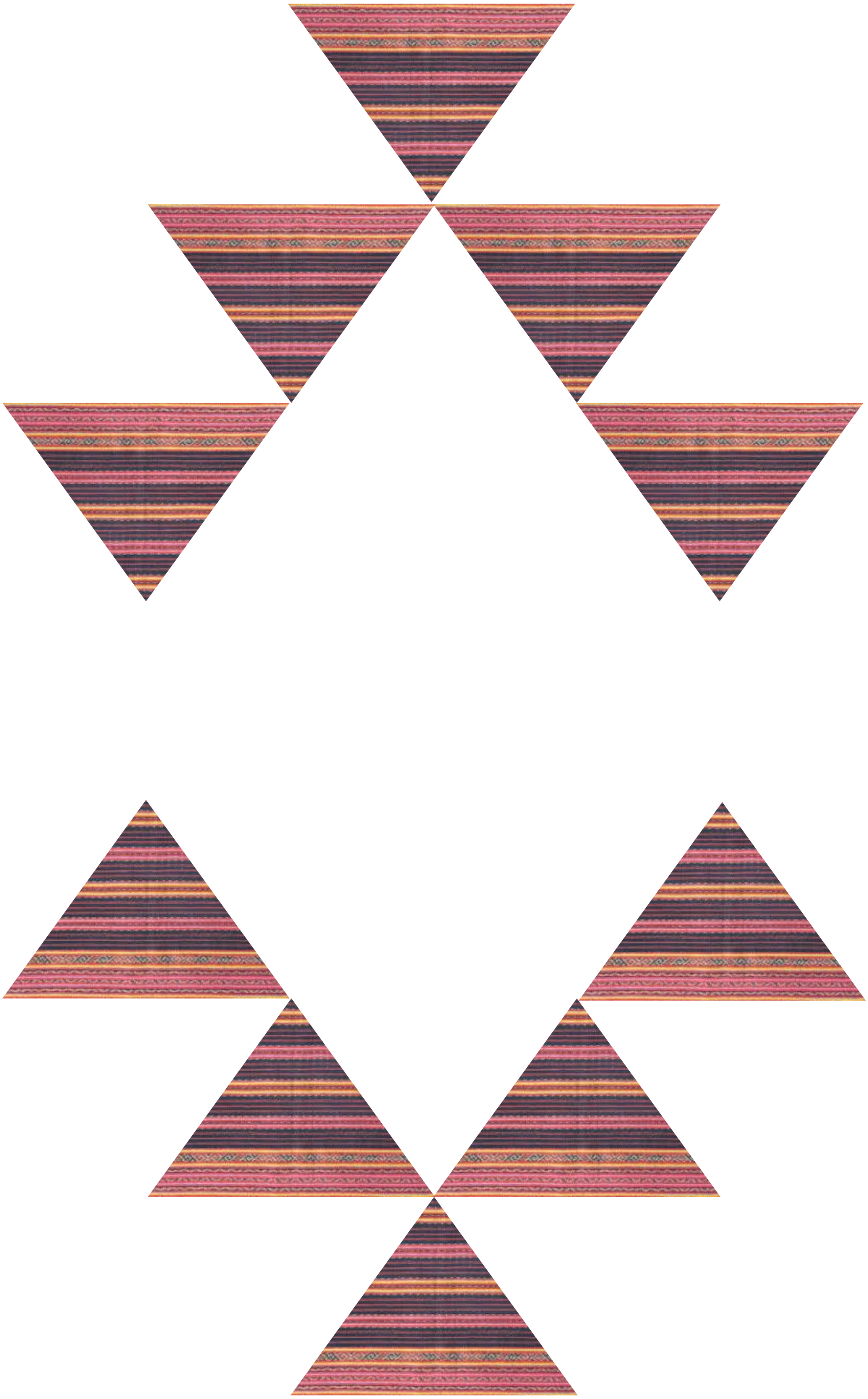
República Democrática de Timor-Leste

SECOND NATIONAL COMMUNICATION

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

November 2020

Secretary of State for Environment



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FOREWORD

Timor-Leste had already ratified all the 3 Rio Conventions by 2008 and has taken important steps towards internalizing these convention obligations and responsibilities into national development processes. Article 61 of the Timorese Constitution establishes that "everyone has the right to a "healthy and ecologically balanced environment" and they and the State have a duty to safeguard "and improve it for the benefit of the future generations". The government of Timor-Leste is fully committed to follow up on the constitutional rights of Timorese population through government's workplan, the overarching strategic development plan of Timor-Leste. Simultaneously, as a member of the global community, we are also committed to fulfill our commitments and targets related to global environmental obligations, particularly through the three Rio Conventions including the UNFCCC.

Timor-Leste has also ratified the Paris Agreement, the global framework to address threats arising from climate change. The full implementation of the Paris Agreement means that practical actions will be unlocked with respect to all elements of the climate regime that countries are building : (1) adaptation to climate change impacts, (2) ambitious reduction in emissions, and (3) support developing countries, in the form of technology cooperation, capacity building, and, especially financial support for climate-resilient development. These elements all need to function together in an inter-connected and transparent manner. The country is also fully committed to follow the Enhanced Transparency Framework under the Paris Agreement's Article 13 which will feed into the Global Stocktaking process under Article 14.

I believe that the Second National Communication process has contributed significantly to address these issues. National Communication is an extremely important element of the Enhanced Transparency Framework and global stocktaking processes. This particular National Communication has been an important step towards updating our national greenhouse gas inventory, laying out the national mitigation plan and finalization of the Nationally Determined Contributions. Simultaneously, this process has updated our national circumstances, our national adaptation needs and laid out the issues related to policy gaps and constraints.

Though Timor-Leste is one of the smallest contributors to global climate change, we are one of the major victims of this phenomenon. However, considering the climate shocks that our country is exposed to, we still feel a lot is yet to be done and achieved to safeguard our development and protect the vulnerable communities of our country.

Demétrio do Amaral de Carvalho
Secretary of State for the Environment

EXECUTIVE SUMMARY

Timor-Leste ratified 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) and United Nations Development Program (UNDP), Timor-Leste had submitted its Initial National Communication (INC) in 2014 and started the development of Second National Communication (SNC) in 2017. Development of the SNC involved representation from local government institutions who are grouped into sectoral Working Group and worked mostly on development of Greenhouse Gases (GHG) Inventory and mitigation scenario. Timor-Leste's SNC 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 km2. This includes the main land area of 13,989 km2, the Special Administrative Region Authority of Oé-Cusse Ambeno (RAEOA) of 817 km2, Atauro Island of 140 km2 and Jaco Island of 8 km2. The topography, particularly of the mainland, is comprised of hills and mountain ranges. Climate is hot with an average temperature of 21°C and 80% humidity. 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. Rainfall in Timor-Leste is strongly influenced by monsoon in the north and south of Timor-Leste. Annual rainfall along the northern coastline is lower than 1,000 mm per year and as little as 600 mm per year in some locations such as Manatuto, whereas Same in the south receives over 2,000 mm per year. In the central and elevated regions of the country, the rainfall generally ranges from 1,500 mm to 2,000 mm per year, up to 2,500 mm per year at the highest elevations (Keefer 2000 *in* Barnett 2003; SoL 2012).

Though Timor-Leste is the newest country in Southeast Asia, its population has grown rapidly over the last 10 years and projected to continue increasing. In 1990, the population of the country was only 0.75 million people and it reached 1.18 million people in 2015. By 2030, the Timor-Leste population may reach 1.6 million people (Figure 1). About 70% of the population lives in rural areas and a majority of which derive their livelihoods from agriculture. The agriculture is vulnerable to climate variability and change. The frequency and intensity of extreme climate events (drought, flood, and landslide) is increasing, creating risks and challenges and mostly impact vulnerable rural communities. Crop losses caused by the droughts/floods majorly affect food security. Extreme drought in the 2015/2016 El Nino event affected Timor-Leste's farming communities that put crops and animals under immense water stress. Nearly half of the country's planted area for maize and rice was affected by extreme drought and more than half affected population reported loss of livestock (i.e. through death, non-productive sickness and/or distressed selling). It was estimated that 50% of households affected and experienced severely food insecure (FAO 2018).

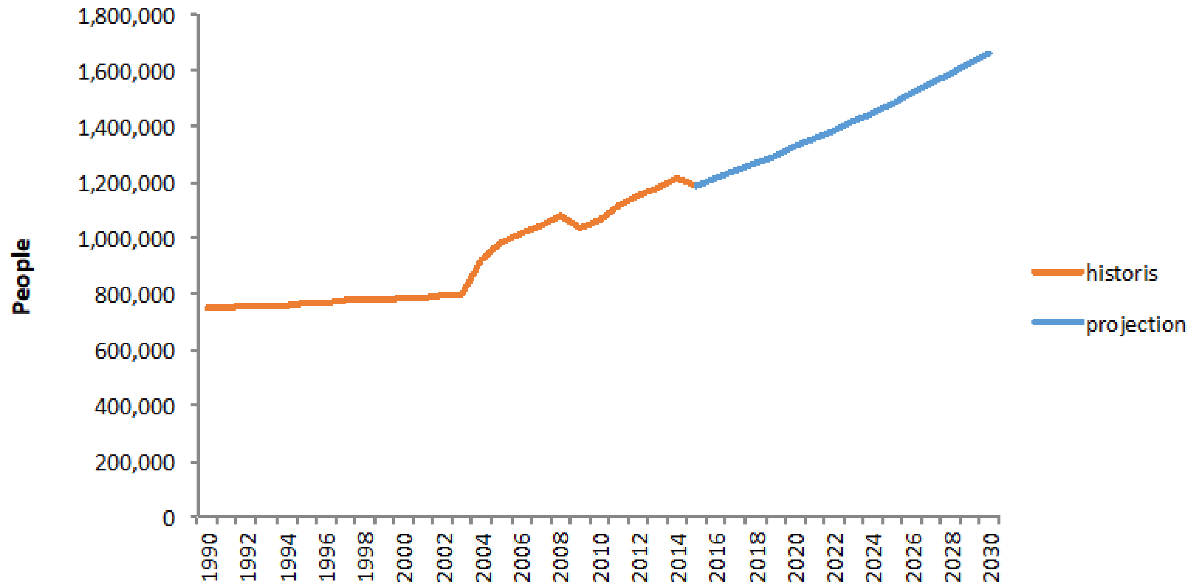

Figure 1. Trend in Timor-Leste's Population 1990 - 2030

In 2015, the Gross Domestic Product (GDP) of Timor-Leste was about US$ 3.1 billion. Main contributor to the national GDP are industry, services and agriculture sectors including forestry and fishery, and oil.

National GHG Inventory

In 2015, total GHG emissions for the three main GHGs (CO_2, CH_4 and N_2O) Forestry and Other Land Use (FOLU) was 5,303.86 Gg CO_2-e. With the inclusion of FOLU, total GHG emissions from Timor-Leste decreased to about 3,825.12 Gg CO_2-e (Table 1). Without FOLU, CO_2 is the largest contributing GHG with generated amount of 3,031.32 Gg CO_2e (57% of total emissions), while methane (CH_4) and nitrous oxide (N_2O) each contribute 573.1 Gg CO_2e (10% of total emissions) and 220.71 Gg CO_2e (4% of total emissions), respectively. The main contributors to emission generation are energy sector, followed by agriculture and waste.

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

Table 1. Summary of 2015 GHG emission (in Gg CO_2e)

Sources	CO2	CH4	N2O	Total
Energy	4,441.34	8.11	7.47	4,456.92
Agriculture	0.03	476.75	188.99	665.76
FOLU	-1,478.73	NE	NE	-1478.73
Waste	68.68	88.24	24.25	181.1k7
Total	***3,031.32***	***573.78***	***220.71***	***3,825.12***
Biomass utilization				
International Bunker for Aviation*				
GHG from oil and gas production				

Notes: GHG emissions from energy used in industry/manufactures were not included in this INC inventory due to there is practically no industry activities in Timor -Leste. GHG from the utilization of solvent and other product are also not covered in this SNC inventory due to inavailability of data. The GHG emissions from biomass utilization, international bunker for aviation, and activities in offshore oil and gas production facilities are reported separately from energy sector. GHG from offshore is under join operation of Timor-Leste and Australia.

Within the period of 2005-2015, it can be seen that GHG emissions from agriculture and waste sectors were experiencing increase. The GHG emission from energy sector was fluctuating due to the fluctuation of emission from natural gas combustion, which is in line with the decrease of oil and gas production. It should be noted the main sources of emission in energy sector is from gas combustion in oil and gas facilities. Agriculture sector and energy remains as the main source of emissions in Timor-Leste during this period, which is accounted for more than 90% of the total country emission.

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

Sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy	757	885	918	892	756	729	815	861	932	725	4,456.92
Agriculture	557	566	592	630	632	614	616	633	630	641	665.77
FOLU	-303	1,183	-5,587	-4,564	-2,422	-279	-3,430	-2,859	-2,640	1,439	-1478.73
Waste	123	127	132	136	131	135	142	146	150	154	181.17
Total	***1,134***	***2,761***	***-3,946***	***-2,905***	***-904***	***1,199***	***-1,857***	***-1,219***	***-928***	***2,959***	***3,825.12***
Biomass utilization	141	135	129	124	119	114	109	105	100	96	92

Within the four sectors, there are 25 sub-categories of emission sources. Of these 25 sources, only 12 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 12 key categories, two sources already contributed to 50% of the total emissions, namely emissions from forest remaining forest (CO_2) and (ii) oil and gas production facilities (CO_2).

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 (GoTL) assigned the Directorate for International Environmental Affairs and Climate Change (DIEACC) to develop an Initial National Communication in 2011. This directorate was 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 SNC was conducted by project team, under UNDP and National Directorate for Climate Change in collaboration with six Thematic Working Groups (TWGs) 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 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 GoTL has developed the country's Intended Nationally Determined Contribution (INDC) document on climate change adaptation and mitigation. Timor-Leste adopted the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) in 2015, including Goal 13: To take urgent action to combat climate change and its impacts. The key national policy documents referring to climate change to date have been the National Strategic Development Plan (2011-2030) and a Basic Environmental Law (Decree Law No.26/2012).

Measures to Mitigate Climate Change

Timor-Leste has submitted their INDC to UNFCCC in November 2016 in which mitigation will be carried out in four sectors namely (i) energy, (ii) agriculture, forestry and land use change, and (iii) waste sectors.

By 2030 it is estimated that the 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.

Table 3. Key mitigation measures

Key Sectors	Mitigation Measures
Energy	- Improvement of energy efficiency in supply side (fossil fuel combustions), transportation, and demand side (household and commercial buildings) - Increase use of renewable energy (biomass, biogas, hydro, solar PV, wind turbine, etc.)
Agriculture	- Reduction of GHG emissions from livestock through biogas and composting activities - Reduction of slash and burn practices by introducing permanent agriculture with improved management practices
LUCF	- Development of agroforestry and community forestry on degraded land
Waste	- Implementation of MSW management to reduce open burning - Development of managed landfill equipped with LFG recovery system

Measures to Facilitate Adequate Adaptation to Climate Change

Due to its geographical location, topography and socioeconomic conditions, Timor-Leste has been considered as one of the top 10 countries most at risk of disasters (9th rank). Together with the other 10 countries, the vulnerability and susceptibility of Timor-Leste are 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. The vulnerable and very vulnerable sucos are characterized by high level of exposure and sensitivity and low adaptive capacity. The level of exposure, sensitivity and adaptive capacity of the sucos are represented by socio economic and bio-physical condition. The most vulnerable sucos are mainly located in the western part of the country. 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 suggested 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).

The abovementioned situation contributes to risk of natural disasters such as droughts, floods, strong winds, landslides erosion, soil desertification, coastal erosion, inundation, and ocean acidification, as well as increase occurrence of vector borne and respiratory diseases.

A National Adaptation Programme of Action (NAPA) was developed in 2010. It provides a national vision to work towards more resilience to climate change. Nine following priority areas are proposed with the summary of adaptation options in Timor-Leste's NAPA:

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 & 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 rise
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.

Other Information

Timor-Leste has carried out a survey on environmentally sound technologies (EST) covering aspects of methodology used for assessment of technology needs such as technology needs, enabling conditions for technology transfer, needs for capacity building for technology transfer, international support for Timor-Leste in technology transfer and the status of RSO in Timor-Leste. The survey shows implementation of EST mostly in development of renewable energies for energy sector, improved agriculture practice through sustainable land management system, application of integrated agriculture system, and improved irrigation system for agriculture sector, development on agroforestry and mangrove restoration for forestry sector, as well as rain-harvesting technology and water catchment wells for water resource management. In heath and sanitation, implemented programs are among others integrated community health service (SISCA), clean and safe water treatment, mosquito and vector control, and early warning and response system for climate-related disease outbreak such as diarrhea, malaria and dengue fever. However, more financial and technical supports as well as human resources for implementation of EST is still needed.

In terms of climate-related researches, there is a need to establish a body that coordinate research activities and also a clearing house that organizes all the data, information and result of the research activities.

On climate and weather observation system, there are four weather stations in Timor-Leste that are registered in the World Meteorological Organization (WMO). They are located in RAEOA, Dili, Baucau and Suai. More stations are needed to at least one in each district. For agricultural activity purpose, there are 58 manual weather stations providing information related to rainfall and are managed under the authority of Ministry of Agriculture and Fishery (MAF).

In terms of Education, Training, and Public Awareness (ETPA), Timor-Leste's Ministry of Education have incorporated in the subject of natural science at the primary education and the subject of integrated science system at the secondary education. Awareness rising through practical environmental education has also become part of the subject of art and culture through the project of school garden.

Various training workshop to increase awareness on climate change issue have been conducted by the Secretary of State for the Environment. Topics on the training ranges on climate change mitigation and adaptation. Collaboration with agencies from aboard have also been implemented as part of awareness raising and information sharing.

On development of GHG Inventory, Timor-Leste still requires capacity building especially in data collection and estimation of emissions. For mitigation, capacity building is needed for development of baseline, in addition to financial support needs. Support in conducting impact analysis is also required along with method to prioritize and design adaptation actions. Funding is considered as the main obstacles to implement climate change mitigation and adaptation in Timor-Leste due to limited government budget and also less attractive country's circumstances for foreign investment that might facilitate technology transfer.

According to the OECD DAC Reporting system, Timor-Leste has received financial support of US$102.5 million in the period of 2010 – 2014 for the implementation of climate actions, especially adaptation. Based on donor countries, Japan was the biggest source of finance in Timor-Leste, particularly for supporting irrigation projects, followed by Australia and the Least Developed Countries Fund in supporting water, sanitation and development of environmental policy.

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GLOSSARY OF ABBREVIATION

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ADO	Automative Diesel Oil
ANPM	Autoridade Nacional do Petróleo e Minerais
AR5	Fifth Assessment Report
AusAID	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
CO_2	Carbon Dioxide
COP	Conference of the Parties
CTI	Coral Triangle Initiative
DGE	Directorate General for Environment
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 Mudanca Party
GCMs	Global Climate Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GgCO2e	Gigaton CO2 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
MoE	Ministry of Education
MoF	Ministry of Finance
MoU	Memorandum of Understanding
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NAPA	National Adaptation Plan of Action
NDCC	National Directorate for Climate Change
NDFWMR	National Directorate for Forestry, Watershed Management and Reforestation
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
RAEOA	Administrative Region Authority of Oé-Cusse Ambeno
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
SSE	Secretary of State for the Environment
SSTA	Sea Surface Temperature Anomalies
TLEA	Timor-Leste Exclusive Area
TLSDP	Timor-Leste Strategic Development Plan
TWG	Thematic Working Group
ULP	Un-Leaded Petrol
UNDP	United Nations Development Programme
ESCAP	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 CIRCUMTANCES

1.1 Geography

Timor-Leste occupies the eastern half 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. 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 3,000 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).

Figure 1-1 Map of Timor-Leste

1.2 Population

Though Timor-Leste is the newest country in Southeast Asia, its population has grown rapidly over the last 10 years. In 1990, the population of the country was only 0.75 million people and in 2015 it reached 1.18 million people (Figure 1-2), about 70 percent living in rural areas and a majority of which derive their livelihoods from agriculture. The population structure in 2015 for age 0 – 14, 15 – 59, and more than 59 was approximately 39%, 53% and 8% of the total population respectively, with a relatively high portion of the younger generation as depicted in Figure 1-3 The number of households in 2015 was approximately 0.2 million, with the number of the persons per household 5.8 (Timor-Leste Census, 2015). Many East Timorese are actually the descendants of Tetun-Terik speakers, originally inhabitants of the south-central part of Timor Island.

The mean annual population growth in 2015 is approximately 2.10% per year (Timor-Leste in Figure, 2015). The rapid growth of population in the country is contributing to high rates of unemployment and underemployment. Based on Ministry of Finance and World Bank Group (2016) about 30% of the population in 2014 is reported to live below the poverty line.

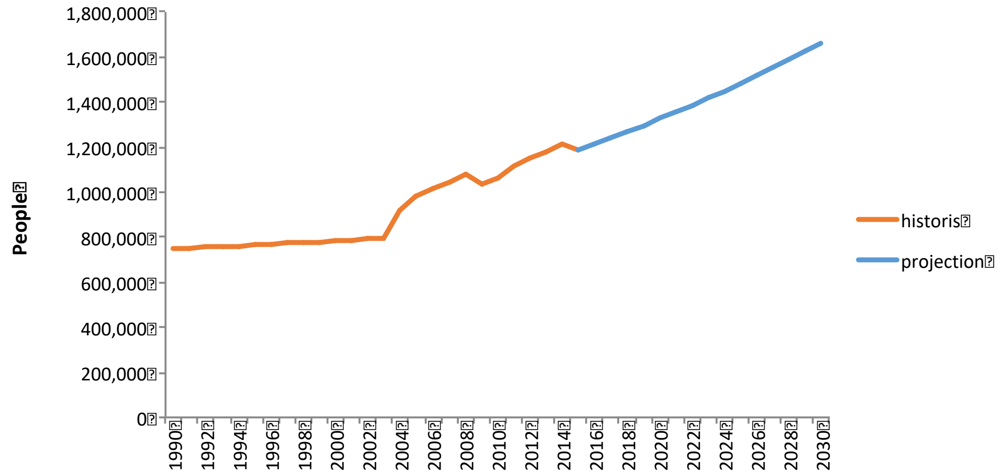


Figure 1-2 Trend in Timor-Leste's Population 1990 – 2030

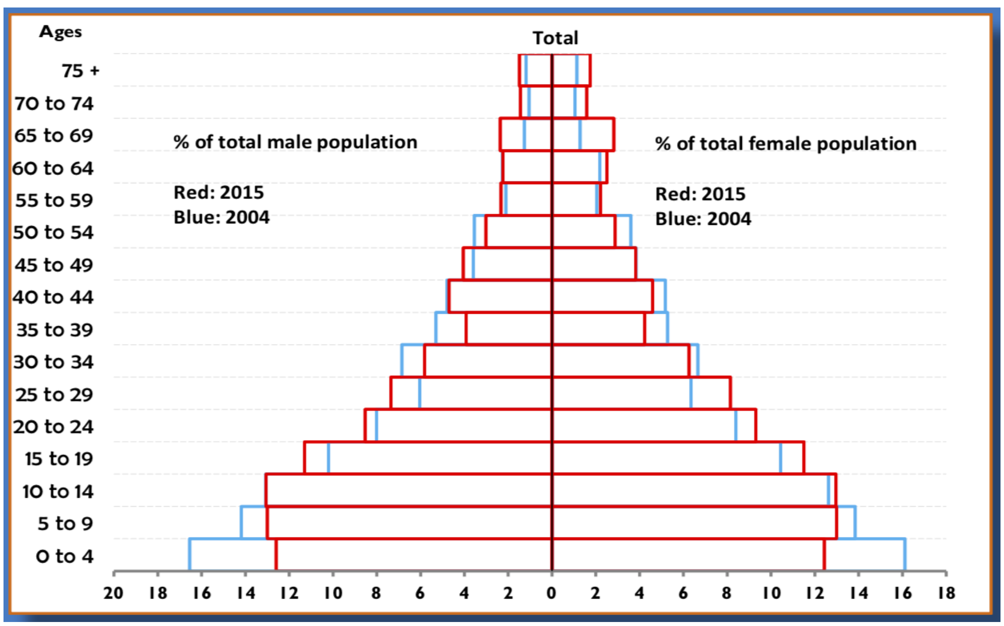
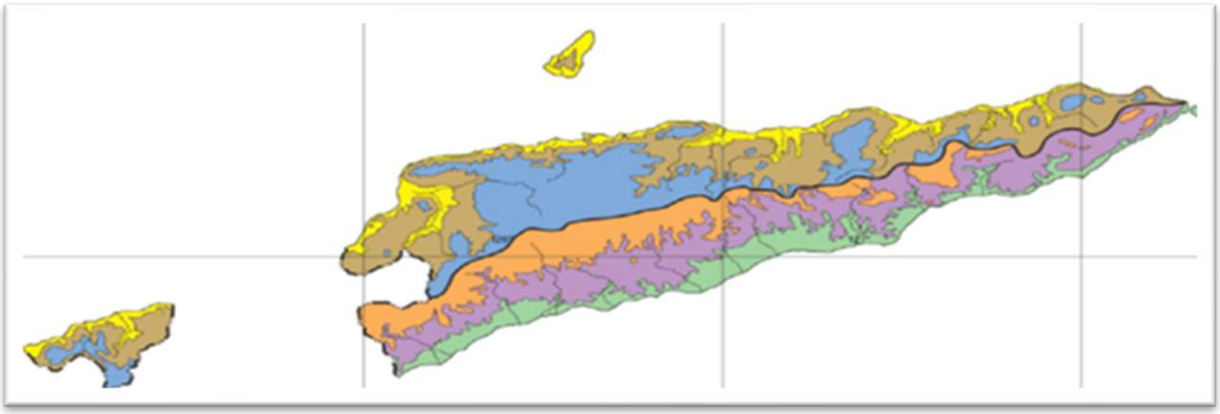


Figure 1-3 Timor-Leste's Population Pyramid 2015

1.3 Climate

Timor-Leste occupies the eastern half of Timor Island, in the north is bordered by the Sawu Sea and Straits of Wetar, and in the south by the Timor Sea. With such a structure, six agro-climatic zones exist in the Timor-Leste (

; Fox, 2003) such as north coast lowlands, northern slopes, northern uplands, southern uplands, southern slopes, and southern coast lowlands. Rainfall in Timor-Leste is strongly influenced by monsoon in the north and south of Timor-Leste (see figure 1.5). Annual rainfall along the northern coastline is lower than 1,000 mm per year and as little as 600 mm per year in some locations, such as Manatuto, whereas Same in the south receives over 2,000 mm per year. In the central and elevated regions of the country, the rainfall generally ranges from 1,500 mm to 2,000 mm per year, up to 2,500 mm per year at the highest elevations (Keefer 2000 *in* Barnett 2003; SoL 2012).



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 1-4 Agro-climatic zones of Timor Leste

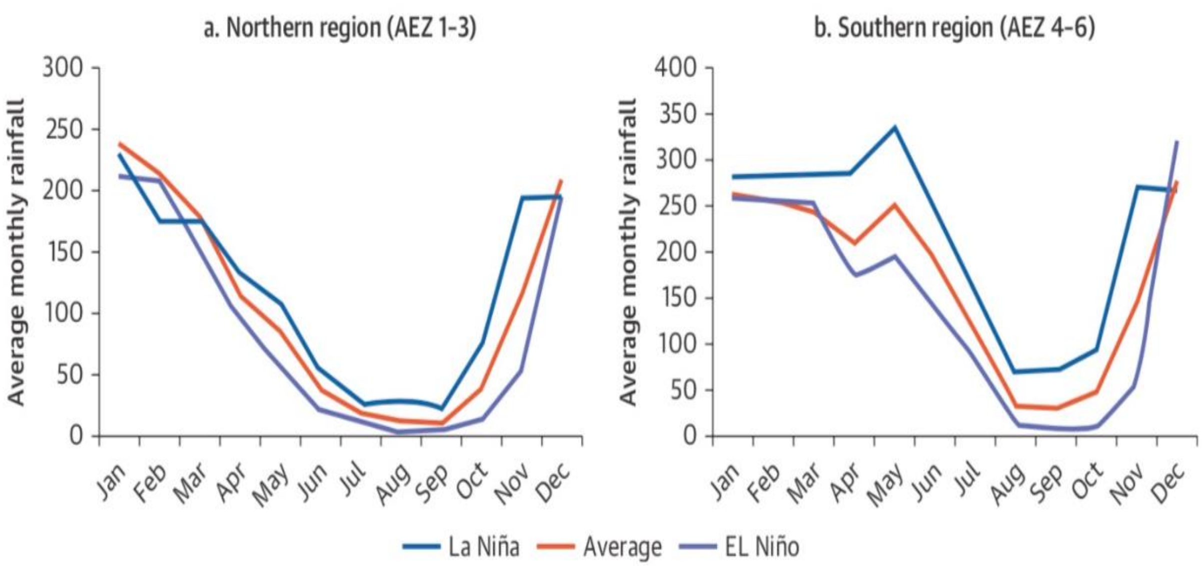


Figure 1-5 Change in Average Monthly Rainfall during El Niño and La Niña Years in the Northern Region and in the Southern Region

Rainfall variability strongly affects the reliability and volume of monsoon wet season rains in Timor-Leste. Several global climate influences impact on the regional climate of Timor-Leste, including El Niño and La Niña, Indian Ocean, tropical cyclones and the Madden-Julian Oscillation (Da Silva and Moniz, 2011; SoL 2012). These influence the regional climate on intra-annual, interannual, and inter-decadal time scales and have a substantial impact on the level of precipitation and water resources availability in Timor-Leste. Extreme drought years, which are commonly associated with El Niño also cause serious drought. Extreme heavy rainfall in the wet season influenced particularly by tropical cyclones, and also by the MJO may result in heavy flooding and also landslides (Barnett, 2003).

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.

The frequency and intensity of extreme climate events (drought, flood, and landslide) is increasing, creating risks and challenges and mostly impact vulnerable rural communities. The extreme climate events caused serious crop losses. Extreme drought in the 2015/2016 El Nino event has put Timor-Leste's farming communities under immense water stress. It was estimated that 50% of households affected and experienced severely food insecure (FAO 2018).

1.4 Economic and Social Development

1.4.1 Economic profile

As the most democratic country in Southeast Asia, Timor-Leste is also one of the oil-rich countries. 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, National Parliament of Timor-Leste unanimously approved the Petroleum Fund (PF) law after went through the public consultation (IMF, 2009). This PF law was aimed to effectively manage and invest oil revenues to ensure these funds are invested in the country's development after exploitation of these resources ends.

Petroleum sector considered as a major source for the national income of Timor-Leste. Since Timor-Leste declared its restoration of independence in 2002, the country is heavily relied on oil and gas revenue as a main source of funding for the government expenditure, oil and gas contributes about 90% of total budget revenue for the country In addition, oil wealth is estimated at 24.3 billion or US$ 22,000 per capita (IMF, 2011). Furthermore, Timor-Leste's petroleum fund balance was US$ 16.2 billion in 20015 and US$ 5,4 billion in 2009, and in 2010 this fund has reached 6.9 billion (ADB, 2011). Furthermore, Timor-Leste's petroleum fund balance was US$ 16.2 billion at the end of 2015 and declined to US$ 15.8 billion in 2016. In 2017, favorable economic conditions and strong investment performance allowed the petroleum fund balance increased from previous year to US$ 16.8 billion (Ministry of Finance, 2016; 2017; 2018).

In 2015, the Gross Domestic Product (GDP) in Timor-Leste was worth 3.1 billion US dollars (Figure 1-6). The GDP averaged 2.6 USD Billion from 2006 until 2015, reached an all-time high of 3.9 USD Billion in 2012 and recorded as the lowest with 2.6 USD Billion in 2014 and (WB, 2018). With regards to non-oil GDP, sectors of Industry and services together with Agriculture including its sub sectors forestry and fishery are the two main sectors, which dominated Timor-Leste's economy. In 2015, agriculture GDP was 17.5% of non-oil GDP and 9.1% of total GDP. The GDP of oil and non-oil sector of Timor-Leste from 2005 to 2015 is presented on Table 1-1 (WB, 2018). The trend for percentage share of non-oil GDP and agriculture GDP shows a constant increase in the period 2005-2015, while oil GDP decline.

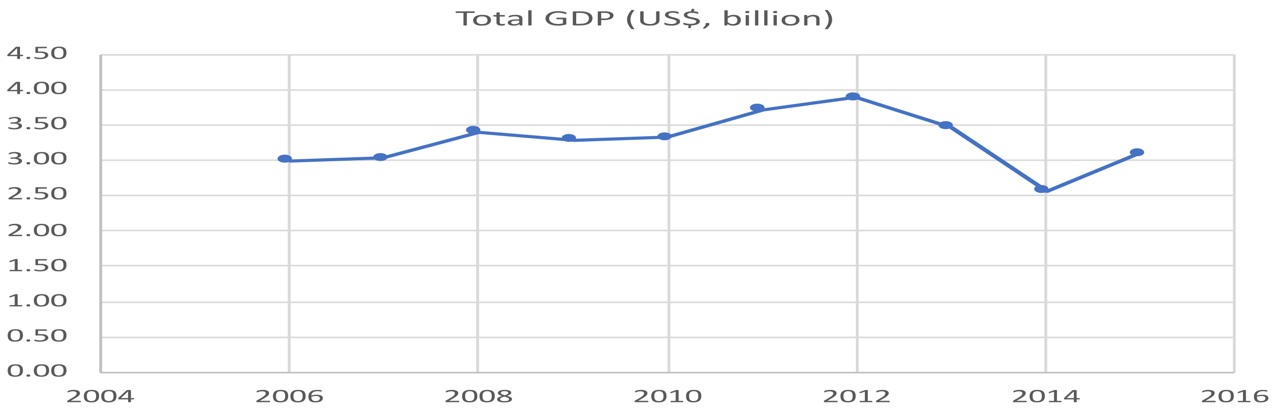


Figure 1-6 GDP growth in Timor-Leste

Table 1-1 Oil GDP and non-oil GDP of Timor-Leste in the period 2006-2015

Year	Non-oil GDP (US$, millions)	Oil GDP (US$, millions)	Total GDP (US$, millions)	AgGDP (US$, millions)	AgGDP (% of non-oil GDP)	AgGDP (% of total GDP)
2006	804	2,191	2,995	277	34.5	9.3
2007	896	2,138	3,034	268	29.9	8.8
2008	1,023	2,387	3,411	268	26.2	7.9
2009	1,156	2,138	3,294	291	25.1	8.8
2010	1,274	2,050	3,323	283	22.2	8.5
2011	1,374	2,345	3,719	241	17.6	6.5
2012	1,443	2,454	3,897	263	18.2	6.7
2013	1,481	1,989	3,470	282	19.0	8.1
2014	1,544	1,022	2,566	280	18.1	10.9
2015	1,607	1,496	3,102	281	17.5	9.1

Source: World Bank, forthcoming (a).
Note: Agriculture GDP (AgGDP) includes all agriculture, forestry, and fisheries occurring within the Timor-Leste economy. Data on weather conditions and agricultural outputs come from the Global Information and Early Warning System (GIEWS) Country Brief published by the Food and Agriculture Organization of the United Nations (FAO) for the period 2009 to 2016. Although weather data are relatively reliable, production data should be considered with caution as low capacity and lack of adequate resources result in low-quality crop monitoring and production estimates by the ministry. Official production estimates tend to be higher than surveyed data from development partner projects/programs.

1.4.2 Education

Timor-Leste is facing enormous challenges in secondary and higher education institutions. 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 and destroyed. In 2015, there were 1,264 schools including basic education, general and technical schools registered as public and private, with total student and teacher numbers of 321,451 and 10,884 respectively. Number of students enrolled by level of education and by gender in 2015 can be shown in Table 1-2 (MoF, 2015).

Table 1-2 Students enrolled by level of education and by gender

	2011	2012	2013	2014	2015	Nº
Educação Básico	304,057	304,396	311,003	316,074	321,451	**Basic Education**
masculino	157,447	157,418	159,971	160,924	163,559	male
feminino	146,610	146,978	151,032	155,150	157,892	female
Secundário Geral	37,782	41,717	42,053	43,285	45,400	**General Secondary**
masculino	18,803	20,608	20,610	20,808	21,851	male
feminino	18,979	21,109	21,443	22,477	23,549	female
Secundário Técnico	6,586	5,889	5,496	5,423	6,022	**Technical Secondary**
masculino	3,579	3,292	3,102	3,113	3,541	male
feminino	3,007	2,597	2,394	2,310	2,481	female

Fonte/Source: Ministério da Educação/Ministry of Education

Due to pressing demand from young people to enter university after the country separated from Indonesia, in 2000 the Universidade Naçional de Timor-Lorosa'e (UNTL) was established. 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 the 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. Until now, there is only one public university fully financed by the government, the 'Universidade Naçional de Timor Lorosa'e (UNTL). Within the 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 these research institutions 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).

