plan for the deployment of renewable energy in electricity generation and rural energy supply from 2013 – 2017.

Table 5-6 **Renewable Energy Development Plan in Timor-Leste, 2013-2017**

Sector	Objectives/Target		Activities
	Main Objective	5 years program	
Utilization of RE (renewable energy) resource	Gradual access to national electrification network or program to eliminate dependency on imported fuel, to addres the environment issue and for job creation.	Promote and develop energy resources, specifically Renewable Energy until 2017, to eliminate 10% of dependency on Fossil Fuel	Utilization of RE (renewable energy) resource
			Incentive for investment through BOO and PPP for solar power exploration
		Plan to construct hydropower in 3 sites connected to the national grid in order to reduce fuel consumption.	Construct Magapo 1,2 and 3 Hydropower with installed capacity 23.1 MW and annual production 89.7 GWh
	Rural electrification program to supply communities in rural areas through renewable energy resources	Promote and develop alternative energy resources, specifically solar energy until 2017 in order to reduce dependency on fossil fuel by 10%.	Continuation of installation solar system and establishment of management committee.
			Illuminate the street light by solar Energy System
		Rural electrification program provides a proportion of power supply to the community in rural areas through alternative energy resources	Improvement of actual biogas system which have been constructed
		Reduce the dependency on fossil fuel for rural area communities through the use alternative energy sources (Agro Energy)	Continuation support of establishment of center for the improvement of technical cultivation and production, by involvement of company in discussion process

Table 5-7 **Milestone of deployment of renewable energy in electricity generation**

Objectives/Target		Activities	Milestones				
SDP*	5 years program		2013	2014	2015	2016	2017
Gradual access to national electrification network or program to eliminate dependency on imported fuel, to improve the environment issue and job creation.	Promote and develop energy resources, specifically Renewable Energy until 2017, to eliminate 10% of dependency of Fossil Fuel.	Incentives for investment through Build-Own-Operate (BOO) and Public Private Partnership (PPP) schemes for wind power generation	Construction of wind energy in Larigutu 1 & Lariguto 2 with installed capacity 11.1 MW. Larigutu 1 (investment 28.1 million USD) and Larigutu 2 with installed capacity 6.0 MW (Investment cost 14.8 million USD), financing from GoTL State Budget	Continuation of intensive assessment of wind potential at Larigutu 1,2 for electricity production, with installed capacity 11.1 MW Larigutu 1 (Invest. 28.1 million USD) and Larigutu 2 with installed capacity is 6 MW (Investment 14.8 million USD) financing from GoTL State Budget	Access to operation of the national electricity grid	Construction of Wind Farm in Bobonaro 1 & 2 power production with installed capacity 25.5 MW Bobonaro (Investment 62 million USD) and Bobonaro 2 (investment 21.2 million USD) Power production, with installed capacity 8.5 MW. Funded by GoTL	Continuation of Wind Farm in Bobonaro 1 & 2
		Incentives for investment through BOO and PPP for solar power generation	Construction of Photovoltaic Centre to produce electricity with installed capacity of 50 kW on Atauro (Investment cost 1.4 million USD)	Construction of Photovoltaic Centre, for production of electricity with installed capacity of 50 kW in Oecusse (Investment cost 1.4 million USD)	Construction of Photovoltaic Plant for power production with installed capacity of 50 kW in Molop, Bobonaro (Investment Cost 1.4 million USD)	Construction of Photovoltaic Centre, for production of electricity with installed capacity 50 kW in Kota Mutu (Investment cost 1.4 million USD)	Continuation of establishment of central photovoltaic system in Osulai, Lautem
	Plan to construct hydropower in 3 sites connected to the national grid in order to reduce fuel consumption.	Construct Magapo 1, 2, 3 Hydropower with installed capacity of 23.1 MW and annual production of 89.7 GWh	Establish an MoU, based on the initial investment for construction.	Construction of Hydropower plant in Magapu 3, with installed capacity 13.4 MW	Establish an MoU, to detail the investment agreement, for initial construction	Continuation Construction of Hydropower in Magapu 1 with installed capacity 4.9 MW and Magapu 2 with installed capacity 4.8 MW	Continuation of establishment of central photovoltaic system in Osulai, Lautem

(*) Sustainable Development Plan

Table 5-8 **Milestone of deployment of renewable energy in rural energy supply**

Objectives/Target		Activities	Milestones				
SDP*	5 years program		2013	2014	2015	2016	2017
Rural Electrification program to supply community in the rural area through the renewable energy resources	Promote and develop energy resource,specifically solar energy until 2017 in order to reduce 10% dependency on fossil fuel.	Continuation of installation of solar systems and establishment of management committees.	Installation of 2000 units of solar panel and formation of management committees at the village level to assign the task of management and control to beneficiaries in Oecusse, Atauro and other identified remote areas (Investment Cost 1.6 million USD invested by GoTL)	Installation of 10,000 units and set up management committees at village level, to assign the tasks of management and control to the beneficiaries in Oecusse, Atauro and other identified remote areas. (Investment Cost 8 million USD, financing by GoTL)	Installation of 15,000 units of solar panel and setup of management committees at the village level to assign the management and control to the beneficiaries in Oecusse, Atauro and other identified remote areas (Investment Cost 12 million USD funded by GoTL)	Installation of 20,000 units of solar panel and setup of management committees at the village level to assign the management and control to the beneficiaries in Oecusse, Atauro and other identified remote areas (Investment Cost 16 million USD funded by GoTL)	Installation of 250,000 units of solar panel and establishment of management committees at the village level to assign management and control to the beneficiaries in Oecussi, Atauro and other identified remote areaa (Investment Cost 20M USD funded by GoTL)
		Illuminate street lights with solar energy systems	Oecusse District	Dili District, Atauro	Expansion to other Districts	Expansion to other Districts	Expansion to other Districts
	Rural Electrification Program is proportional of supply power to the community in the rural area through the alternative energy resources	Improvements to existing biogas systems	Improvement and maintenance of biogas plants in Liquiça $20m^3$, (Construction Cost is 10,000 USD) and Baucau $20m^3$ (construction cost 10,000 USD) funded by GoTL State Budget	Improvement and maintenance to Biomass plant in Suai $63m^3$ (Investment cost 35,000 USD) funded by GoTL.	Improvement and maintenance to Biomass plant in Ermera $142m^3$ (Investment cost 40,000 USD) funded by GoTL.	Improvement and maintenance to Biomass plant in Ainaro Baicala $20m^3$ (Investment cost 10,000 USD) funded by GoTL.	Improvement and maintenance to Biomass plant in Dili $24m^3$ (Investment cost 15,000 USD) funded by GoTL.
	Reduce the dependency on fossil fuel for rural area community through the alternative energy (Agro based-energy)	Continuation of support for establishment of centre for improvement of technical cultivation and production, by involvement of company in discussion process	A operational centre for distribution of seed supplies to beneficiary groups in Dili and Metinaro. Investment cost is 40,000 USD. Financed by GoTL	A operational centre for distribution of seed supplies to beneficiary groups in Oecusse. Investment cost is 40,000 USD. Financed by GoTL	A operational centre for distribution of seed supplies to beneficiary groups in Bobonaro. Investment cost 40,000 USD. Funded by GoTL	A operational centre for distribution of seed supplies to beneficiary groups in Viqueque (Investment Cost 40,000 USD) funded by GoTL	A operational centre for distribution of seed supplies to beneficiary groups in Viqueque (Investment Cost 40,000 USD) funded by GoTL

5.2.2.2 Mitigation Action Potential in Oil and Gas Production

As discussed previously, fuel combustion activities for own use energy supply at oil and gas production facilities is the biggest contributor to national GHG emissions in the energy category for Timor-Leste. Therefore it is challenging to reduce GHG emissions in this source category. One of the possibilities is increasing efficiency so that own use energy in oil and gas production can be reduced. However, limited availability of data regarding these facilities will lead to a need for thorough energy audits. Energy audits for these facilities will need to identify energy efficiency potentials.

5.2.2.3 Electricity Generation

In 2005, GHG emission from fossil fuel combustion in electricity generation plants is the third contributor to the national GHG emissions for Timor-Leste. In the near future, the GHG emissions level from this activity may become the second contributor after own use energy consumption in oil and gas production facilities and will be followed by GHG emissions from fossil fuel combustion activities in the transportation, commercial, and residential sectors and also fugitive emissions from oil and gas production facilities (gas flaring and venting). Therefore, GHG emissions from electricity generation activities must be included in developing any mitigation action plan, aligned with the national energy development plan and the framework of sustainable development objectives for the energy sector.

Energy efficiency can be improved throughout the entire process of energy generation and energy supply through the utilization of cleaner and newer energy technologies, where diesel generators are currently being used for electricity generation, leading to decreases in CO_2 emissions. Among these technologies are biogas, micro and/or mini hydropower, photovoltaic (solar home systems), and wind propelled electricity generators. Other possible options for GHG emissions mitigation in energy generation are the utilization of solid waste incineration to generate electricity. However, at present there is no plan to utilize solid waste to generate electricity in Timor-Leste. The replacement of diesel oil with other fossil fuels (coal or natural gas) is not considered as it will face many obstacles, particularly in supplying these fuels since the country does not have coal mining or gas pipeline infrastructure (from offshore oil and gas production facilities to the power plants).

Currently, all the electricity generation plants in Timor-Leste are fuelled by diesel oil. The electricity generation capacity was 71,958 MWh in 2005 and increased to 136,909 MWh in 2010 (see Table 5-9).

Table 5-9 **Electricity generation capacity in Timor-Leste**

Year	**2006**	**2007**	**2008**	**2009**	**2010**
Electricity Generation, MWh/year	71,958	91,788	110,514	131,700	136,909
Fuel consumption, kilo ton/year	17.43	23.54	26.8	32.35	35.48
Fuel consumption, Ton/kWh	0.24	0.26	0.24	0.25	0.26

Since the utilization of oil products (diesel oil) to generate electricity will significantly increase the cost of future electricity generation, the country's national energy plan prioritizes increasing efficiency for electricity generation and also inclusion in renewable energy programs in order to achieve energy supply security.

The utilization plan and milestones for the deployment of renewable energy in electricity generation plants are presented in Table 5-10. The table also provides an estimation of GHG emissions reduction and the cost of reduction USD/Ton for CO_2 emissions reduction. The GHG emissions reduction is estimated using several parameters and assumptions, namely:

Operation hour per year:	7884
Baseline:	Diesel oil
Fuel Specific consumption (kTon/MWH):	0.26
Fuel NHV, TJ/kTon:	43.33
Ton C/TJoule (NHV basis):	20

It can be seen in Table 5-10, that hydropower has the lowest cost for GHG emissions reduction in the power generation sub-sector, with a cost of between 0.2-0.3 USD/Ton CO_2e compared to other technology (PV or wind power), which will cost up to 0.34 USD/Ton CO_2e for wind power and 11.6 USD/Ton CO_2e (PV).

5.2.2.4 Demand Side

Industrial Sector

A large source of the abatement process on the demand side is the conservation of energy, which is particularly valid for the industrial, residential and commercial sector of this society. Emissions abatement should include the following measures:

- Upgrading of the general thermal efficiency of fossil fuel consuming stations from about 33% to at least 45%.
- Establishment of new power stations with more efficient technology.
- Improvement to management and maintenance concepts.
- Separation of energy production from energy distribution.
- Reduction of transmission losses through power transmission on the public grid.

On the demand side, energy conservation will tend to reduce the co2 emissions. In this regard the following measures and policies are recommended:

- Improvement of energy management systems through the use of high efficiency motors, fans, compressors and drive controls.
- Monitoring of energy demand through data collection on industrial energy consumption and energy consumption indicators.
- Promotion of energy efficiency and environmental protection.