1.4.3 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 2013 indicated that about 23,400 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 1-3).

Table 1-3 Numbers of unemployed, unemployment rate, by sex and locality

Category	*Number unemployed*	*Unemployment rate*
Timor Leste	23,400	11%
Urban	12,764	12%
Rural	10,636	10%
Male	12,185	11%
Female	11,215	10%

Source: TL-LFS, 2013; 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. Based on Timor-Leste in Figure (MoF, 2015) number of registered job seekers in 2015 was 3,781people and a half lower than in 2013 (Table 1-4).

Table 1-4 The numbers of registered job seekers in 2015

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	
Masculino	324	1,301	4,272	3,556	2,755	2,517	Male
Feminino	311	1,149	2,644	2,702	1,144	1,264	Female
Total	**635**	**2,450**	**6,916**	**6,258**	**3,899**	**3,781**	**Total**

1.5 Sectoral Condition

1.5.1 Energy sector

Energy system in Timor-Leste comprises energy production activities (supply side) and consumption activities (demand side). In the supply side, the main source of GHG emissions include fossil fuels (natural gas and diesel oil) combustions for own use and fugitives from gas flaring and venting activities in oil and gas industries, and fossil fuel (diesel oil) combustion activities for generating electricity. In the demand side, the main sources of GHG emission include industry, transportation, and commercial and household sectors.

There are three operating oil and gas fields in Timor-Leste, namely EKKN (Elang-Kakatua-Kakatua North), Kitan, and Bayu-Undan. Kitan is commenced production on 10 October 2011 with up to 34.6 million barrels of oil that estimated to be recoverable and ceased production on 16 December 2015 while Bayu udan is estimated to contain 3.4 TCF of LNG and 110,000 barrels of condensate). All of these fields are under the JPDA (Joint Petroleum Development Area between Timor-Leste and Australia), which established through the treaty between the Government of Timor-Leste and Australia (signed on 20 May, 2002). The JDPA is located in Timor Sea. Before 2018, the upstream data is taken from the JPDA. The production data represents 3 fields, i.e. EKKN, Kitan, and Bayu Undan. Based on the Article 2 of the treaty (2002), Timor-Leste has 80% to the sharing revenue if the Greater Sunrise Fields are developed by means of a pipeline to Australia. The production period of EKKN is 2005-2007, Kitan is 2011-2015, and Bayu-Undan is 2005-2018. During the indicated period, data from JPDA represents production for both Australia and Timor-Leste, therefore, it was suggested by the ANPM to utilize these data accordingly when calculating the GHG emissions only for Timor-Leste.

However, in 6th March 2018, the treaty between Australia and Democratic Republic of Timor-Leste just established their maritime boundaries in the Timor Sea. The treaty is signed at the UN Head Quarters in New York. Under this Treaty, after 2018, Kitan and Bayu Udan fields are fall completely under the Maritime territory of Timor-Leste jurisdiction.

In Bayu-Undan and Kitan, natural gas is also produced in association with the production of crude oil, condensate and LPG. Since there is no consumers around the facilities, the natural gas is directly transferred to Darwin liquefication plant and for own use in the field. However, for safety reason, the natural gas is being flared or vented. In order to perform flaring or venting, the operator must have flaring/venting allowance approved by ANPM (Autoridade Naçional do Petróleo e Minerais), government body responsible for managing and regulating petroleum activities in Timor-Leste. Since 2012, there is no venting practice undertaken in the production area.

The production data for crude oil, condensate, propane, butane, and natural gas, the amount of natural gas for own use, flaring and venting data from all fields in the JPDA during 2005 – 2015 is presented in Table 1-5 while the data from each field is presented in Table 1-6 to 1-8. In addition to the data in Table 1-5 to 1-8, there is also data on diesel consumption of power generation (10,220,882.10 liter diesel oil in 2014) for Kitan and Bayu Udan oil and gas fields. In these fields, the diesel oil was use for the replacement of own use gas in order to maintain the export gas capacity. Although only one year data, the GHG emissions from the combustion of this diesel oil is also included in the NGHGI of the SNC. Production capacity of each type of oil and gas products from all fields in JDPA is presented in Figure 1-7 and the natural gas production capacity and its utilization in the fields are presented in Figure 1-8.

Table 1-5 Production of crude oil, condensate, propane, butane, natural gas, own use, export gas, venting, flaring from all oil and gas fields in the JDPA, MMBOE

Year	*Crude Oils*	*Condensate*	*Propane*	*Butane*	*Natural Gas*	*Natural Gas for Own Use*	*Export*	*Gas flaring*	*Gas venting*
2005	330.88	21.33	6.04	4.88	53.54	52.32	0.26	0.94	0.02
2006	369.09	25.90	7.24	5.99	65.66	39.93	25.15	0.58	0.02
2007	188.55	22.76	6.19	5.20	59.17	29.11	29.39	0.67	0.01
2008	0	23.74	7.63	6.06	79.23	45.23	33.53	0.47	0.02
2009	0	22.10	7.53	5.94	62.82	28.70	33.53	0.60	0.01
2010	0	19.99	6.69	5.34	58.17	26.30	31.18	0.68	0.01
2011	4.88	20.84	6.85	5.29	64.19	30.64	32.97	0.59	0.01
2012	129.08	17.90	6.26	4.72	61.69	29.54	31.62	0.53	0.01
2013	242.36	14.61	4.98	3.76	56.96	20.43	35.97	0.56	0.01
2014	284.41	9.31	3.14	2.39	43.64	10.83	32.40	0.41	0.01
2015	309.00	8.66	2.94	2.21	52.23	15.15	36.70	0.38	0.01
2016	0	7.26	2.50	1.93	52.87	16.95	35.66	0.26	0.00
2017	0	5.61	2.09	1.60	42.18	9.63	32.28	0.27	0.00
2018	0	3.58	1.44	1.08	36.85	3.64	32.76	0.45	0.00

Source: ANPM 2019

Table 1-6 Production of crude oil, condensate, propane, butane, natural gas, own use, export gas, venting, flaring from EEKN Oil and Gas Field (closed 2007), MMBOE

Year	*Crude Oils*	*Condensate*	*Propane*	*Butane*	*Natural Gas*	*Natural Gas for Own Use*	*Export*	*Gas flaring*	*Gas venting*
2005	330.88	-	-	-	0.12	0.08	-	0.04	0.0009
2006	369.09	-	-	-	0.10	0.08	-	0.02	0.0008
2007	188.55	-	-	-	0.05	0.05	-	0.01	0.0004

Source: ANPM 2019

Table 1-7 Production of crude oil, condensate, propane, butane, natural gas, own use, export gas, venting, flaring from Kitan Oil and Gas Fields (operation 2011- 20015), MMBOE

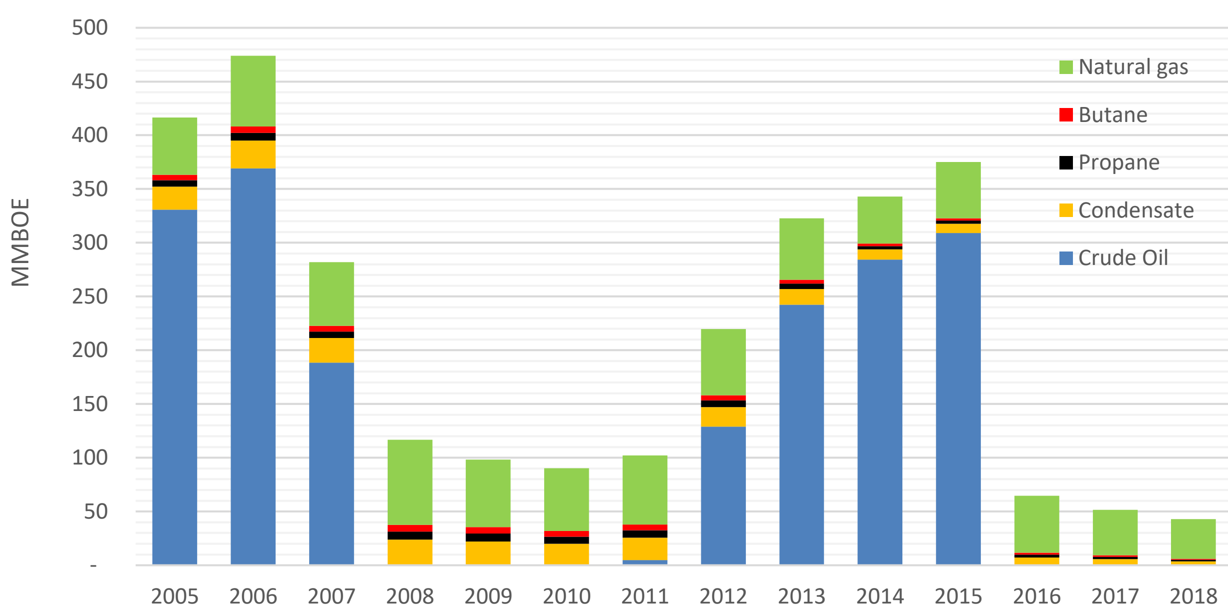
Year	*Crude Oils*	*Condensate*	*Propane*	*Butane*	*Natural Gas*	*Natural Gas for Own Use*	*Export*	*Gas flaring*	*Gas venting*
2010	-	-	-	-	-	-	-	-	-
2011	4.88	-	-	-	0.13	0.0000	-	0.13	-
2012	129.08	-	-	-	0.00	0.0002	-	0.00	-
2013	242.36	-	-	-	0.22	0.0003	-	0.22	-
2014	284.41	-	-	-	0.07	0.0002	-	0.07	-
2015	309.00	-	-	-	0.03	0.0001	-	0.03	-

Source: ANPM 2019

Table 1-8 Production of crude oil, condensate, propane, butane, natural gas, own use, export gas, venting, flaring from Bayu Udan Natural Gas Field, MMBOE

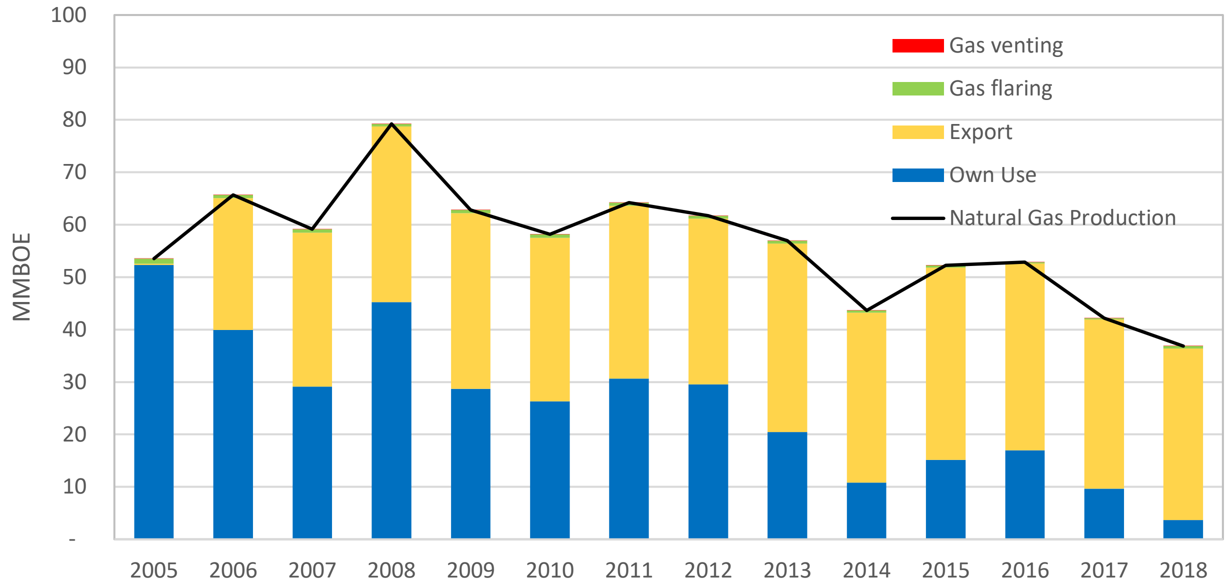
Year	*Crude Oils*	*Condensate*	*Propane*	*Butane*	*Natural Gas*	*Natural Gas for Own Use*	*Export*	*Gas flaring*	*Gas venting*
2005	-	21.33	6.04	4.88	53.42	52.24	0.26	0.91	0.01
2006	-	25.90	7.24	5.99	65.55	39.85	25.15	0.56	0.02
2007	-	22.76	6.19	5.20	59.12	29.07	29.39	0.67	0.01
2008	-	23.74	7.63	6.06	79.23	45.23	33.53	0.47	0.02
2009	-	22.10	7.53	5.94	62.82	28.70	33.53	0.60	0.01
2010	-	19.99	6.69	5.34	58.17	26.30	31.18	0.68	0.01
2011	-	20.84	6.85	5.29	64.07	30.64	32.97	0.46	0.01
2012	-	17.90	6.26	4.72	61.69	29.54	31.62	0.53	0.01
2013	-	14.61	4.98	3.76	56.74	20.43	35.97	0.34	0.01
2014	-	9.31	3.14	2.39	43.57	10.83	32.40	0.34	0.01
2015	-	8.66	2.94	2.21	52.20	15.15	36.70	0.36	0.01
2016	-	7.26	2.50	1.93	52.87	16.95	35.66	0.26	0.00
2017	-	5.61	2.09	1.60	42.18	9.63	32.28	0.27	0.00
2018	-	3.58	1.44	1.08	36.85	3.64	32.76	0.45	0.00

Source: ANPM 2019



Source: Processed from ANPM 2019

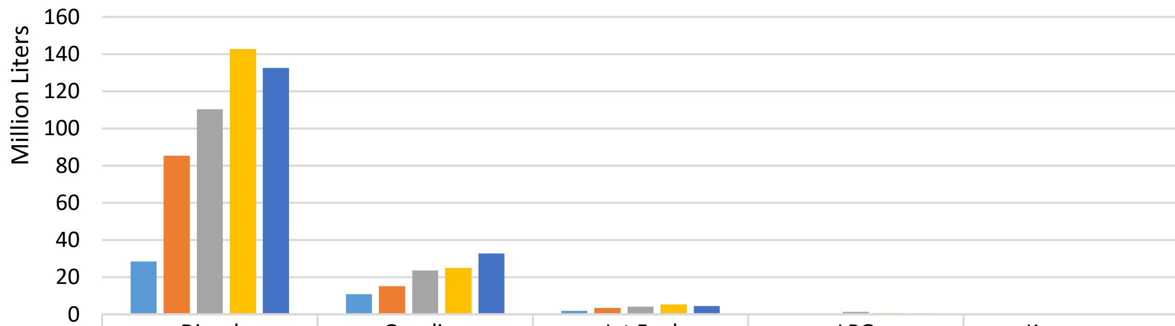
Figure 1-7 Production of crude oil, condensate, propane, butan, and gas from EKKN, Kitan and Bayu Udan oil and gas fields in the JDPA, 2005 – 2018



Source: Processed from ANPM 2019

Figure 1-8 Natural gas production, export, own use, flaring and venting data from EKKN, Kitan and Bayu Udan oil and gas fields in the JDPA, 2005 - 2018 (ANPM, 2019)

As mentioned before, all petroleum product in Timor-Leste are supplied from import activities, which presented in Figure 1-9. It can be seen in the Figure 1-9, more than half of the imported diesel oil is used in power plant. The rest of the imported diesel oil is used for transportation and industrial sector. In addition to diesel oil, gasoline and jet fuel are also used in transportation. There is not much industries in Timor-Leste, in which the biggest industry is beer manufacturing while the rest is very small industries (households). Most of these industries use electricity, biomass, and small portion of diesel oil (for genset only). There is also imported LPG and kerosene used in residential and commercial sector.



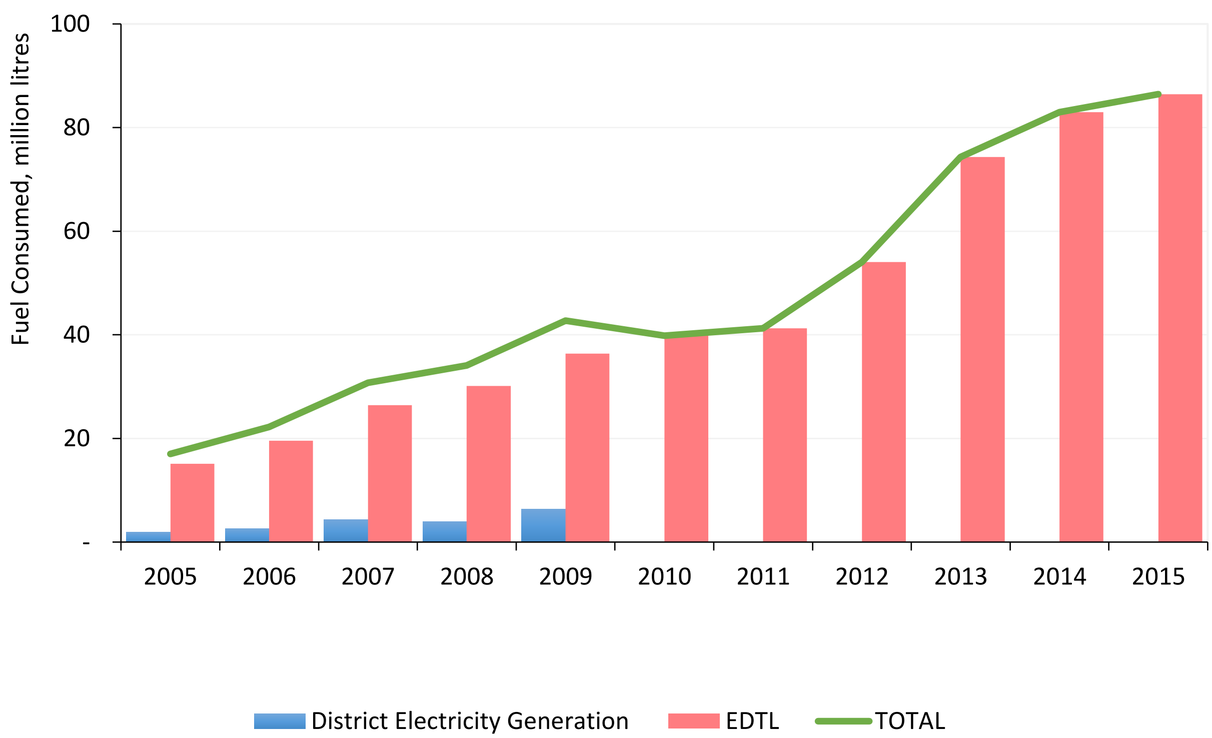
	Diesel	Gasoline	Jet Fuel	LPG	Kerosene
2011	28,336,781	10,791,813	1,842,594	213,400	472,717
2012	85,250,175	15,163,385	3,363,170	440,300	466,714
2013	110,295,742	23,517,425	4,034,641	1,373,434	
2014	142,749,750	24,996,758	5,371,239	680,670	30,000
2015	132,532,851	32,717,459	4,408,339	443,000	0

Source: ANPM, 2018

Figure 1-9 Imported fuels, Liter

The electricity generation and supply systems in Timor-Leste are managed by a national or state own enterprise/company, EDTL (Eletrisidade de Timor-Leste). In order to provide more reliable electricity supply, GoTL has completed the construction of 715 km of high voltage transmission line that can supply all locations in the country except Oe-Cusse Ambeno and Atauro Islands. The development of national grid system affected the ratio of electrification in Timor-Leste that has increased from 40% in 2010 to become 83% in 2016.

The national grid system is supplied by two diesel power plants, i.e. Hera Generating Station (119.5 MW) and Betano Generating Station (136.6 MW). These power plants replaced the scattered small-scale district power generations. With the addition of an idle 27.5 MW Comoro diesel power plant, the grid will be over supplied for current demand and next future years. In terms of energy efficiency, in average, the power plants have reached 0.23 litre/kWh specific fuel consumption, lower than the 0.27-0.29 litre/kWh of the old power plants. In 2015, other power plants, 17.3 MW Inur Sakato, was operated for supplying Oe-Cusse district. Table 1-6 provides data of electricity generation managed by EDTL and the district generation while Figure 1-10 shows diesel oil consumption for electricity generation in Timor-Leste. The use of diesel generation aims to provide flexibility for the power plant to be converted to be fueled by natural gas (CNG, LGV, LPG) when the domestic supply is available. In addition, the government also encouraged the use of renewable energy from solar power and biogas. Beside the data in Table 1-6, there are some other utilization of renewable power generation that operated by various entity such as non-governmental organization or community. Some of the technology that are being used or developed in the country are solar street light, solar energy pumping system, solar-diesel hybrid power plant and wind power plant. However, the available data is only solar PV for power generation, which the electricity is supplied for national grid.



Source: National Directorate for Electricity Development and Research, EDTL, 2018

Figure 1-10 Diesel oil consumptions for electricity generation in Timor-Leste, Millions Liter

Table 1-9 Electricity generation by type of power generation, Kton/year

Year	*Diesel Oil*		*Renewable Energy (EDTL)*	*Total*
	District Generation kWh	*National Grid Generation (EDTL) kWh*	*Solar PV kWh*	*Electricity Generation kWh*
2005	7,095,110	55,896,498		62,991,608
2006	9,714,689	71,958,471		81,673,160
2007	14,972,138	91,788,978		106,761,116
2008	14,545,793	110,514,113		125,059,906
2009	23,215,030	131,700,316		154,915,346
2010	0	136,908,654		136,908,654
2011	0	179,361,809		179,361,809
2012	0	234,979,000		234,979,000
2013	0	323,086,000		323,086,000
2014	0	350,757,000		350,757,000
2015	0	369,481,420	657,287	370,139,221

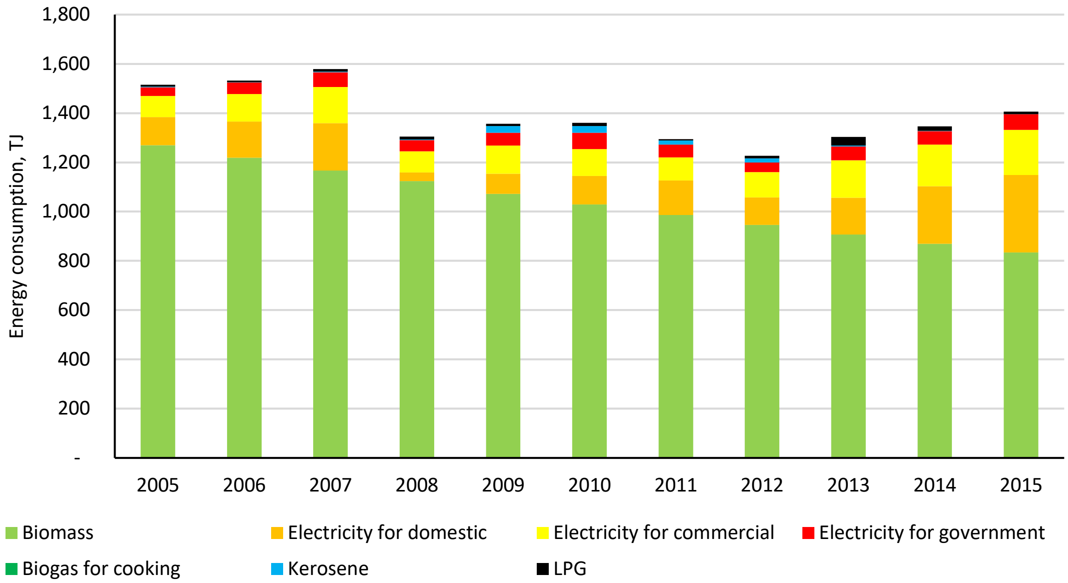
Sources: processed from EDTL Data, 2011; data 2012 ï 2014 is projection plan

The demand side consists of fuel consumptions in commercial and residential sectors. The fuel consumption data in these sectors is too small and cannot be separated. Therefore, the GHG emissions from fuel combustions in these sectors are estimated together. For cooking, many people especially in rural area still use biomass in spite have access to LPG. The historical data of fuel consumption in commercial and residential sector is shown in Table 1-7 (physical units), Figure 1-11 and Figure 1-12 (in energy unit).

Table 1-10 Fuel consumption data in the commercial and residential sectors, 2005 – 2015

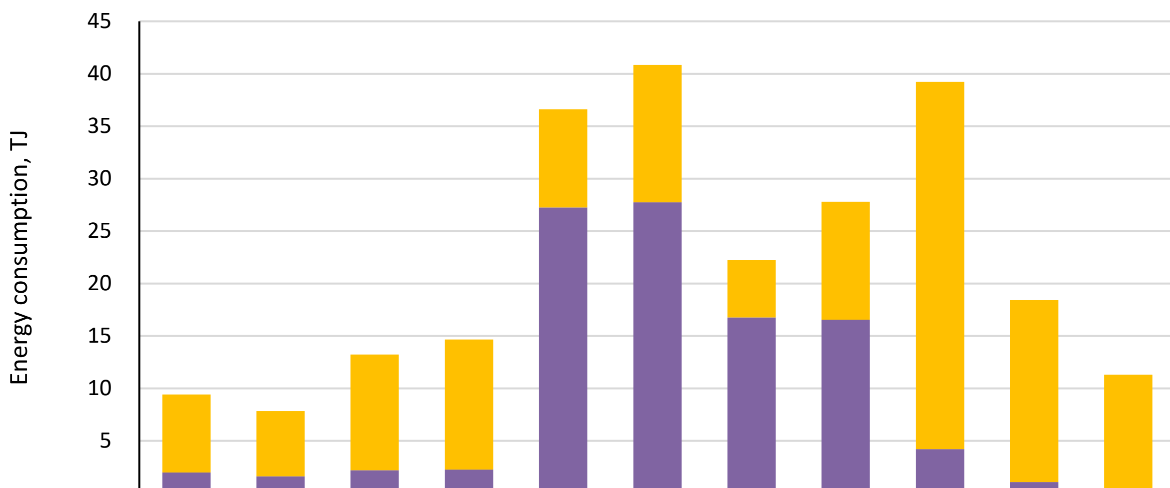
Year	***Population***	***Household***	***Biomass, Ton***	***Kerosene, Liter***	***LPG, kG***	***Electricity from renewables, kWh***
2005	983,369	162,686	81,400	56,000	157,000	62,991,608
2006	1,015,187	170,657	78,100	45,000	132,000	81,673,160
2007	1,047,632	176,111	74,800	62,000	233,000	106,761,116
2008	1,080,742	181,677	72,050	63,000	262,400	44,431,000
2009	1,032,501	173,568	68,750	767,900	197,800	66,184,000
2010	1,066,409	184,652	66,000	781,979	276,800	77,563,000
2011	1,120,392	186,609	63,250	472,717	115,023	76,385,000
2012	1,148,958	191,367	60,646	466,714	237,322	67,768,000
2013	1,180,069	196,549	58,149	NA	740,281	95,391,000
2014	1,212,107	201,885	55,754	30,000	366,881	122,351,000
2015	1,183,643	204,597	53,459	-	238,777	150,082,000

Source: Kerosene and LPG data from PERTAMINA ï DILI (2011), PERTAMINA INTERNATIONAL TIMOR (2018) and ANPM (2018); Biomass data from FAO



Source: Kerosene and LPG data from PERTAMINA ï DILI (2011), PERTAMINA INTERNATIONAL TIMOR (2018) and ANPM (2018); Biomass data from FAO Statistics, 2018

Figure 1-11 Energy use in residential and commercial sectors (Tjoule), 2005 – 2016



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LPG	7	6	11	12	9	13	5	11	35	17	11
Kerosene	2	2	2	2	27	28	17	17	4	1	-

Source: Pertamina-DILI (2011), Pertamina INTERNATIONAL TIMOR (2018) and ANPM (2018);

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

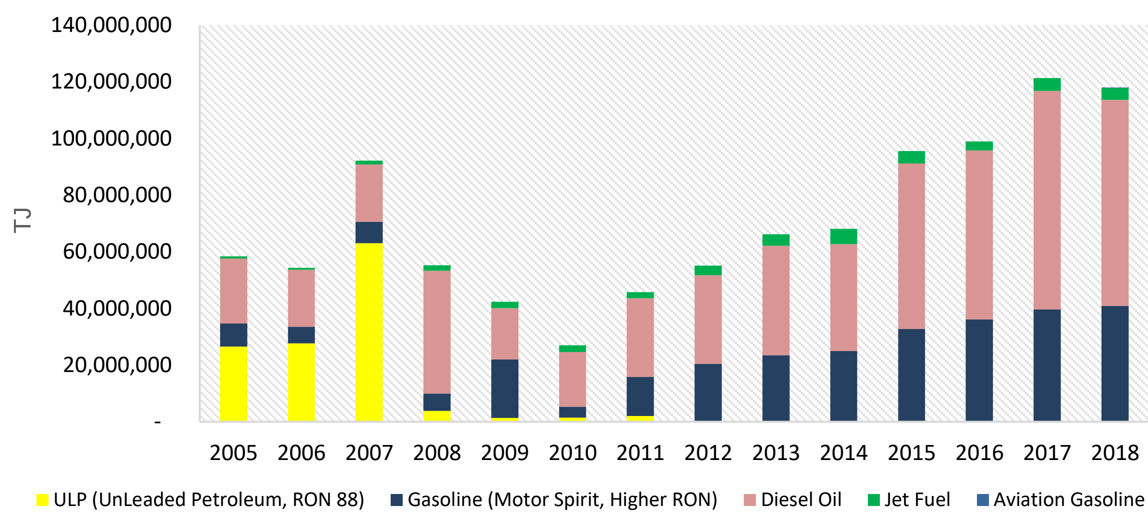
1.5.2 Transportation

The type of fuel used in the transportation sector includes gasoline, ULP (un-leaded petrol), and diesel oil for road transport and aviation and jet-kero for air transportation. Fuel consumptions in transportation data within 2005 – 2011 is provided by Pertamina Dili, Tiger Fuel, and TOLL. After 2011, the data is provided by ANPM and import statistics. Table 1-8 and Figure 1-13 present fuel utilization in transportation.

Table 1-11 Fuel consumption in Transportation sector, 2005 – 2015

Year	*Gasoline (RON 92)*	*ULP (RON 88)*	*Diesel Oil*	*Jet-Kero*	*Aviation Gasoline*
2005	8,140,000	26,515,000	22,882,000	832,000	
2006	5,883,000	27,706,000	20,078,000	609,000	
2007	7,536,600	63,063,700	20,142,400	1,418,000	
2008	6,105,600	3,827,300	43,388,000	1,867,000	
2009	20,717,700	1,356,300	17,990,870	2,280,914	
2010	3,847,800	1,437,000	19,374,905	2,359,300	
2011	13,737,000	2,040,000	27,763,719	2,150,368	
2012	20,482,389	-	31,205,005	3,363,170	
2013	23,517,425	-	38,603,510	4,034,641	
2014	24,996,758	-	37,663,494	5,371,239	
2015	32,717,459	-	58,419,446	4,408,339	
2016	36,316,247	-	59,620,978	3,134,109	
2017	39,671,918	-	77,063,573	4,547,126	
2018	40,895,060	-	72,723,376	4,165,023	65,600

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



Sources: processed from Pertamina Data (2011), TOLL Data, Tiger Fuel Data, and ANPM 2019

Figure 1-13 Fuel consumptions in Transportation (Tjoule)* ULP = Un-Leaded Petroleum; Jet Kerosene (JET A1/F35) = Avtur (international bunker)

1.5.3 Waste

Waste generation in Dili as per 2015 is 0.7 kg/cap/day, an increase of around 37% from the previous rate of 0.51 kg/cap/day identified during 2010 census. There is quite a distinction in waste management facilities between Dili and other districts (see Table 1-9). MSW in Dili is managed in Tibar dumpsite which at the moment, applying open dumping system with occasional burning to clear space for new waste pile. In other districts, dumpsites are smaller and mostly regional. They also have limited collection transport making only around 5% of waste generated are being collected. In Dili, some private recycling facility exist and targeting mostly bottle, plastic and metal can for export[1].

There are eight health facilities throughout Dili operating incineration for their medical waste. One facility in Dili incinerate around 150 kg of waste/week, while the other seven in other districts have each an average waste incinerated of 50 kg/week.

Table 1-12 Waste stream data in Timor-Leste

MSW Management	*Dili*	*Other districts*
MSW to disposal	45%	8.359 ton/year (± 5%)
Recycling	3%	-
Open burning	32%	89%
Untreated	20%	
Incineration (clinical waste)	150 kg/week	total 350 kg/week
Source:	Survey by ADB, 2014 - 2015	Based on discussion with WG waste

In general, until 2010 Dili's population account for 22% of Timor-Leste's total population. The proportion changed into 23% in 2011 and used from 2011 onward (see Table 1-10).

Table 1-13 Waste generation data based on population

Y e a	***P o p u l a t i o n***			***Wa s t ee rGaet ni o n (***		
	Timor-Leste	**Dili**	**Other Districts**	**Timor-Leste**	**Dili**	**Other Districts**
2 0 0	983,369	216,341	767,028	183	40	143
2 0 0	1,015,187	223,341	791,846	189	42	147
2 0 0	1,047,632	230,479	817,153	195	43	152
2 0 0	1,080,742	237,763	842,979	201	44	157
2 0 0	1,032,501	227,150	805,351	192	42	150
2 0 1	1,066,409	234,610	831,799	199	44	155
2 0 1	1,120,392	257,690	862,702	209	48	161
2 0 1	1,148,958	264,260	884,698	214	49	165
2 0 1	1,180,069	271,416	908,653	220	51	169
2 0 1	1,212,107	278,785	933,322	226	52	174
2 0 1	1,183,643	277,279	906,364	302	71	232

[1] Source: Ministry of Planning and Strategic Investment, JICA 2016. The Project for Study on Dili Urban Master Plan in the Democratic Republic of Timor-Leste, Final Report Part I: Current Condition

Information on waste composition is only available for Dili, but considered representative of typical composition throughout Timor-Leste. While most Asian countries' largest share of waste come from food, this is not the case in Timor-Leste. Food waste are mostly used for livestock feed such as pigs thus the number is small compare to other types of waste (see Table 1-11).

Table 1-14 Solid waste composition in Timor-Leste

Waste type	***Percentage***
Paper/cardboard	18.0%
Textiles	02.0%
Food waste	12.0%
Wood waste	00.0%
Garden/park waste	33.0%
Napies	00.0%
Rubber/ Leather	00.0%
Plastic	18.0%
Metal	01.0%
Glass	02.0%
Others/inert waste	14.0%

Source: Summary Solid Waste Management in Dili, Ministry of State Administration, 2015

Access to domestic wastewater facility is still an issue in most districts outside Dili with less than 50% population having access to sanitation, albeit basic ones. While in Dili more than 70% population have access to improved sanitation system, less than 20% population in other districts have it (see Table 1-12).

Table 1-15 Degree of Utilization based on Type of Treatment in Timor Leste

Type of treatment	**Other districts**	**Dili district**
Septic tank	17.60	74.45
Pond/field	1.24	1.99
River/ lake/ ocean	1.78	1.15
Hole	33.89	17.06
Shore/ open field	42.60	3.93
Other	2.89	1.42

1.5.4 Forestry Sector

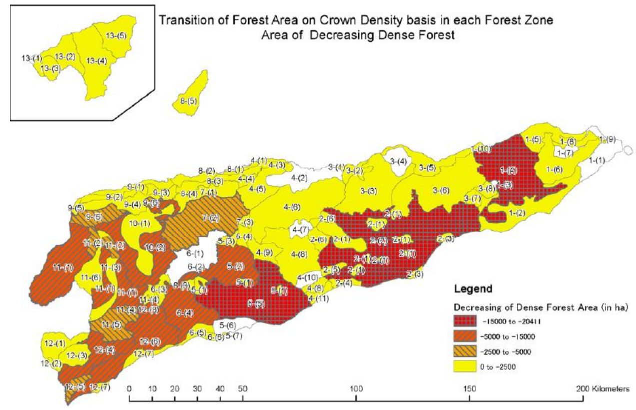


Figure1-14 Forest Zones with Significant Deforestation of Dense Forest between 2003 and 2010 (Nippon Koei Co., Ltd, 2010)

Timor-Leste's forest cover has experienced a significant deforestation in 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 (Figure 1-15). Reduction in dense forest coverage is especially rampant in Lautem, Viqueque, Bobonaro and Manufahi districts (Nippon Koe, 2010). Most of the land in Timor-Leste is still cover with forest ecosystems. However, most of the forests are heavily degraded as a result of extensive timber and firewood extraction and grazing. The forest cover is approximately 869,000 ha or 58% of the whole country in 2012. The total area of the dense forests, with crown cover of 60%–70%, is approximately 313,000 ha while the area of sparse forest is approximately 556,000 ha. The area of sparse forest is almost 1.8 times of the area of dense forest nationwide. The relatively large areas of the dense forests are very rare, and small areas of dense forests are scattered nationwide. Moreover, almost half of the total lands in the country are categorized under the mosaic land use, which are distributed forest lands and non-forest lands, including grass lands, cultivation lands, and residential areas. Therefore, most of the forest areas are easily accessible, and consequently, these forest lands are susceptible to logging and converted to grasslands or cultivated lands. As a result, most of the remained forests have been intervened by human activities, and most of the dense and high-quality forests are susceptible to become sparse forests (MAF, 2013).

Based on land use and cover assessment in 2010 conducted by the National Directorate for Forestry, Watershed Management and Reforestation (NDFWMR)) the forest remains the largest land in the country, of which nearly 932 thousand ha or 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 1-13).

Table 1-16 Land use and land cover of Timor-Leste in 2010

IPCC Category	*Land 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%

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 which good regenerative capacity are *Eucalyptus alba* and *Leucaena leucocephala*, *Pouteria sp.*, *Mallotus philippensis* and *Schleichera oleosa*. Furthermore, MAF develop SDP 2011-2030 as a basis for the formulation and implementation of forestry management plans to facilitate the sustainable management of forest resources in. Efforts will be made to encourage the participation of rural communities and other stakeholders in all aspects of forest resource management in the nation. The key focus areas are: (a) reforestation and forest rehabilitation; (b) forest protection and forest resources management; and, (c) forest production and utilization (MAF, 2012).

1.5.5 Agriculture

Agriculture dominates economic activities in Timor-Leste. It is subsistence agriculture with low inputs and outputs. The agriculture sector comprised of crop and livestock, fisheries and forestry employ more than 75% of Timorese people. Staple crops are maize, rice, cassava with sweet potato, potato, mung bean, peanut and soya bean being widely grown in farm lands on steep slopes excepting the rice crop which is mostly found on flat areas or terraces made 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.

Table 1-14 shows that there was a quite significant decrease in the overall harvested area of cereals such as rice, maize, sorghum, and others; while the yield and cereals production increased over the past 10 years. In 2015, the harvested area and production of cereals was 82,540 ha and 213,902 ton respectively (FAO, 2018).

Table 1-17 Harvested Area and production of Paddy in Timor-Leste, 2005 – 2015

Cereals	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Area harvested (ha)	98,000	116,000	103,400	125,068	110,338	106,803	57,260	87,086	70,818	65,443	82,540
Yield (ton/ha)	1.54	1.5	1.28	1.44	2.32	2.45	2.59	2.09	2.66	2.92	2.59
Production (ton)	151,106	174,394	131,946	180,430	255,490	261,816	148,080	182,005	188,121	191,297	213,902

In addition, food and crop production by commodities, i.e. rice, maize, cassava and vegetable, in Timor-Leste can be seen Table 1-15, while production for each district based on the 2015 statistic is summarized in Table 1-16. These tables show that crops production fluctuated in the period 2005-2015 (Table 1-14), and most of food crops are produced in districts of Oe-cusse, Viqueque, Baucau, Bobonaro, Covalima, and Ermera (Table 1-15). Production of rice, maize, cassava and vegetable was 71,541-ton, 142,361-ton, 130,670 ton, and 106,435 ton respectively.

Table 1-18 Food and Crops production in Timor-Leste

Toneladas/Tons

	2010	2011	2012	2013	2014	2015	
Arroz	112,925	71,594	119,166	X	X	71,541	Rice
Milho	148,323	49,783	62,839	X	X	142,361	Maize
Mandioca	94,834	22,197	94,834	X	X	130,670	Cassava
Vegetais	78,605	X	34,012	36,332	X	106,435	Vegetables

Table 1-19 Food and Crops production by district

Municípios	Arroz	Milho	Mandioca	Vegetais
Aileu	2,586	7,039	6,885	6,015
Ainaro	2,734	9,476	8,210	7,740
Baucau	12,606	17,904	15,134	10,681
Bobonaro	8,527	15,128	12,897	10,062
Covalima	4,099	10,335	10,049	9,721
Dili	3,013	7,999	7,542	4,808
Ermera	4,659	17,271	17,125	13,639
Lautém	3,487	9,652	7,863	4,750
Liquiça	1,734	10,196	9,670	7,532
Manatuto	3,026	4,607	4,271	3,991
Manufahi	2,661	8,018	7,838	6,886
Oecusse	13,294	13,393	11,596	10,528
Viqueque	9,115	11,343	11,590	10,082
Total	**71,541**	**142,361**	**130,670**	**106,435**
Municipalities	**Rice**	**Maize**	**Cassava**	**Vegetables**

Coffee is the most important of the commercial export tree crops grown in Timor-Leste with 48% of the production area in the district of Ermera (Old and Cristovão, 2003; Gusmão 2003). It is main non-oil export and is grown by 27.5% of all households. The production area is about 54,000 ha with annual production varied 10,000 – 15,000 ton (Timor-Leste Census, 2010). The main exporting venue for Timorese coffee production is the United States of America (USA) and Germany with annual export earning about US$ 15 million (approximately 1% of non-oil GDP). This figure shows that coffee production provides a significant income after oil and gas.
Livestock is one of the most important sources of farmer’s income in Timor-Leste, especially in rural areas. Income from livestock in rural areas is higher than from non-agricultural activities (off-farm workers) or transfers (e.g. pensions and welfare) (NSD, 2011). 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, pig, cattle and buffalos in 2015 compared to 2011. However, there was a reduction for goats, sheep and horses in the same period of time (Table 1-17). Despite these signs of the increases 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.

Table 1-20 Livestock population in Timor-Leste

Nº de cabeças/Nº of heads

	2011	2012	2013	2014	2015	
Galinhas	739,702	778,906	820,188	863,658	928,806	Chicken
Suínos	345,635	363,954	383,243	403,555	419,169	Pigs
Bovinos	170,223	173,115	176,059	176,280	221,767	Cattle
Búfalos	98,122	103,324	108,801	109,022	128,262	Buffalo
Caprinos	160,435	168,938	177,892	178,581	158,467	Goats
Cavalos	55,739	53,734	51,798	52,266	50,751	Horses
Ovinos	49,388	58,278	68,767	69,001	40,498	Sheep

Despite increases in the number of livestock in the country, it is still insufficient to supply livestock product: milk, meat and eggs for the domestic needs. Therefore, imported such products to the country is unavoidable. 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, National University of Timor Lorosa'e (UNTL) to improve livestock production in Timor-Leste.

1.5.6 Coastal, Marine Resources and Fisheries

Timor-Leste has approximately 700 km of coastline and claim on an Exclusive Economic Zone (EEZ) of 200 nautical miles. The country holds many coastal and marine resources including fish, seagrasses, seaweeds and coral reefs, mangrove forests and beaches. 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 abundance and diversity of local fish stocks with each different habitat contributing to the spawning and recruitment process of inshore and offshore species (Figure 1-15). About 42% of all the villages in Timor-Leste have a coastal border (McWilliams, 2003), this includes the RAEOA 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 1-15 One of Species of fish in Timor-Leste (ECO-Science for Sustainability, Credit © Gerald Allen/CI, 2013)

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 institution 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[2] due to illegal fishing in the country.

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). In 2000, the commercial catches were declined to 400 tonnes, but have since increased to approximately 2,000 tonnes/year by 2009. Small-scale catches during this time increased in importance, increasing from approximately 2,500 tonnes in 1999 to approximately 3,500 tonnes/year by 2009. Overall, estimated total catches increased from approximately 1,600 tonnes in 1950 to approximately 5,600 tonnes in 2009 (Barbosa and Booth, 2009).

1.5.7 Water Resources

Timor-Leste has more than 100 rivers (Figure 1-16). 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.

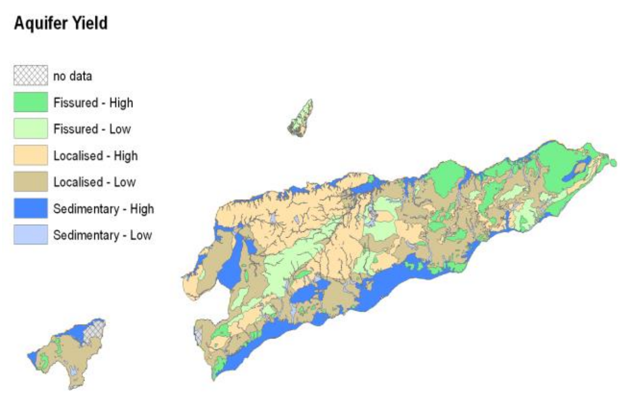


Figure1-16 Potential Aquifer Yield in Timor-Leste (Geoscience Australia in Research Institute for the Environment and Livelihood 2011)

Source: Geoscience Australia in Vulnerability of Groundwater Resources to Climate Change in Timor-Leste (Research Institute for the Environment and Livelihood, November 2011).

1.6 Priorities related to Climate Change Mitigation

The National Strategic Development Plan – 2011 to 2030 and the Basic Environmental Law, Decree Law No. 26/2012 are main reference in climate policy ini Timor-Leste. Furthermore, the National Adaptation Programme of Action (NAPA), and Initial National Communication (INC) have laid the groundwork and provided guidance and set targets towards planning and implementing climate change adaptation and climate change mitigation initiatives. The NAPA, as mentioned above, has identified nine priority areas which need immediate and urgent climate adaptation interventions. Similarly, the INC provides an account of national efforts channeled towards adaptation and mitigation, the current status of the greenhouse gas emissions.

[2] 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

In 2017, Timor-Leste developed National Climate Change Policy (NCCP). The goal of the NCCP is to provide a vision, policy guidance and climate resilient development pathways to government and non-government actors working on different aspects of climate change inter alia, adaptation, mitigation, climate change finance, and loss and damage to contribute towards building a climate resilient Timor-Leste (MoCIE, 2017). Related to the climate change mitigation, the NCCP is directed towards energy efficient, low carbon options and less polluting development strategies, without compromising national economic development potential. Under this climate change mitigation, there are six areas that needs interventions as follow:

a. Identifying emission development options that are low carbon and are energy efficient to fuel existing national economic development aspirations.
b. Supporting sustainable energy promotion programmes to increase energy security at the community level and reduce carbon emissions
c. Exploring carbon market potential by promoting low emission development options such as energy efficiency in public buildings, REDD+, afforestation programmes, waste management, fuel efficient cook stoves, increasing off-grid renewable energy supply in the overall electricity supply mix.
d. Developing a Low Carbon Development Strategy that supports climate resilient development
e. Initiating research and development of energy efficient technologies that can be promulgated and scaled up at the commercial level.
f. Engaging the private sector to support in the use and promotion of low carbon development options.

1.7 Institutional Arrangement for Development of National Communication

During the development of the Second National Communication (SNC), Government of Timor Leste already set up institutional arrangement for the development of National Communication. The coordination still follows the Initial National Communication (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. Throughout the SNC development, the six TWGs have merged into one large working group as many members were actually relevant to more than one working group (Figure 1-17). 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 workshops and focus group discussions.

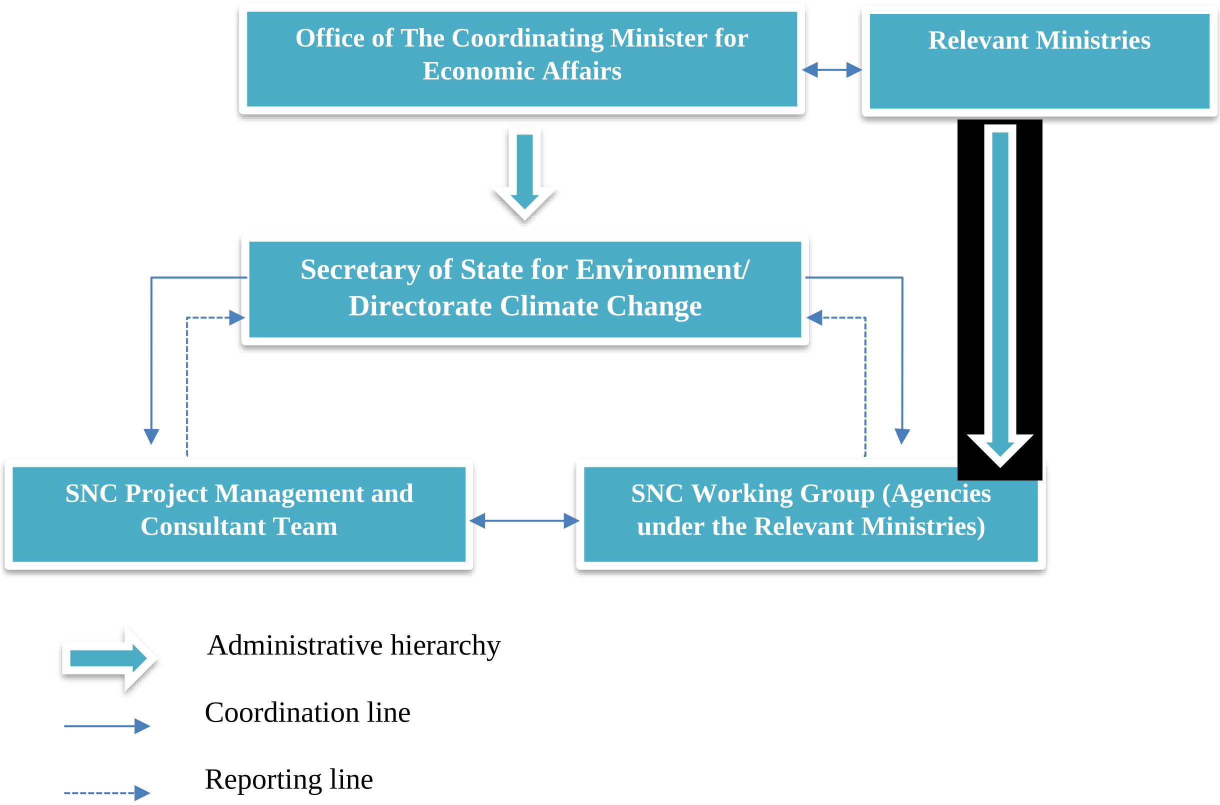


Figure 1-17 Institutional Arrangement for the Second National Communication

Members of the TWG 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 is presented in Table 1-16 and 1-17.

Table 1-21 Stakeholder of SNC Working Group

Energy/Industry	Agriculture	Forestry	Waste
1. Jaime Camacho (Coordinator)	1. Florindo Neto (Coordinator)	1. Celestina Barreto (Cordinator)	2. Cosme Saldanha (Coordinator)
2. Deodato Alves	2. Terezinha de Araujo	2. Nelson Madeira	3. Abraao Joaquim
3. Ligia Purificacao	3. Fernanda C. Silva	3. Eva Fernandes	4. Eva Magno
4. Zelia Anita	4. Maximiano Gama	4. Arlindo Silveira	5. Terezinha Vicente

Table 1-22 Member of SNC WG

No	Name	Position/Title/Organization	Contact
1	Mr. Florindo Morais Neto	Technical Staff, ALGIS, Ministry of Agriculture & Fisheries	Phone#: 77311013 Email: florindo.moraissoltimor@gmail
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3	Mrs. Teresinha de A. Baptista	Technical Staff, General Directorate of Statistics, Ministry of Finance	Phone#: 75188876 Email: taraujo@mof.gov.tl
4	Mrs. Eva Fernandes	Technical Staff, General Directorate of Statistic, Ministry of Finance	Phone#: 77233720 Email: efernandes@mof.gov.tl
5	Ms. Eva Merita Magno	Technical Staff, Department of Environmental Health, Ministry of Health.	Phone#: 762208917 Email: meritamagno9395@gmail.com
6	Mrs. Fernanda C. da Silva	Technical Staff, National Directorate for Biodiversity Conservation & Protection, Directorate General for Environment, MCIE	Phone#: 77513439 Email: jnsilva39@ymail.com
7	Mrs. Ligia Purificacao	Technical Staff, National Directorate for Climate Change, Directorate General for Environment, Secretary of State for Environment	Phone#: 77616829 Email: ligiadossantos95@gmail.com
8	Mr. Nelson Madeira	Chief of Department, National Directorate for Climate Change, Directorate General for Environment, Secretary of State for Environment	Phone#: 77327533 Email: lsonmadeira72@yahoo.com
9	Mr. Arlindo Silveira	Technical Staff, National Directorate for Climate Change, Directorate General for Environment, , Secretary of State for Environment	Phone#: 77615530 Email: silveiralindo@yahoo.co.id
10	Mr. Abrao J. de Sa	Technical Staff, National Directorate for Climate Change, Directorate General for Environment, , Secretary of State for Environment	Phone#: 77295906 Email: aquem69@gmail.com
11	Mr. Jaime Camacho	Technical Staff, National Directorate for Research and Electricity Development (EDTL), Ministry of Public Works	Phone#: 77236183 Email: itn@yahoo.com

No	Name	Position/Title/Organization	Contact
12	Mr. Deodato Alves da Costa	Technical Staff, National Directorate for Research and Electricity Development (EDTL), Ministry of Public Works	Phone#: 77416622 Email: fehan_6622@yahoo.com
13	Mrs. Celestina Barreto	Technical Staff, National Directorate of Forestry, Ministry of Agriculture & Fisheries	Phone#: 77065140 Email: celestina.barreto.aty@gmail.com
14	Mrs. Zelia Anita Maria	Technical Staff, National Directorate for Climate Change, Directorate General for Environment, Secretary of State for Environment	Phone#: 77308535 zeliaanitam@yahoo.com
15	M. Maximiano Ximenes Gama	Technical staff National Directorate of Control Pollution and Environment, Directorate General for Environment, Secretary of State for Environment	Phone#: 77322782 Email: ximenesgama2017@gmail.com
16	Mrs. Terezinha Vicente	Technical staff National Directorate of Control Pollution and Environment, Directorate General for Environment, Secretary of State for Environment	Phone: 77879634 Email: vjinha@yahoo.com

2. NATIONAL GHG INVENTORY

2.1 Introduction

The National Greenhouse Gas Inventory (NGHGI) of the Second National Communication (SNC) of Timor-Leste contains the information related to emissions and removals of GHGs under the territory of Timor-Leste for the period 2005-2015. The NGHGI was developed using IPCC2006 Guideline as reference, in which most of the GHGs were calculated using Tier 1 of the IPCC2006 Guideline. Refer to this guideline, the NGHGI only reports three out of the six major GHGs, i.e. carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases are generated from tree main sources, i.e. (i) energy, (ii) AFOLU (agriculture, forestry and other land-use), and (iii) waste sectors.

In addition to these gasses, there are also GHGs generated during production processes in industries, i.e. CO_2, N_2O, and Perfluorocarbons (PFCs) such as CF_4 and C_2F_6 and also GHGs used in products such as refrigerators, foams or aerosol cans. For example, HFCs are used as alternatives to ozone depleting substances (ODS) in various types of applications. Similarly, Sulphur-hexafluoride (SF_6) and N_2O are used in a number of products used in industry, i.e. SF_6 used in electrical equipment, N_2O used as a propellant in aerosol products primarily in food industry or by end-consumers (SF_6 used in running-shoes, N_2O used during anaesthesia. All of these gases are considered as GHGs from IPPU (Industrial Processes and Product Uses).

The GHGs from IPPU are not included in the NGHGI of this SNC because there is no industrial process in Timor-Leste that generates GHG emissions at the moment and also there is no data related GHG emission from product use available. However, Timor-Leste plans to develop Cement industry in the near future, in which the Feasibility and Environmental Impact Assessment already available to support the development and operation of this industry. Since the CO_2 released during clinker production in cement industry is considered as GHGs from IPPU, therefore, GHGs from Cement industry will be included in the NGHGI. Beside the GHGs related to the IPPU, there are also other non-CO2 gases, i.e. CO, NOx, NMVOC, and SOx, in which only CO and NOx from biomass burning are included in the NGHGI.

2.2 Institutional Arrangement

The development of NGHGI of this SNC was carried out by a Working Group (WG) of the National of GHG Inventory. The WG comprises team from various government institutions related to energy and mining sector, industry sector, transportation sector, waste sector, agriculture and forestry sector. The WG was officially established under Office of the Coordinating Minister for Economic Affairs, and worked under the coordination of the Directorate General of Environment, National Directorate for Climate Change (Figure 2-1).

The role of WG in the NGHGI development is mainly to provide data, information and the parameter related to the GHG Inventory. With supports from international consultants through a series focus group discussion (FGD) and stakeholders consultations. the WG also estimates the GHGs level of each sector for developing the NGHGI. The international consultant team supported the WG, particularly in determining of the scope of GHG inventory (type of gases, main sources and sinks, and type of sources) and carried out training for capacity building of each member of WG in estimating and developing NGHG inventory. The coordinator of WG compiles and distributed data, information, parameter related to GHG inventory, also GHG emissions estimation and reports them to the National Directorate of Climate Change under Directorate General of Environment, Ministry of Commerce, Industry and Environment.

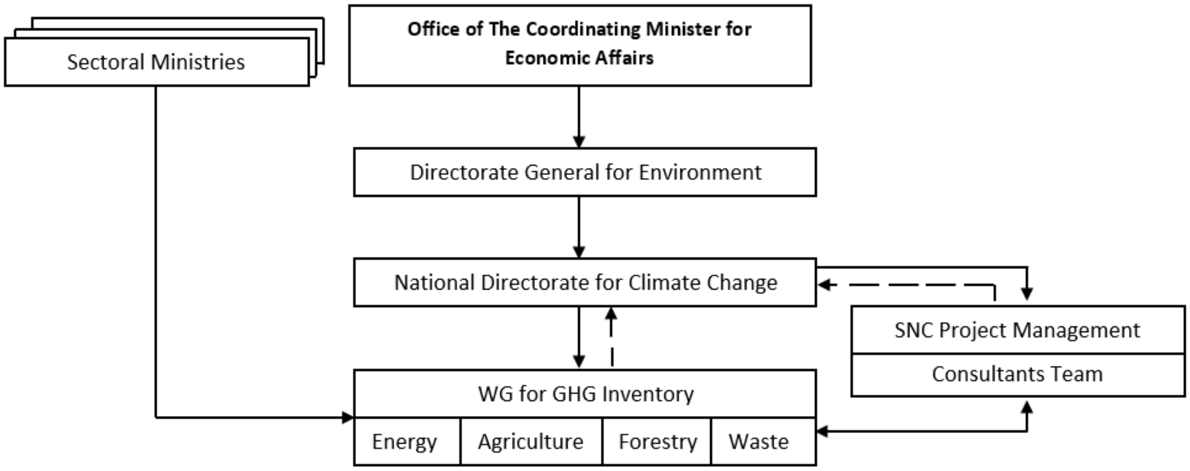


Figure 2-1 Institutional arrangement for developing the NGHGI

2.3 Overview of Source and Sink Category Emission Estimates for year 2015

2.3.1 Methodology

The methodology used in the estimation of GHG emissions or removals for the period of 2005-2015 is basically based on the Tier 1 methodology of the 2006 IPCC Guidelines. This methodology is different with methodology used in the NGHGI of the Initial National Communication (INC), which was the revised 1996 IPCC Guidelines. Therefore, the estimated emissions in the INC for the period of 2005-2010 were recalculated and emissions for the period of 2011-2015 were added and completed. As the result, the emissions estimates for the 2005-2010 are different with emissions estimated in the INC. The different are also due to updating activity data and applying assumptions. Refer to IPCC 2006, the NGHGI covers 3 (three) gases. i.e. CO2, CH4, and N2O that generated form 3 (three) main sources, i.e. Energy; Agriculture; Forestry and Other Land Use (FOLU); and Waste. Under Tier 1 IPCC2006, the estimation of GHG emission level uses default value of the IPCC 2006. The values of Global Warming Potential (GWP) follow the IPCC's Second Assessment Report as shown in Table 2-1 below.

Table 2-1 Global warming potential values *)

No.	*Type of Green House Gas (GHG)*	*GWP (CO_2e)*
1	CO_2	1
2	Methane (CH_4)	21
3	Nitrous Oxide (N_2O)	310
4	PFC-14 (CF_4)	6,500
5	PFC-116 (C_2F_6)	9,200
6	Sulphur hexafluoride (SF_6)	23,900

**) Based on Second assessment report (SAR) for 100 years time horizon*

2.3.2 National Emission

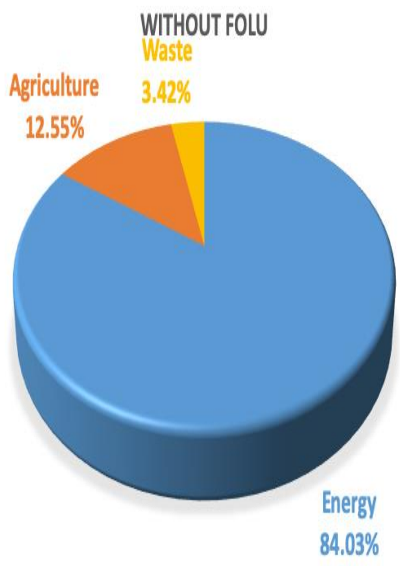
Total GHG emissions in 2015 for the three main greenhouse gases (CO_2, CH_4 and N_2O) reached 3,825.12 Gg CO_2e. During the period 2005-2015, the annual GHG emissions from energy sector tend decrease, agriculture sector and waste sector tend to increase. Meanwhile the annual GHG emissions from FOLU tend to fluctuate due to dynamics in emissions and CO2 removal from these sub-categories. In 2015, the emissions from energy, agriculture and waste sectors were 5,303.85 Gg CO_2e, while FOLU sector was net sink in amount of 1,478.73 Gg CO_2, so the total

GHG emissions only reached 3,825.12 Gg CO_2e in 2015 (Table 2-2). They decreased by 74% compared to the emission level on the year of 2005 of 14,997.36 Gg CO_2e

Without the inclusion of FOLU, total GHG emissions from Timor-Leste decreased about 64% to 5,303.85 Gg CO2e compared to emissions from the same sector in 2005 with energy as the main contributor (84.03%), followed by agriculture (12.55%) and waste (4.42%). The GHG emissions were distributed unevenly between the three gases recorded: carbon dioxide (CO_2) totaled 4,510.04 Gg, representing 85.03% of the total emissions; methane (CH4) totaled 573,10 Gg CO_2e or 10.81% of the total emissions; and nitrous oxide (N2O) totaled 220.71 Gg CO_2e or 4.16% of the total emission (Figure 2-2). Further detailed national GHG emissions in 2015 can be shown in Table 2-3.

Table 2-2 Summary of national GHG emissions in year 2005 and 2015 (Gg CO2e)

No	Sectors	Year	CO_2	CH_4	N_2O	CF_4	C_2F_6	CO	NOx	NMVOC	SOx	Total 3 Gases
1	Energy	2005	13,988.87	14.73	11.47	NO	NO	NE	NE	NE	NE	14,015.07
		2015	4,441.34	8.11	7.47	NO	NO	NE	NE	NE	NE	4,456.92
2	Agriculture	2005	0.08	400.44	156.01	NO	NO	NO	NO	NO	NO	556.54
		2015	0.03	476.75	188.99	NO	NO	NO	4.16	71.39	NO	665.76
3	AFOLU	2005	302.74	NE	NE	NO	NO	NO	NO	NE	NE	302.74
		2015	-1,478.73	NE	NE	NO	NO	NO	NO	NE	NE	-1,478.73
5	Waste	2005	42.02	64.41	16.58	NO	NO	NE	NE	NE	NE	123.01
		2015	68.68	88.24	24.25	NO	NO	NE	NE	NE	NE	181.17
Total (CO_2-eq)		2005	14,353.56	22.48	0.60	0.00	0.00	0.00	0.00			15,013.06
		2015	3,031.32	573.10	220.71	0.00	0.00	0.00	4.16			3,825.12



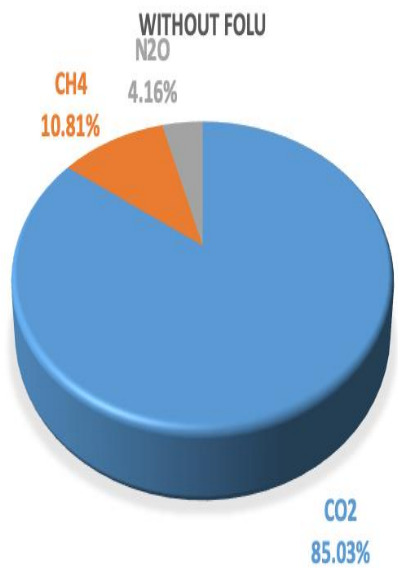


Figure 2-2 GHG emission estimates by sectors (left) and by gases (right) in 2015 without forestry and other land use

Table 2-3 Summary of national GHG emissions in year 2015 (in Gg CO2-e)

Categories	Total 3 Gas	Net CO_2 (1) (2)	CH_4	N_2O		HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO_2
	(Gg CO2e)				(Gg)									
Total National Emissions and Removals	**3,825.12**	**3,031.32**	**573.10**	**220.71**							**4.16**	**71.39**		
1 ENERGY	**4,456.92**	**4,441.34**	**8.11**	**7.47**										
1A Fuel Combustion Activities	**4,455.74**	**4,440.43**	**7.84**	**7.47**										
1A1 Energy Industries	**4,197.85**	**4,193.48**	**1.66**	**2.71**										
1A1a Main activity electricity	199.98	199.31	0.17	0.50										
1A1b Oil and Gas Production Facility	3,997.88	3,994.17	1.50	2.21										
1A1c Coal Processing	NO	NO	NO	NO										
1A2 Manufacturing Industries and Construction	NE	NE	NE	NE										
1A3 Transport	**250.88**	**246.24**	**0.92**	**3.73**										
1A3a Civil Aviation	11.26	11.16	0.00	0.10										
1A3a&b Road and Water-Borne Transportation	239.62	235.08	0.92	3.63										
1A4 Other Sectors	7.00	0.71	5.26	1.03										
1A4a Commercial/Institutional	NE	NE	NE	NE										
1A4b Residential	7.00	0.71	5.26	1.03										
1A5 Other/Non-Specified	NE	NE	NE	NE										
1B Fugitive Emissions from Fuels	**1.18**	**0.91**	**0.27**	**0.00**										
1B1 Solid Fuels	NO	NO	NO	NO										
1B1a Underground coal mining	NO	NO	NO	NO										
1B1b Surface coal mining	NO	NO	NO	NO										

Categories	Total 3 Gas	Net CO_2 (1) (2)	CH_4	N_2O		HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO_2
	(Gg CO2e)				(Gg)									
1B2 Oil and Natural Gas	1.18	0.91	0.27	0.00										
1B2a Oil	NE	NE	NE	NE										
1B2b Natural gas	1.18	0.91	0.27	0.00										
1B3 Other Emissions from Energy Production	NE	NE	NE	NE										
1C Carbon Dioxide Transport and Storage	NO	NO	NO	NO										
1C1 Transport of CO_2	NO	NO	NO	NO										
1C2 Injection and Storage	NO	NO	NO	NO										
2 INDUSTRIAL PROCESSES AND PRODUCT USE	**NO**	**NO**	**NO**	**NO**										
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	**-812.96**	**-1,478.70**	**476.75**	**188.99**							4.16	71.39		
3A Livestock	492.11		**385.29**	**106.82**										
3A1 Enteric Fermentation	313.14		313.14											
3A2 Manure Management	72.15		72.15											
3 A 2b Direct N2O Emissions from Manure Management	106.82			106.82										
3B Land	**-1,478.73**	**-1,478.73**	**0.00**	**0.00**										
3B1 Forest Land	-1,607.26	-1,607.26	NE	NE										
3B2 Cropland	1.19	1.19	NE	NE										
3B3 Grassland	118.98	118.98	NE	NE										
3B4 Wetlands	0.00	0.00	NE	NE										
3B5 Settlements	0.00	0.00	NE	NE										

Categories	Total 3 Gas	Net CO_2 (1) (2)	CH_4	N_2O		HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO_2
	(Gg CO2e)				(Gg)									
3B6 Other Land	8.35	8.35	NE	NE										
3C Aggregate Sources and Non-CO2 Emissions Sources on Land	173.66	**0.03**	**91.46**	**82.17**							4.16	71.39		
3C1 Biomass Burning	121.24	NE	52.58	68.66							4.16	71.39		
3C2 Liming	NE	NE												
3C3 Urea Application	0.03	0.03												
3C4 Direct N_2O Emissions from Managed Soils	2.76			2.76										
3C5 Indirect N_2O Emissions from Managed Soils	2.75			2.75										
3C6 Indirect N_2O Emissions from Manure Management	8.00			8.00										
3C7 Rice Cultivations	38.89		38.89											
3C8 Other (please specify)	0.00	NE	NE	NE										
3D Other	**NE**	**NE**	**NE**	**NE**										
3D1 Harvested Wood Products	NE	NE	NE	NE										
3D2 Other (please specify)	NE	NE	NE	NE										
4 WASTE	181.17	68.68	88.24	24.25										
4A1 Managed Solid Waste Disposal	NO	NO	NO	NO										
4A2 Unmanaged Waste Disposal Sites	NO	NO	NO	NO										
4A3 Uncategorized Waste Disposal	9.09	NE	9.09	NE										
4B1 Biological Treatment of Domestic Solid Waste	0.00	NE	NE	NE										

Categories	Total 3 Gas	Net CO_2 (1) (2)	CH_4	N_2O		HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO_2
	(Gg CO2e)				(Gg)									
4B2 Biological Treatment of Industrial Solid Waste	NO	NO	NO	NO										
4C Incineration and Open Burning of Waste	110.54	68.68	31.23	10.64										
4C1 Waste Incineration	0.02	0.02	0.00	0.00										
4C2 Open Burning of Waste	110.53	68.66	31.23	10.64										
4D Wastewater Treatment and Discharge	61.53	0.00	47.92	13.61										
4D1 Domestic Wastewater Treatment and Discharge	61.53	NE	47.92	13.61										
4D2 Industrial Wastewater Treatment and Discharge	NE	NE	NE	NE										
4E1 Other - Industrial Sludge Handling	NE	NE	NE	NE										
5 OTHER	NE	NE	NE	NE										
5A Indirect N2O Emissions from the Atmospheric Deposition of Nitrogen in NOx and NH3	NE	NE	NE	NE										
5B Other (please specify)	NE	NE	NE	NE										

*Notes: *The offshore oil and gas production facility is under Joint Production of Timor-Leste and Australia but there is no agreement for the GHG emission, therefore the GHG emissions is reported separately below Memo Items (see 3rd row from below of the above table) although the estimation is under energy sector. ** NE: Not Estimated and NO: Not Occurring. *** Global Warming Potential (GWP) for CH4 and N2O used were 21 and 310 respectively. ****Estimation of non-CO2 (CH4, N2O, 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 CO2 biomass emission (not accounted in Energy Sector inventory) and non-CO2 biomass emission (accounted in Energy Sector inventory).2*

2.4 Sectoral Emissions

The following sections discuss the national GHG inventory conducted in 2015 and the trend during 2005-2015 by sectors, including details of the anthropogenic emissions by sources/sinks, covering (a) energy, (b) Agriculture, (c) FOLU, and (d) waste sectors.

2.4.1 Energy Sector

2.4.1.1 Source Categories

In Timor-Leste, GHG emissions of energy sector is generated from two main sources, i.e. fuel combustions (1A) and fugitives (1B). The fuel combustion's emissions reported in the National GHG Inventory of Timor-Leste covers emissions from some sectors, i.e. 1.A.1.a Main Activity Electricity, 1.A.1.b Upstream Oil and Gas Industry, 1.A.3.a Civil Aviation and 1.A.3.b&d Road and Water-Borne, and 1.A.4.a&b Commercial/Institution and Residential. The fuel combustions in the main activity electricity cover diesel oil combustions for electricity generation while in the oil and gas industries cover natural gas and diesel oil combustions for own use. The fuel combustion in the civil aviation and road and water-borne transportation cover petroleum product combustions for transportation, i.e. gasoline with RON 88 and higher than RON88, automotive diesel oil (ADO), marine fuel oil (MFO), jet fuel, and aviation gasoline. The fuel combustions in residential and commercial/institution cover fuel combustions for cooking, hot water, and generating electricity in buildings, particularly kerosene, LPG and diesel oil. The GHG from fugitives are released during gas flaring and venting in the upstream oil and gas industry.