Conservation measures in the residential and commercial sector can also contribute significant amounts of energy savings and therefore reduction of co2 if summarized over a long time periods. This could be achieved through implementation of the following measures:

- Improvement of energy management systems, which could be achieved through regular maintenance, turning off unnecessary lightning in offices, houses, and other buildings, and maintenance of equipment including air conditioning, etc. A main step in realizing this is the promotion of awareness among occupants.
- Use of solar heating systems instead of electrical boilers for heating water. All these require studies to define ways and means of developing programs to encourage the use of the above-mentioned improvements.

Table 5-10 **GHG emission reduction potential and cost of the deployment of renewable energy in the five years plan of electricity generation**

Activities	**Milestones (by year)**				
POWER GENERATION	**2013**	**POWER GENERATION**	**2013**	**POWER GENERATION**	**2013**
Incentives for investment through Build-Own-Operate (BOO) and Public Private Partnership (PPP) schemes for wind power generation	Wind power: Larigutu 1 (installed capacity 11.1 MW, Investment cost. 28.1 million USD) Larigutu 2 (installed capacity 6.0 MW, Investment cost 14.8 million USD), Finance: GoTL	Incentives for investment through Build-Own-Operate (BOO) and Public Private Partnership (PPP) schemes for wind power generation	Wind power: Larigutu 1 (installed capacity 11.1 MW, Investment cost. 28.1 million USD) Larigutu 2 (installed capacity 6.0 MW, Investment cost 14.8 million USD), Finance: GoTL	Incentives for investment through Build-Own-Operate (BOO) and Public Private Partnership (PPP) schemes for wind power generation	Wind power: Larigutu 1 (installed capacity 11.1 MW, Investment cost. 28.1 million USD) Larigutu 2 (installed capacity 6.0 MW, Investment cost 14.8 million USD), Finance: GoTL
Reduction, Gg CO_2e	99,004	Reduction, Gg CO_2e	99,004	Reduction, Gg CO_2e	99,004
Reduction cost, USD/ton CO_2e	0.344	Reduction cost, USD/ton CO_2e	0.344	Reduction cost, USD/ton CO_2e	0.344
Incentives for investment through BOO and PPP for solar power generation	Centralized Photovoltaic in Atauro with installed capacity 50 kW, Investment cost 1.4 million USD)	Incentives for investment through BOO and PPP for solar power generation	Centralized Photovoltaic in Atauro with installed capacity 50 kW, Investment cost 1.4 million USD)	Incentives for investment through BOO and PPP for solar power generation	Centralized Photovoltaic in Atauro with installed capacity 50 kW, Investment cost 1.4 million USD)
Reduction: Gg CO_2e	121	Reduction: Gg CO_2e	121	Reduction: Gg CO_2e	121
Reduction cost: USD/Ton CO_2e	11.6	Reduction cost: USD/Ton CO_2e	11.6	Reduction cost: USD/Ton CO_2e	11.6
Develop Magapo 1, 2 and 3 Hydropower with installed capacity 23.1 MW and annual production 89.7 GWh	Provide the MoU, based on the initial investment and construction.	Develop Magapo 1, 2 and 3 Hydropower with installed capacity 23.1 MW and annual production 89.7 GWh	Provide the MoU, based on the initial investment and construction.	Develop Magapo 1, 2 and 3 Hydropower with installed capacity 23.1 MW and annual production 89.7 GWh	Provide the MoU, based on the initial investment and construction.
Reduction: Gg CO_2e	-	Reduction: Gg CO_2e	-	Reduction: Gg CO_2e	-
Reduction cost: USD/Ton CO_2e	-	Reduction cost: USD/Ton CO_2e	-	Reduction cost: USD/Ton CO_2e	-

Source: Estimated from energy data and information from National Directorate Coordination Renewable Energy Activities, 2012

The high initial costs oppose the implementation of these technologies in sparsely populated rural areas. However, there are no industries in Timor-Leste that consume significant amounts of energy. Therefore, on the demand side, efficiency in the industrial and commercial sub-sectors is not included in the GHG emissions mitigation action plan. Detailed discussion of the renewable energy development plan and the implication of this development in reducing GHG emissions is presented as follows.

Transportation sector

Mitigation in the transportation sector includes measures towards increasing the efficient use of energy and reducing demand. In this regard the following are mentioned:

- Mitigation through improvement of vehicle controls and maintenance.
- Rehabilitation and maintenance of transport ways.
- Introduction of electrified railways for mass transportation within the city, taken against the back ground of increasing number of cars and automobiles, and worsening traffic and transport problems.

Residential (households) in rural areas

The utilization plan and milestones for the deployment of renewable energy in residential/households is presented in Table 5-11. This table also provides an estimation of GHG emissions reductions and the costs of reduction as USD/Ton CO_2. The GHG emissions reduction is estimated using several parameters and assumptions, namely:

PV SHS	
Electricity generation, watt-peak/unit:	60
Peak hour per year (8 hrs/day):	2920
Baseline:	Kerosene
Fuel consumption equivalent, TJ/MWh:	0.00374
EF Kerosene, ton C/TJ:	19.5
BIOGAS	
Methane concentration in biogas:	60 – 65%
Baseline:	Kerosene
EF of Kerosene, Ton C/TJ:	19.5
NHV (Net Heating value)	
Kerosene, TJ/litre:	0.000052
LPG, TJ/kg:	0.000036
Biogas, TJ/m3:	0.000022
Biomass Fire Woods, TJ/kg:	0.000014
Biomass Charcoal, TJ/kg:	0.0000303
Conversion Factor 1 m3 Biogas equivalent to:	
Kerosene, litre	0.4231
LPG, kg	0.6085

As can be seen in Table 5-11, improvement and maintenance to biogas plant has the lowest cost of GHG emissions reductions in rural energy supply, with costs between (-0.5) – (-0.8) USD/Ton CO_2e compared with other technology (PV), with costs between 0.13-0.17 USD/Ton CO_2e for PV. Negative cost means that mitigation actions will not need investment but that the activity will reduce the cost. The cost of PV varies according to the number of PV plants to be installed.

5.3 ASSESSMENT OF MITIGATION POTENTIAL FOR AFOLU SECTOR

From the key category analysis, it is clear that emissions from agriculture, forest and other land uses are the main sources of emissions namely (i) Forest and grassland conversion, (ii) Enteric fermentation, (iii) Emissions from agricultural soils, (iv) Manure management, (v) Other Emissions from LUCF, Changes in forest and other woody biomass stocks and (vi) rice cultivation. Efforts to reduce emissions from these sources will have significant impact on the country's total emissions. Therefore, mitigation assessment for this sector is very important. However due to data limitation, the mitigation assessment was only undertaken for the land use change and forestry (LUCF) sector.

5.3.1 Mitigation Options for LUCF sector

The land use change and forestry (LUCF) sector in Timor-Leste has been considered as the sector with the most potential not only for mitigating climate change but also for increasing the climate resilience of many ecosystems in the country. The strategy for mitigating climate change in this sector is closely associated with poverty alleviation. As stated in the Timor-Leste Strategic Development Plan 2011–2030 (TLSDP 2011-2030) 'the sustainability of Timor-Leste's forests is essential for families who rely on forests for firewood for income generation, for farmers who suffer as a result of erosion caused by deforestation and damage to water catchments, and for all Timorese who value their natural beauty'.

Mitigation measures in forestry can be classified into three broad categories (Sathaye and Ravindranath, 1997), i) conservation of forest, ii) enhancing and expanding carbon sink, and iii) fossil fuel substitution with biomass energy. Conservation of forest carbon is done by controlling deforestation, protecting forests, changing harvesting regimes, and controlling other anthropogenic disturbances, such as fires and pest outbreaks. Enhancing and expanding carbon sinks is done by increasing forest area and/or biomass through planting trees in low carbon sink lands and by increasing storage in durable wood products. Fossil fuel substitution is through the use of biomass energy or the use of biomass products in place of energy-intensive ones.

Table 5-11 **GHG emission reduction potential and cost of the deployment of renewable energy in the five years plan of rural energy supply**

Activities	Milestones (and of year)				
	2013	2014	2013	2016	2013
Continuation of installation of solar systems and establishment of management committees.	Installation of 2,000 units of solar panels and formation management committees at village level to assign the task of management and control to beneficiaries in Oecusse, Atauro and other identified remote areas (Investment cost 1.6 million USD invested by GoTL)	Continuation of installation of solar systems and establishment of management committees.	Installation of 2,000 units of solar panels and formation management committees at village level to assign the task of management and control to beneficiaries in Oecusse, Atauro and other identified remote areas (Investment cost 1.6 million USD invested by GoTL)	Continuation of installation of solar systems and establishment of management committees.	Installation of 2,000 units of solar panels and formation management committees at village level to assign the task of management and control to beneficiaries in Oecusse, Atauro and other identified remote areas (Investment cost 1.6 million USD invested by GoTL)
Reduction, $GgCO_2e$	93.70	Reduction, $GgCO_2e$	93.70	Reduction, $GgCO_2e$	93.70
Cost of Reduction, USD/Ton CO_2e	17.08	Cost of Reduction, USD/Ton CO_2e	17.08	Cost of Reduction, USD/Ton CO_2e	17.08
Illuminate street light by solar energy systm	Oecusse District	Illuminate street light by solar energy systm	Oecusse District	Illuminate street light by solar energy systm	Oecusse District
Reduction, $GgCO_2e$	n.a	Reduction, $GgCO_2e$	n.a	Reduction, $GgCO_2e$	n.a
Cost of Reduction, USD/Ton CO_2e	n.a	Cost of Reduction, USD/Ton CO_2e	n.a	Cost of Reduction, USD/Ton CO_2e	n.a
Improvement of existing biogas systems	Improvement and maintenance of biogas plant in Liquiça $20m^3$, (Construction cost is 10,000 USD) and Baucau $20m^3$ (Construction cost USD 10,000) invested by GoTL State Budget	Improvement of existing biogas systems	Improvement and maintenance of biogas plant in Liquiça $20m^3$, (Construction cost is 10,000 USD) and Baucau $20m^3$ (Construction cost USD 10,000) invested by GoTL State Budget	Improvement of existing biogas systems	Improvement and maintenance of biogas plant in Liquiça $20m^3$, (Construction cost is 10,000 USD) and Baucau $20m^3$ (Construction cost USD 10,000) invested by GoTL State Budget
Reduction from kerosene replacement with biogas, Gg CO_2e	3.5	2.8	6.2	0.9	1.0
Reduction from manure treatment, Gg CO_2e	7.1	11.2	25.2	3.5	4.3
Total reduction, Gg CO_2e	10.55	13.92	31.38	4.42	5.30
Cost of reduction (include investment & kerosene saving) for total reduction, USD/Ton CO_2	(86)	(51)	(52)	(51)	(50)
Continuation support of Centre establishment to improve technical cultivation and production, by involvement of company in discussion process	An operational centre for distribution of seed supplies to beneficiary groups in Dili and Metinaro. Investment cost is 40,000 USD, Financed by GoTL	An operational centre for distribution of seed supplies to beneficiary groups in Oecusse. The Investment cost is 40,000 USD, Financed by GoTL	An operational centre for distribution of seed supplies to beneficiary groups in Bobonaro. The Investment cost is 40,000 USD, funded by GoTL	An operational centre for distribution of seed supplies to beneficiary groups in Viqueque (Investment cost is 40,000 USD) funded by GoTL	An operational centre for distribution of seed supplies to beneficiaries groups in Viqueque (Investment cost is 40,000 USD) funded by GoTL

Five potential mitigation measures have been assessed: (i) planting of teak, (ii) rosewood and (iii) sandalwood for rotational management in shrub areas; (iv) agroforestry using candlenut as the main tree crop on agriculture mixed shrub areas, and (v) mangrove restoration on swampy shrub lands. It was found that potential mitigation of these measures range from 59 to 308 tonnes C per ha[7] in which mangroves provide the highest potential and sandalwood the least potential. Using a real discount rate of 10%, the investment required to implement these mitigation activities ranged from $US 1.49 to $US 6.98 per ton C, with a life cycle cost ranging from $US 0.05 to $US 9.33 USD/Ton of C and a net present value of benefits from –$US 0.89 to $US 22.46 per Ton of C (Table 5-12). Mitigation options which yield negative financial benefits were mangrove restoration and reforestation using teak and rosewood, while those which yield positive financial benefits were reforestation using sandalwood and agroforestry. However, further study on this needs to be done using more precise data as much of the input data used for these options was assumed.

Table 5-12 **Cost effectiveness of the mitigation options**

Option	Investment Cost		Life Cycle Cost		NPV Benefit	
	$/t C	$/ha	$/t C	$/ha	$/t C	$/ha
Teak	1.49	128.82	3.64	315.17	-0.89	-77.20
Cendana	3.28	193.24	7.00	412.16	18.08	1064.81
Aina	2.05	171.77	4.51	378.52	-3.73	-313.53
Agroforestry	6.98	615.11	9.33	822.46	22.46	1980.02
Mangrove	1.54	475.55	0.05	15.00	-3.60	-1107.48

5.3.2 Area of Wastelands Available for Mitigation

Land areas suitable for mitigation can be classified into three categories, i) shrubs, ii) swampy shrubs and iii) agriculture mixed with shrubs. Based on the three scenarios, total land used for the implementation of mitigation measures is given in Table 5-13. Table 5.13 shows that the implementation of mitigation measures under the three scenarios would not use all of the suitable lands. In 2010, the total areas of shrubs, swampy shrubs and agriculture mixed with shrubs available for mitigation activities were about 535,309 ha, 10,444 ha and 420,733 ha respectively.

5.3.3 Development of Land Use Change Scenarios for Mitigation

The implementation of mitigation actions in the LUCF sector follows three scenarios namely (i) baseline scenario, (ii) government plans scenario, and (iii) mitigation scenario, each with specific assumptions. Baseline scenario (B) is developed with the assumption that future land use follows historical land use. The government plans scenario (G) follows government plans as defined in MAFFs targets for 2014-2018 and consultation with related agencies. In many cases, the government scenario is unlikely to be achieved. The government scenario thus sets an upper boundary on what could be achieved under conditions of ideal implementation. The mitigation scenario (M) assumed that the rate of reforestation is increased above the baseline but below the government plan. The rate of reforestation after 2018 is decreased considering the availability of land for the implementation of these measures.

[7]Includes carbon accumulated in the soil and carbon stored in wood products.

Table 5-13 **Land area used for mitigation options (ha)**

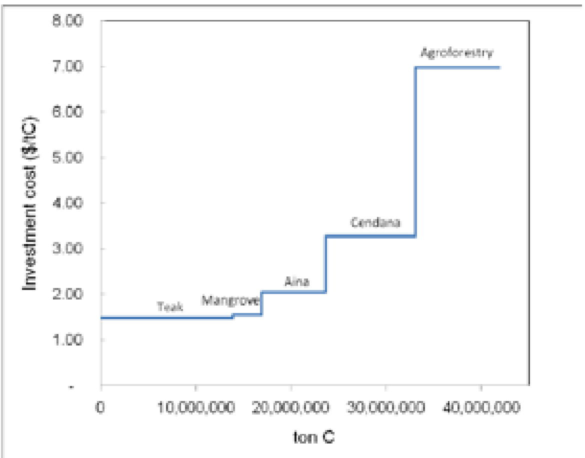
Land cover categories	Area technically available in 2010	Total area required for mitigation scenario (2011-2020)	Total area required for mitigation scenario (2021-2030)	Total area required for mitigation scenario (2031-2041)	Total area required for mitigation scenario (2041-2050)
	Baseline				
Shrubs	535,309	**0**	**0**	**0**	**0**
Teak		0	0	0	0
Sandalwood		0	0	0	0
Rosewood		0	0	0	0
Swampy Shrubs	10,444	**0**	**0**	**0**	**0**
Mangrove rehabilitation		0	0	0	0
Agriculture mixed with Shrubs	420,733	**900**	**900**	**900**	**900**
Agroforestry (Candlenut)		900	900	900	900
	Government Scenario				
Shrubs	535,309	**24,600**	**25,000**	**25,000**	**15,100**
Teak		9,840	10,000	10,000	10,000
Sandalwood		9,840	10,000	10,000	5,000
Rosewood		4,920	5,000	5,000	100
Swampy Shrubs	10,444	**100**	**100**	**100**	**100**
Mangrove rehabilitation		100	100	100	100
Agriculture mixed with Shrubs	420,733	**12540**	**1200**	**1,200**	**1,200**
Agroforestry (Candlenut)		12540	1200	1,200	1,200
	Mitigation Scenario				
Shrubs	535,309	**14,600**	**12,500**	**12,500**	**12,500**
Teak		5,840	5,000	5,000	5,000
Sandalwood		5,840	5,000	5,000	5,000
Rosewood		2,920	2,500	2,500	2,500
Swampy Shrubs	10,444	**100**	**100**	**100**	**100**
Mangrove rehabilitation		100	100	100	100
Agriculture mixed with Shrubs	420,733	**1,200**	**1,200**	**1,200**	**1,200**
Agroforestry (Candlenut)		1,200	1,200	1,200	1,200

Based on the above assumptions, in the period of 2011-2050, the total area of shrubs used for the implementation of mitigation measures under baseline (B), government (G) and mitigation (M) scenarios were 0 ha, 89,700 ha and 52,100 ha respectively. While for swampy shrubs, the total area used under the three scenarios were 0 ha, 400 ha, and 400 ha respectively, and for agriculture mixed with shrubs were 3,600 ha, 16,140 ha, and 4,800 ha respectively.

The results of this analysis suggest that following the government scenarios, there are still large areas available for the implementation of mitigation measures. However, increasing the rate of reforestation might not be possible due to limited availability of funds. If all available lands for the implementation of mitigation measures are used, the potential mitigation would reach about 41,892,915 Tons of C (Figure 5-5) with a total investment of about $US 131 million and a total life cycle cost of around $US 229 million (Table 5-14). The total available lands are defined based on the following assumptions:

- Shrubs that could be used are only 400,000 ha since some of the lands will be needed for the development of new agricultural land. Of the 400,000 ha about 40% will be for teak, 40% for sandal wood and 20% for rosewood.
- Agriculture land mixed shrubs that can be used for agroforestry is only 100,000 ha (25%) since most of this land is normally used to grow annual crops.

Swampy shrub is assumed to be allocated for fish ponds for about 444 ha, thus the available land for mangrove restoration is only 10,000 ha.



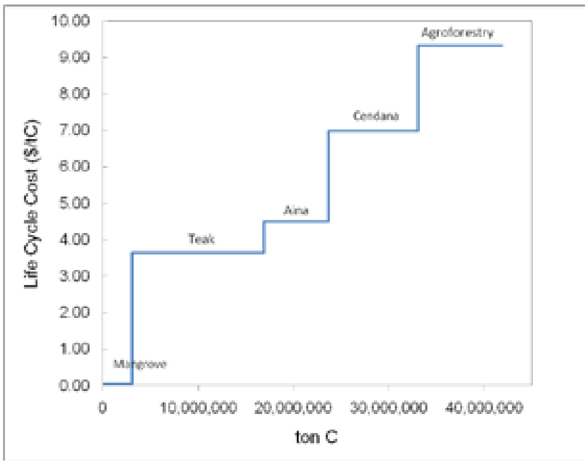


Figure 5-5 **Abatement cost and potential emissions reduction from the implementation of the five mitigation measures**

Table 5-14 **Total investment and life cycle cost required for the implementation of mitigation measures in all available lands**

Options	Potential Area (ha)	Investment Cost ($/ha)	Total Investment Cost ($)	Life Cycle Cost ($/ha)	Total Life Cycle Cost ($)
Teak	160,000	128.82	20,611,896	315.17	50,427,534
Sandalwood	160,000	193.24	30,917,845	412.16	65,945,201
Rosewood	80,000	171.77	13,741,264	378.52	30,281,846
Agroforestry	100,000	615.11	61,510,794	822.46	82,245,888
Mangrove	10,000	475.55	4,755,456	15.00	149,964
			131,537,255		229,050,433

5.3.4 Impact of the Implementation of Mitigation on the National Carbon Pool

Under the baseline scenario, the national carbon pool tends to decrease continuously through 2050 (Figure 5-6). This is due to the higher rate of deforestation than reforestation. Under government scenarios, the national carbon pool also decreases up to 2020 and then increases through 2050 while for mitigation it would decrease up to 2030. The rapid increase of carbon stock under the government scenarios is because the rate of reforestation is much higher than that of the mitigation scenarios. Unlike the government scenario, the increase of carbon stock under the mitigation scenario is not enough to offset the loss of carbon due to deforestation since 2010. The carbon stock in 2050 under the mitigation scenario is still lower than that of 2010.

The results of this analysis suggest that the implementation of government scenarios would increase the carbon stock back to the condition of 2010. As the government scenario will not use all the available land, the condition of carbon stock in 2050 can be further increased above the 2010 level. However this will require high investment as shown in Table 5-14. Barriers to the implementation of the mitigation options should be removed. The involvement of CBOs with strong roots in the community where members are living near the rehabilitation site will be needed to increase survival rates. The involvement of the private sector will be crucial to accelerate the establishment of plantations by improving market conditions and wood industries. Under current conditions, the establishment of timber plantation is not profitable.

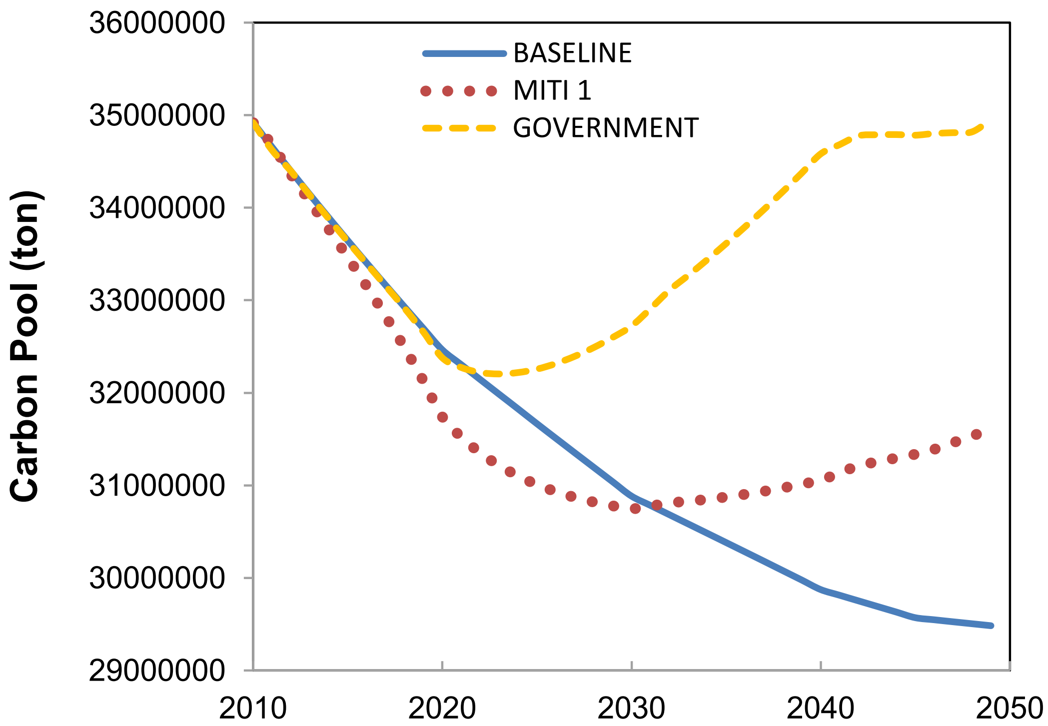


Figure 5-6 **Change in carbon pool under baseline and mitigation scenario (ton of Biomass)**

5.4 ASSESSMENT OF MITIGATION POTENTIAL FOR WASTE SECTOR

The GHG emissions abatement potential in the waste management activity category is identified based on historical data from the GHG inventory. Based on the GHG inventory analysis, potential measures for GHG mitigation in the waste sector are:

- Implementation of managed landfill for SWM (e.g. flaring /leachate treatment).
- Use of waste for energy (MSW as RDF) for power generation plant (incineration).
- Collected domestic wastewater treatment (an-aerobic) although the potential is very low.