It should be noted that the oil and gas industries are located in the area where the maritime territory of Timor-Leste just has determined in 6th March 2018 (see the Treaty Between Australia and the Democratic Republic of Timor-Leste Establishing Their Maritime Boundaries in the Timor Sea signed at UN Head Quarters in New York). Under this Treaty, all Oil and Gas industries (Bayu-Undan field) will fall completely are under the Maritime territory of Timor Leste jurisdiction. Refer to the IPCC2006 Guideline, the GHG emission from this facility has to be calculated under Timor-Leste and cannot be omitted from the National GHG Emissions Inventory of Timor-Leste.

The upstream data for the period of 2005-2018 is taken from the Joint Petroleum Development Area (JPDA), which is the joint area between Timor-Leste and Australia established through the Timor Sea treaty between the Government of Timor-Leste and Australia (signed on 20 May, 2002). The production data represents 3 fields, i.e. EKKN (Elang-Kakatua-Kakatua North), Bayu Undan, and Kitan. Based on the Article 2 of the treaty (2002), Timor-Leste will have 80% to the sharing revenue if Greater Sunrise Fields are developed by means of a Pipeline to Australia. The share of GHG emissions from the oil and gas facility of Timor-Leste will be in lined with the share of revenue of Timor-Leste, i.e. 80%. The coverage of production period of Kitan is 2011-2015, EKKN is 2005-2007, and Bayu-Undan is 2005-2018. During the indicated period, data from JPDA represents the production for both Australia and Timor-Leste. Therefore, it was suggested by the ANPM to utilize these data accordingly when calculating the emissions only for Timor-Leste.

The GHG emissions from road and water-borne transportation cannot be reported separately due to the breakdown of activity data is not available. Similarly, emissions from residential and commercial also cannot be reported separately due to the data availability. Under this national GHG inventory, fugitive emission is also reported, in which the main source covers gas flaring and venting in oil and gas production facilities. In this SNC, GHG from manufacturing industry was not estimated/reported due to lack of data whether the industry used electricity or fossil fuels.

2.4.1.2 Time Frame

The GHG Inventory in this report covers GHG emissions generated from the year 2005 until 2015 in some cases, the GHG Inventory covers 2005 until 2018.

2.4.1.3 Type of Gases and Type of Sources

Refer to 2006 IPCC GL, the types of GHG emissions estimated in energy sector included CO_2, CH_4 and N_2O gases. Type of fossil fuels combusted in energy sector of Timor-Leste is liquid and gas fuel (see chapter of National Circumstances). Liquid fuel comprises of gasoline, diesel oil, and unleaded petroleum for transport, diesel oil for power generation, kerosene and LPG for residential, and avtur or jet-kerosene for international aviation. Gas fuel only covers natural gas for own use in oil and gas field. In addition to fossil fuels, there is a significant amount of biomass used in Timor-Leste, i.e. wood biomass is used in commercial and residential sectors.

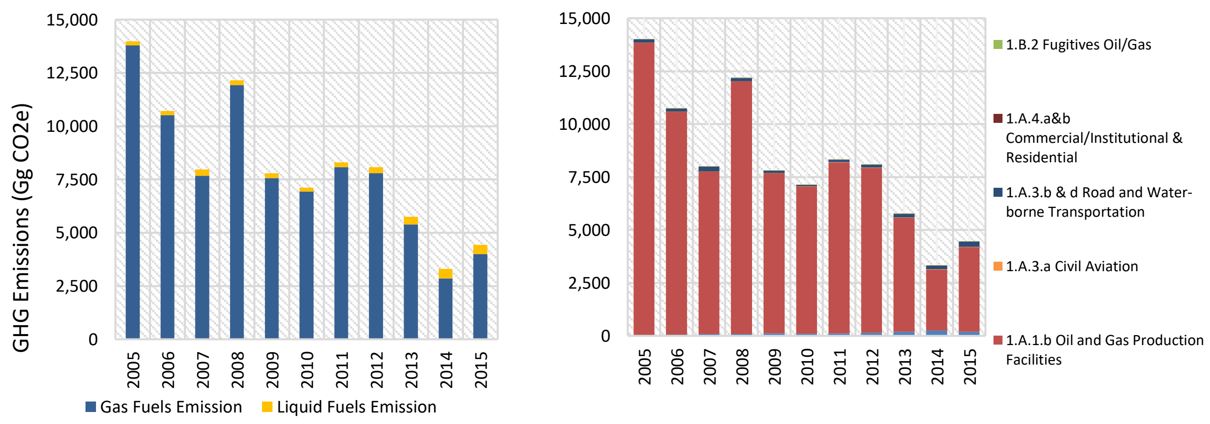
2.4.1.4 Data Sources

All related data and information on GHG emissions inventory in energy sector were from various sources, i.e.: PERTAMINA – Dili (2011), PERTAMINA International Timor (2018) and ANPM (2018). The GHG emissions from year 2005-2010 are recalculated using activity data taken from the INC of Timor-Leste, in which the GHG emissions from oil and gas industries (2005 – 2018) is recalculated base on the rule of the Maritime Treaty between Australia and Timor-Leste (see Sub-chapter 2.4.1.1.1). The activity data in 2010-2015 are taken from data published by PERTAMINA Dili in 2011, PERTAMINA International Timor in 2018 and ANPM 2018.

2.4.1.5 Estimation of GHG Emissions

Reference and Sectoral Approaches

According to the 2006 IPCC, the emissions level is estimated using reference and sectoral approaches. The reference approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustions of fossil fuels, while the sectoral approach is a bottom-up approach, using fuel data of stationary as well as mobile combustions in several sectors of energy category to calculate CO_2, CH_2, N_2O emissions. It is good practice to apply both sectoral and reference approaches to estimate a country's CO_2 emissions from fuel combustion and to compare the results of these two estimates. Figure 2-3 presents GHG emissions level estimated under reference approach by type of fuels and under sectoral approach by type of sector category. In 2015, GHG emissions by sectoral approach reached 4,437 Gg CO2e, while by reference approach were 4,441 Gg CO2e.



Source: Processed from ANPM Annual Report (2011, 2017, 2018, 2019), External Trade Statistics (2011,2012), General Directorate of Electricity of Timor-Leste (2018), Timor-Leste in Figures (2011-2016), Pertamina Dili (2011), Pertamina International Timor (2018)

Figure 2-3 GHG emission level calculated using reference (left) and sectoral (right) approaches

It can be seen in Figure 2-4 (left), by type of fuel the major sources of CO_2 emissions in energy sector is gas fuels combustions. Figure 1 (right) shows the sectoral sources of CO_2 emissions in energy during 2005-2015 is dominated by the up-stream oil and gas production facility, in which the GHG emissions is generated from natural gas combustions for own use in the up-stream oil and gas production facility. After this up-stream facility, the main sectoral sources are dominated by road and water-born transportation, power generation, residential and fugitive. However, after 2012 the contribution of GHG emissions from fuel combustions for power generation increase exceeds the GHG emissions from fuel combustions for the road and water-born transportation. The calculation of CO_2 emissions from fuel combustions using sectoral approach usually is slightly higher if compare those are calculated by reference approach. It indicates possible problems with the collection of activity data and parameters used in estimating GHG emission level that related to net calorific values, carbon content, excluded carbon calculation, etc. The reference approach still can be used in the estimation of GHG emissions in energy sector if there is no comprehensive energy balance table available in the national Statistics. However, for the case of Timor-Leste, the comparison of the calculation of CO_2 emissions from fuel combustions under reference and sectoral approaches shows that there is no significant discrepancy (see Figure 2-4). It can be seen from the figure that the discrepancy is almost neglected, and it is only occurred in 2015, i.e. 0.02%.

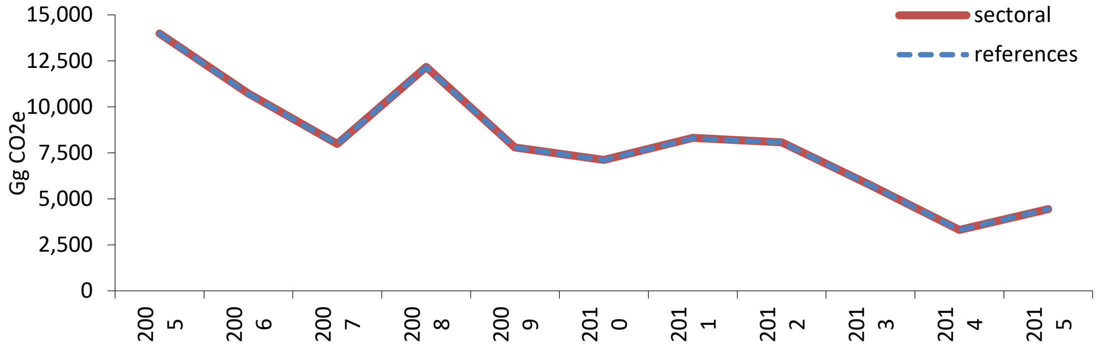


Figure 2-4 Discrepancy of GHG emissions estimates based on sectoral and reference approach

GHG Emissions of Energy Sector by Type of Gas

By type of gas, the trend of GHG emission from energy sector is presented in Figure 2-5. It can be seen in the figure that GHG emission is dominated by CO_2, followed by CH_4 and N_2O. Figure 3 (right) shows in 2015 the share of each type of gas is CO_2 99.65%, CH_4 0.18% and N_2O 0.17%. The National GHG emissions from energy activity is dominated by CO_2 as all the emissions are from fossil fuel combustions.

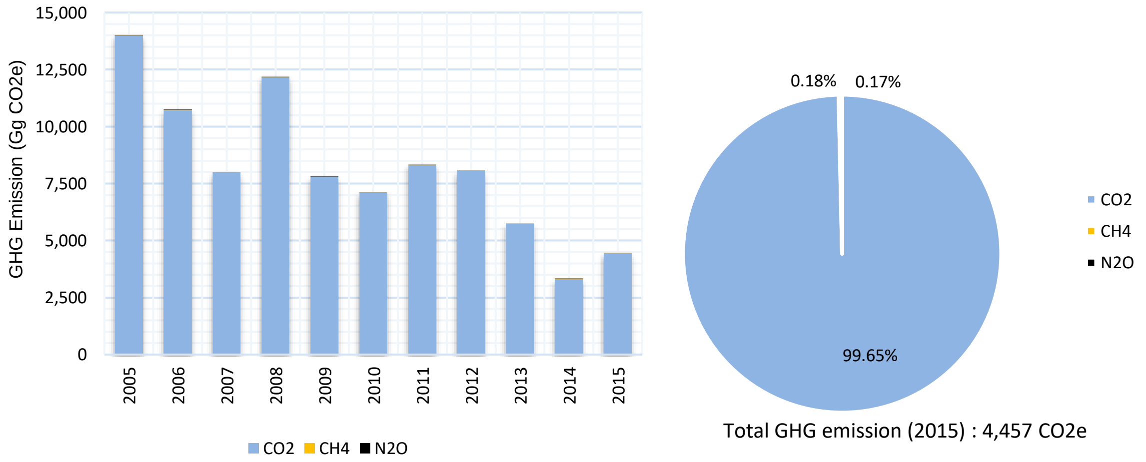


Figure 2-5 GHG emissions level by type of gas 2005-2015 (left) and share of GHG in 2015 (right)

GHG Emissions of Energy Sector by Type of Fuel

By type of fuel, the trend of GHG emission of energy sector is presented in Figure 2-7. It can be seen in Figure 2-7 (left) GHG emission in energy sector from 2005-2015 tent to decrease in line with the decreasing GHG emission from oil and gas facilities. This trend is in line with decreasing oil and gas production from JPDA field (see Chapter 1). Figure 2-7 (right) presents GHG emission from natural gas and diesel oil combustions (for own use) in oil and gas industries are the main contributor, which accounted for 89.70% to overall energy sector's emission in 2015. In addition to GHG emission from natural gas and diesel oil combustions for own use, GHG emission from fugitives was also released from these facilities although only accounted for 0.03%. It should be noted, as discussed previously in sub-chapter 2.4.1.1.1 (Source Category), the GHG emission from these industries have to be calculated under Timor-Leste and cannot be omitted from the NGHGI of Timor-Leste. However, during 2005-2018, GHG emissions from this facility is under JDPA management, in which the responsibility of Timor-Leste for the GHG emissions inventory is only 80% (in line with the share of revenue allocation from oil and gas production for Timor-Leste).

By the inclusion of GHG emission from oil and gas production facility, the sequence of the main sources of GHG emission in 2015 becomes natural gas and diesel oil combustions for oil and gas production, followed by diesel oil combustion for transportation and for electricity generation in the power plants or backup gensets in commercial buildings. The GHG emission from diesel oil combustion in power plant contributed around 4.5% of the total GHG emissions in 2015, followed by diesel oil combustion in transportation (3.6%), gasoline combustion in transportation (1.79%), jet-kerosene for civil aviation (0.25%), biomass (wood/wood waste) combustions in residential (0.14%), and liquefied petroleum gases (LPG) combustion in residential (only 0.02%).

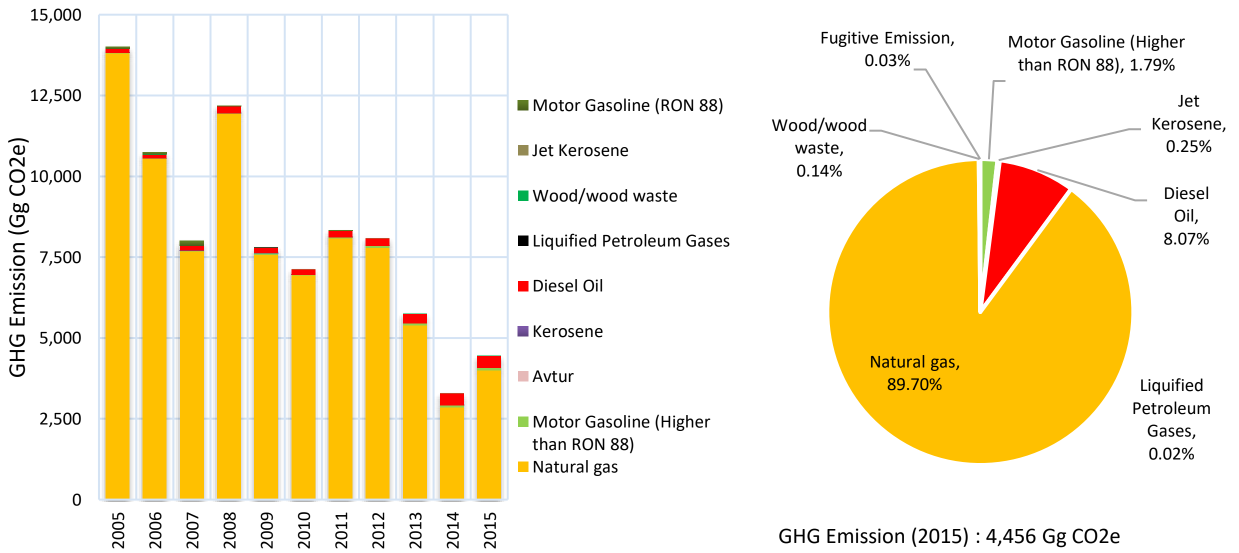


Figure 2-6 GHG emission level 2005 – 2015 and share (2015) by type of fuels from energy sector

GHG Emissions by Sources in Energy Category

The main sources of GHG emissions in energy sector is oil and gas production facilities followed by electricity generation, transportation, and residential. The trend of GHG emissions level of each sources, i.e. oil and gas production facilities, transportation, and electricity generation, is presented in Figure 2-7, 2-,8 2-9 and 2-10 respectively.

GHG Emission from Oil and Gas Industries (1A.1.b)

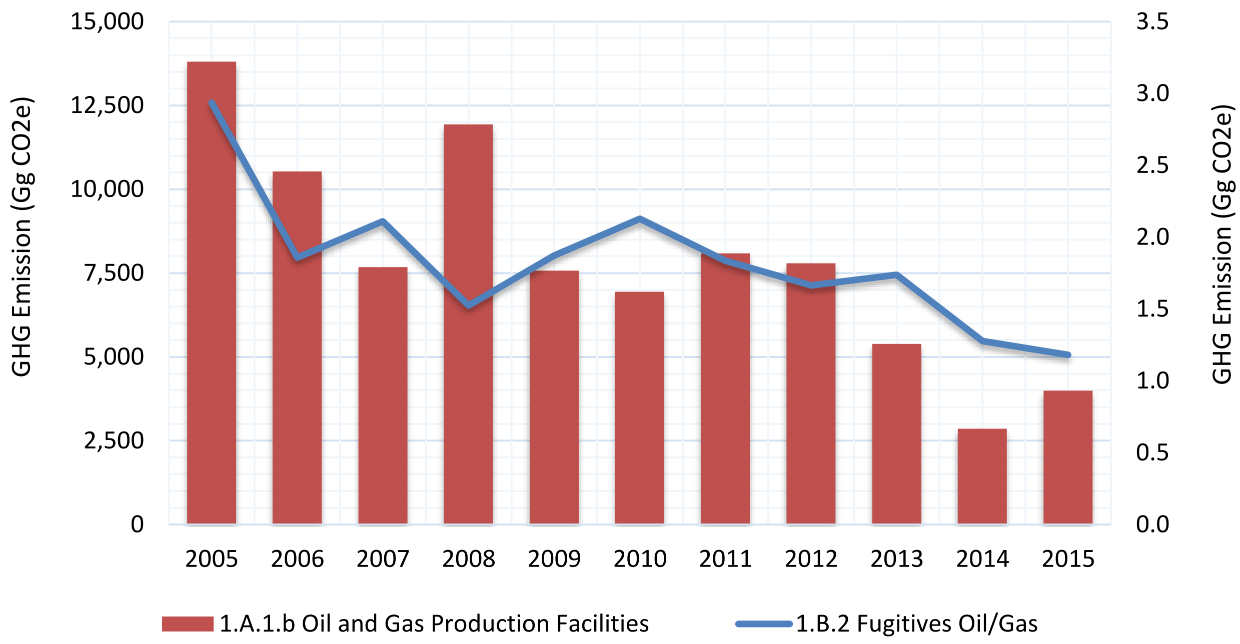


Figure 2-7 GHG emissions level (Ggram CO2-e) in oil and gas production facilities

It can be seen in Figure 2-7, the GHG emission in oil and gas production facility for 2015 is mainly from natural gas combustion for own use that accounted for 99.97% and fugitives that accounted only 0.03%. The trend of GHG emission from natural gas combustion during 2010 – 2015 tent to be fluctuated, in which a significant decreased of the emission occurred in 2013-2014. During that period, the gas production declined. For maintaining the export, the facilities reduced the utilization of own use gas through efficiency and the replacement of the gas with diesel oil. The trend of GHG emissions from fugitive tent to decrease. However, in 2010, data in Figure 2-7 shows the fugitive emission increased significantly related to the decrease of condensate, propane, and butane production (see Table 1-5, Chapter 1). The decreasing of condensate, propane, and butane production may be caused by condensate recovery unit did not work optimally. Therefore, for safety reasons, the natural gas flaring was increase.

GHG Emission by Type of Fuels from Transportation

In 2015, GHG emissions from fuel oil (diesel oil and gasoline) combustion for road and waterborne transport accounted for 63.71% (diesel oil) and 31.80% (gasoline, higher than Ron 88) and from jet-kerosene combustion for Civil Aviation accounted for 4.49% (see Figure 2-8 (right)). As the main sources of GHG emission from transportation, the trend of GHG emission from diesel oil combustion for road and water-borne transportation affected directly to total GHG emission from transportation. Figure 2-8 (left) presents the trend of the level of GHG emission from transportation. It can be seen in the figure, the GHG emission from motor gasoline combustion increased significantly in 2007. Although it decreased in 2008, but the emission kept increase during 2010 and beyond until 2015 (except in 2012). In the other hand, the trend of GHG emission from diesel oil combustion increased significantly in 2008 but it decreased significantly in 2009. However, it slightly increased in 2009 and beyond (until 2015). These fluctuating changes of the GHG emission level were in line with the fuel oil consumption data (see Chapter 1).

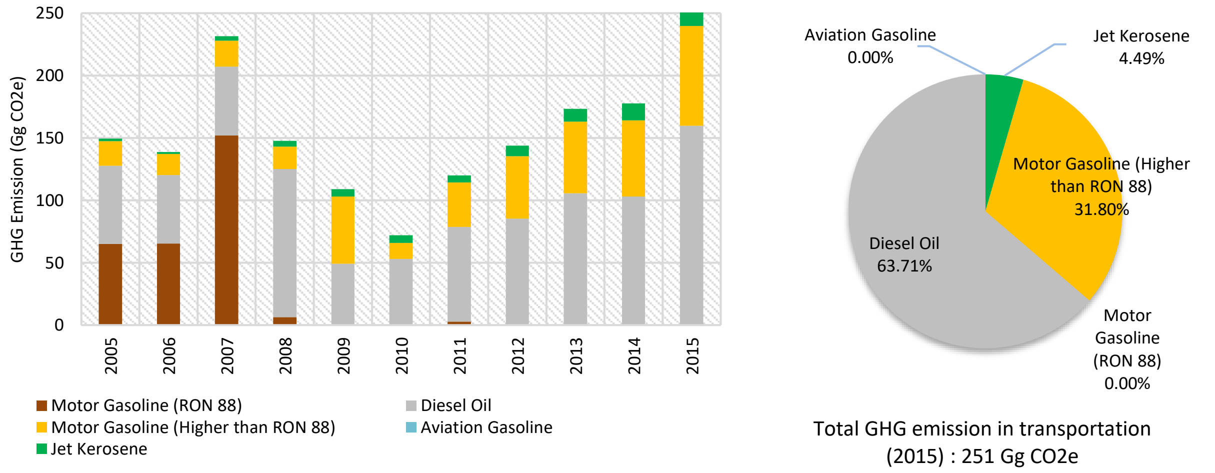


Figure 2-8 Trend of GHG emission level (2005 – 2015) and share (2015) by type of fuels in transportation

In addition to the GHG from motor gasoline and diesel oil combustion, there is also GHG emission from jet-kerosene combustion for Civil Aviation contributed in the GHG emission from transport. The trend of GHG emission from jet-kerosene combustion for Civil Aviation increased slightly after 2008 until 2015 in line with the increased of jet-kerosene consumption for Civil Aviation and the increased of international and domestic air transportation activities in the country.

Distribution of GHG Emission by Type of Fuels from Electricity Generation

Electricity generation in Timor-Leste is supplied by diesel power plant. The GHG emission from power plant is mainly released from diesel oil combustion activity for electricity generation. Figure 2-9 shows the trend of GHG emission of this source for the period of 2010-2015. It can be seen from the figure that the GHG emission level from the electricity generation keep on increasing (except in 2015) in line with the increasing of diesel oil consumption for the power plant and the development of power plant capacity in the country that still rely on diesel oil.

Figure 2-9 GHG emission level by type of fuel in electricity generation

Distribution of GHG Emission by Type of Fuels from Residential

The residential and commercial sub-sectors in Timor-Leste use kerosene, LPG and biomass for supplying their demand of energy. Figure 2-10 presents GHG emission from fuel combustion in both sub-sectors, commercial and residential. The GHG emission from these sub-sectors cannot be reported separately due to lack of activity data (fuels use in each sectors). It can be seen in Figure 8 that biomass combustion is the main sources of emission as the biomass is the main fuel supply in this sub-sector. It should be noted that CO_2 emission from biomass combustion is considered to be zero as it is neutral carbon and reported (in Table 2-4) separately from energy sector while CH_4

and N_2O emissions from biomass combustion are reported in sub-sector 1.A.4. Others (1.A.4.a Commercial/Institutional and 1.A.4.b. Residential). Therefore, GHG emission from this sub-sector category was mainly CH_4 and N_2O from combustion of biomass for cooking in residential and CO_2 from combustion of kerosene and LPG for cooking and hot water and. The trend of GHG emission contribution from biomass (CH_4 and N_2O) was slightly declining in line with the decreased of biomass utilization. The contribution of CO_2 from kerosene combustion was significant during 2009–2012. However, after 2012 the contribution level become low/zero in line with the phase out of kerosene utilization in commercial/institution and residential that was replaced by LPG. Beyond this period the contribution of LPG utilization in this sub-sector increased and GHG emission from LPG became dominant.

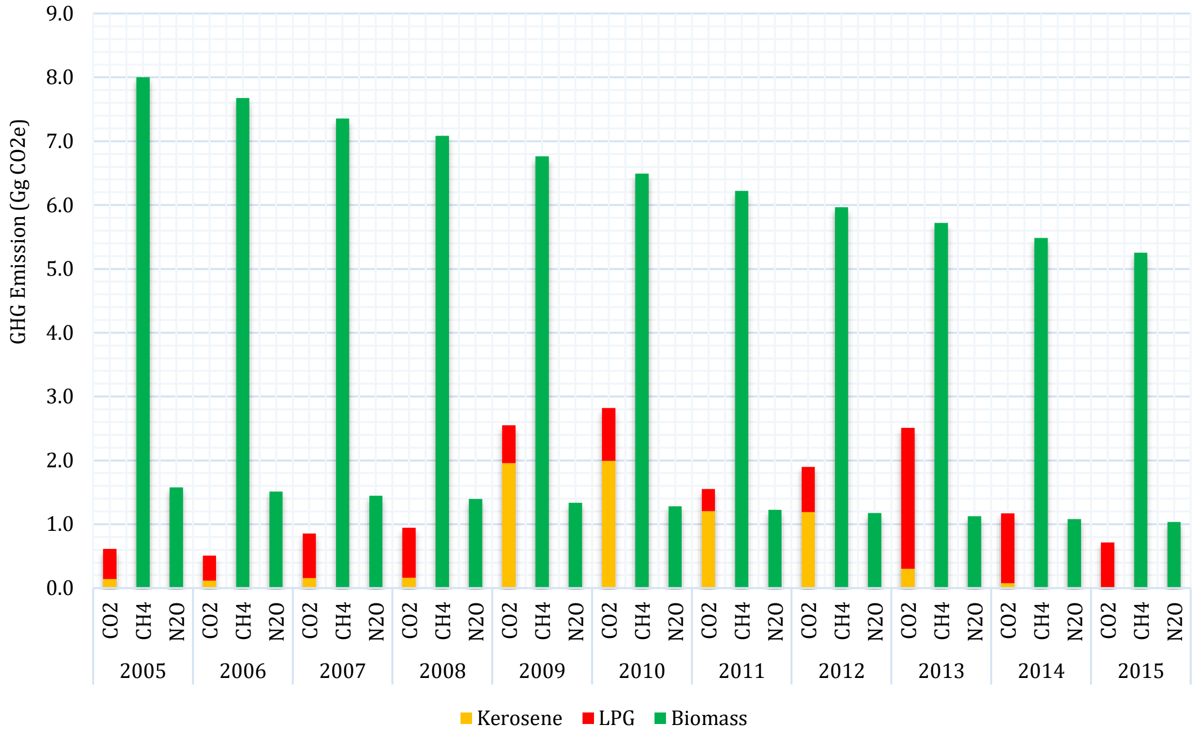


Figure 2-10 GHG emission level by type of fuels in residential and commercial sub-sector

Summary of GHG Emission Inventory of Energy Sector

Table 2-4 presents the detail of GHG emissions in energy sector for reference and sectoral approaches in the period of 2005-2015. It should be noted that there are significantly changes between the INC and SNC in GHG emissions inventory of the energy sector. The key changes due to the changes of activity data, particularly in oil and gas industries sub-sector. The activity data has been updated by ANPM (2019), in which all the energy data (natural gas for own use and flaring & venting) are provided in BOE unit. In addition to this data, there is an additional diesel oil consumption for own use in 2014 due to lack of natural gas supply for own use. In transportation sub-sector, the category of fuel consumption data for civil aviation has been changed from Aviation Gasoline to jet-kerosene, in which the heating value of jet-kerosene is lower than AVGAS and the fuel density and the EF of jet-kerosene are higher compared to AVGAS. In the transportation sector, the GHG emissions of gasoline consumption in the INC is estimated base on RON 88 quality, where in the SNC, the GHG emissions of gasoline consumption is estimated based on higher RON (RON 92).

Table 2-4 Detail data of GHG emissions in energy sector for reference and sectoral approaches in the period of 2005-2015

Source of GHG Emissions	Emission (Gg CO2e)										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
By Type of Fuel											
1. Liquid Fuels	189	192	302	236	222	180	228	286	369	455	443
2. Solid Fuels	-	-	-	-	-	-	-	-	-	-	-
3. Gas Fuels	13,794	10,526	7,675	11,924	7,565	6,934	8,077	7,787	5,386	2,855	3,994
Total by type of fuel	**13,892**	**10,719**	**7,977**	**12,160**	**7,787**	**7,114**	**8,305**	**8,074**	**5,749**	**3,310**	**4,437**
By Sector/Sources											
1.A.1. Energy Industries	**13,852**	**10,596**	**7,765**	**12,027**	**7,688**	**7,048**	**8,195**	**7,940**	**5,585**	**3,141**	**4,198**
1.A.1.a Main activity electricity	46	60	83	92	115	108	111	146	193	256	200
1.A.1.b Oil and Gas Production	13,806	10,536	7,682	11,935	7,572	6,941	8,084	7,795	5,391	2,885	3,998
1.A.1.c Coal Processing	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1.A.2 Manufacturing Industries and Construction	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
1.A.3 Transportation	**150**	**139**	**232**	**148**	**109**	**72**	**120**	**144**	**173**	**178**	**251**
1.A.3.a Civil Aviation	2	2	4	5	6	6	5	9	10	14	11
1.A.3.b&d Road and Water-borne Transportation	147	137	228	143	103	66	114	135	163	164	240
1.A.4 Other Sector	**10**	**10**	**10**	**9**	**11**	**11**	**9**	**9**	**9**	**8**	**7**
1.A.4.a&b Commercial/Institutional & Residential	10	10	10	9	11	11	9	9	9	8	7
1.A.5 Other/Non-specified	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
1.A Fuel Combustion	**14,012**	**10,744**	**8,006**	**12,184**	**7,807**	**7,131**	**8,324**	**8,093**	**5,767**	**3,326**	**4,456**
1.B Fugitives	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**
1.B.1 Fugitives Solid Fuels Mining	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1.B.2 Fugitives Oil/Gas	3	2	2	2	2	2	2	2	1	1	1
1.B.3 Other Emission from Energy Production	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total Energy Sectoral	**14,015**	**10,746**	**8,009**	**12,185**	**7,809**	**7,133**	**8,326**	**8,095**	**5,769**	**3,327**	**4,457**
Biomass *	141	135	129	124	119	114	109	105	100	96	92

* only CO_2 from Biomass combustion in 1.A.4.b Residential, in which CH_4 and N_2O from the biomass combustion has been included in Residential sub-sector; NO = Not Occurre; NE = Not Estimate due to lack of data and information

2.4.1.6 Key Category Analysis

Key category analysis (KCA) for energy sector is summarized in Table 2-5. It can be seen in Table 2-5 that the contribution of GHG emission from fuel combustion for Civil Aviation Transportation, fuel combustion for Residential, and fugitives from oil and gas production facility can be excluded from the National GHG Emission Inventory because their contribution into total GHG emissions from energy sector is too small, i.e. 0.25%, 0,16%, and 0.03% respectively. However, in the future the GHG emissions from fuel combustion for Civil Aviation Transportation and for Residential tend to keep increases in line with the activity of air transport to and from Timor-Leste and the significant changes of biomass energy in Residential to LPG or hydrocarbon fuels in the next future.

Table 2-5 Key Category Analysis for all sources of GHG emissions

Code	Category	Total GHG Emissions (Gg CO2e)	Level/Rank
1.A.1.b	Fuel Combustion for Own Use in Oil & Gas Production Facility	3,998	89.70%
1.A.3.b & d	Fuel Combustion for Road and Water-Borne Transportation	240	5.38%
1.A.1.a	Fuel Combustion for Main Activity Electricity Production	200	4.49%
1.A.3.a	Fuel combustion for Civil Aviation Transportation	11	0.25%
1.A.4.b	Fuel combustion for Residential	7	0.16%
1.B.2	Fugitives from Oil &Gas Production Facility	1	0.03%
Total		4,457	

2.4.2 AFOLU

The 2006 IPCC GL classify the AFOLU sector into three categories, i.e. 3A Livestock, 3B Land, and 3C Aggregate sources and non-CO_2 emissions sources on land. The 3C source category also includes indirect N2O emission from manure management. In this inventory we group category 3A and 3C into the agricultural sector, while category 3B will be discussed in forestry and other land use (land base) sector.

2.4.2.1 GHG Inventory in Agriculture

2.4.2.1.1 Livestock

This report provides estimation of methane (CH4) emissions from enteric fermentation in livestock, and methane and nitrous oxide (N2O) emissions from manure management.

2.4.2.1.1.1 Source Category

The sources of GHG emissions of livestock sector cover GHG emissions from enteric fermentation and manure management. The estimation for both sub-categories were based on Tier 1 approach using livestock population data. However, to estimate source in sub-category such as direct and indirect N2O emissions from manure management, an assumption based on national condition was applied to determine the types of management/treatment for cattle manure, because nitrous oxide emissions from manure management vary significantly between the types of management system used.

2.4.2.1.1.2 Time Frame

The GHG inventory reported in this document covers GHG emissions generated for the year 2005 until 2015. The GHG Inventory for the period of 2005 – 2010 is available from the Timor-Leste INC and recalculated using updated activity data, while the period of 2011 to 2015 used current statistic data.

2.4.2.1.1.3 Data Sources

Livestock population data and relevant information to GHG Inventory were gathered from a single source, i.e., Timor-Leste INC and Timor-Leste in Figure 2000 – 2015. Since cattle are an important source of CH4 due to their large population and high CH4 emission rate, their annual population are adjusted with scale factor 0.72 to get annual population of mature cattle.

2.4.2.1.1.4 Estimation of GHG Emissions

Livestock population in Timor-Leste has increased year by year, with the largest population being poultry and the lowest sheep. In 2015, the total GHG emissions from livestock were 492.11 Gg CO_2e, and they were slightly (10%) higher than the 2014's emissions of 445.44 Gg CO_2e, 24% higher compared to 2010 and 30% higher compared to 2005 (Figure 2-11). This was caused by increased in population, especially from beef cattle due to their high methane emission rate.

The largest source of emissions for livestock sub-category in 2015 was CH4 derived from enteric fermentation (63.63% of total livestock emission), followed by direct N2O emissions from manure management (21.71%), and CH4 emissions from manure (14.66%).

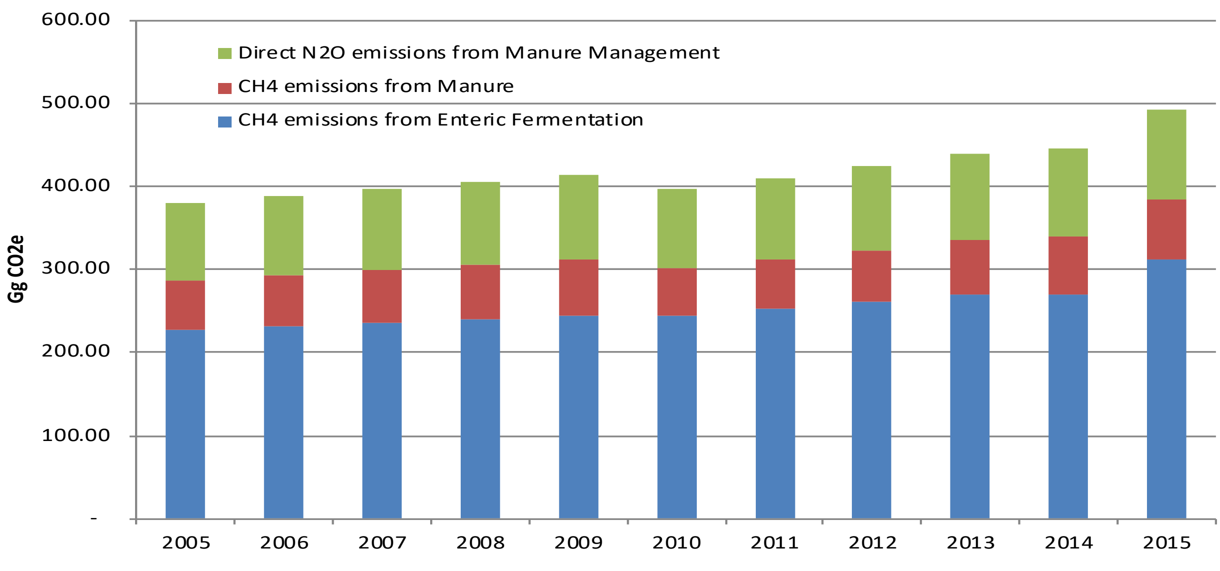


Figure 2-11 Trend in CO2e Emission from Livestock from 2005 to 2015

<u>Methane Emission from Livestock</u>

According to the emission sources, the main source of methane emission from livestock was from enteric fermentation (Figure 2-12). In Timor-Leste it was mostly generated from beef cattle (50%), buffalo (34%), horses (6%), goats (5%), swine (3%) and sheep (2%). The 2015 emission level from this sub-category was 313.14 Gg CO_2e. This emission from enteric fermentation is main source in livestock for Timor-Leste and also other countries due to because of their large population and high CH4 emission rate.