Considering the waste management target of Timor-Leste, the mitigation measures for this sector compares to those of the baseline are presented in 5-15.

Table 5-15 **Mitigation measures for GHG emission reduction in Waste Sector**

Waste Management	Baseline	Mitigation	Remarks
Open Burning	41%	-	Stop before 2020
Composting and 3 R	-	20%	Starts from 2020
Waste to SWDS	9.9%	50%	Starts from 2020
a. Un-managed-shallow	100%	30%	
b. Managed Landfill	-	70%	Starts from 2020
Land Fill Gas (LFG)	LFG is not managed	LFG is to be recovered for flaring or utilization	Starts from 2020

By implementing all of the potential mitigation measures in Table 5.15 starting in 2020, the resulting cumulative emissions reduction between 2020 and 2030 is about 126 Gg CO_2e (Table 5-16). The projection of emissions under the BaU and Mitigation Scenarios is given in Figure 5-7 and 5-8.

Table 5-16 **Potential GHG reductions resulting from mitigation actions in the waste sector**

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
G CO2e	5	6	8	9	10	11	13	14	15	17	18

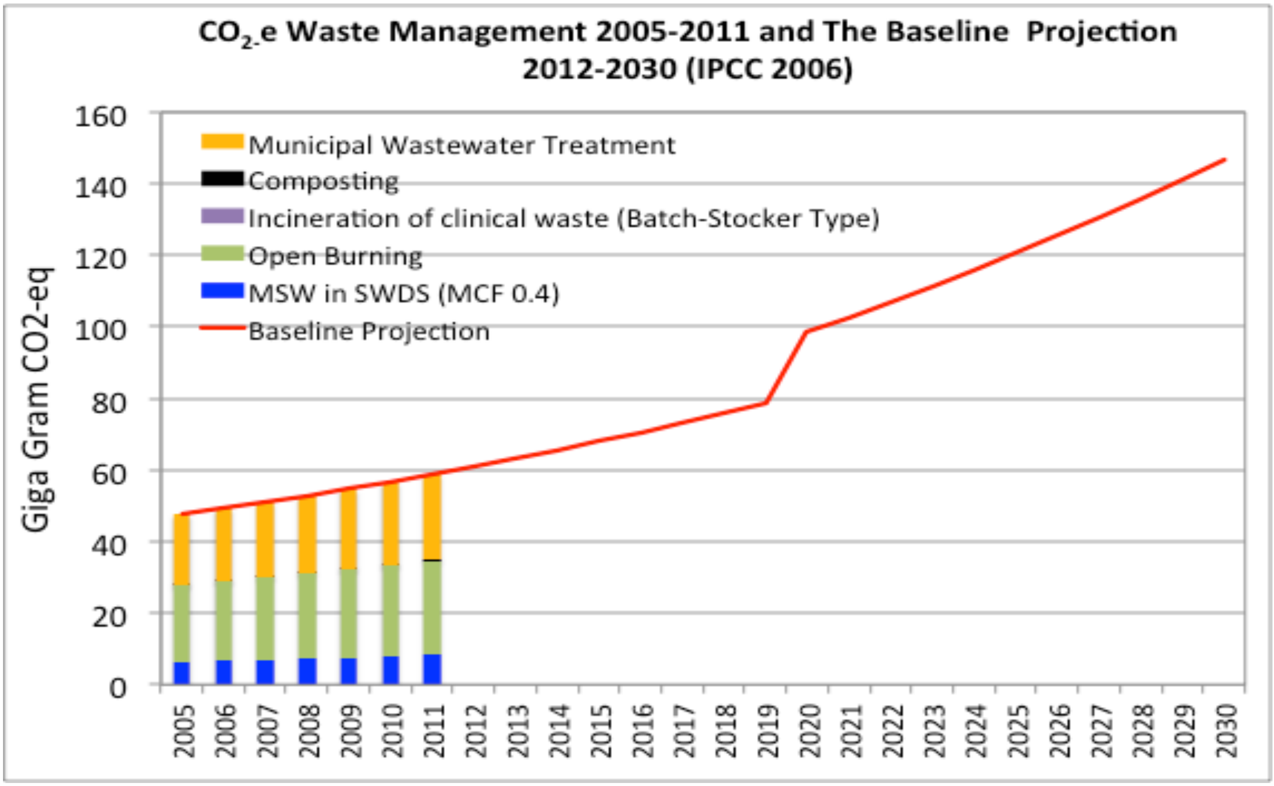


Figure 5-7 **Historical data (2005-201) and it's projection (2012-2030)**

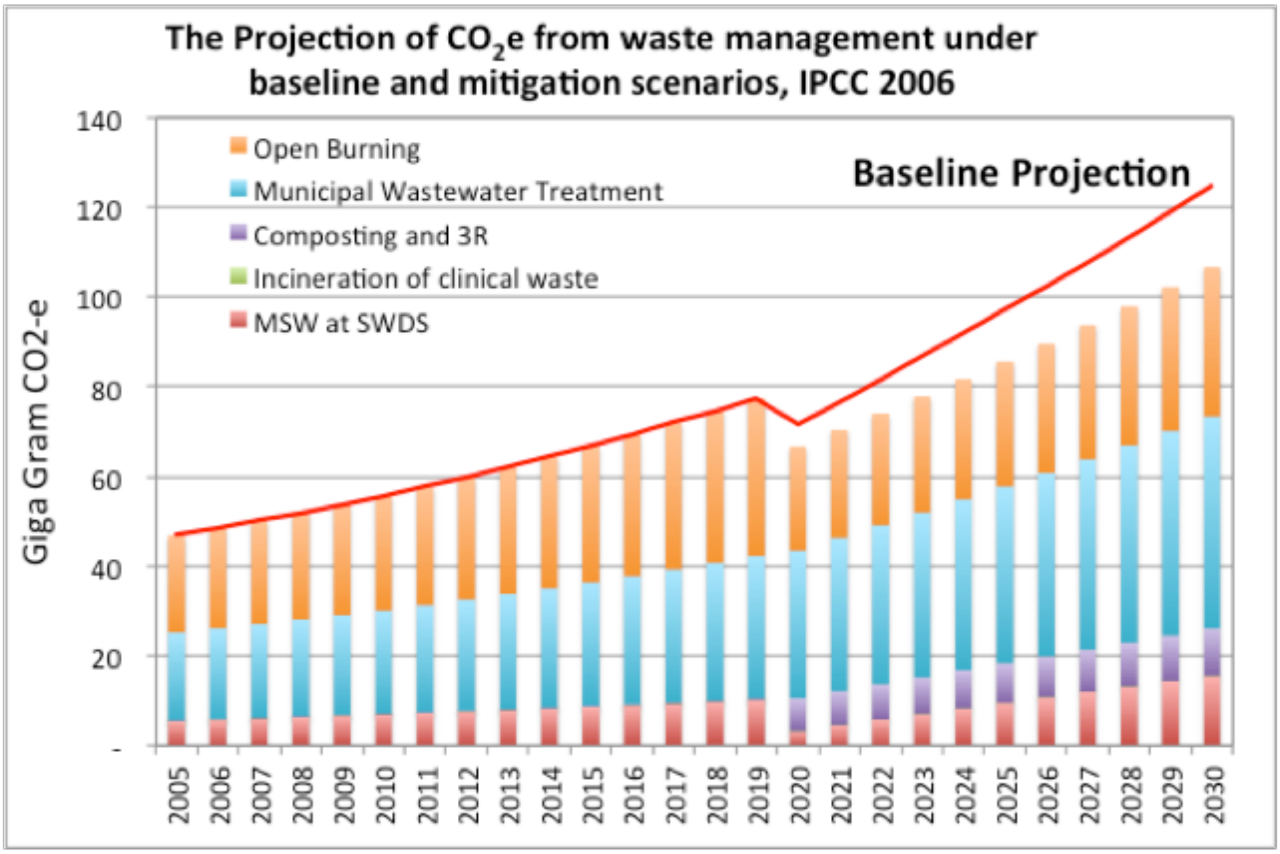


Figure 5-8 **The projection of CO_2e under baseline and mitigation scenarios**

5.5 EMISSIONS PROJECTIONS BETWEEN BAU AND MITIGATION SCENARIOS

Implementation of all mitigation measures in power, transportation, LUCF and waste sectors in Timor-Leste can potentially reduce the GHG emission by about 17% from the BaU emission by 2030 or equivalent to about 362 Gg CO_2eq (Figure 5-9). However, there are a number of barriers to achieving this condition. Among others, the main barriers are lack of finance, lack of extension services, and lack of capacity in using the mitigation technologies.

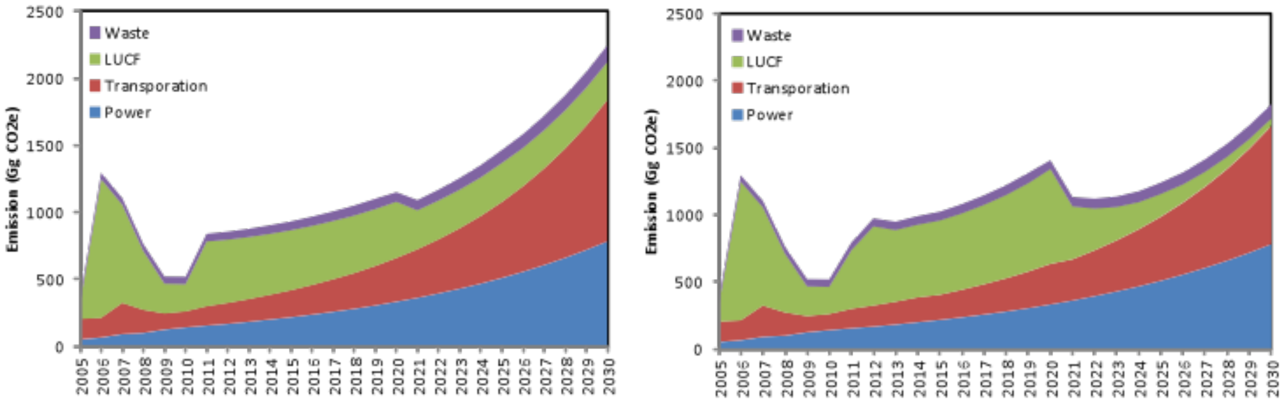


Figure 5-9 **Projection of GHG emission under BAU (left) and Mitigation scenarios (right).**

Note: From LUCF, there would be a sudden decrease in emission in 2021 as it is assumed that there no development of new agriculture area after 2020

6 OTHER INFORMATION

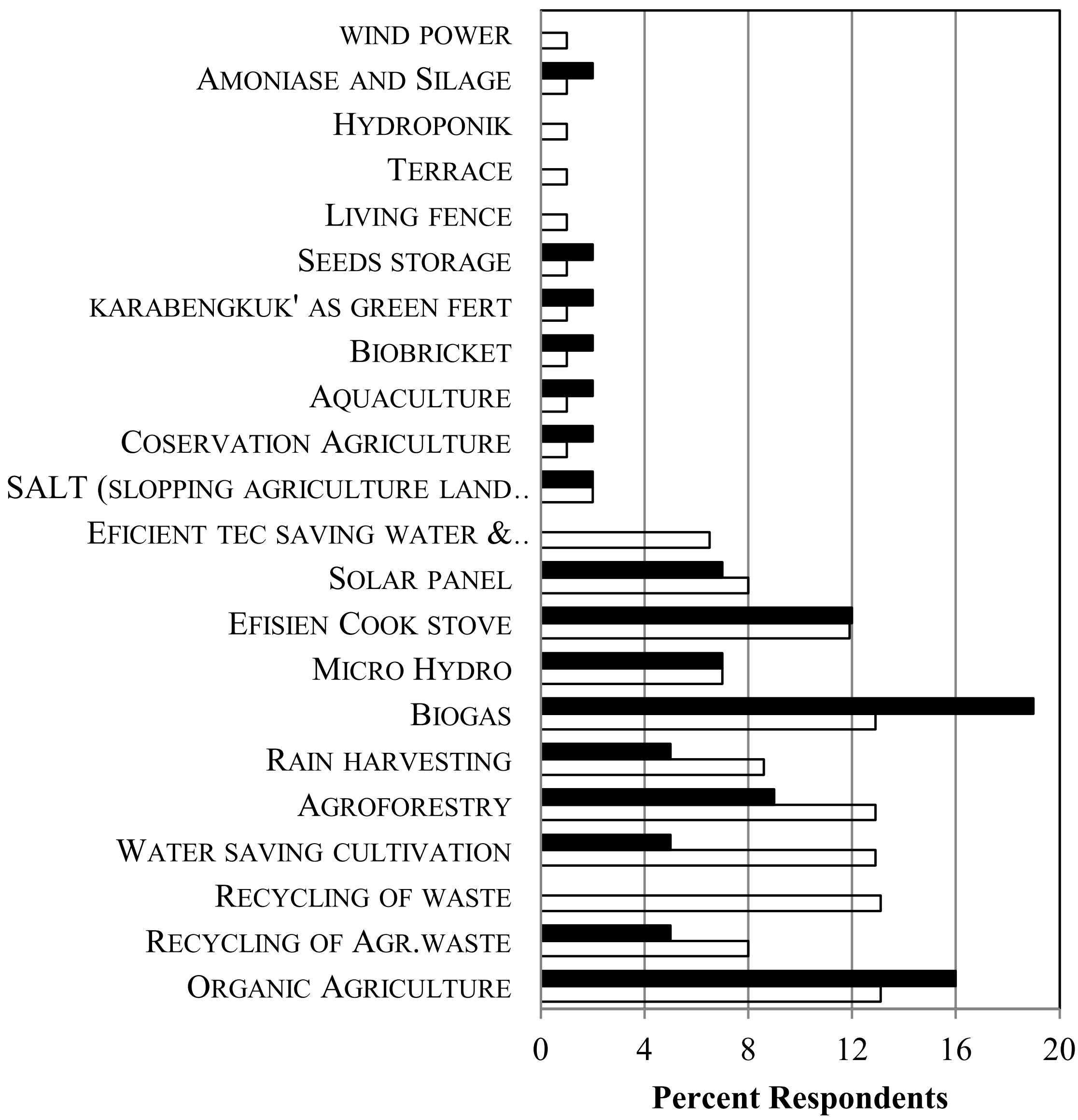
Photo by UNMIT/Martine Perret

6.1 TECHNOLOGIES ON MITIGATION AND ADAPTATION

Due to limited sources of information on technology needs, and in conjunction with the development of its Initial National Communication, Timor-Leste conducted a survey on Environmentally Sound Technology (EST), aimed at assessing technology needs, enabling conditions for technology transfer, the need for capacity building for technology transfer, international support for Timor-Leste in technology transfer and the status of Research and Systematic Observation (RSO) in Timor-Leste. The survey (Tavares, 2013) targeted respondents from various government, NGO, and donor agencies (i.e. 29 respondents). Information in this section is mostly based on the result of this survey derived from respondents knowledge and opinions, and thus cannot objectively reflect the situation in Timor-Leste.

According to the survey, climate change related technologies that have been implemented in Timor-Leste include biogas, organic agriculture, efficient cook stoves, agro-forestry, and rainfall harvesting, while technologies on organic agriculture, agro-forestry, rainfall harvesting, recycling of agriculture waste, biogas, efficient cook stoves, and water conservation are perceived as the most important technologies for further development (Figure 6-1).

Figure 6-1 **Technologies deemed most needing development (white bar) and most implemented (black bar)** (Tavares, 2013)



Timor-Leste has implemented a number of programs for supplying electricity in rural areas through the use of renewable energy, particularly hydro power, solar PV and biogas. Up to 2012, the government had installed pico hydro in three districts supplying electricity for 733 HH; Solar PV about 9,300 units with total capacity of about 0.465 MW and biogas energy for 270 HH and 1 school.

With regard to adaptation, Timor-Leste is currently involved in only a few adaptation projects and it is considered that there is a smaller number in comparison to other developing countries in East and Southeast Asia. To date it appears that the projects with which they are involved are only those that also include other countries. Several of these projects are being undertaken in collaboration with Pacific region countries, reflecting in part Timor-Leste's status as a small island nation. Each of these projects has a strong focus on capacity building. The vulnerable sectors addressed through these projects include agriculture, water, natural resource management, coastal zone management, marine management and policy and planning. The Asian Development Bank (ADB), the Global Environment Facility (GEF), and the Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA), and the countries of Canada, Sweden and the United States are funding these projects.

6.2 RESEARCH AND SYSTEMATIC OBSERVATIONS

There are a number of national and international institutions in Timor-Leste that are actively involved in conducting climate change research and systematic observation. ALGIS and the National Directorate for Meteorology and Geophysics (NDMG) are the two main national agencies working on climate research, while international agencies are UNDP and the BOM-Australia.

However, Timor-Leste has not yet developed a national research program on climate change and according to the survey, the majority of national and international institutions being interviewed agreed that Government of Timor-Leste needs to develop a National Research Program on Climate Change.

Research activities that have been implemented so far are mainly focused on climate change impact assessment, especially on agriculture and fisheries, socio-economic impact, and utilization of environmentally friendly local technology for climate change mitigation and adaptation (see Figure 6-2).

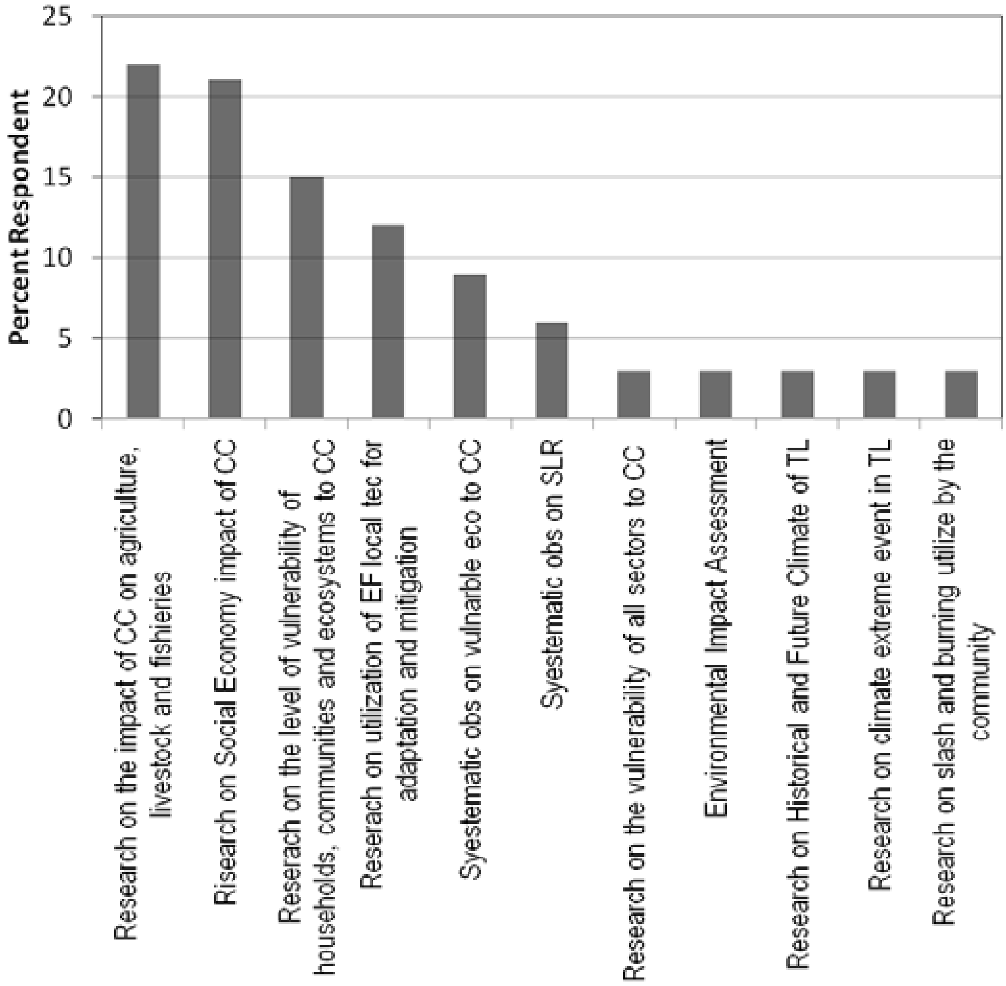


Figure 6-2 **Result of survey on research activities being conducted most in Timor-Leste** (Tavares, 2013)

The survey also shows respondents' suggestions to maintain research in the areas that have been developed so far, with more attention directed toward research related to vulnerability, and less on socio-economic impact. New areas proposed for research are about climate change impact on infrastructure (Figure 6-3).

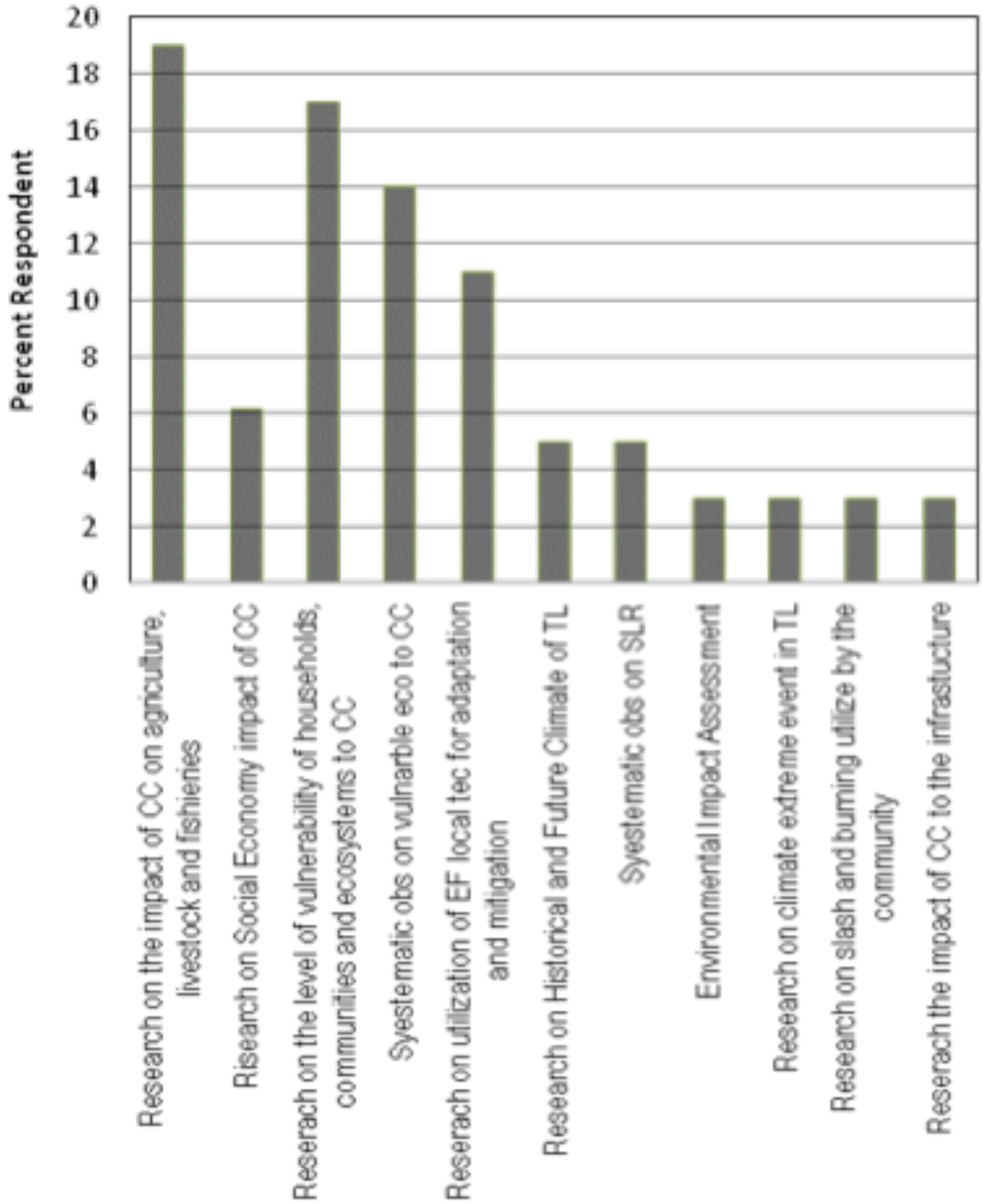


Figure 6-3 **Recommended climate change researches activities from national and international agencies in Timor-Leste** (Tavares, 2013)