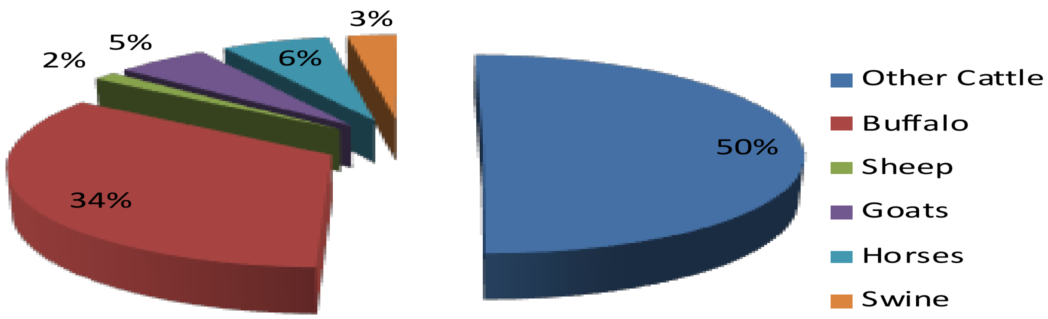


Figure 2-12 Contribution to CH4 emissions from enteric fermentation by livestock species

Meanwhile, the methane emissions from manure in 2015 was 72.15 Gg CO_2e and mostly contributed by swine (86%), followed by buffalo (5%), beef cattle (5%) and horses (3%). Emissions from other types of livestock contributed less than 1% of the total emissions from this sub-category (Figure 2-13).

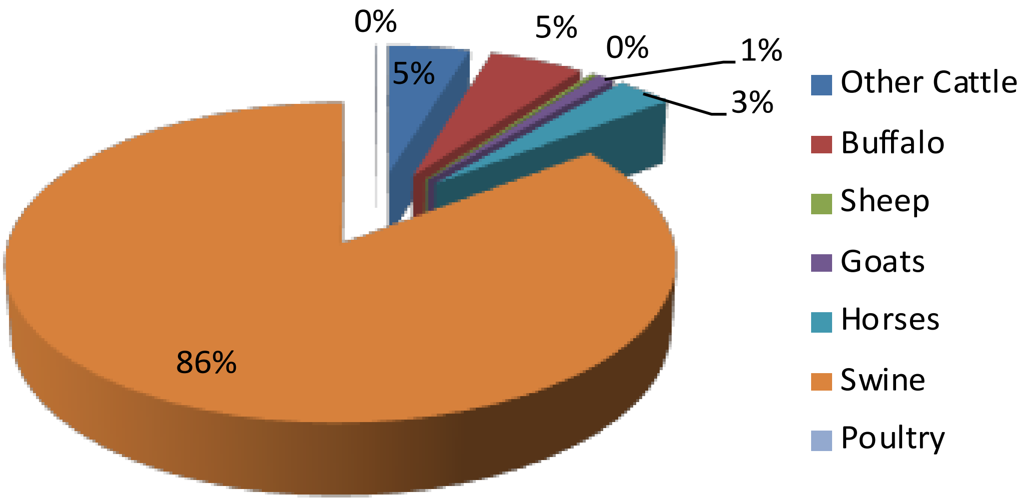


Figure 2-13 Contribution to CH4 emissions from manure management by livestock species

Direct N2O Emission from Manure Management

Buffalo, goats, swine, horses, beef cattle, and sheep were the most contributing livestock species to the direct N^2O emissions from manure management. In 2015, the total N_2O emissions from manure management was 106.82 Gg CO_2e. Compare to the same emission in 2014, this figure is relatively constant (Figure 2-14). However, in general the direct N^2O emissions increased steadily from 2005 to 2015. It increased by 15% since 2005 and by 13% compared to the 2010.

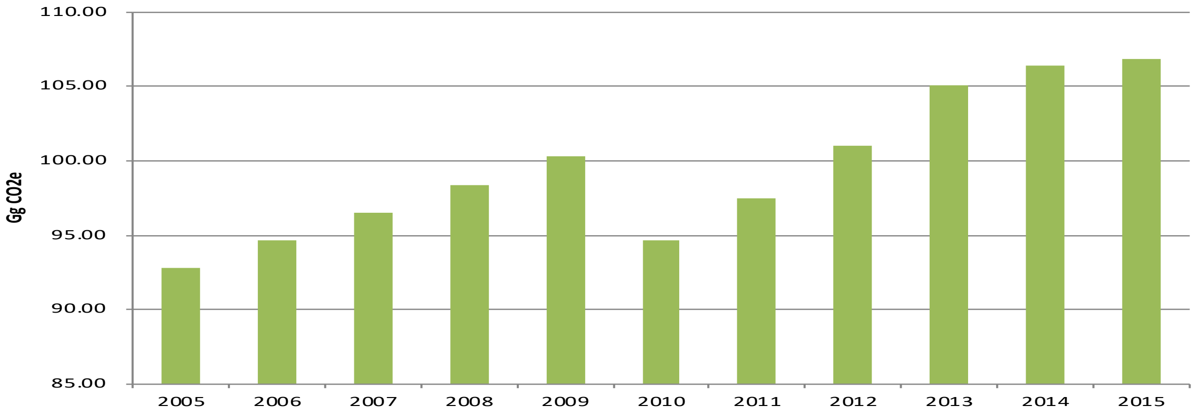


Figure 2-14 Trend of direct N2O emission from manure management for the 2005-2015 period

2.4.2.1.2 Aggregate Sources and Non-CO2 Emission Sources on Land

This emission sources deals with GHG emissions generated from agricultural activities, in addition to livestock.

2.4.2.1.2.1 Source Category

Sources of GHG emissions reported in this category include six sub-categories: 3C1 biomass burning, 3C2 urea application, 3C4 direct N_2O emission from managed soil, 3C5 indirect N_2O emission from managed soil, 3C6 indirect N_2O emission from manure management, and 3C7 rice cultivation. In this report, only CH4 and N2O emissions from biomass burning in cropland and grassland were estimated, while emissions from biomass burning in forest land and other land were not estimated due to unavailability of activity data on burnt area.

2.4.2.1.2.2 Time Frame

The GHG inventory reported in this document covers GHG emissions in the year 2000 until 2014. GHG Inventory for the period of 2005 – 2010 was taken from INC document, with updated activity data.

2.4.2.1.2.3 Data Sources

Activity data used in the estimation of GHG emissions from this category were obtained from various publications. Activity data for biomass burning in cropland were estimated from harvested area of rice cultivation gathered from INC and Agriculture in Number (2011-2016), which is sourced from the Timor-Leste in Figure, while biomass burning in grassland were estimated from area of savanna generated from interpretation of Landsat images. Activity data for urea application, N_2O from managed soils, indirect N_2O from manure management, and rice cultivation were obtained from agriculture statistic of Ministry of Agriculture and Fisheries (2011, 2013, 2014 and 2015).

2.4.2.1.2.4 Estimation of GHG Emissions

Emissions trend from this category shows relatively fluctuating values, this is mainly because the sources of methane emissions from rice cultivation showed fluctuating figures from 2005 to 2015. Meanwhile, emissions from other sources tend to increase from year to year. In 2015, the total GHG emissions were 173.66 Gg CO_2e, slightly lower than the 2014's emissions of 195.54 Gg CO_2e (Figure 2-15).

The largest source of emissions for this sub-category in 2015 was biomass burning in grassland (68.00%), followed by rice cultivation (22.39%), and indirect N2O emission from manure management (4.60%).

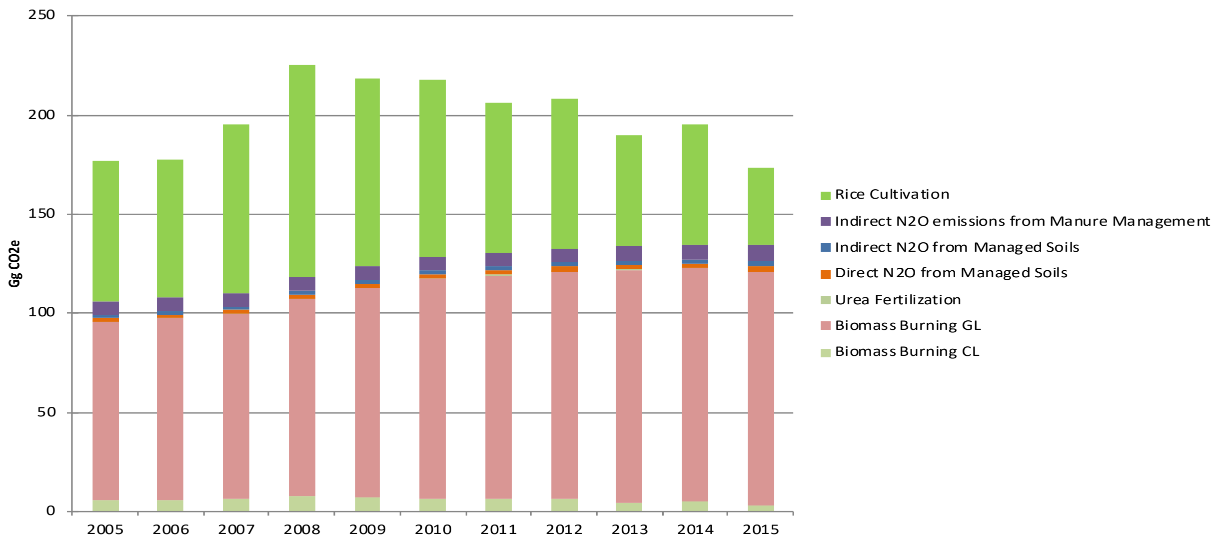


Figure 2-15 Trend in aggregate sources and non-CO2 emission sources on land from 2005 to 2015

Biomass Burning

Non-CO_2 emission from biomass burning was calculated based on burning in agriculture residues (cropland) and in savanna (grassland). Emissions from agricultural residue burning were estimated from the burned rice fields, where 50% of the crops residues in the field are assumed to 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 2015 the GHG emissions from agricultural residue burning was 3.15 Gg CO_2e that consist of CH_4 emission of 72.32% and N2O emission 27.68 % (Figure 2-16).

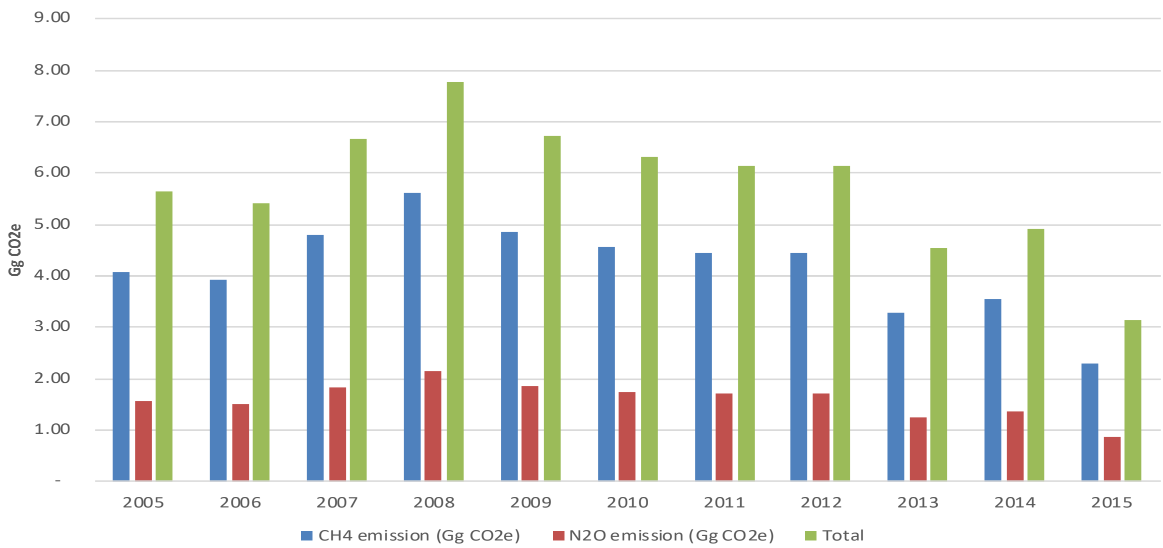


Figure 2-16 Trend of biomass burning in cropland from 2005 to 2015

Savanna is one type of land use where the vegetation is dominated by grasses, whose area is generated from Landsat satellite images (2005-2015). It was assumed that the percentage of area of savanna, which is burned, is 50%. In 2015, the GHG emissions from savannah burning account for 118.09 Gg CO_2e. The main source was N_2O emissions with 57.41% followed by CH4 emissions with 42.59% (Figure 2-17).

Figure 2-17 Trend of biomass burning in grassland from 2005 to 2015

Urea Application

Annual amount of urea fertilizer was provided by Ministry of Agriculture and Fisheries, Timor-Leste, but data is available only for the period 2008 – 2015. Activity data for 2005 – 2007 was estimated from proxy between harvested area and the annual amount of urea fertilizer from the available data. CO_2 emissions from this sub-category as shown in Figure 2-18 tend to fluctuate between 0.03 and 0.3 Gg. This figure is very low and this is reflected in the fact that annual urea fertilizer used for agricultural land was also very low. It is because farmers in Timor-Leste apply very little fertilizers for crops.

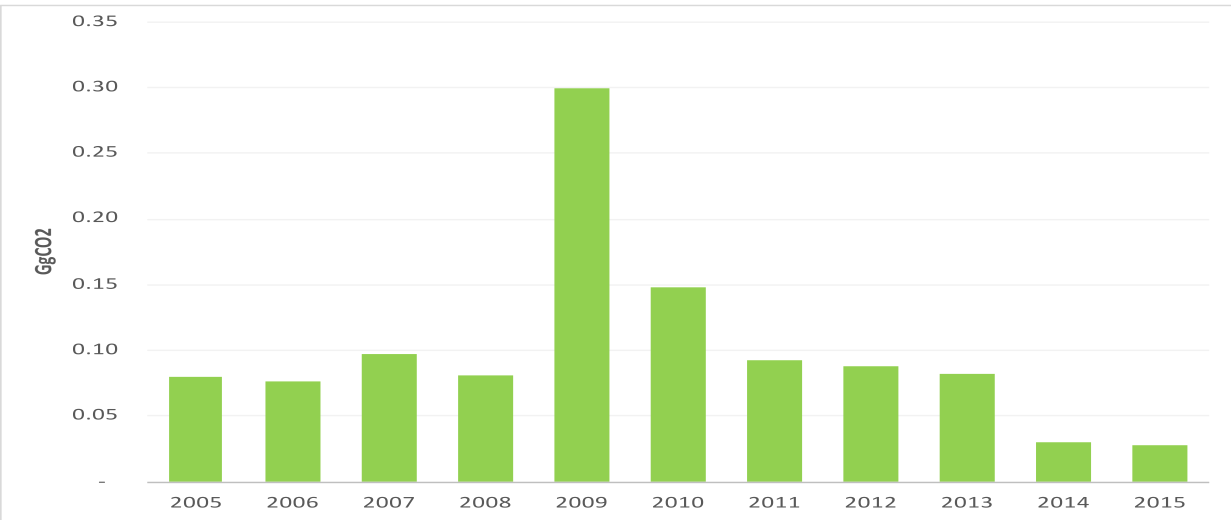


Figure 2-18 CO2 emissions from urea application for the 2005-2015 period

N2O emission from managed soils

Nitrogen oxide emissions from managed soil arise from biogenic processes that occur in the soil due to the addition of nitrogen fertilizers, animal manure, crop residue or urine and dung N deposited by grazing animals. The N_2O emissions consist of direct emissions and indirect emissions. The emissions were only estimated from the total use of nitrogen synthetic fertilizer (urea) and nitrogen excretion from animal manure management system on pasture. Annual amount of synthetic fertilizer N applied to soils equals to the amount of N contained in the annual amount of urea fertilizer used in urea application.

The estimated direct N2O emissions is presented in Figure 2-19. In 2015 the direct N_20 emission from soils due to urea application and urine/dung N deposited by grazing animal was 2.76 Gg CO_2e it is higher than that of 2005. This figure is much lower when compared to INC in the period 2005 – 2010. It is because the amount of annual synthetic fertilizer used in the GHG inventory for the SNC was lower than that used to estimate emissions from N2O in INC. In INC, data on the use of urea fertilizer are based on surveys conducted by national consultant. The survey results show that the use of urea fertilizer in Timor-Leste was approximately 35 kg per ha for rice.

Figure 2-19 Direct and indirect N2O emission from managed soils for the period 2005-2015

Similar figures are also indicated by indirect emission, where emission in 2015 was 2.75 Gg CO_2e. Figure 2-20 shows also that the direct and indirect N2O emissions from soils tend to increase from year by year. This is largely due to an increase in cattle population in Timor-Leste, where most of urines or dungs deposited in the pasture. Meanwhile, the applied nitrogen fertilizers in soils only emits very little N2O due to limited urea application.

Indirect N2O emission from manure management

In 2015, indirect N_2O emission was 8.00 Gg CO_2e and was lower than direct N_2O emission from manure management. As with direct N_2O emission, buffalo, goats, swine, horses, beef cattle, and sheep were the most contributing livestock species to the indirect N^2O emissions. Figure 2-22 shows that indirect N2O emissions increased consistently from 2005 to 2015 due to an increase in livestock population in Timor-Leste.

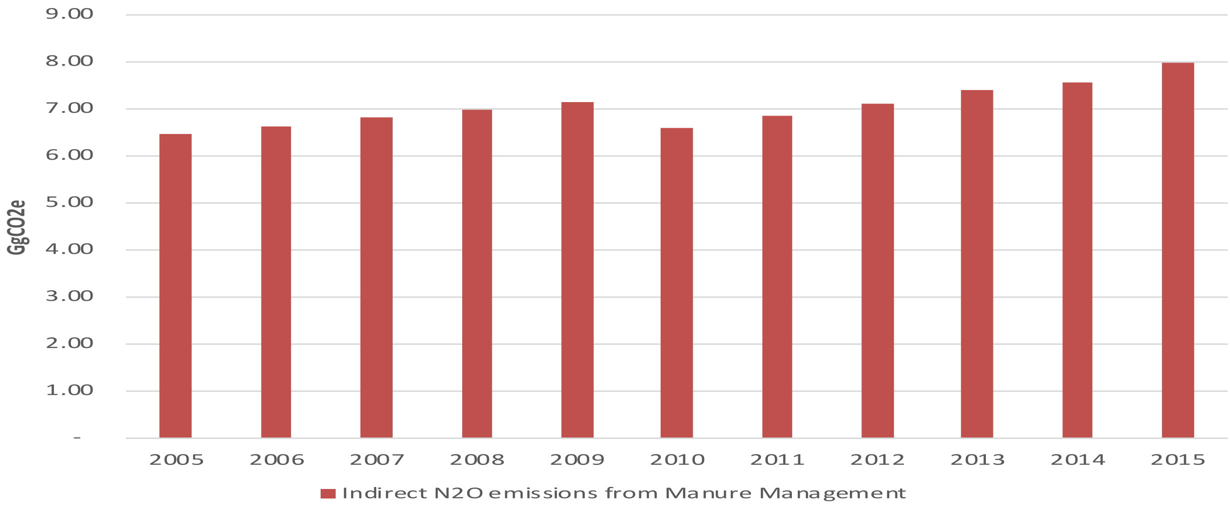


Figure 2-20 Trend of indirect N2O emission from manure management for the 2005-2015 period

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 (2015). The harvested area was grouped into two water regimes based on amount of irrigated area and non-irrigated area, in which the rice fields with irrigation systems was 27% and with no irrigation or rainfed 73% (Table 2-6). The harvested area of rice cultivation in Timor-Leste in the period 2005 – 2010 is summarized in Table 2-6. Methane emissions from rice cultivation in 2005 and 2015 were 71.29 Gg CO_2e and 38. 89 Gg CO_2e, respectively (Figure 2-21). The emission in 2015 was lower than emissions from previous years and even that was the lowest emissions in the period 2000-2015.

Table 2-6 Harvested area of rice cultivation in 2005-2015

Rice Harvest Area (ha)	**200 5**	**200 6**	**2007**	**200 8**	**200 9**	**201 0**	**201 1**	**201 2**	**201 3**	**201 4**	**201 5**
Irrigated rice field	9,503	9,854	11,782	17,182	15,576	14,919	9,527	9,535	7,065	7,631	4,898
Rainfed Rice Fields	23,222	21,532	26,800	27,813	23,422	21,629	26,035	26,055	19,308	20,853	13,384
Total	32,725	31,386	38,582	44,995	38,998	36,548	35,562	35,590	26,373	28,484	18,281

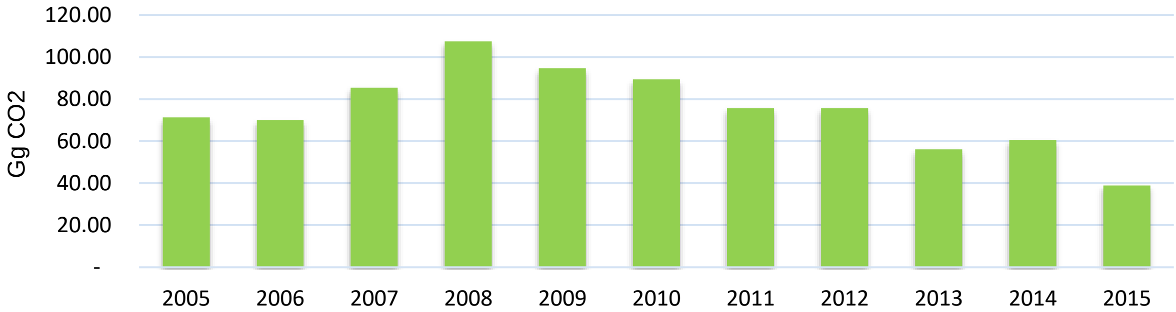


Figure 2-21 Methane emissions from rice cultivation in 2005-2010

The methane emission trend from rice cultivation shows a little fluctuating, but the numbers have decreased consistently from 2008 to 2015. Emission in 2008 was 107.38 Gg CO2e and declined for the following year, falling 68.50 Gg CO2e to 38.89 Gg CO2e in 2015. This was in line with the decline in harvested area of rice cultivation in Timor-Leste, which began in 2009 (Table 2-6). To meet the consumption of rice that cannot be supplied from rice cultivation, the Timor-

Leste government still needs to depend on rice imports. Data of Timor-Leste in Figure shows that value imports of cereal increased almost five times since 2011 from the previous USD 9.2 million to USD 45.8 million in 2015 (National Directorate of Statistic, 2015).

2.4.2.1.3 Summary of GHG Emission in Agriculture

The agriculture sector emitted significant GHGs. The estimation shows that in 2015, total emissions of the three main GHGs (CO2, CH_4 and N_2O) reached 665.76 Gg CO_2e. They increased by 19.63% since 2005, by 8.29% compared to 2010, and by 3.87% compared to the previous year (Table 2-7). This figure is lower than INC, because there is some improvement in activity data specifically for cattle and buffalo populations, which are multiplied by a correction factor of 0.72 to obtain adult livestock populations. Table 2-6 shows that CH4 emissions contributed to approximately 71.61% of the total emissions, while N_2O contributed 28.39% and CO_2 less than 0.1%. Figure 2-22 shows that the shares of GHG emissions from the agriculture sectors by source category. The largest source of agriculture sector is enteric fermentation from livestock accounting for 47.03%. It is followed by emissions from biomass burning in grassland with 17.74%, direct N2O emissions from manure management with 16.04%, methane emission from manure with 10.84%, and rice cultivation with 5.84%.

Table 2-7 GHG emissions from the agriculture sector from 2005 to 2015 by gas

Gas	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CH_4 (Gg)	19.07	19.35	20.46	21.98	21.78	21.11	21.00	21.56	21.16	21.59	22.70
N_2O (Gg)	0.50	0.51	0.52	0.54	0.56	0.55	0.57	0.58	0.60	0.60	0.61
CO2 (Gg)	0.08	0.08	0.10	0.08	0.30	0.15	0.09	0.09	0.08	0.03	0.03
Total in Gg CO_2e	556.54	565.59	591.98	630.12	631.63	614.25	616.42	633.08	629.96	640.98	665.76

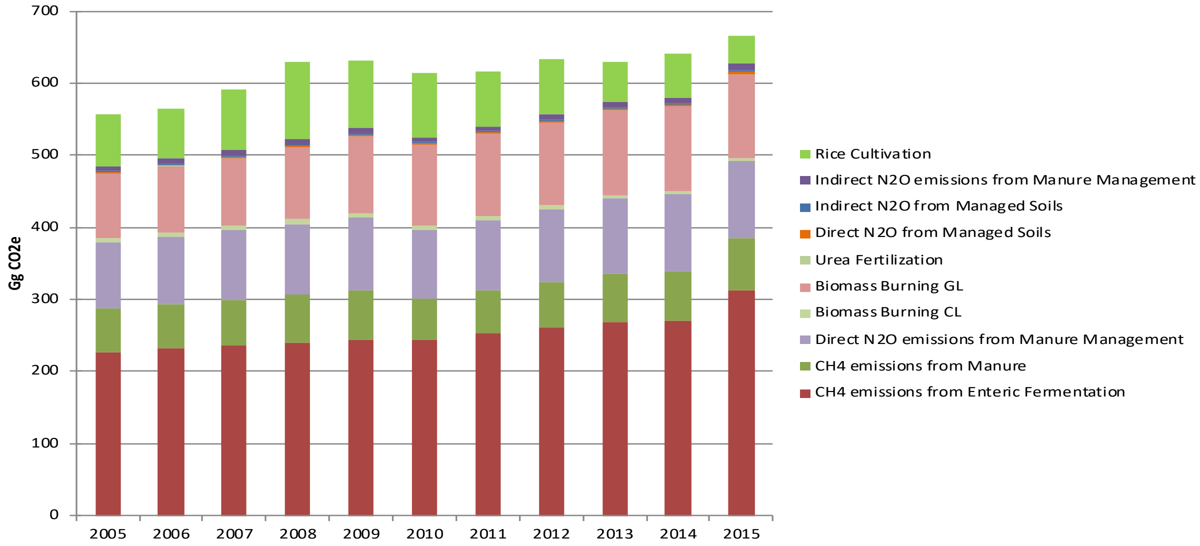


Figure 2-22 GHG emissions from the agriculture in 2005 – 2015 by source category

2.4.2.1.4 Key Category Analysis

Result of Key Category Analysis for agriculture sector is presented in Table 2-8 and show that CH4 emission from enteric fermentation, GHG emissions from biomass burning in grassland, direct N2O emission from manure management, CH4 emission from manure, and CH4 emission from rice cultivation were mainly contributed in agriculture sector.

Table 2-8 Key category analysis for all sources in agriculture sector

Code	Category	Total GHG Emissions (Gg CO2e)	Level/Rank	Cumulative
3A1	Enteric fermentation	313.14	47.03%	49.94%
3C1c	Biomass Burning in Grassland	118.09	17.74%	64.77%
3A2b	Direct N2O from Manure Management	106.82	16.04%	80.82%
3A1	Manure	72.15	10.84%	91.65%
3C7	Rice Cultivation	38.89	5.84%	97.49%
3C6	Indirect N2O Manure Management	8.00	1.20%	98.69%
3C1b	Biomass Burning Cropland	3.15	0.47%	99.17%
3C4	Direct N2O Soils	2.76	0.41%	99.58%
3C5	Indirect N2O Soils	2.75	0.41%	100.00%
3C3	Urea Fertilization	0.03	0.00%	100.00%
Total		666		

2.4.2.2 Forestry and Other Land Use

The 2006 IPCC Guidelines was used throughout the calculations for this sector and default values were provided by various tables in the IPCC Guideline were also used to calculate CO_2 emissions and removal for this sector.

2.4.2.2.1 Source Category

On this sector, GHG emission/removal was classified into the six IPCC land use categories, in which land is categorized to, lands remaining in a land use category and lands converted. The emission/removal from LUCF is therefore classified into 12 categories, i.e. (1) forest land remained as forest, (2) land converted to forest land, (3) cropland remained crop land, (4) land converted to cropland, (5) grassland remained grassland, (6) land converted to grassland, (7) wetlands remained wetlands, (8) land converted to wetlands, (9) settlements remained settlements, (10) land converted to settlements, (11) other land remained other land, (12) land converted to other land.

The total CO_2 emissions/removals from C stock changes for each land use category is the sum of those from these all subcategories by considering the five carbon pools: (i) above ground biomass, (ii) below ground biomass, (iii) dead wood, (iv) litter, and (v) soil. SNC used Gain-Loss Method to estimate CO_2 emissions/removals from annual carbon stock changes in any pool. Gains are growth (increase of biomass) and transfers of carbon from another pool. Losses are transfers of carbon from one pool to another or emissions due to decay, harvest, burning, etc. Due to limited available data, loss from fuelwood was estimated using FAO data while loss from wood removal was estimated base on forest degradation.

2.4.2.2.2 Type of Gases

According to the 2006 IPCC GL, GHGs that fall under the category of land use change and forestry (LUCF) are CO_2, CH_4 and N_2O. However, this document will only cover the estimated CO_2 emissions.

2.4.2.2.3 Time Frame

The GHG emissions inventory reported in this document provides the GHG emissions for the period of 2005 to 2015.

2.4.2.2.4 Data Sources

Land cover map generated from visual interpretation of Landsat satellite images from year 2004 to 2015 was used as the basis for generating activity data to estimate GHG emissions under this category of emission source. The land cover maps were not validated through ground truth survey due to limited time and funding, but the maps were harmonized with forest transition map 2010 produced by National Directorate of Forestry, Ministry of Agriculture and Fishery. The classification system of land cover used in the visual interpretation is sourced from the Indonesian Ministry of Environment and Forestry. Reclassification of the land cover category into land use category in Timor-Leste and IPCC 2006 is summarized in Table 2-9. Emissions and removals are estimated from the transition matrix of land use categories / subcategories resulting from overlaying land cover maps of 2 consecutive years from 2004/2005 until 2014/2015.

Table 2-9 Land use category

Indonesia Land Use Classification	**Timor Leste Land Use Classification**	**IPCC**
Forest Plantation	Dense forest	**FL**
Primary dryland forest		
Secondary dryland forest		
Primary swamp forest		
Secondary swamp forest		
Primary mangrove forest		
Secondary mangrove forest		
Shrubs	Sparse forest	**FL**
Swampy shrubs		
Agriculture mixed with shrubs	Very sparse forest	**FL**
Agriculture land	Dry field/Dry farm	CL
Paddy field	Paddy field	
Savanna	Grassland	GL
Fishpond	Inland water	WL
Water body		
Swamp		
Airport	Settlements	SL
Harbor		
Settlement		
Mining		
Bare land	Bare land	OL

2.4.2.2.5 Estimation of GHG emissions

Based on assessment of forest cover changes within land cover maps from 2004 to 2015 the annual loss of forest cover in Timor-Leste is found to be around 1.42% per year. This deforestation rate is slightly lower than the forest cover change assessment by Nippon Koei (2012) that use as reference of deforestation and degradation by National Directorate of Forestry, Ministry of Agriculture and Fishery. According to study of Nippon Koei the change of dense forest and sparse forest to other types of land uses was 2.18% per year. The difference in deforestation rate arises because the spatial resolution of the images used for the analysis of land cover in SNC is much lower than that used by Nippon Koei and no ground truth was carried out. As previously mentioned, land cover maps in SNC was interpreted visually from Satellite Landsat images without ground truth survey.

Table 2-10 shows the type and area of land use in Timor-Leste from 2005 to 2015. In 2015, Timor-Leste's forest area is composed mainly of dense forest and sparse forest with a total 857,772 ha. Forest land is the main land use with a percentage of 64.69% of the total area, followed by grass land 347,383 ha (23.28%), crop land 77,442 ha (5.19%), other land 56,484 ha (3.79%), wet land 36,361 ha (2.44%) and settlement 9,127 ha (0.61%). In addition, forest land tended to decrease during 2005 – 2015 while grass land, crop land, other land and settlement tended to decrease. Following this historical change, in the future forest land will decrease constantly and followed by increase of other land uses particularly grass land and crop land (Figure 2-23).

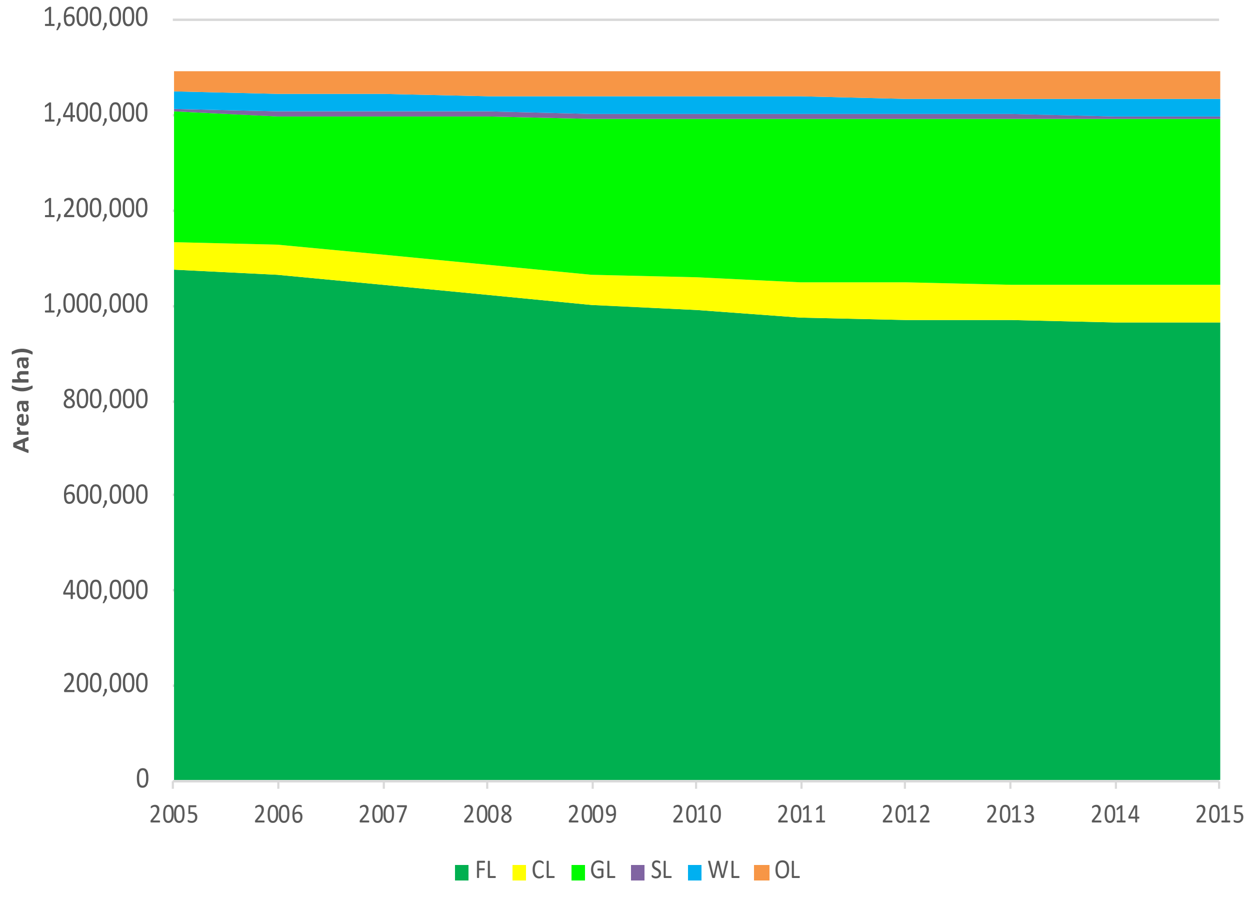


Figure 2-23 Land use transition for the period 2005 to 2015 in Timor-Leste

The GHG emissions and removals estimated from land use change and forestry can be seen in Figure 2-24. In the period of 2005 and 2015, the CO2 emission and removal tended to fluctuate with an annual average emission of 1,635 Gg CO_2. Emissions occurred in 2005 and in the period of 2007-2013, whereas in 2006, and 2014 and 2015 there were net sink because in this period forest degradations did not occur in the forest land remaining forest land of 2005/2006, and 2013/2014 and 2014/2025. The net sink in 2015 was 1,479 Gg CO_2, it was increase by 1,781 CO_2 since 2005, increase by 1,7581 CO_2 compared to 2010, and increase by 34 CO_2 compared to previous year.