In cooperation with Australia, through a program called Seeds of Life (SoL), the Ministry of Agriculture and Fisheries have established a number of observation stations throughout Timor-Leste. At the moment, there are 19 stations managed by the Ministry and 20 stations managed through the SoL program.

Meteorological observation is currently conducted at Nicolau Lobato Airport. There is also a plan to establish meteorological stations in other districts. The Timor-Leste government have a cooperation agreement on meteorological observation with the Australian authority in Darwin.

6.3 INFORMATION ON EDUCATION, TRAINING, PUBLIC AWARENESS & CAPACITY BUILDING

The Timor-Leste government attaches great importance to education, training and public awareness on environment and climate change. As a result Timor-Leste has sped up training and education on climate related issues, and has made considerable effort to raise public awareness on climate change to promote sustainable development.

6.3.1 Education

The World Bank has been supporting the education and training sector in Timor-Leste since 2000, with support from Australian Aid and other partners through financial as well as technical assistance. In recent years, support has focused on expanding access to primary and secondary education through improving school facilities and learning and teaching materials, and strengthening the quality of learning through teacher training and curriculum development.

Since 2008, over 600 teachers have graduated and around 7000 completed 2 year training courses with a degree in basic education from the National Institute for the Training of Teachers and Education Professionals, as part of a strategy to both improve access and quality of basic education.

Also with the support of the World Bank, Timor-Leste developed the Education Sector Support Project (ESSP), which according to the donor's Mid-Term Review of sector support undertaken in August-November 2010, has been implemented satisfactorily. The ESSP has been flexible, has disbursed rapidly and has been responsive in supporting a sector characterized by fragile capacity and rapid change. In the future, Timor-Leste intends that all children will have access to secondary education, after graduating from basic education at the age of 15. To achieve this target, the education program will focus on improving access to secondary education and providing adequate infrastructure as well as qualified teachers.

6.3.2 Training

Training activities related to climate changes are still limited in Timor-Leste. However, a number of government agencies including NGOs, donor and other international agencies have implemented a number of capacity building activities related to environmental issues. In 2011, besides the local environment related technical training (see Table 6-1), DNAAI also invested in English and Portuguese Language courses as a tool to improve its staff's capacity for communication with international counterparts.

Table 6-1 **List of training and workshops on environmental issues participated in by Timor-Leste government representatives**

Training / Workshop	Year
General	
English course for staff organized by DNAAIAC	2011
Portuguese course for staff organized by Instituto Português de Apoio ao Desenvolvimento (IPAD)	2011
Workshop on Sustainable Development Concept – Run Up to Rio+20 organized by SEMA	2011
Workshop on wastewater treatment plant currently being constructed in Tibar. Workshop organized by DNSAS.	2011
Workshop on MEAs and Negotiation Skills organized by Ministry of Foreign Affairs.	2011
Workshop on Communication Education and Public Awareness organized by Catholic Relief Service.	2011
UNCBD	
Workshop on Biophysical Profile of the Arafura and Timor Seas at Hotel Arbiru, Dili. Workshop was organized by State Secretary for Fisheries and within the framework of ATSEF.	2011
Workshop on Integrated Marine Observing System (IMOS) Through Flow Moorings organized by State Secretary for Fisheries and within the framework of ATSEF.	2011
Workshop on indigenous knowledge organized by Haburas NGO. Purpose of workshop was to Increase participants' knowledge on local customary practices that are relevant for the conservation of biodiversity in the coastal, mountain, dry and wetland areas. Additionally, ways to strengthen local customary laws were discussed.	2011
Workshop on Biosphere Reserve and its assets, potential and challenges in Timor Leste. Workshop was organized by the National Directorate for Forestry.	2011
UNFCCC	
Training on internet-based climate change models at the Ministry of Public Works. Training was provided by the Australian Environment and Sustainable Directorate.	2011
National Capacity Self-Assessment	
Participation in the *Workshop on Environmental Health and the National Curriculum Connection*, Delta Lounge in New Dili, Timor Leste, in order to better understand climate change can affect human health and the need to include Environmental Health in the National Curriculum	2010
Participation in the *Workshop on General Secondary Education Curriculum* in the Meeting Hall of the Ministry of Education, Dili, in order to discuss the proposed restructuring of the curriculum for general secondary education in the territory of Timor Leste	2010

Sources: entrega do processo de governação, 2011

6.3.3 Public Awareness

Public awareness refers to the important role that community enthusiasm and knowledge has in building sustainable societies. Delivering knowledge to remote communities requires strategies for effective communication. There is still a considerable lack of awareness of the interrelated nature of all human activities and the environment, due to inaccurate or insufficient information. Timor-Leste in particular lacks relevant technologies and expertise. There is a need to increase public sensitivity to environment and development problems and involvement in their solutions and foster a sense of personal environmental responsibility and greater motivation and commitment towards sustainable development.

Public awareness is conducted using a combination of media, communication materials and public awareness activities, appropriate messages and the needs of the target audience. It is run by the State Secretariat of the Environment under the Directorate of the Environment and Environmental Education for the public (communities), teachers, students, civil servants, etc. However implementation has been very slow because of the lack of human resources, finances and facilities to support public awareness activities.

Table 6-2 **List of Public Awareness in Timor-Leste**

Media	Newspaper, radio, television, social media and internet, special media such as community stage plays, visit-and-learn, etc
Communication Material	Poster, brochures, comics, etc.; material for radio and television; exhibits, video presentations, others communications materials.
Public Awareness	Conferences, meetings and dialogues; training, seminars and workshops, contests and awards; public events and celebrations; tree planting activities; clean up activities; others public awareness activities.

Sources: INC and TWGs, 2013

For formal education programs, the environmental education curriculum is currently being developed by the Ministry of Education and UNICEF. Non-formal education is provided by the government through training, seminars and workshops. The materials are provided by a national team and presented to teachers and students. Topics covered include land conservation, reforestation, fire, and protection of biodiversity. Where possible, links with climate change issues are also presented.

6.3.4. Challenges in the Implementation of ETPA

Based on interviews, a number of challenges in the implementation of ETPA have been identified. These include among others:

- Lack of funding for environmental education.
- Lack of trainers and teachers with an environmental background.
- Lack of awareness of sustainable development.
- Poor access to internet and unavailability of reliable electricity supply.
- Lack of coordination between donors to utilize available training programs efficiently.
- Few available instructional materials, especially ones appropriate to local context.

6.4 EFFORTS TO PROMOTE INFORMATION SHARING

Since 2005, Timor-Leste has participated in several international events related to climate change such as the COP and SBSTA, as well as those related to UNCCD and sustainable land management.

To disseminate information on matters related to the international treaties on climate change, the Timor-Leste government has engaged in a project called ETPA (Education, Training, and Public Awareness) aimed at enabling Timor-Leste to fulfil its commitments and obligations as required by Articles 6 of the convention and also related to COP Decision 11/CP.8: New Delhi Work Programme of the UNFCCC by preparing and reporting its INC and building the country's institutional, scientific, technical, informational and human capacity at all levels. To achieve these objectives, the project generates, analyses and communicates information relevant for the preparation and submission of Timor-Leste's INC that includes (i) education training and public awareness; (ii) Research and systematic observation also including the important topics there is (a) compilation of the national Greenhouse Gas Inventory; (b) analysis of potential measures to mitigate greenhouse gas emissions; and (c) a vulnerability assessment and analysis of adaptation options.

Over 70% of Timorese live in rural areas with limited access to information and means of communication, which hinders dissemination of information. Fortunately, there is still a strong connection between individuals, communities, the environment, history and cultural traditions. To make use of this strong connection, it is important to engage tribal leaders in information dissemination efforts.

With regard to utilization of multimedia in information dissemination, the survey shows that majority of institutions in Timor-Leste have no web-based information system, with almost none in local (district) level.

As part of the information dissemination effort, the government have introduced environmental education (climate change education) on primary, secondary and university level. The curriculum is still being developed under cooperation with UNICEF. General introduction on environmental issues (e.g. climate change) will be introduced at elementary school level at class grade 5 and related subjects will be continued in higher grades. The environmental education is planned to be disseminated to 13 districts, and at the moment it has been implemented in four districts.

6.5 GENDER

Ever since its independence, Timor-Leste has made serious efforts to improve gender equality and women's empowerment through policy reform, legislation, institutional mechanisms and public awareness campaigns. Equality for women is stipulated in the Constitution, and the Convention on the Elimination of All Forms of Discrimination (CEDAW) has also been ratified. The status of the national women's directorate was elevated in 2008 to a State Secretariat reporting directly to the Prime Minister's Office, which strengthens its authority to develop and implement policies and programmes that address women's needs and concerns.

There are several government and non-government institutions involved in the promotion of gender equality, such as (i) SEPI (the Secretary of State for the Promotion of Equality); (ii) the UNTL Gender Studies Centre; (iii) Fokupers, Alola Foundation; (iv) Caucus; (v) Oxfam; and (vi) Care International Timor-Leste.

Aside from the abovementioned institutions, there are also several other ministries with programs related to the promotion of gender equality (see Table 6-3).

Table 6-3 **Gender-Related Activities by Other Ministries**

Name of Ministry	Activity(s)
Ministry of Education	Setting up of gender units. Promotion of gender equality in accessibility to nine years of basic education. Introduction of gender perspective in new curriculum (making textbooks to teach sex education, gender-based violence and reproductive health).
Ministry of Health	Currently conducting gender assessment of health sector and drafting gender policies. Introduction of Integrated Community Health Services (SISCA) system to improve maternal and child health at the Suco level. Promotion of birthing at medical facilities and family planning.
Ministry of Agriculture and Fisheries	Currently drafting gender policies. Setting up of gender units and gender working groups. Rights of women from the perspective of food security as well as accessibility to land and resources. Conduct of research on gender and agriculture in three districts.
Ministry of Justice	One Gender Focal Point is assigned. Introduction of gender perspective in penal code for gender-based violence (domestic violence, sexual assault and human trafficking). Promotion of gender equality in accessibility to land and property in Law on Land and Property Rights and civil law.
Secretary of State for Vocational Training and Employment (SEFOPE)	One GFP is assigned. Provision of support for entrepreneurship by women and microfinance for women's groups. Vocational training for women. Creation of employment through participation in rural infrastructure projects.
Ministry of Economic Development	Nine Gender Focal Points are assigned. International gender advisor is planned to be assigned. Income generation for women groups. Job creation is implemented through the rural infrastructure construction project.
Ministry of Social Solidarity	Reports on gender analysis by female Minister. Nine GFPs are assigned. Provision of support for widows and victims of violence against women in conflict, provision of shelters and improvement of referral network system by "Department for Protection of Women Victims and Integration of Vulnerable Families".