By source sub-categories, forest land remaining forest land in 2015 was the main sink with 1,607.24 Gg CO2e annually, while land converted to grass land, land converted to other land, and land converted to crop land emitted 118.98 Gg CO2, 8.35 Gg CO2 and 1.19 Gg CO2 respectively

(Table 2-11). On average in the period 2005 to 2015, the emissions from forest land remaining forest land are 1,207 Gg CO2, land converted to grass land 319.45 Gg CO2, land converted to other land 86.83 Gg CO2, and land converted to crop land 20.80 Gg CO2. Compared to INC, the emissions of FOLU sector reported in this SNC are higher (Table 2.12). As mentioned previously, these differences are mainly due to significant change in activity data. SNC used the land use classification system in Timor-Leste and the transition of land use from 2004 to 2015 was obtained from land cover cover/use maps, which were generated from visual reinterpretation of Landsat images without ground truth. Table 2.12 presents the differences in emissions of INC and SNC. It is clear that emission level in the SNC is much higher than INC, except for 2006 which shows the opposite condition (sink).

Figure 2-24 GHG emissions and removal from forestry and other land use (Gg CO2e) for the 2000-2014 period

Table 2-10 Land cover type of Timor-Leste in 2000 – 2005

Landuse	Year										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dense Forest	379,678	376,759	350,976	329,150	315,178	308,020	290,641	275,202	260,780	260,358	259,975
Sparse Forest	610,882	605,204	601,657	603,889	598,942	599,765	599,331	600,820	600,164	598,236	597,796
Very Sparse Forest	82,989	81,882	89,313	88,727	88,059	83,743	86,682	93,604	107,195	107,088	107,318
Dry field/Dry farm	22,792	23,540	24,129	24,129	25,110	30,546	34,223	37,125	37,088	37,326	37,519
Paddy field	37,323	38,304	38,537	38,539	39,294	39,317	39,292	39,727	39,739	39,903	39,923
Grassland	271,749	272,944	292,186	311,902	327,383	332,755	342,256	344,004	345,955	346,250	347,383
Inland water	36,477	36,362	36,362	36,354	36,361	36,361	36,361	36,361	36,361	36,361	36,361
Settlements	8,712	8,712	8,778	8,842	9,084	9,084	9,086	9,095	9,116	9,116	9,127
Bare Land	41,283	48,179	49,949	50,356	52,475	52,296	54,014	55,948	55,489	57,248	56,484

Table 2-11 Emissions and removals from forestry and other land use (Gg CO2e) for the 2005-2015 period

Code IPCC	(Gg CO2 e)										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3B1A (Forest Land)	-375.67	-1,932.95	4,956.48	3,921.31	1,943.35	-76.19	2,970.64	2,563.69	2,527.85	-1,605.17	-1,607.24
3B1b_Land Converted to FL	-0.10	0.00	-0.03	-0.01	0.00	0.00	-0.06	0.00	-0.04	0.00	-0.02
3B2a_CL Remaining CL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B2b_Land Converted to CL	15.91	64.93	13.22	1.23	28.12	53.23	52.75	-3.20	0.85	0.52	1.19
3B3a_GL Remaining GL_TL2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B3b_Land Converted to GL	326.91	522.27	555.44	619.05	416.94	275.96	289.09	247.19	22.47	119.62	118.98
3B6b_Land Converted to OL	335.69	162.32	62.35	21.96	33.90	26.38	117.61	51.16	89.19	46.23	8.35
Total	302.74	-1,183.43	5,587.47	4,563.54	2,422.31	279.38	3,430.02	2,858.84	2,640.32	-1,438.80	1,478.73

Table 2-12 Comparison of emissions/removals estimates from FOLU between INC and SNC

Emissions	NCs	2005	2006	2007	2008	2009	2010
Gg CO2	INC	114.89	1,036.68	734.57	441.63	225.37	206.21
	SNC	302.74	-1,183.43	5,587.47	4,563.54	2,422.31	279.38
Difference		187.86	-2,220.11	4,852.90	4,121.91	2,196.94	73.16

2.4.2.2.6 Key Category Analysis

Key category analysis for forestry and other land use sector is summarized in Table 2-13. It can be seen in Table 2-13 that GHG emission from forest remaining forest, lands converted to grass, and lands converted to other land classified as key category because their total contribution into total GHG emissions reaches 95%.

Table 2-13 Key category analysis for all sources in forestry and other land use sector

Code	Category	Total GHG Emissions (Gg CO2e)	Level/Rank	Cumulative
3B1a	Forest remaining Forest	1,607.24	92.59%	92.59%
3B3b	Lands to Grassland	118.98	6.85%	99.45%
3B6b	Lands to Otherland	8.35	0.48%	99.93%
3B2b	Lands to Cropland	1.19	0.07%	100.00%
3B1b	Lands to Forest	0.02	0.00%	100.00%
3B2a	Cropland remaining Cropland	0.00	0.00%	100.00%
3B3a	Grassland remaining Grassland	0.00	0.00%	100.00%
3B4a	Wetland remaining Wetland	0.00	0.00%	100.00%
3B4b	Lands to Wetland	0.00	0.00%	100.00%
3B5a	Settlement remaining Settlement	0.00	0.00%	100.00%
3B5b	Lands to settlement	0.00	0.00%	100.00%
3B6a	Otherland remaining Otherland	0.00	0.00%	100.00%
Total		666		

2.4.3 Waste Sector

2.4.3.1 Source Category

The sources of GHG emission from waste sector are municipal solid waste (MSW) dumped in un-categorized SWDS, MSW open burning, clinical incineration, and domestic wastewater treatment (WWT). Although, there are also some activities, i.e. industrial solid waste and waste water treatment, identified as emission sources but those sources were not included in the GHG Emission Inventory of this Second National Communication (SNC) due to small number or rarely implemented as limited number of industries in the country. In addition, composting of MSW also were not included in this SNC since implementation of composting was still limited although it will become future activity for MSW management and GHG emission mitigation in the waste sector.

2.4.3.2 Type of Gases

Based on the 2006 IPCC GL, the types of GHG from waste sector includes CO_2, CH_4, and N_2O. CO_2 was released from open burning of waste. CH_4 was mainly released from anaerobic digestion processes, i.e. at solid waste disposal site or SWDS (landfill) and decay of organic matter at wastewater treatment plant. N_2O was mainly released from biological process in composting activity and municipal wastewater treatment facilities.

2.4.3.3 Time Frame

The GHG inventory reported in this document covered the GHG emissions generated in the year 2005 to 2015, and updated from the INC for period of 2005 – 2010 due to changes in methodology and revision of activity data and related parameters.

2.4.3.4 Data Sources and Parameters

Activity data and other relevant parameters used in estimating GHG emissions level were classified based on the source category of the 2006 IPCC GL, i.e. MSW treatment, domestic liquid waste treatments, and industrial wastewater treatment. They are gathered from National Census in 2010 (2010), Timor-Leste in Figure (2016), FAOStat (2016).

2.4.3.5 Estimation of GHG Emissions

In preparing the SNC for GHG emission inventory from MSW treatment facilities, there are some updated data and information on MSW management, generation, and characteristics (composition, dry matter content, DOC, etc). In the Initial National Communication (INC), all of these data referred to default value of IPCC 2006 while in this SNC some of those data are collected from national statistics and domestic surveys by ADB and UNDP, i.e. MSW stream management (brought to SWDS, open burning, and untreated) while the MSW generation and characteristics were still referred to default value of IPCC. Due to those updated data and information, this SNC recalculated the GHG emissions reported in the INC for the period 2005-2010.

There are also updated data and information in preparing the GHG emission inventory from domestic WWT, i.e. type of WWT and its degree of utilization (obtained from survey conducted for National Census in 2010), protein consumption (from FAOStat for the period of 2005-2013, while value for 2014 and 2015 was estimated value based on the trend of 2005-2013). Therefore, similar to the GHG emission inventory from MSW treatment, the GHG emissions from domestic WWT are also recalculated. The summary of estimated GHG emissions from waste sector of Timor-Leste during 2005 – 2015 is presented in Figure 2-25.

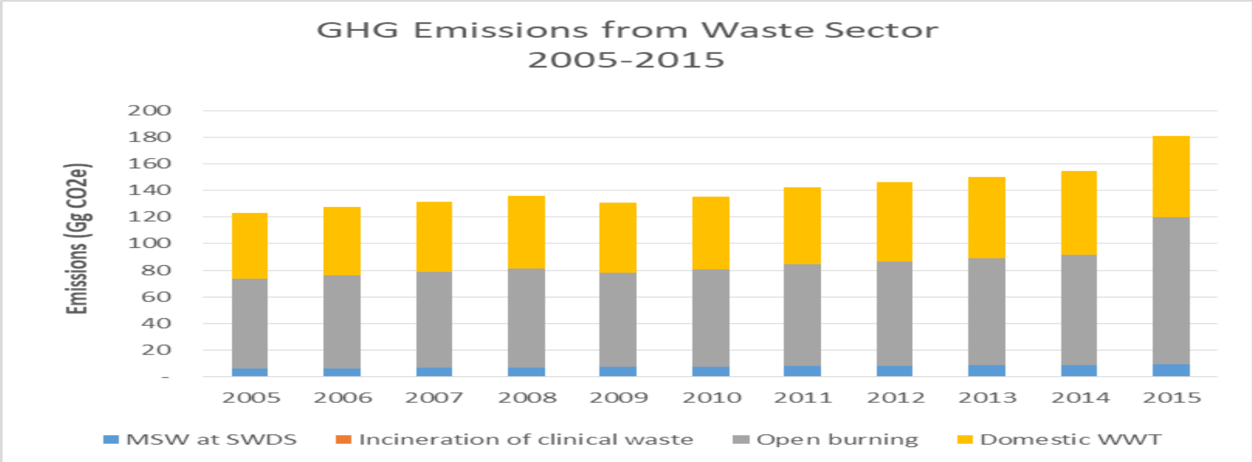


Figure 2-25 GHG emissions from waste sector in Timor-Leste, 2005 – 2015

It can be seen from the Figure 2-25 that the main source of GHG emission is from MSW open burning, followed by domestic WWT. During 2005 – 2015, the contribution of GHG emission from open burning and domestic WWT tend to increase while the contribution of GHG emission from MSW treatment at SWDS and clinical waste incineration remains low. These figures are in line with the people behavior that tend to do ‘open burning’ instead of bring their MSW to SWDS, which still lack of MSW treatment facility. However, the GHG emissions level of waste sector during 2009 and 2010 showed slightly decrease, particularly the GHG emissions from open burning and domestic WWT activities. The declining of GHG emissions from these two activities is related to the decrease of population in 2009 and 2015 due to emigration. Accordingly, the fluctuation of the number of population also reflected in emissions from MSW and domestic wastewater treatments. The amount of clinical waste processed in incineration are considered the same throughout the inventory period, i.e. 150 kg/week from the health facility in Dili and total 350 kg/week from 7 health facilities in other districts.

Since the main sources of GHG emission from the waste sector in 2015 were from open burning and domestic WWT activities, the GHG emission of waste sector was dominated by CH_4 (49%), followed by CO_2 (38%) and N_2O (13%) such presented in Figure 2-26. The large contribution of CH_4 is from domestic WWT while the CO_2 is from open burning.

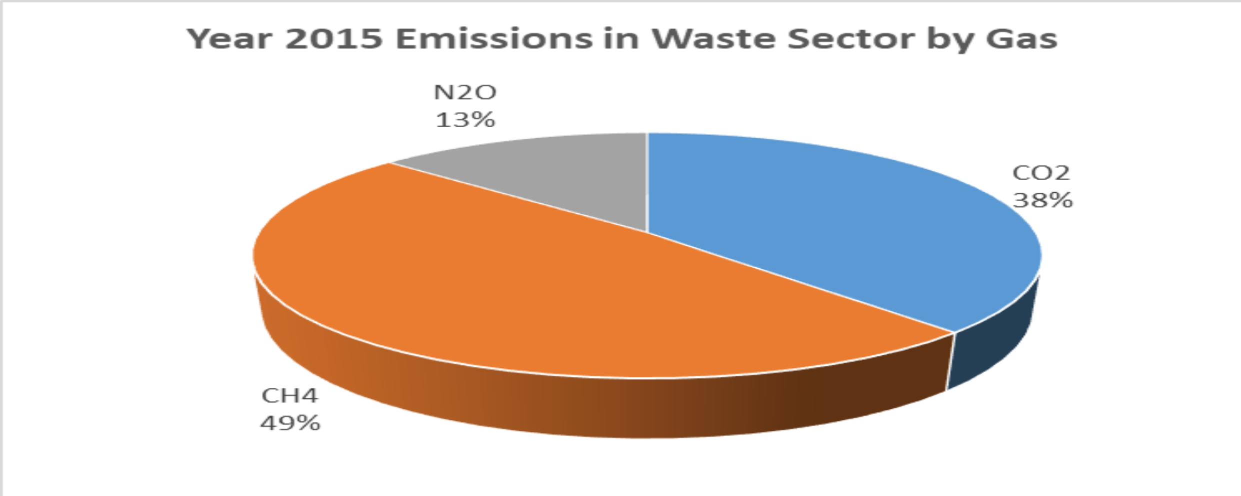


Figure 2-26 The distribution of GHG emissions from waste sector by type of gas

<u>GHG Emission from Municipal Solid Waste (MSW) Treatment</u>

Due to the MSW treatment streams in Dili were not the same with those in other districts, therefore the calculation of GHG emission from the MSW treatment in Dili were carried out separately from other districts. For estimating the amount of MSW treated for each treatment facility (waste stream) in Dili, data from survey by ADB (2014-2015) were used. Based on these data, it was assumed that 45% of population in Dili brought their MSW to SDWS, 35% of the people treat their MSW trough open burning, 20% of the people did not treat their MSW (un-treated) while for the amount of clinical waste to be incinerated was assumed 150 kg/week.

For other districts, the assumption of the amount of MSW brought to the SWDS, MSW open burning, MSW untreated, and clinical waste incinerated was determined based on Focus Group Discussion (FGD) with Waste Working Group of Timor-Leste. The MSW and clinical waste treatment data in Dili and other districts are summarized in the following Table 2-14.

Table 2-14 Solid waste stream in Dili and other districts

Waste Treatment	**Dili**	**Other districts**
MSW to SWDS	45%	8.359 ton/year (+ 5%)
Open burning	32%	89% → percentage of rural areas
Untreated	20%	+ 5%
Incineration (clinical waste)	150 kg/week	total 350 kg/week from 7 other health facilities
Source:	*Survey by ADB, 2014 - 2015*	*Based on discussion with WG waste*

<u>CH4 From Municipal Solid Waste at Disposal Sites</u>

In the SNC of Timor-Leste, the amount of MSW treated in SWDS in Dili and other districts were estimated using parameter presented in Table 2-15. As discussed previously about these parameters (see Table 2-14), the amount of MSW treated in SWDS in Dili is estimated using data from surveys carried by ADB during 2014-2015. This data was used to estimate GHG emission from this facility for the period 2015 – 2010 and to recalculate the GHG emission for the period 2005 – 2010 in order to improve the quality of GHG emission inventory of the MSW treatment at SWDS. It should be noted, the waste generation rate of 0.7 kg/cap/day is used for estimating the amount of MSW in 2015 while waste generation rate of 0.51 kg/cap/day is used for estimating the amount of MSW for the period of 2005 – 2014.

The GHG emission from MSW treatment in SWDS only covered CH_4, while CO_2 was not covered in GHG emission inventory of MSW treatment in SWDS due to the CO2 is categorized as biogenic origin. The level of CH_4 from this treatment facility was estimated using Tier 1 of IPCC 2006. Under this approach, GHG emission is estimated using First Order Decay (FOD) methods. Data used for the estimation of the CH_4 emission under the FOD methods is presented in Table 2-15 while the results of GHG emissions calculation is presented in Figure 2-26.

Table 2-15 List of parameters for estimating the CH4 (methane) emission in SWDS

Year	Number of Population (person)	Total MSW (Ggram)	MCF and k or methane generation rate (1/year)	Other parameter
1990	747,557	139	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})	Waste generation rate = 0.51 kg/cap/day for the period of 1990-2014, 0.7 kg/cap/day for 2015 onward 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	140		
1992	754,638	140		
1993	758,203	141		
1994	761,785	142		
1995	765,385	142		
1996	769,001	143		
1997	772,634	144		
1998	776,285	145		
1999	779,952	145		
2000	783,638	146		
2001	787,340	147		
2004	791,060	147		
2005	794,798	148		
2006	923,198	172		
2007	983,369	183		
2008	1,015,187	189		
2009	1,047,632	195		
2010	1,080,742	201		
2011	1,032,501	192		
2012	1,066,409	199		
2013	1,120,392	209		
2014	1,148,958	214		
2015	1,180,069	220		

* The amount of MSW dumped into SWDS is estimated from 1990 (historical data needed for the FOD method at least the past 10 years) following estimated numbers presented in Timor-Leste's INC.

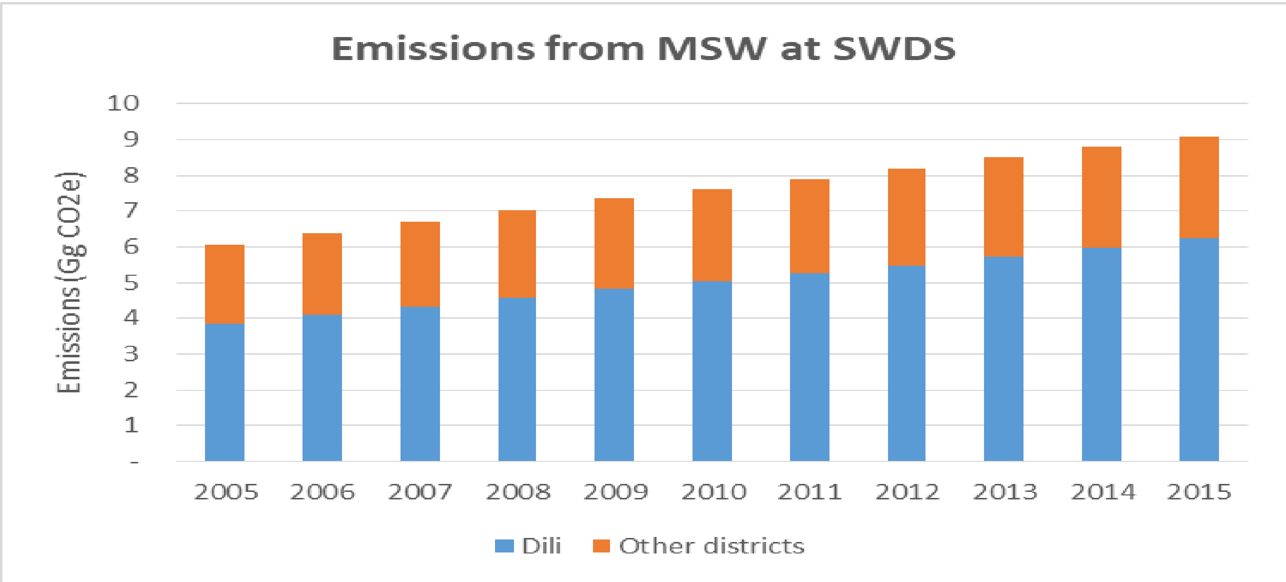


Figure 2-27 GHG emissions from municipal solid waste treatment in disposal site

GHG emissions from MSW Open Burning

The contribution of GHG emission from open burning is significant since open burning is common practice in Timor-Leste, particularly in the rural area. In Dili, it is assumed that around 32% of MSW in the city was burned, while in other district open burning of the waste is common practice in rural areas. Therefore, the percentage of open burning in other districts is assumed based on the average proportion of rural population in those area, which is 89%. The result of GHG emission calculation from MSW open burning activity is presented in Table 2-16.

Table 2-16 GHG Emission from MSW open burning activity

Year	Emissions (Gg)			in Gg CO_2e
	CO_2	CH_4	N_2O	
2005	42.01	0.91	0.02	67.62
2006	43.37	0.94	0.02	69.81
2007	44.75	0.97	0.02	72.04
2008	46.17	1.00	0.02	74.32
2009	44.11	0.96	0.02	71.00
2010	45.55	0.99	0.02	73.33
2011	47.50	1.03	0.02	76.47
2012	48.71	1.06	0.02	78.42
2013	50.03	1.08	0.03	80.54
2014	51.39	1.11	0.03	82.73
2015	68.66	1.49	0.03	110.53

GHG Emission from Domestic Waste Water Treatment (WWT)

In the INC of Timor-Leste, GHG emission from domestic wastewater treatment is estimated under the IPCC 2006 as Gg CO_2e and only covers CH_4 and N_2O (see Figure 2-29). Information on type of domestic wastewater treatment and its degree of utilization was obtained from surveys that were conducted during a Census in 2010 (see Table 2-17). Protein consumption for estimation of N2O is available at FAOStat for the period of 2005-2015. For the period of 2014 and 2015, estimated value based on trend of the 2005-2015 value were used (see Table 2-18).

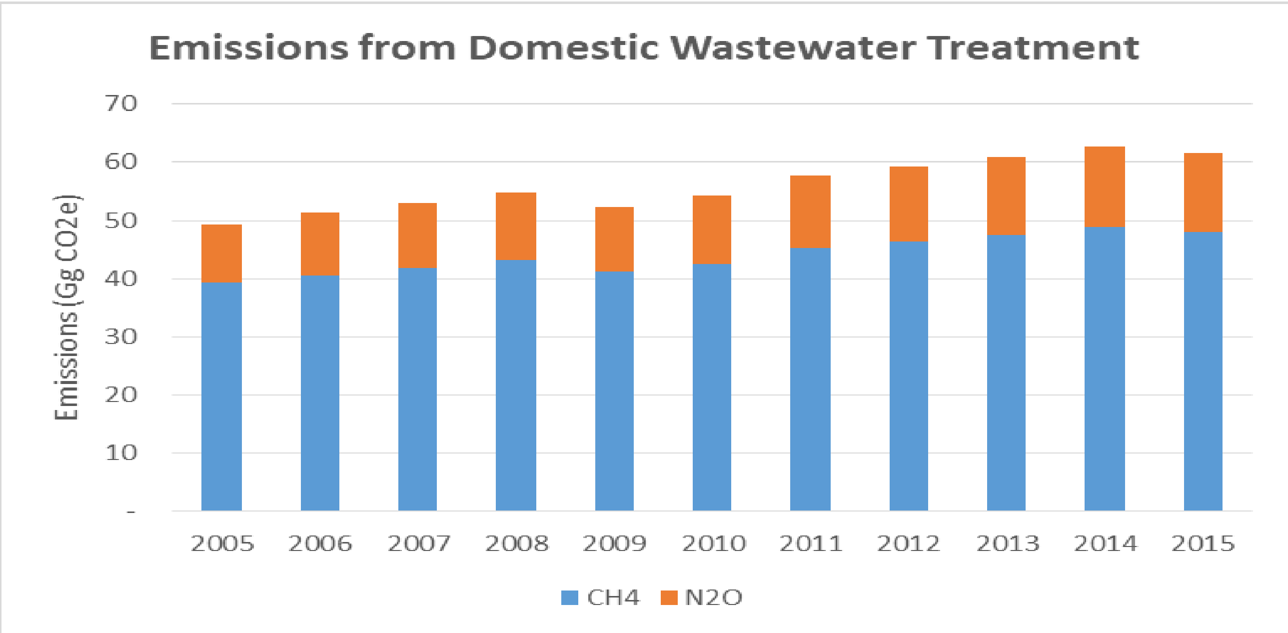


Figure 2-28 CH4 and N2O generated from domestic wastewater treatment and handling

Table 2-17 Type of domestic wastewater treatment and its degree of utilization

Type of wastewater treatment	Degree of Utilization (%)	
	Average Timor-Leste	Dili district
Septic tank	17.60	74.45
Pond/field	1.24	1.99
River/ lake/ ocean	1.78	1.15
Hole	33.89	17.06
Shore/ open field	42.60	3.93
Other	2.89	1.42

Source: Ministry of Planning and Strategic Investment and JICA, 2016.

Table 2-18 Protein consumption data

Year	Population	Protein consumption	
		(g/cap/day)	(kg/cap/yr)
2005	983,369	52.37	9.12
2006	1,015,187	54.13	19.76
2007	1,047,632	54.41	19.86
2008	1,080,742	54.95	20.06
2009	1,032,501	54.8	20.00
2010	1,066,409	56.09	20.47
2011	1,120,392	56.98	20.80
2012	1,148,958	57.66	21.05
2013	1,180,069	57.72	21.07
2014	1,212,107	58.65	21.41
2015	1,183,643	59.28	21.64

GHG Emission from Industrial Waste Water Treatment (WWT)

GHG emission from industrial wastewater was not included in the NGHGI because large industrial activity practically does not exist before 2017, and data on smaller industries such as tofu production is not available. Therefore, the GHG emission from industrial wastewater is considered as NE (not estimated). This source is likely to be included in the Third National Communication.

The Summary of GHG Emissions from the Waste Sector in 2015

Table 2-19 presents the summary of GHG emission from waste sector in 2015. It can be seen that the GHG emission in waste sector was 181.17 GgCO2e, which was dominated by emissions from open burning (61.01%), followed by domestic WWT. By type of gas, CO2 was the main gas generated from this sector

Table 2-19 Estimate Results of Waste Sector Emissions in Year 2015

GHG EMISSION SOURCE AND SINK CATEGORIES	CO_2(1)	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	(Ggram or kTon)						
Total Waste Sector							
A. MSW Treatment in SWDS							
1. Managed waste disposal sites	NO	NO					
2. Unmanaged waste disposal sites	NO	NO					
3. Uncategorized waste disposal sites	NO	0.43					
B. Biological treatment of solid waste							
1. Composting		NE	NE				
2. Anaerobic digestion at biogas facilities		NO	NO				
C. Incineration and open burning of waste							

GHG EMISSION SOURCE AND SINK CATEGORIES	CO_2(1)	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	(Ggram or kTon)						
1. Waste incineration	0.02	0.00	0.00				
2. Open burning of waste	68.66	1.49	0.03				
D. Wastewater treatment and discharge							
1. Domestic wastewater		2.28	0.04				
2. Industrial wastewater		NE	NE				
3. Other (as specified in Table 5.D)							
E. Other (please specify)							

The current GHG Inventory in waste sector have not yet included the category of composting and industrial waste water due to lack of sufficient data for estimating GHG emissions. The next GHG Inventory is planned to include the two categories, as more sufficient data is expected to available at the time. For data on composting, a district-level survey will be needed, at least percentage of waste being composted as well as type of waste being composted. The survey is planned to be conducted in near future, as part of monitoring of improvement in waste management.

As for industrial wastewater, two types of industries have been identified as source of emissions generation from wastewater, i.e. tofu and beer production. Tofu industries are small scale and data on its operation have not been managed sufficiently thus at the moment, there is no information on production capacity and type of wastewater handling on this industry. The beer factory started its operation in 2017 and have not yet published enough information on its production process, including its waste management. With regard to activity data in estimating GHG Inventory from MSWM, site-based waste data is expected to be available for Dili in the future, but other districts would most likely still use population-based waste generation data.

2.4.3.6 Key Category Analysis (KCA)

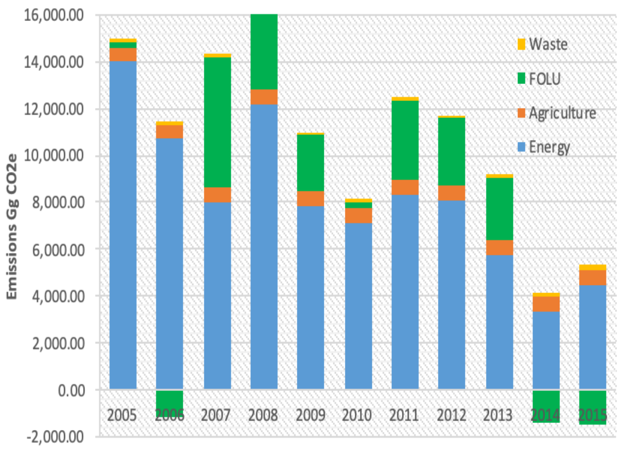
Key category analysis (KCA) for waste sector is summarized in Table 2-20. It can be seen in Table 2-20 that the contribution of GHG emission from sub-sector 4.A.2 Unmanaged waste disposal sites and 4.C.1 Waste incineration are too small, i.e. around 5.05% and 0.01% respectively. However, the GHG emission from MSW treatment at Uncategorized SWDS cannot be excluded from the National GHG Inventory because in the next future their contribution will be significant in line with the increase of MSW to be brought to the SDWS. Moreover, there will be an improvement of SWDS from uncategorized (MCF = 0.6) to become managed SWDS (MCF = 1.0) in Dili. On the other hand, the GHG emission from clinical waste incineration can be excluded from the National GHG Inventory because its contribution to the GHG emissions in the waste sector is too small (0.01%).

Table 2-20 Key Category Analysis in Waste Sector (2015)

Code	Category	Total GHG Emissions (Gg CO2e)	Level/Rank	Cumulative
4.C.2	Open burning of MSW	110.53	61.01%	61.01%
4.D.1	Domestic WWT	61.53	33.96%	94.97%
4.A.2	MSW Treatment at Un-categorized SWDS	9.10	5.02%	99.99%
4.C.1	Incineration of clinical waste	0.02	0.01%	100.00%
Total		181.17		

2.5 Trend of National GHG Emissions

In 2015, the national GHG emissions reached 3,825.12 Gg CO2e for 3 gases (CO2, CH4, N2O). The emissions in 2015 is significantly lower by 11,172.24 Gg CO2e than emissions in 2005, significantly lower by 4,336.62 Gg CO2e than in 2010, and higher by 1,141.24 Gg CO2e than previous year. The average emissions during 2005-2015 were 8,927.75 Gg CO2e, where the lowest emissions occurred in 2014 in amount of 2,683.88 Gg CO2e and the highest in 2005 was 14,997.36 Gg CO2e (Figure 2-29). The highest emissions in 2005 compared to other years were due to high emissions in the energy sector, while the lowest emissions in 2014 were caused by declining emissions from the energy sector and sinks from the remaining forest from the forests that occurred in 2014. Trend of national GHG emission 2005-2015 is given in Table 2-21.



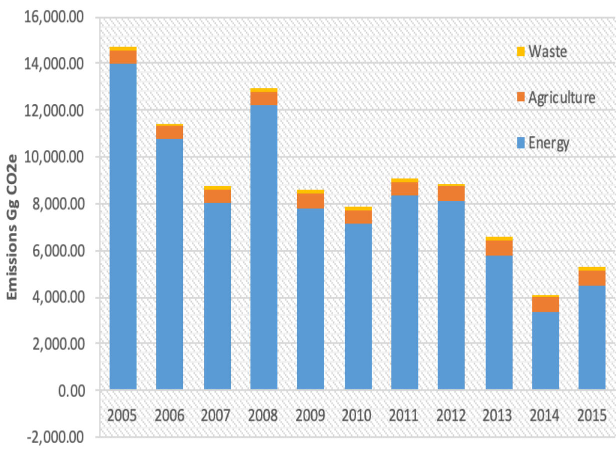


Figure 2-29 Trend of national GHG emissions with FOLU (left) and without FOLU (right) during 2005 – 2015

Based in Figure 2-29, the national GHG emissions decreased with an average rate of 3.55% per year with AFOLU, and 6.10% per year without FOLU in the period of 2005 – 2015. This showed that land-based sectors, especially forestry, also has a significant contribution to the national GHG emissions in Timor-Leste in addition to the energy sector.

Table 2-21 National GHG emissions in Timor-Leste, 2005 – 2015

Year	Energy	Agriculture	FOLU	Waste	Total
2005	14,015.07	556.54	302.74	123.01	14,997.36
2006	10,746.34	565.59	-1,183.43	127.48	10,255.97
2007	8,008.51	591.98	5,587.47	131.73	14,319.69
2008	12,185.32	630.12	4,563.54	136.11	17,515.09
2009	7,809.05	631.63	2,422.31	130.64	10,993.62
2010	7,132.88	614.25	279.38	135.23	8,161.74
2011	8,326.23	616.42	3,430.02	142.03	12,514.70
2012	8,095.01	633.08	2,858.84	145.91	11,732.83
2013	5,768.67	629.96	2,640.32	149.95	9,188.90
2014	3,327.39	640.98	-1,438.80	154.32	2,683.88
2015	4,456.92	665.76	-1,478.73	181.17	3,825.12

2.6 Key Category Analysis

Based on first approach to all emission sources with inclusion of FOLU sector, the key category analysis indicated that there are 9 main sources of emission for Timor-Leste. The first four main categories that contributing to more than 87.50% of the total emissions were from (i) 1A1b Oil and gas production facilities, (ii) 3B1a Forest remaining forest, (iii) 3A1 Enteric Fermentation, and (iv) 1A3b & d Road and water-borne transportation (Table 2-22).

Table 2-22 Key Category Analysis for National GHG Inventory (three gases) with FOLU

IPCC Code	IPCC Source Category	GHG	Emissions in 2015 (Gg CO2e)	Level/ Rank	Cumulative
1A1b	Oil and Gas Production Facilities	CO_2	3,994.17	56.74%	56.74%
3B1a	Forest remaining Forest	CO_2	-1,607.24	22.83%	79.57%
3A1	Enteric Fermentation	CH4	313.14	4.45%	84.02%
1A3b & d	Road and Water-borne Transportation	CO_2	235.08	3.34%	87.36%
1A a	Main Activity Electricity	CO_2	199.31	2.83%	90.19%
3B3b	Non-Grassland to Grassland	CO_2	118.98	1.69%	91.88%
3A2	Direct N2O Emission from Manure Management	N_2O	106.82	1.52%	93.40%
3A1b	Manure Management	CH_4	72.15	1.02%	94.42%
3C1c	Biomass Burning GL	N_2O	67.79	0.96%	95.38%

Meanwhile for key category analysis with exclusion of FOLU sector, there were 8 key sources that had been identified (Table 2-23). The first four main categories were (i) 1A1b Oil and gas production facilities, (ii) 3A1 Enteric fermentation, (iii) 1A3b & Road and water-borne transportation, and (iv) 1A1a Main activity electricity, with cumulative emissions as much as 90% of the total emissions excluded FOLU in 2015.

Table 2-23 Key Category Analysis for National GHG Inventory (three gases) without FOLU

IPCC Code	IPCC Source Category	GHG	Emissions in 2015 (Gg CO2e)	Level/ Rank	Cumul ative
1 1b	Oil and Gas Production Facilities	CO2	3,994.17	75.31%	75.31%
3A1	Enteric Fermentation	CH4	313.14	5.90%	81.21%
1A3b & d	Road and Water-borne Transportation	CO2	235.08	4.43%	85.64%
1A1a	Main Activity Electricity	CO2	199.31	3.76%	89.40%
3A2	Direct N2O Emission from Manure Management	N2O	106.82	2.01%	91.41%
3A1b	Manure Management	CH4	72.15	1.36%	92.78%
3C1c	Biomass Burning GL	N2O	67.79	1.28%	94.05%
4C2	Open burning of waste (Other Districts)	CO2	61.86	1.17%	95.22%

This analysis suggests that improvement of activity data and emission factors for these key categories were very important to improving the Timor-Leste National GHG Inventory especially such as oil and gas production, forest and land use change, livestock population, energy use in transportation as these sources.

2.7 Uncertainty Analysis

The overall uncertainties of the National GHG inventory without LUCF for 2005 and 2015 were approximately 4.84% and 4.47% respectively with trend uncertainty 1.13%. With the inclusion of LUCF, the level of uncertainty increased significantly for both years, i.e. 4.93% and 15.74% respectively with trend uncertainty 4.96%. This indicated that inclusion of activity data and emissions from forestry and other land use in the analysis increase the uncertainty. Improvement of activity data and emissions factors of Forestry and Other Land Use need to be carried out in the next national communication preparation. Mapping land cover map on annual basis, which is derived from satellite data using medium and high resolutions including ground truth is suggested in the next GHG inventory. In addition, because the energy sector contributes more than 65% of total emissions, improvements in data activity focus on energy balance and data disaggregation need to be considered in the next national communication report.

2.8 Plan for Improvement

Improvement in GHG Inventory is needed particularly in data collection, archiving and quality. In addition, QA/QC for the process of developing the GHG Inventory is necessary to improve in the future to ensure quality of activity data, and to document and archive the data and information. Plans for the improvement in energy sector focused on (i) improved energy balance, (ii) dis-aggregate activity data in transportation sector into road transportation sub-sector and water borne navigation sub-sector, (iii) dis-aggregate activity data in other sector into residential sub-sector and commercial sub-sector, (iv) collecting activity data for industry sub-sector, (v) collecting activity data of energy use in agriculture and construction activities, and (vi) development of emission factors for oil and gas.

In IPPU sector, improvement plans are focused on completing the scope of GHG emission sources by adding the estimation from IPPU category. First step is to identify the source from IPPU category exists in Timor-Leste. Plans for the improvement in agriculture focused on the (i) data for harvested area of rice cultivated, (ii) amount of fertilizer in agriculture, (iii) livestock population by subcategory, (iv) identification of manure management system for each category of livestock, and improvement of emission factors for rice paddy. In FOLU, improvement plans are focused on reducing the uncertainty of emissions estimates related to land cover changes and better utilization of remote sensing technology validated by ground truth.

In waste sector, plans for improvement include the estimation the category of composting and industrial waste water, a district-level survey of composted waste and type of waste being composted, data on production capacity and type of wastewater of tofu and beer production, and improvement of site-based waste data for Dili.

3. MEASURES TO MITIGATE CLIMATE CHANGE

3.1 Introduction

Timor-Leste has submitted their Intended Nationally Determined Contribution (INDC) to UNFCCC in November 2016. All mitigation actions stated in INDC were developed based on several national documents and research studies. Under the INDC, the implementation of climate change mitigation actions in Timor-Leste are carried out base on the potential sources of GHG emissions, which classified into (i) energy, (ii) agriculture, forestry and land use change, and (iii) waste sectors. The coverage of GHG types are three main gases, i.e. CO2, CH4, and N2O. The implementation of mitigation actions under INDC will be started in 2021 with the base year is 2010. In the SNC of Timor-Leste, the total GHG emission level in 2015 is 3,825.12 Gg CO2e (see Chapter 2). Although Timor-Leste has not determined reduction target under their INDC, however, there are several potential activities (either already being implemented or under planning) that potentially reduced their national GHG emissions.

Refer to the INDC of Timor-Leste and the identified potential mitigation options, in this SNC report, mitigation actions of Timor-Leste can be grouped into activities that have similar type of actions and/or the same sub-sector. In energy sector, mitigation measures can be grouped into four types of activity, i.e. (a) improvement of energy efficiency in supply side (fossil fuel combustions) and increasing use of renewable energy (biomass, biogas, hydro, solar PV, wind turbine, etc.) in power generation sector, (b) improvement of efficiency in transportation for reducing mobile GHG emissions through the increasing use of public transport and more efficient vehicle (5 year minimum age of vehicle), (c) improvement of energy efficiency in demand side and increasing use of less emitting carbon fuels (biomass and LPG in household and commercial buildings), for reducing stationary GHG emissions, and (d) reducing of fugitive emissions from oil and gas production facilities (offshore). However, based on the sector of GHG emission sources, mitigation measures can be grouped into four main sectors, i.e. (a) power, (b) transportation, (c) household and commercial sectors, and (d) oil and gas. In AFOLU sector, potential mitigation actions in agriculture are (a) reducing GHG emissions from livestock through biogas and composting activities, (b) reducing slash and burn practices by introducing permanent agriculture with improved management practices while in forestry are mainly from the development of agroforestry and community forestry on degraded land. The potential mitigation actions in waste sector are mainly from (a) implementation of MSW management to reduce open burning and the amount of MSW disposed in open dumping landfill, (b) improvement of open dumping landfill to managed landfill that equipped with LFG recovery system, (c) improvement of household sanitation system (equipped with sludge removal to be treated), (d) improvement of industrial wastewater treatment plant, and (e) utilization of industrial waste (solid and liquid). It should be noted that those mitigation options were determined based on key category analysis, inputs from Working Group and relevant stakeholders, and analysis of government program.

3.1.1 Assessment of Mitigation Potential for Energy Sector

3.1.1.1 Mitigation Potential for Energy Sector and the Associated GHG Emissions

As discussed previously, the INDC of Timor-Leste has not determined the reduction target of GHG emissions in all source categories, including energy sector. Potential mitigation actions in energy sector category under the INDC of Timor-Leste are listed in Table 3-1. It can be seen that the table only presents the mitigation actions classification and several potential actions. In this SNC of Timor-Leste, the potential of GHG emissions reduction of mitigation actions in energy sector is assessed base on the list of mitigation actions in the INDC as well as identified mitigation options and programs either those are already being implemented or still under planning. This sub-chapter assessed potential mitigations of energy sector category under the INDC of Timor-Leste, several identified potential mitigation actions (either already being implemented or under planning), and the associated GHG emissions reduction.

Table 3-1 Potential mitigations of energy sector category under the INDC of Timor-Leste

Classification of Mitigations	**Potential Mitigation Actions**
Renewable and Low Carbon Energy	Higher efficiency and less carbon emissions in power through the use of (pico/micro-hydro), biomass biogas, solar PV, wind power at different scales, natural gas for power generation, etc. Reducing dependency on imported fuel.
Rural electrification	Enhancing rural electrification using renewable energy to supply energy in rural communities.
Energy efficient cookstoves	Reduce dependency on fossil fuels for cooking. Reduce the average amount of fuel wood used for cooking in private households, and thereby deforestation by introducing fuel substitution and supporting the use of energy-efficient cookstoves.
Energy efficiency	To promote the use of higher efficiency technologies in end users (efficient lamps, efficient electric motors, building codes and efficient energy systems).
Energy efficiency in transportation sector	Continue to promote and implement the current Decree Law (No. 30/2011) on used vehicles which are imported into Timor Leste to be less than 5 years of factory production.
Public transport	Promote use of public transport by enabling convenient (routes to all areas) and reliable access to bus or micro-bus, constructing appropriate facilities such as proper bus stops, terminals, and establish necessary regulation to control the transportation system.

Source: The INDC of Timor-Leste, 2016

The identified mitigation options were determined based on key category analysis and inputs from Working Group of National Communication as well as Government Programs, namely

a. mitigations in power sector through the improvement of fuel combustion efficiency for reducing stationary GHG emissions and the utilization of renewable energy (pico/micro-hydro, biogas, solar PV, and wind power), higher efficiency technology, and less carbon emissions (natural gas) for power generation, etc.
b. mitigations in transport for reducing ‘mobile GHG emissions’ through the improvement of transport system efficiency, i.e. encourage ‘mode shift’ from private vehicles to public transport (bus/mini/micro bus), increase efficiency of fuels combustions in transport by using more efficient vehicles through the restriction of vehicles with above 5 year age, replacing of old cars with the new one for taxis through incentives, providing pedestrian and bicycle lanes to encourage people for walking or using bicycle, replacement of oil fuels with gas fuels (LPG, CNG or LGV) through developing infrastructure for gas utilization in transport (conversion kits, gas station, gas supply infrastructures, etc.).
c. mitigations in buildings (residential and commercial) through improvement of efficiency by the use of higher efficient technology in end user (efficient electric appliances) and the replacement of kerosene with LPG.
d. mitigations of fugitive emissions in oil and gas production facilities by reducing the rate of gas flaring dan venting.

The assessment of GHG emission reduction potential from the implementation of mitigation actions during 2010 – 2015 and its projection 2020 to 2030. It can be seen that the projection of BaU and mitigation scenario will lead to the reduction potential of about 1,487 Gg CO2e. Figure 3-1 presents the GHG emissions under BaU and mitigation projection scenario and the GHG inventory, while the reduction potential for historical and its projection is presented in Figure 3-2, the achievement of emissions reduction (2010 to 2015) and potential reduction (2016 – 2030) is presented in Figure 3-3, and the breakdown of potential reduction of each emissions sources in energy sector is presented in Table 3-2.

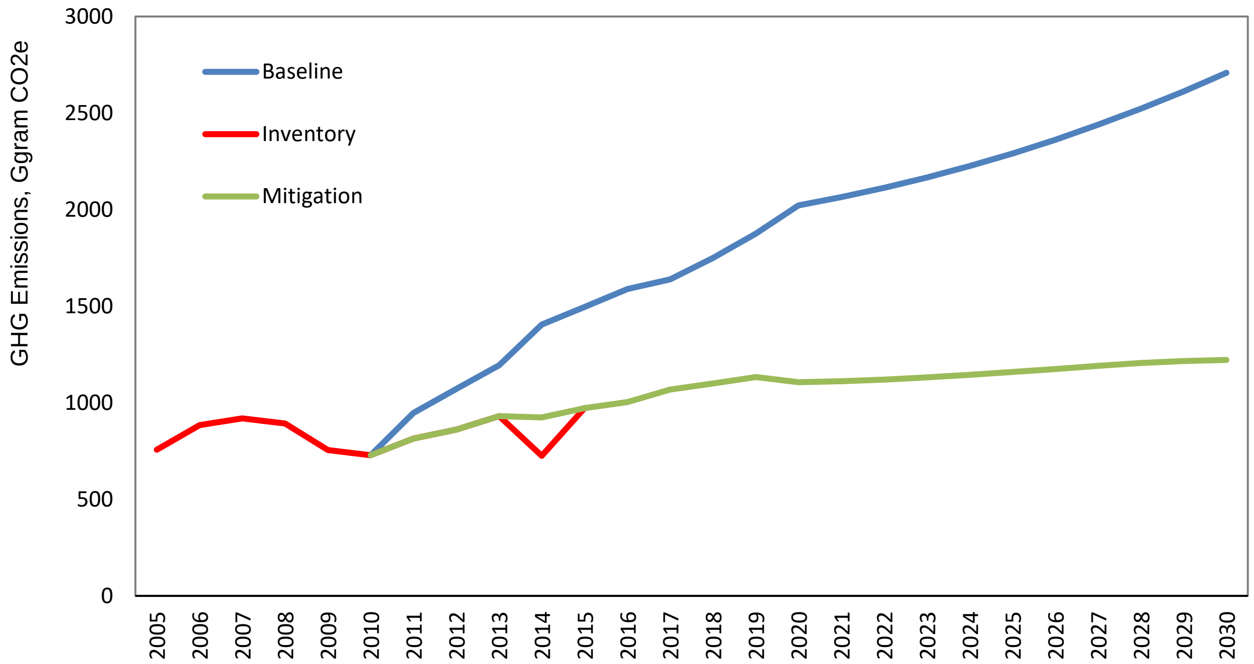


Figure 3-1 The projection of GHG emissions under the baseline, mitigation, and inventory

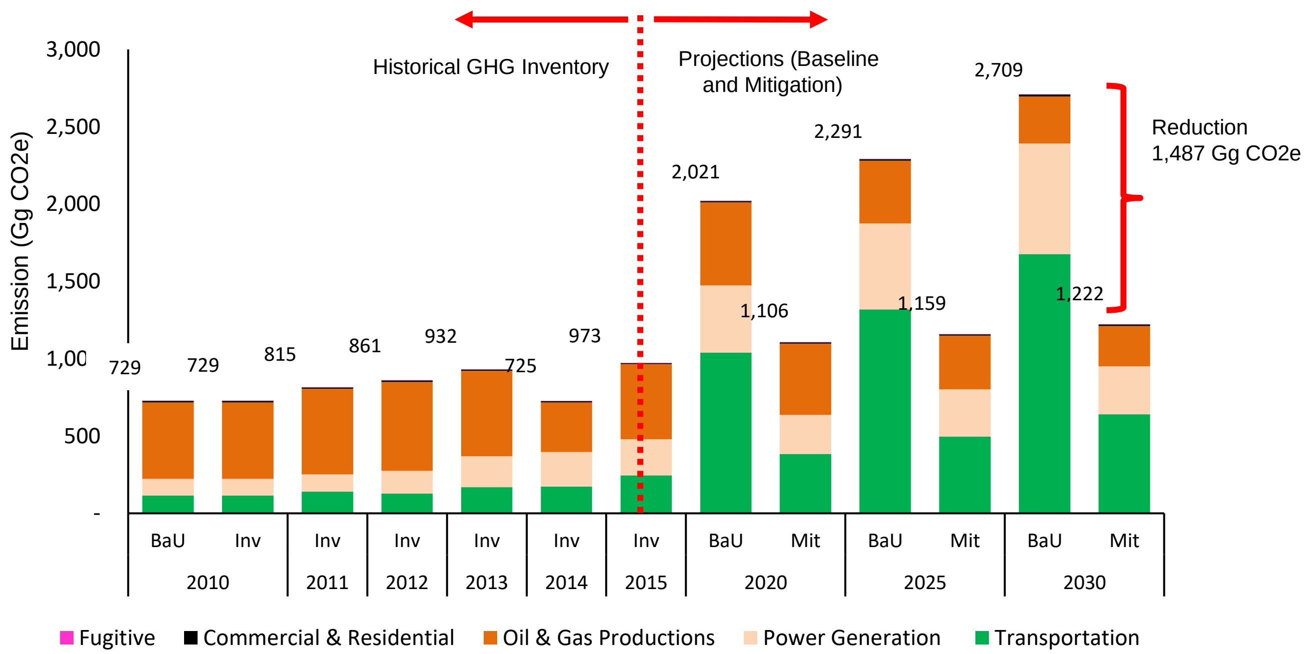


Figure 3-2 GHG Emission reduction potential for historical data and its projection in 2030

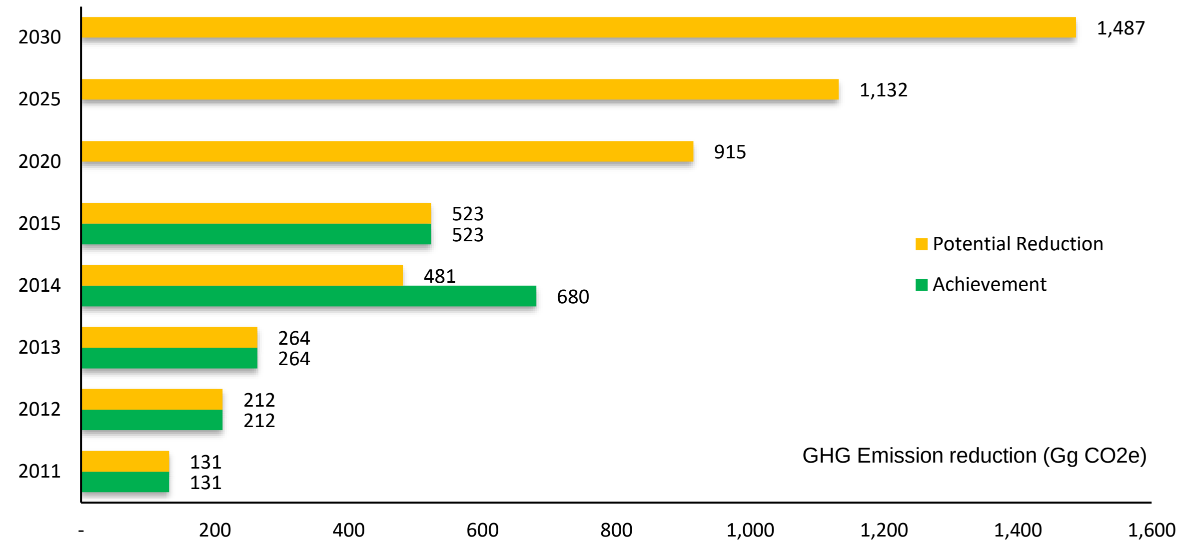


Figure 3-3 GHG emissions reduction (2010 to 2015) and it's potential (2016 to 2030)

Table 3-2 Breakdown of potential reduction of each GHG emissions sources in energy sector

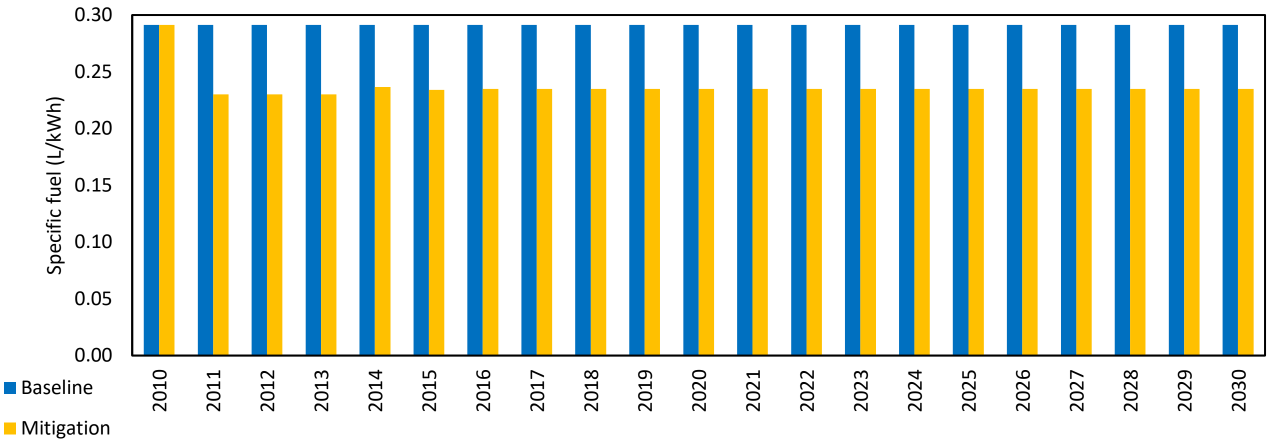
Source of GHG Emissions	2010	2030		2030		2010 – 2030
	Base year	Baseline	Mitigation	Reduction	To Baseline	Growth
	Gg CO2e	Gg CO2e		Gg CO2e	%	%
1.A Fuel Combustion	**727**	**2,707**	**1,221**	**1,487**	**55%**	**35%**
1.A.1. Energy Industries	**602**	**1,020**	**571**	**449**	**17%**	**8%**
1.A.1.a Power generation	108	716	309	402	15%	10%
1.A.1.b Oil and Gas Productions	494	304	262	42	2%	-2%
1.A.2 Manufacturing Industries and Construction						
1.A.3 Transportation	**115**	**1,676**	**641**	**1,035**	**38%**	**27%**
1.A.3.a Civil Aviation	5	54	34	20	1%	13%
1.A.3.b & d Road &Waterborne Transportation	109	1,621	607	1,015	37%	14%
1.A.4 Other Sector	**11**	**12**	**9**	**3**	**0**	**0**
1.A.4.a&b Commercial/ Institutional and Residential	11	12	9	3	0.1%	0.5%
1.A.5 Other/Non-specified						
1.B Fugitives	**2**	**1**	**1**	**-**	**-**	**-3%**
1.B.1 Fugitives Solid Fuels Mining						
1.B.2 Fugitives Oil/Gas	2	1	0.77	-	0%	-3%
1.B.3 Others Energy Production						
Total GHG emission by sources	**729**	**2,709**	**1,222**	**1,487**	**55%**	**7%**

3.1.1.2 Greenhouse Gas Emissions Reduction of Mitigation Actions in Power Sector

The reduction of stationary GHG emissions can be achieved through efficiency improvement in the supply and demand side of energy sector by utilizing more efficient technology. In the supply side, GHG emissions can be reduced by increasing the efficiency of fuels combustion and the use of cleaner energy (renewable energy and less emitting fuels) in power generation.

The Improvement of Fuels Combustion Efficiency in Power Generation

GHG emission from power generation for the baseline and mitigation scenario is estimated according to the specific energy consumption of each scenario. Figure 3-4 presents specific fuels consumption in the existing power generation (2005 – 2015) and its projection (2020 – 2030) under the baseline and mitigation scenarios. It can be seen in the figure, specific fuel consumption (litre/kWh) for mitigation scenario is slightly decreased in line with increasing of power efficiency due to the installment of new and efficient power plant technology. The EDTL new installed power plants (Hera and Betano, 2011/2012) have more efficient than old power plants. The fuel specific consumption of new plants is 0.23-0.24 Litre/kWh while the specific consumption of old plants is 0.27-0.29 Litre/kWh. The baseline is developed base on specific fuel consumption of old power plants while mitigation scenario is developed base the new plants. The projection of electricity generation and its fuel consumptions for BaU, mitigation scenario, and inventory is shown in Figure 3-5.



Sources: Processed from EDTL Data, 2010-2015; 2020 – 2030 is projected

Figure 3- 4 Specific fuel consumption (L/kWh electricity generation)

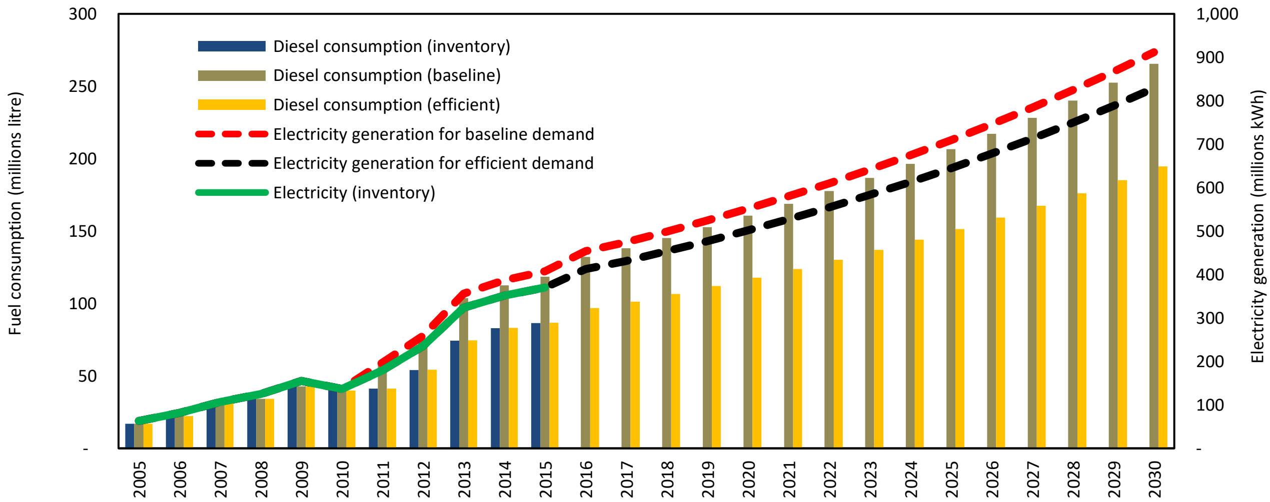


Figure 3-5 Electricity generation and fuel consumptions (BaU, efficient scenario, inventory)

The projection of electricity generation in Figure 3-5 is developed with assumption that the electricity production is inline with the consumption of electricity under the BaU (no efficiency in the demand side) and inline with the consumption of electricity under the mitigation scenario that has already efficient due to demand side management (see sub-chapter 5.2.3). The associated GHG emissions reduction potential from the improvement of specific fuel consumption efficiency in power generation plants is presented in Table 3-4 and Figure 3-6.

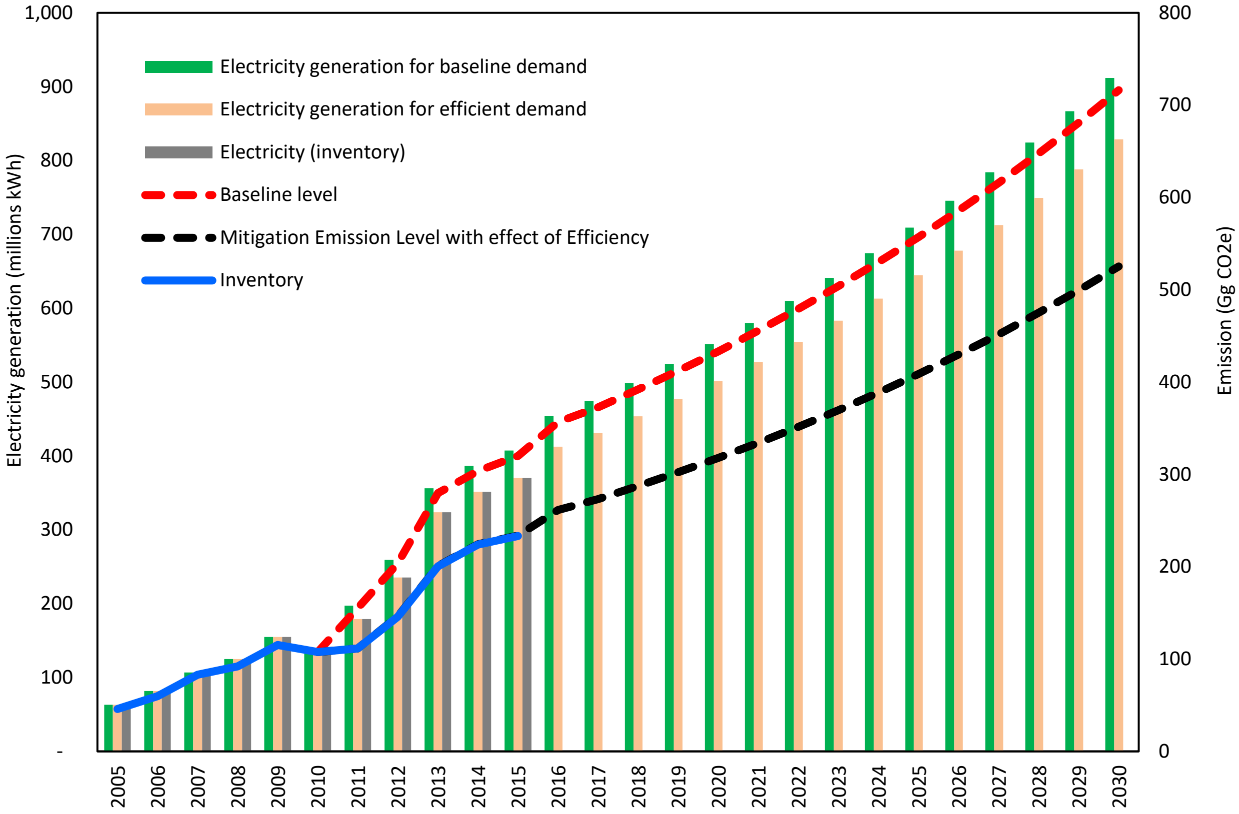


Figure 3-6 Electricity generation and GHG Emissions (BaU, efficient scenario, inventory)

Table 3-3 Electricity generation, fuel consumptions, and GHG emissions

Year	Electricity generation (kWh)			Fuel consumption (millions litre)			GHG emission, Gg CO2e		
	Electricity generation for baseline demand	Electricity generation for efficient demand	Reduction	Baseline	Mitigation	Reduction	Baseline	Mitigation	Reduction
2005	62,991,608	62,991,608	-	17	17	-	14.4	14.4	-
2006	81,673,160	81,673,160	-	22	22	-	18.8	18.8	-
2007	106,761,116	106,761,116	-	31	31	-	26.0	26.0	-
2008	125,059,906	125,059,906	-	34	34	-	28.8	28.8	-
2009	154,915,346	154,915,346	-	43	43	-	36.1	36.1	-
2010	136,908,654	136,908,654	-	40	40	-	33.6	33.6	-
2011	197,297,990	179,361,809	17,936,181	57	41	16	48.5	34.8	13.7
2012	259,199,600	235,636,000	23,563,600	75	54	21	63.7	45.7	18.0
2013	356,117,616	323,743,287	32,374,329	104	74	29	87.5	62.8	24.7
2014	386,555,716	351,414,287	35,141,429	113	83	29	95.0	70.2	24.8
2015	407,153,154	370,139,231	37,013,923	119	87	32	100.1	73.1	27.0
2016	453,999,899	412,727,181	41,272,718	132	97	35	111.6	81.8	29.7
2017	474,481,763	431,347,057	43,134,706	138	101	37	116.6	85.5	31.1
2018	498,925,709	453,568,827	45,356,883	145	107	39	122.6	89.9	32.7
2019	524,628,938	476,935,399	47,693,540	153	112	41	128.9	94.6	34.4
2020	551,656,324	501,505,750	50,150,575	161	118	43	135.6	99.4	36.1
2021	580,076,084	527,341,895	52,734,189	169	124	45	142.5	104.5	38.0
2022	609,959,949	554,509,045	55,450,904	178	130	47	149.9	109.9	40.0
2023	641,383,345	583,075,769	58,307,577	187	137	50	157.6	115.6	42.0
2024	674,425,585	613,114,169	61,311,417	196	144	52	165.7	121.5	44.2
2025	709,170,067	644,700,061	64,470,006	206	151	55	174.3	127.8	46.5
2026	745,704,486	677,913,169	67,791,317	217	159	58	183.2	134.4	48.8
2027	784,121,053	712,837,321	71,283,732	228	167	61	192.7	141.3	51.4
2028	824,516,733	749,560,666	74,956,067	240	176	64	202.6	148.6	54.0
2029	866,993,483	788,175,893	78,817,589	252	185	67	213.0	156.3	56.8
2030	911,658,513	828,780,466	82,878,047	265	195	71	224.0	164.3	59.7

Renewable Energy in Power Generation

In addition, diesel fuels for power generation can be replaced by biomass or biogas based power generation. There are potential sources of biomass in Timor-Leste, i.e. agriculture waste and municipal solid waste (MSW). However, there is no plan to utilize the MSW to generate electricity in Timor-Leste. 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 transportation 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 National Strategic Development Plan 2011-2030, the target for power generation in Timor-Leste is 800 GWh to be operated in 2020. However, it will be less likely to be realized considering until recent there is no addition on installed capacity and the biggest additional demand in the near future is not yet completed (Tibar Port 12 MW will not be commencing until some times after 2020). Therefore, supply projection is based on reasonable electricity consumption intensity for Timor-Leste to be obtained in 2030, which will be around 660 kWh/capita. Referring to this target (supplying 660 kWh/capita or equal to 1,093,990 MWh in 2030) and energy mix planning based on potential energy sources, the projection of electricity generation is presented in Table 3-4 below. The supply mix of power generation is depicted in Figure 3-7.

Table 3-4 Power generation projection by type of energy source

Year	Generation, MWh					
	Diesel Generation	Hydro-power	Wind	Solar PV	Biogas	Total Power Supply
2005	62,992					62,992
2006	81,673					81,673
2007	106,761					106,761
2008	125,060					125,060
2009	154,915					154,915
2010	136,909					136,909
2011	179,362					179,362
2012	234,979			657		235,636
2013	323,086			657		323,743
2014	350,757			657		351,414
2015	369,481			657	0.52	370,139
2016	410,214	1,855		657	0.52	412,727
2017	428,242	2,448		657	0.52	431,347
2018	449,682	3,229		657	0.52	453,569
2019	472,018	4,260		657	0.52	476,935
2020	495,229	5,619		657	0.52	501,506
2021	515,699	7,413	3,504	725	0.52	527,342
2022	538,702	9,779	5,227	800	0.52	554,509
2023	561,494	12,901	7,798	882	0.52	583,076
2024	583,488	17,019	11,634	973	0.52	613,114
2025	603,820	22,451	17,356	1,073	0.52	644,700
2026	621,220	29,617	25,892	1,184	0.52	677,913
2027	633,833	39,071	38,626	1,306	0.52	712,837
2028	638,953	51,543	57,624	1,440	0.52	749,561
2029	632,626	67,996	85,966	1,588	0.52	788,176
2030	609,082	89,700	128,246	1,752	0.52	828,780

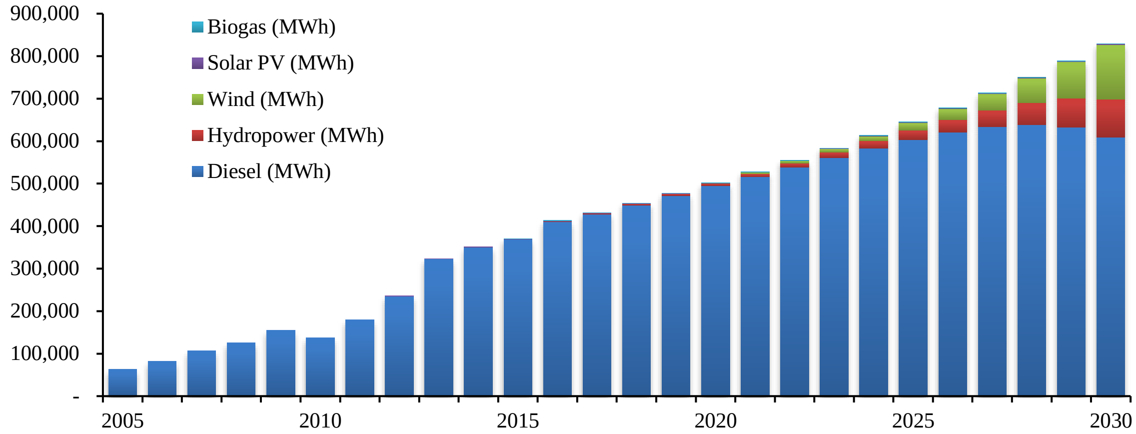


Figure 3-7 Energy supply mix of the power generation

In estimating GHG emissions level for the baseline scenario, diesel oil is assumed to be the sole fuel to supply power. In mitigation scenario, the GHG emissions will come mostly from lower diesel oil consumption due to shifting to renewable energy and low emission fuels, which includes hydro, wind, diesel, biogas and biodiesel (blended in diesel). Fuels consumed in each baseline and mitigation scenario, associated GHG emissions level and reduction potential are presented in Table 3-5 below and illustrated in Figure 3-8. The GHG emissions under each of baseline and mitigation scenario are depicted in Figure 3-9.