Timor-Leste's future plans for the promotion of gender equality are among others focusing on political and economical aspects, such as their participation in decision making processes, and the promotion of behavioral change in some sectors such as agriculture.

7 OBSTACLES, SHORTAGES AND NEEDS RELATED TO FUNDING, TECHNOLOGY AND CAPACITY

Photo by UNMIT/Martine Perret

7.1 FINANCIAL

The EST survey (Tavares, 2013) mentioned that funding is considered as the main obstacle to development and implementation of technologies that may assist in climate change mitigation and adaptation (see Figure 7-1). The funding issue is also considered to limit research activities.

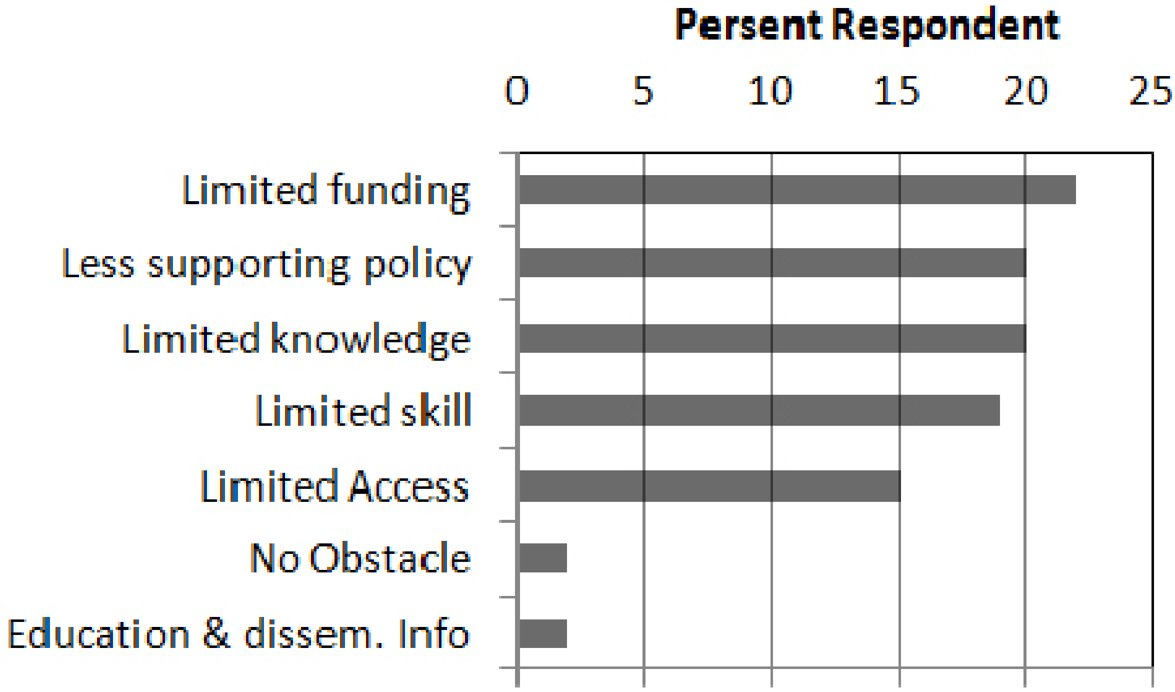


Figure 7-1 **Factors considered as obstacles to development and implementation of EST** (Tavares, 2013)

7.2 TECHNOLOGY TRANSFER

Aside from a lack of advanced technology to deal with climate change mitigation and adaptation, Timor-Leste also lacks the skilled human resources needed to operate such technology.

7.3 CAPACITY BUILDING

Interviews with teachers in six districts across Timor-Leste consistently suggested that a lack of guides and teaching manuals for teachers that would support implementation of the revised curriculum has led to confusion regarding the objectives and content of the new curriculum. While teachers and schools rapidly identified their participation in the UNICEF-sponsored 'curriculum training programmes,' they also cited the need for 'regular and ongoing' training programmes and supplementary training materials that 'work clearly with the defined curricula' and 'match the content of the training programme.' Teachers cited the need for support for environmental education materials (books) to be included in environmental science and health education.

Institutional and capacity development for staff and community should be continuously assessed, challenged and improved to make the greatest impact on the country by assisting all stakeholders. A combination of a variety of mechanisms, from various data collections and verification workshops to informal brainstorming with stakeholders should be utilized for this purpose.

Capacity development is a long term process and goes beyond the resident expatriate model. A single development agency cannot provide comprehensive support, and concerted efforts by the people, government and the international community are therefore crucial. The three pillar model, which addresses skills and knowledge, systems and processes, and attitudes and behaviours, could be used as a starting point to develop a comprehensive institutional capacity development plan and codification of lessons learned should be mandatory or at least encouraged periodically.

During the development of the INC, gaps and needs for development of technical capacity were identified. A summary of this identification can be seen in Table 7-1.

Table 7-1 **Gaps and needs on institutional and development of technical capacity**

Gaps	Needs and Priority
• Overlapping roles and responsibilities of ministries • Few people know about climate change • Dissemination of information to people at local levels is very low • Limited academic background and professional training • Human capability financial gaps • Limited human resources • Lack of commitment • Inadequate training program • Lack of facilities, education, socialization, • Economic needs, subsystem farming • Lack of comprehensive inventory/database • Lack of monitoring and evaluation • Lack of information from the MoE Education Management Information System, which has been up and running since 2000 and from other agencies.	• Need to decide the roles and responsibilities of the ministries for environment and climate change. • Need for public awareness and dissemination of information to provide greater benefit for people at local levels; suco, sub district and districts. • There are few ministry programs geared specifically to the country's manpower • Need for capacity building for people at local levels is very important • Protected areas and National Parks • Need fora clear role and commitment of Ministry to share and disseminate information to students, local leaders, and communities. • Need for trainings, workshops, seminars, simulations, etc.

Source: INC and TWGs, 2012/2013

REFERENCES

Adao S. Barbosa and Thematic Working Group for Climate Change, NCSA Thematic Assessment Report on UNFCCC, Government of Timor-Leste, 2007

Aldrian, E., and R. D. Susanto, 2003: Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature. International Journal of Climatology, 23, 1435-1452.

Aldrian, E., L. D. Gates, and F. H. Widodo, 2003: Variability of Indonesian rainfall and the influence of ENSO and resolution in ECHAM4 simulations and in the reanalysis346.

Australian Government, Department of Resources, Energy and Tourism. Joint Petroleum Development

Area and the Greater Sunrise. Retrieve from http://www.ret.gov.au/resources/upstream_petroleum/jpdaandgreatersunrise

Autoridade Naçional do Petróleo, 2009 Annual Report.

Autoridade Naçional do Petróleo, 2010 Annual Report.

Autoridade Naçional do Petróleo, 2011 Annual Report.

Barnet, J. 2003. Climate Change in Timor-Leste: Proceedings from the 1st National Workshop on Climate Change.

Barnett, J., S. Dessai, and R. Jones, 2003: Climate Change in Timor-Leste: science, impacts, policy and planning.

Barnett, J., S. Dessai, and R. N. Jones, 2007: Vulnerability to climate variability and change in East Timor. Ambio, 36, 372-378.

Barnett, J., S. Dessai, and R. N. Jones, 2007: Vulnerability to climate variability and change in East Timor. Ambio, 36, 372-378.

Boer, R., and A. Faqih, 2004: Global climate forcing factors and rainfall variability in West Java: case study in Bandung district. Indonesian Journal of Agricultural Meteorology, 18, 1-12.

Boggs G, Edyvane K, de Carvalho N, Penny S, Rouwenhorst J, Brocklehurst P, Cowie I, Barreto C, Amaral A, Smit N, Monteiro J, Pinto P, Mau R, Amaral J, Fernandes L. (2009). Marine & Coastal Habitat

Carlos Pachero Marques (et al.). 2010. First Forest Inventory of Timor-Leste, districts of Covalima and Bobonaro, 2008-2009, UNTAD

Mapping in Timor-Leste (North Coast) – Final Report. Ministry of Agriculture & Fisheries, Government of Timor-Leste.

Datt, G., M. Cumpa, V. Nehru, N. Roberts, A. Franco, and S. Dhar. 2008. Timor-Leste: Poverty in a Young Nation. Dili, Timor-Leste: Ministe´ro das Financ¸as and Direcc¸a˜o Nacional de Estatı´stica, and Washington: World Bank.

Democratic Republic of Timor-Leste (2011). The National Biodiversity Strategy and Action Plan (NBSAP) of Timor-Leste (2011-2020).

Faqih, A., 2010: Rainfall variability in the Austral-Indonesian region and the role of Indo-Pacific climate drivers. Dissertation, Departement of Biological and Physical Sciences, The University of Southern Queensland.

Fox, J.J. 2003. Drawing from the past to prepare for the future: Responding to the challenges of food security in East Timor. In Agriculture: New directions for a new nation East Timor (Timor-Leste), ACIAR Proceedings No. 113, eds. H. Da Costa, C. Piggin, C.J. Cruz, and J.J. Fox, 105–114. Canberra: Australian Centre for International Agricultural Research.

Francisco, T.B. 2003.Croping Systems in East Timor: in Agriculture: New Directions for a New Nation — East Timor (Timor-Leste). ACIAR Proceedings No. 113, eds. H. Da Costa, C. Piggin, C.J. Cruz, and J.J. Fox, 17-19. Canberra: Australian Centre for International Agricultural Research.

Gusmao M. 2003. Soil Conservation Strategies and Policies for Timor-Leste

Hansen, J., Sato, M., Ruedy, R., Lo,K., Lea, D.W., and Medina-Elizade, M. 2006. Global temperature change. Proceeding of National Academy of Science 103: 14288-14293.

Hendon, H. H., 2003: Indonesian rainfall variability: Impacts of ENSO and local air-sea interaction. Journal of Climate, 16, 1775-1790.

International Monetary Fund, Country Report No. 09/220, July 2009

International Monetary Fund, Country Report No. 11/165, March 2011.

Kalis, H. Orlando (2010), Timor-Leste Fisheries. Perspectives on Coastal Community Fishing Activity. Prepared for: Transboundry Diagnostic Analysis-ATSEF Programme (Fisheries & Socio-economic Profile), National Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Fisheries, Timor-Leste.

Katzfey, J., J. McGregor, K. Nguyen, and M. Thatcher, 2010: Regional climate change projection development and interpretation for Indonesia.

Kirono, D. G. C., 2010: Climate change in Timor-Leste – a brief overview on future climate projections.

Liebmann, B., and Coauthors, 2007: Onset and end of the rainy season in South America in observations and the ECHAM 4.5 atmospheric general circulation model. J. Climate, 20, 2037-2050.

Luciano Hornay, Director at National Directorate of Renewable Energy (Personal Communication, January 17, 2013).

Marques, C.P., Fonseca, T., Ferreira, M. and Laranjeira, P. (December 2010). First Forest Inventory in Timor-Leste: Districts of Bobonaro and Covalima 2008/2009. Second Rural Development Project for Timor-Leste.

Meehl, G. A., J. M. Arblaster, J. T. Fasullo, A. Huand, and K. E. Trenberth, 2011: Model-based evidence of deep-ocean heat uptake during surface-temperature hiatus periods. Nature Climate Change, 1, 360–364.

Mercy Corps Timor-Leste (October 2011). Energy for All Programme (E4A) Timor-Leste: Baseline Assessment Report.

Met-Office, 2013: The recent pause in global warming (2): What are the potential causes?

Ministry of Education, Estudo Do Meio, Government of Timor-Leste, 2005

MoI, 2010: Preparing the Road Network Development Project – TA7100 Final Report.

Moron, V., A.W. Robertson and R. Boer. 2009. Spatial coherence and seasonal predictability of monsoon onset over Indonesia. Journal of Climate 22:840-850.

National Directorate of Forestry and Japan's Grant Aid for Forest Preservation Program in the Democratic Republic of Timor-Leste (March 2013). Completion Report of the Consultant's Services.

Nicholas, M., Gil, R.C., Robert, L.M., Rebecca, A. And Neil, C.T. 2012. Climate change and population growth in Timor-Leste: Implication for food security. AMBIO, DOI 10.1007/s13280-012-0287.

Phillips, D.L. 2000. Social and economic conditions in East Timor. In International conflict resolution program, School of International Affairs Columbia University, New York, eds. J. Pederson, and M. Arnerberg. Oslo: Fafo Institute of Applied Social Science.

Research Institute for the Environment and Livelihoods (RIEL) Charles Darwin University. November 2011. The Vulnerability of Groundwater Resources to Climate Change in Timor-Leste.

Sebastiao da Silva and Terencio F.M. 2011, Climate, climate variability and change of Timor-Leste. Pacific Climate Change Science Program.

Secretário de Estado para a Politíca de Formação Profissional E Emprego (2010) Labour Force Survey 2010. SEFOPE and Dirão Nacional Estatistiça, Timor-Leste.

Seeds of Life (2010). Annual Research Report.

Seeds of Life. 2012.Map of Annual rainfall of Timor-Leste.
State Secretary for Energy Policy and UNDP (May 2008). Rural Energy Policy for Timor-Leste (draft).

Strategic Plan of National Directorate of Livestock and Veterinary Services 2011-2015: Pasture Improvement and Feeding Strategies to Improve Livestock Productivity in Timor-Leste.

Swastika, D.K.S., F. Kasim, K. Suhariyanto, W. Sudana, R. Hendayana, R.V. Gerpacio, and P.L. Pingali. 2004. Maize in Indonesia: Production Systems, Constraints, and Research Priorities. Mexico, D.F.: CIMMYT.

The National Biodiversity strategy and Action Plan of Timor-Leste (2011-2020)

The World Bank (December 2010). Timor-Leste: Key Issues in Rural Energy Policy. 2010 Timor-Leste Population and Housing Census (2012). A Snapshot of Agriculture in Timor-Leste in 2010. Directorate National for Statistic, Ministry of Finance, Timor-Leste and United Nations Population Fund (UNFPA).

Timor-Leste in Figures (2009). National Directorate of Livestock and Veterinary Services.

UNESCO (1997) Environment and Society: Education and public awareness for sustainability, Background Paper prepared for UNESCO International Conference, Thessaloniki, 7.

UNESCO (2002) Teaching and Learning for a Sustainable Future. See www.unesco.org/education/tlsf

United Nations Development Programme (UNDP) Economic and Social Commission for Asia and the Pacific (ESCAP) (2003). Exploring Timor-Leste Mineral and Hydrocarbon Potential.

Veron, J.E.N. and Stafford-Smith, M (Editor) (2000), 'Corals of the World', Australian Institute of Marine Sciences. Australia.

Yatagai, A., K. Kamiguchi, O. Arakawa, A. Hamada, N. Yasutomi, and A. Kitoh, 2012: APHRODITE: Constructing a long-term daily gridded precipitation dataset for Asia based on a dense network of rain gauges. Bull. Amer. Meteor. Soc., 93, 1401–1415.

Yatagai, A., K. Kamiguchi, O. Arakawa, A. Hamada, N. Yasutomi, and A. Kitoh, 2012: APHRODITE: Constructing a long-term daily gridded precipitation dataset for Asia based on a dense network of rain gauges. Bull. Amer. Meteor. Soc., 93, 1401–1415.

Appendix 1: Health modeling: Malaria and Dengue

Similar with the process in water resource modeling, there are 3 major processes Health modeling (Malaria and Dengeu), as depicted by Figure 2, i.e. data preparation, computation the components in potential transmission of malaria and dengue, and mapping the potential transmission. Then, this section will describe the procedure in computation of potential transmission only. Potential transmission (TP) is formulated as follows.

In baseline year:

$$TPO\{i,b\} = \frac{(a0\{i,b\})^2 (p0\{i,b\})^{n0\{i,b\}}}{-\ln(p0\{i,b\})} * CFTO\{i,b\} * CFRO\{i,b\}$$

In future:

$$TP_d^r\{i,b\} = \frac{(a_d^r\{i,b\})^2 (p_d^r\{i,b\})^{n_d^r\{i,b\}}}{-\ln(p_d^r\{i,b\})} * CFT_d^r\{i,b\} * CFR_d^r\{i,b\}$$

Where:

TPO{i,b} : baseline potential transmission in grid i and month b
$TP_d^r\{i,b\}$: future potential transmission (period d and scenario r) in grid i and month b
$CFTO\{i,b\}$ *and* $CFT_d^r\{i,b\}$: Correction factor respect to temperature
$CFRO\{i,b\}$ *and* $CFR_d^r\{i,b\}$: Correction factor respect to rainfall

For ease of understanding, terminology and their determined value (in this research) are as follows.

HBI : Human blood index, (HBI=0.8).
X : Mosquito survival prob. per gonotrophic cycle (malaria : X=0.5, dengue : X=0.6)
Ds : Length of sporogonic cycle, (Ds=111)
Ts : Sporogonic threshold, (Ts=18)
Dg : Length of gonotrophic cycle, (Dg=37)
Tg : Gonotrophic threshold, (Tg=10)
R : Rainfall threshold, sustained for 2 months, (R=25 mm)
dT : Base temperature,(dT= -5)

Based on the parameters, the formula in determining potential transmission is the following:

In baseline year:

$$t = TO\{i,b\} + dT$$

Malaria: $u = 1 + \frac{Dg}{t-Tg}$ and $n0\{i,b\} = \frac{Ds}{(t-Ts)}$

Dengue: $u = 88.247 * e^{(-0.1179*t)}$ and $n0\{i,b\} = 249.95 * e^{-0.1*t}$

Then,

$$a0\{i,b\} = \frac{HBI}{u}$$
$$p0\{i,b\} = \sqrt[1/u]{X}$$

$$CFTO\{i,b\} = \begin{cases} 1 \;\; if \;\; t \geq Ts \\ 0 \;\; if \; t < Ts \end{cases}$$

$$CFRO\{i,b\} = \begin{cases} 1 \;\; if \;\; PO\{i,b-1\} \geq R \;\; and \;\; PO\{i,b-2\} \geq R \\ 0 \;\; if \; other \; condition \end{cases}$$

In future year:

$$t = FT_d^r\{i,b\} + dT$$

Malaria: $u = 1 + \frac{Dg}{t-Tg}$ and $n_d^r\{i,b\} = \frac{Ds}{(t-Ts)}$

Dengeu: $u = 88.247 * e^{(-0.1179*t)}$ and $n_d^r\{i,b\} = 249.95 * e^{-0.1*t}$

Then,

$$a_d^r\{i,b\} = \frac{HBI}{u}$$
$$p_d^r\{i,b\} = \sqrt[1/u]{X}$$

$$CFT_d^r\{i,b\} = \begin{cases} 1 \;\; if \;\; t \geq Ts \\ 0 \;\; if \; t < Ts \end{cases}$$

$$CFR_d^r\{i,b\} = \begin{cases} 1 \;\; if \;\; FP_d^r\{i,b-1\} \geq Rand \; FP_d^r\{i,b-2\} \geq R \\ 0 \;\; if \; other \; condition \end{cases}$$

The block diagram of the analysis is presented in Figure A1.

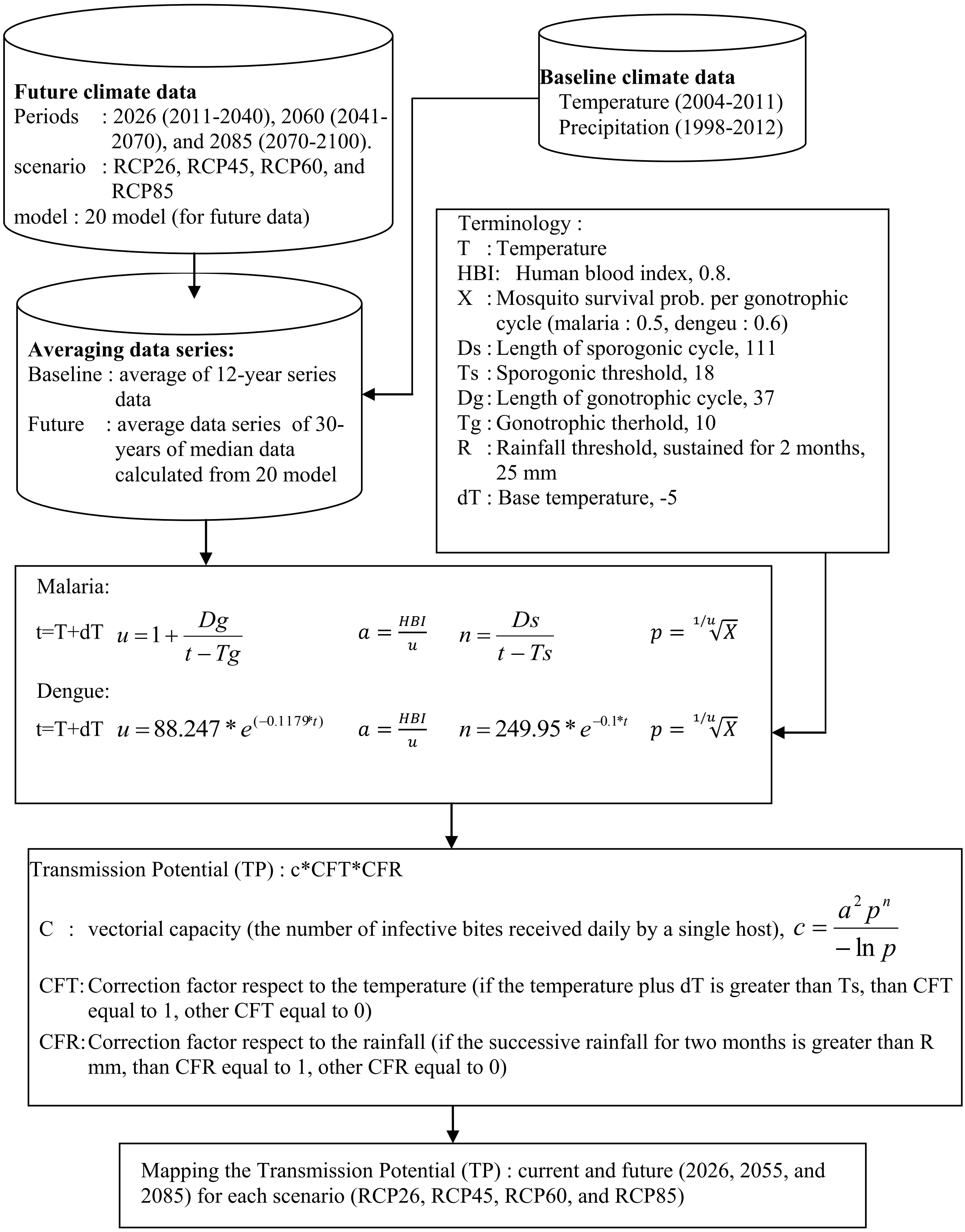


Figure A1. **Block Diagram for Malaria and Dengue Modelling**

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