Table 3-5 GHG emission reduction projection potential from the electricity sector using renewable sources

Year	Fuel consumption for efficient demand, Litres	Mitigation Fuels Consumption, Litres			GHG Emissions, kTon CO2e		
	Diesel Oil	Diesel Oil	Bio in Biodiesel (B20)	Total	Base line	Mitig ation	Potential Reduction
2010	39,861,244	39,861,244	-	39,861,244	108	108	-
2011	41,253,216	41,253,216	-	41,253,216	111	111	-
2012	54,196,280	54,045,170	-	54,045,170	146	146	0.41
2013	74,460,956	74,309,780	-	74,309,780	201	201	0.41
2014	83,146,821	82,991,303	-	82,991,303	224	224	0.42
2015	86,607,116	86,453,198	-	86,453,198	234	233	0.42
2016	96,946,071	96,355,747	-	96,355,747	262	260	2
2017	101,319,720	100,590,284	-	100,590,284	273	271	2
2018	106,539,423	105,626,470	-	105,626,470	287	285	2
2019	112,028,030	110,872,982	-	110,872,982	302	299	3
2020	117,799,395	93,059,978	23,264,995	116,324,973	318	251	67
2021	123,868,083	96,906,704	24,226,676	121,133,380	334	262	73
2022	130,249,414	101,229,246	25,307,311	126,536,557	351	273	78
2023	136,959,492	105,512,130	26,378,033	131,890,163	370	285	85
2024	144,015,254	109,645,115	27,411,279	137,056,394	389	296	93
2025	151,434,509	113,465,649	28,366,412	141,832,062	409	306	102
2026	159,235,983	116,735,341	29,183,835	145,919,176	430	315	115
2027	167,439,366	119,105,637	29,776,409	148,882,046	452	322	130
2028	176,065,365	120,067,647	30,016,912	150,084,559	475	324	151
2029	185,135,750	118,878,677	29,719,669	148,598,347	500	321	179
2030	194,673,416	114,454,420	28,613,605	143,068,025	525	309	216

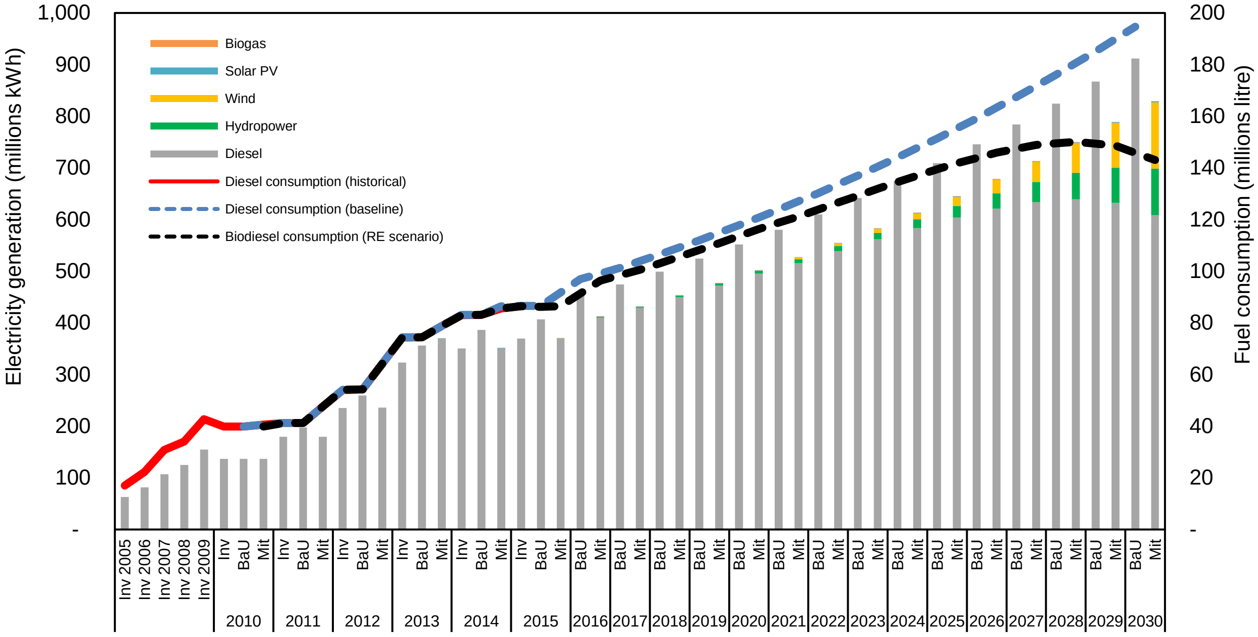


Figure 3-8 Electricity generation and fuel consumptions (BaU, renewable energy scenario,inventory)

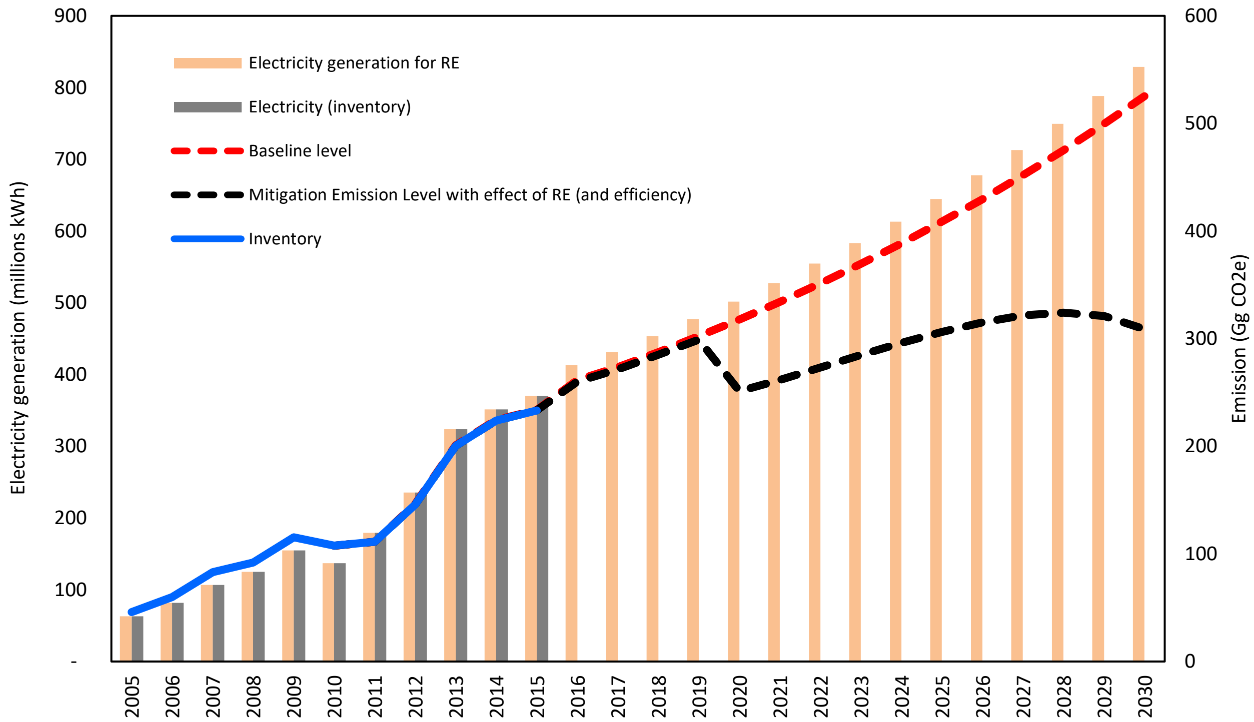


Figure 3-9 Electricity generation and GHG Emissions (BaU, renewable energy scenario, inventory)

Summary for Power Sector

The overall GHG emissions reduction in power sector is depicted in Figure 3-10, through the level difference between baseline and mitigation emissions.

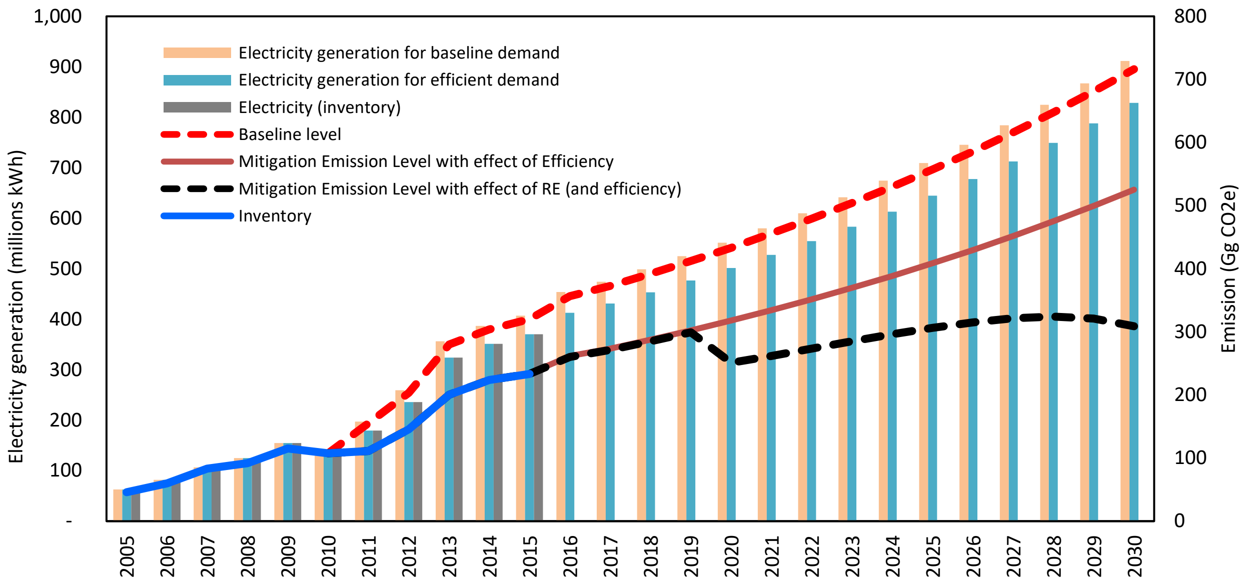


Figure 3-10 Projection of electricity generation and GHG emissions from power generation for baseline and mitigation scenario

Demand Side

A large source of abatement method on the demand side is the energy efficiency and less carbon fuels, which is particularly valid for the industrial, residential and commercial sector of this society.

3.1.1.2.1 Residential and Commercial

The reduction of stationary GHG emissions can be achieved through efficiency improvement in the supply and demand side of energy sector by utilizing more efficient technology. In the supply side, GHG emissions can be reduced by increasing the efficiency of fuels combustion and the use of cleaner energy (renewable energy and less emitting fuels) in power generation.
Demand side projection in residential and commercial is developed by assuming that the energy consumption will increase in accordance to the growth of population. Types of fuels that assessed to be the baseline fuels are kerosene and fuel wood, with the addition of electricity as indirect source. In 2030, it is estimated that kerosene will provide 2.84% of total energy requirement in baseline scenario, while share of fuel wood (biomass) is still the greatest (80.7%) considering historically it is the backbone of energy source in this sector. Electricity consumption in commercial and residential sub-sector will grow accordingly to meet 514 kWh/capita in 2030.

Mitigation scenario assumes LPG will rise 2% per annum throughout 2017-2020 and slightly increase more throughout 2021-2030 (3%) to compensate the phase-out of kerosene. 10% efficiency is implemented in electricity appliances and biomass cook-stoves. Increasing use of renewable energy (biomass, biogas, solar PV, etc.) and less emitting carbon fuels (biomass and LPG in household and commercial buildings) can contribute to reduce GHG emissions from fuel combustions in residential and commercial sectors. These measures considered as potentials in mitigation scenarios, with excluding biogas and solar PV due to several constraints related to sustainability of installation. Other effort that also mitigate the GHG emissions from energy use in residential and commercial can be in the form of electricity efficiency, however this only be reported in the category of indirect source of

GHG emission reduction. Figure 3-11 shows historical and projection energy demand in commercial and residential sub-sector.

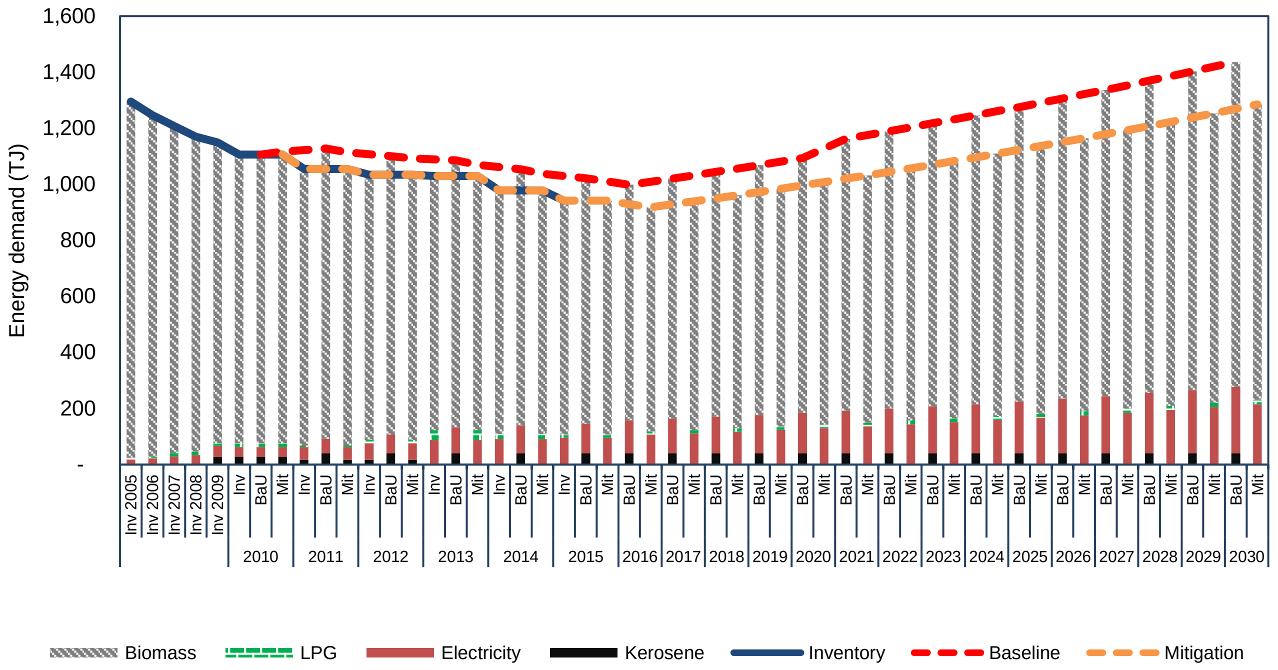


Figure 3-11 Energy demand in commercial and residential sub-sector (historical and projection to 2030)

Figure 3-11 shows direct and indirect emission in residential and commercial sub-sector. In this sub-sector, mitigation action classified into two main categories: i) efficient electric appliances, and ii) replace kerosene to LPG. In Figure 3-12, emission reduction with direct emission amount of 3 Gg CO2e in 2030 due to replacement kerosene to LPG. Furthermore, emission reduction with indirect emission amount 49 Gg CO2e in 2030 due to using more efficient electric appliances.

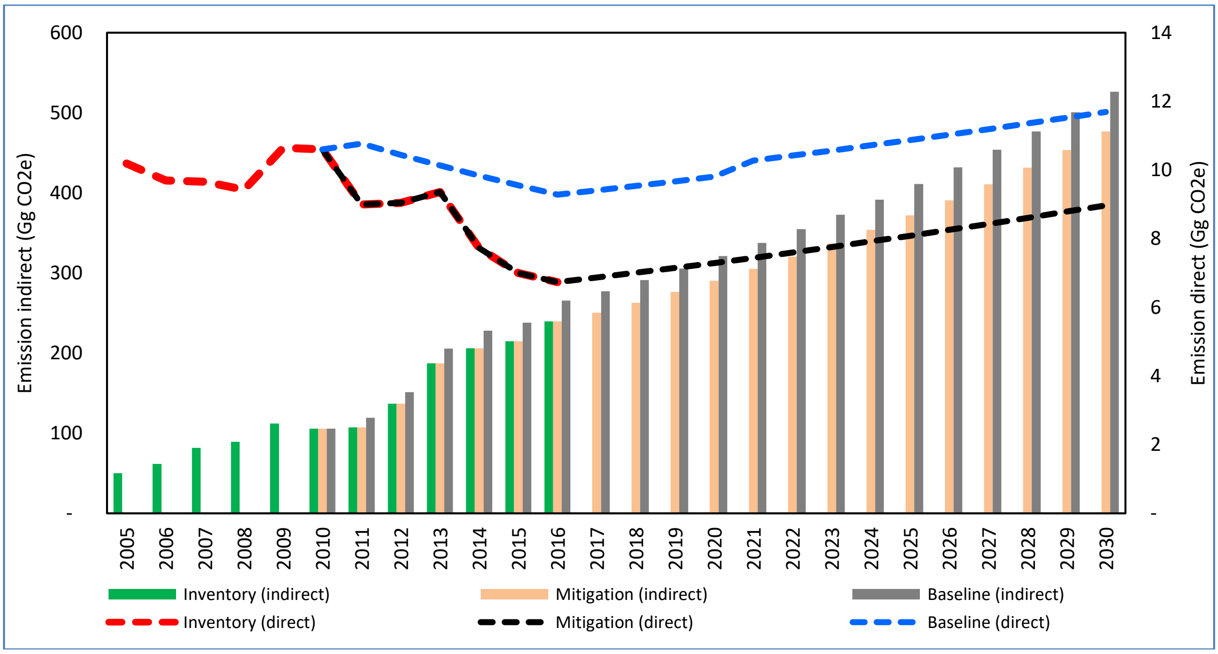


Figure 3-12 Emission direct and indirect in commercial and residential sub-sector (historical and projection to 2030)

3.1.1.2.2 Transportation

In the transportation sector, GHG emissions are generated from fuel combustion. The types of fuel combusted are gasoline, diesel oil and jet/kerosene. Mobile combustion technology is varying and utilized in three modes of transportation activities, i.e. road, maritime (water borne) and aviation. Gasoline is all consumed in road transportation, while diesel oil is common fuel in water borne transportation mode and some vehicles in road transport. The utilization of jet/kerosene in Timor-Leste is mostly for international air transportation and few domestic air transports (helicopter and charter airplane).

In developing the baseline scenario for transportation sector, the number of vehicles for each of transportation mode is estimated using some assumptions regarding the trend of annual growth in period of 2003-2015 (average). The average annual growth of cars consuming gasoline is assumed to be approximately 8% from 2010-2017 and 5% from 2020-2030, diesel oil fueled cars grows 5%, motorcycle use rises 8%, water borne navigation grows 6.5%, and aviation increase 6.5%. Referring to the growth of vehicle number, total fuel consumption in 2030 is estimated to be 677.4 million litre, with share of gasoline is 59.7%, diesel oil 36.7%, and jet-kerosene 3.7% (see Figure 3-13).

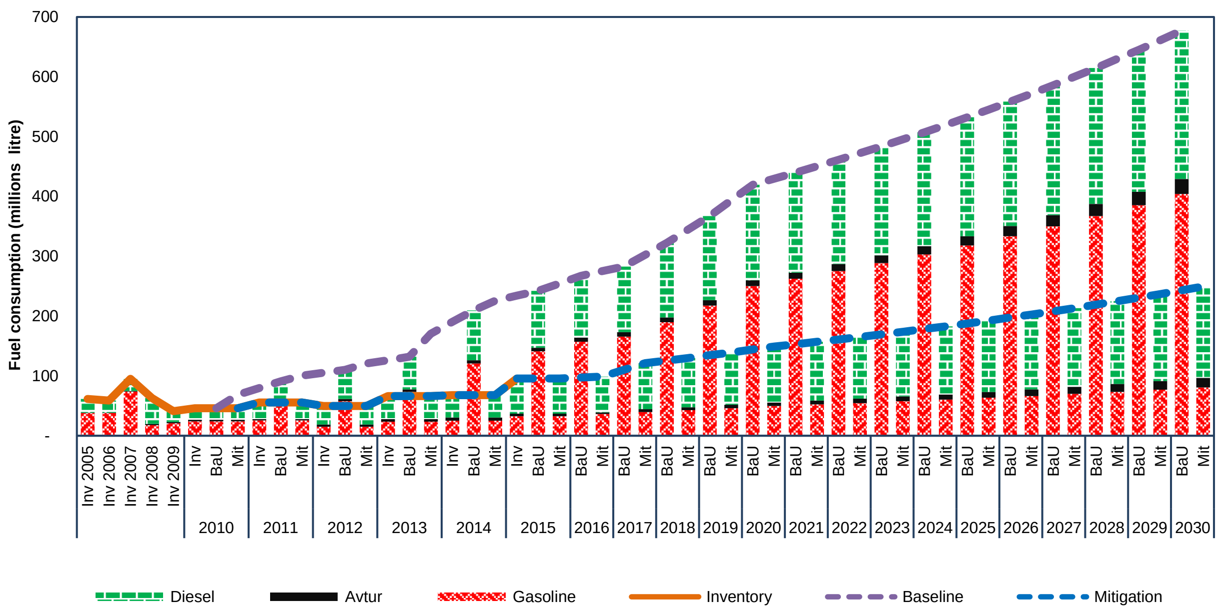


Figure 3-13 Fuels consumption in transportation sector

Taking into consideration the sharing of fuel type and mode of transportation projected in baseline scenario, therefore potential mitigation actions in the country can be achieved by increasing efficiency in mobile combustion technology and increasing efficiency through shifting to public mass transport facilities (bus or micro-bus). It is inline with INDC of Timor-Leste that stated one of the potential mitigation actions in transportation sector is the improvement of energy efficiency in transport for reducing mobile GHG emissions, where improvement of the efficiency is planned through the increasing use of public transport and more efficient vehicle (5 year minimum age of vehicle). In this SNC, it is assessed only the effect of shifting to public transport as the mitigation potential. Mode shift is assumed in each of traffic mode: (i) private car shifts to bus 20%, (ii) motorcycle shifts to bus 30%, and (iii) other cars shifts to bus 50%. The depiction of GHG emissions under each of scenario is presented in Figure 3-14.

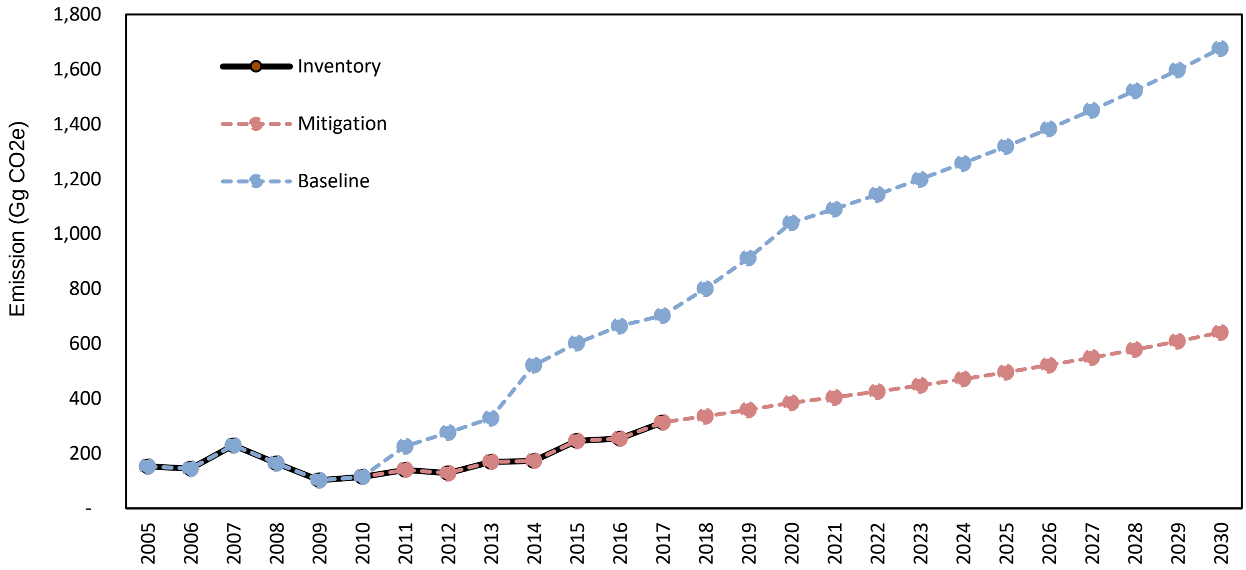


Figure 3-14 GHG emissions in transportation sector under inventory, baseline and mitigation scenario

Virtually, reducing mobile GHG emissions can also be strived by replacing fossil fuels (gasoline or diesel oil) with zero or less emission energy, i.e. natural gas based fuels (CNG, LPG, or LGV), electricity, 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. Electrical vehicles utilization is considered difficult in Timor-Leste, although recently there is some electrical motorcycle (*ojek*) operating to serve as public passengers transport. 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 to biofuels (biodiesel and bioethanol). However, this potential will face a major barrier in the supply of biofuels in Timor-Leste since there is no regulation established to promote biofuels production.

3.1.1.2.3 Industry

There are no industries in Timor-Leste that identified consuming significant amounts of energy. Therefore, on the demand side, efficiency in the industrial sub-sector is not included in this report.

3.1.1.2.4 Oil and Gas Production

As discussed previously, fuel combustion activities for own use energy supply at oil and gas production facilities is included as 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.

Energy efficiency potentials can include measures to reduce of fugitive emissions from oil and gas production facilities (offshore). In any case, actions to manage fugitive sources in oil and gas facilities are considered not in the domain authority of Government of Timor-Leste. Regarding the aforementioned obstacles, this SNC is not assessing the mitigation potentials in oil and gas production. Figure 3-15 shows production and emission from oil and gas production.

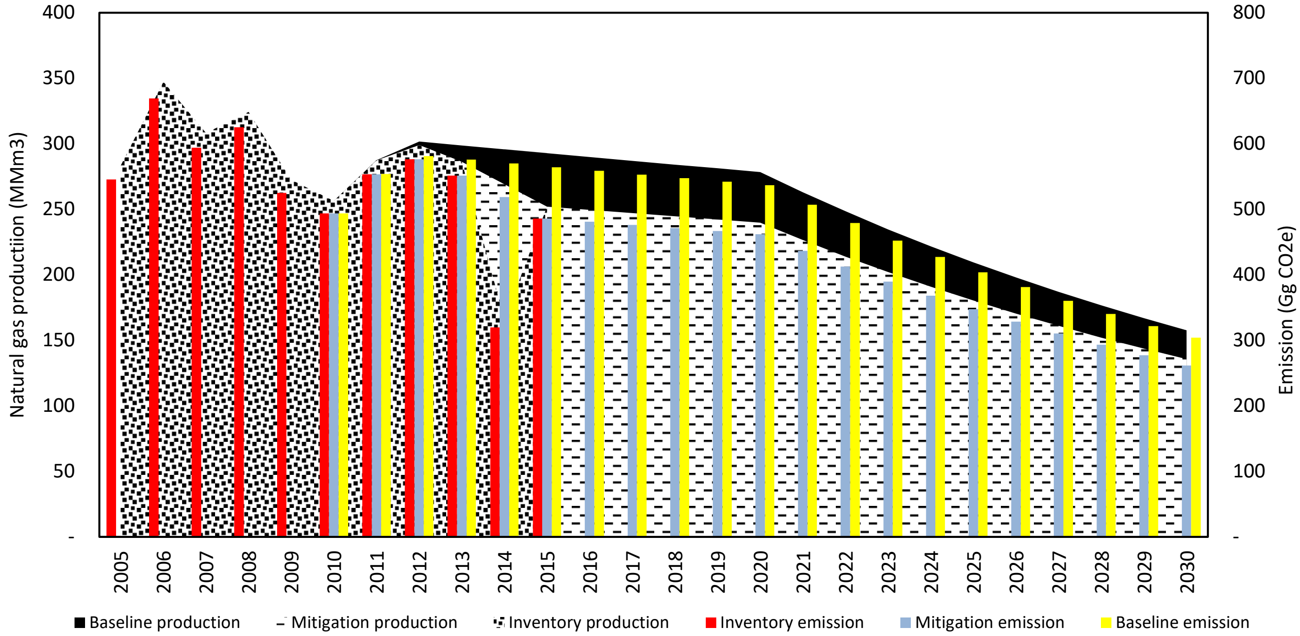


Figure 3-15 Production and emission in oil and gas productions (historical and baseline and projection)

3.1.2 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.

3.1.2.1 Mitigation Measures 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. Implementation of mitigation actions in this sector should also contribute to poverty alleviation. As stated in the Timor-Leste Strategic Development Plan 2011 – 2030 (*TLSDP 2011-2030*) '*the sustainability of Timor-Lesteôs forests i 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), namely conservation of forest, enhancing and expanding carbon sink, and 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.

Eight potential mitigation measures have been assessed namely (i) planting of teak, (ii) rosewood, (iii) sandalwood, (iv) mahogany, (v) coffee and (vi) Candlenut for rotational management in shrub areas; (vii) bamboo for anticipation of high slope and landslide potential in Timor-Leste; and (viii) mangrove restoration on swampy shrub lands. It was found that potential mitigation of these measures ranges from 42.43 to 365.62 tonnes C per ha[3] 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 1.91 to 10.21 USD per ton C, with a life cycle cost ranging from 0.02 to 21.48 USD/Ton of C and a net present value of benefits from –8.45 to 65.63 USD per Ton of C (Table 3-6). 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, mahogany, coffee, candlenut and bamboo. However, further study on this needs to be done using more precise data as most of the input data used for these options was obtained from literature.

Table 3-6 Cost effectiveness of the mitigation measures

Option	Investment Cost		Life Cycle Cost		NPV Benefit		Potential Mitigation
	$/t C	$/ha	$/t C	$/ha	$/t C	$/ha	Ton C ha^{-1}
Teak	4.63	401.05	10.88	942.51	-3.15	-272.72	86.60
Sandalwood	10.21	601.57	21.48	1265.39	65.63	3865.80	58.91
Rosewood	3.15	372.07	7.54	889.91	-8.04	-948.15	117.98
Mahogany	1.91	187.33	7.25	711.11	3.22	315.91	98.08
Coffee	8.23	578.26	14.76	1036.89	4.89	343.76	70.26
Candlenut	4.05	1480.29	0.02	8.84	12.04	4401.89	365.62
Mangrove	3.44	1060.24	0.03	8.84	-8.45	-2601.07	307.95
Bamboo	2.94	124.87	13.95	591.98	35.12	1490.15	42.43

3.1.2.1.1 Area of Wastelands Available for Mitigation

Land areas suitable for mitigation measures can be classified into two categories, i.e., dryland shrubs and swampy shrubs. Total land available in 2015 for the implementation of mitigation measures in these two land categories are about 559,086 ha and 9,903 ha respectively. Of 559,086 ha, the area suitable for teak is 12.94%, for sandalwood 33.33%, for rosewood 9.02%, for mahogany 16.59%, for coffee 13.23%, for candlenut 0.17%, and for bamboo 14.72%. The suitability of land for the commodities was assessed based on biophysical condition of the land (topography, climate, the presence of the plants in the area) and expert judgement. For the swampy shrub, the area targeted for mangrove restoration is 9,734 ha and for fishpond is only 169 ha. The distribution of locations suitable for the implementation of the mitigation measures are presented in Figure 3-16.

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

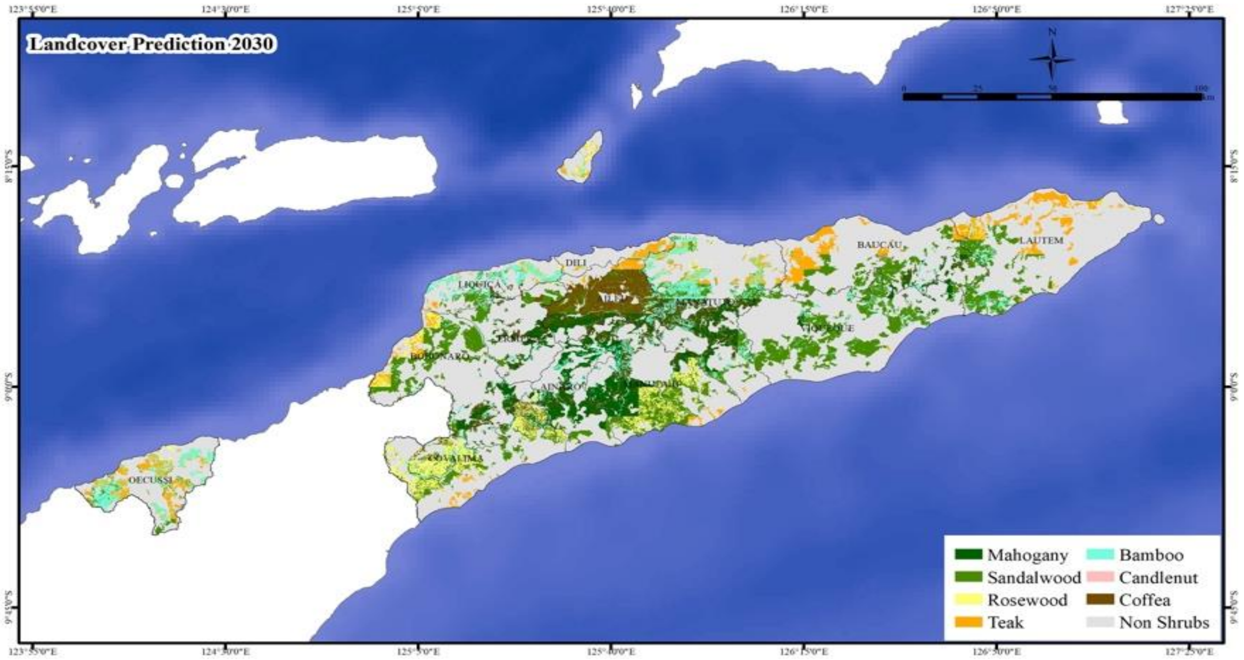


Figure 3-16 Abatement cost and potential emissions reduction from the implementation of the five mitigation measures

3.1.2.1.2 Development of Land Use Change Scenarios for Mitigation

The implementation of mitigation measures in the LUCF sector follows five scenarios namely (i) baseline scenario, (ii) government plans scenario, (iii) mitigation A scenario, (iv) mitigation B scenario and (v) maximum scenario, each with specific assumptions. Baseline scenario (B) is developed with the assumption that future land use follows historical land use as shown in Figure 3-17.

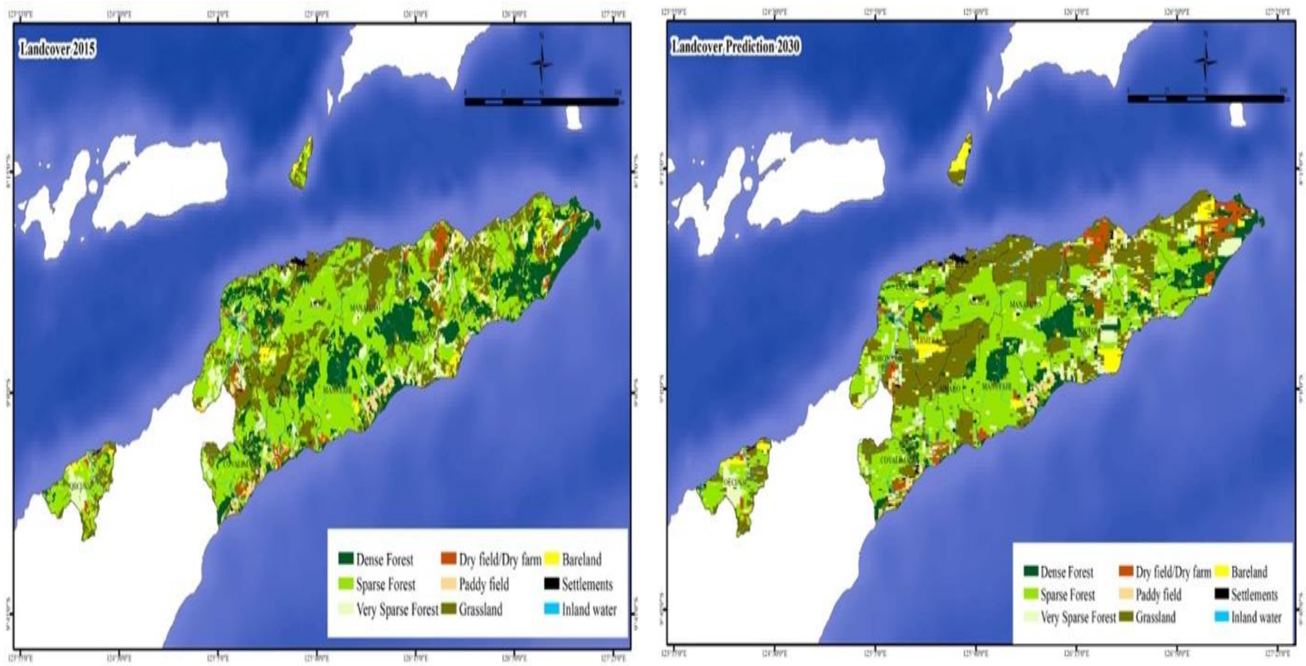


Figure 3-17 Change in carbon pool under baseline and mitigation scenario (ton of Biomass)

In the government scenario (G), the land use change follows land use plans as defined in Timor-Leste National Strategic Development Plan 2011-2030, and the area of dense forest will decrease following historical trend. Mitigation A scenario (MA) is similar to government scenario but the area of dense forest will decrease only up to 228,175 ha follows Forest Conservation Plan while the land demand for agriculture activities follows the historical trend which is similar to BAU. The mitigation B scenario (MB) is similar to MA but the rate of mitigation is only half of those of government scenario. The Maximum scenario (Mx) is also the same as government plants, but the rate of mitigation is higher than those of the government scenario with target that unproductive land (shrubs and swampy shrubs) by 2030 will remain only 10% of the current. The demand of land for agriculture activities for Government, Mitigation B and Maximum scenarios follows sectoral development target. Assumption used in each scenario in projecting future land demand for agriculture is summarized in Table 3-7.

Based on the above assumptions, in the period of 2011-2030, the total area of shrubs used for the implementation of mitigation measures under B, G, MA, MB and Mx scenarios were 0 ha, 301,906 ha, 75,477 ha, 150,953 ha, and 503,177 ha respectively, while those for swampy shrubs are 0 ha, 5,256 ha, 1,314 ha, 2,628 ha, and 8,760 ha respectively. The area used for the implementation of mitigation measures in the five scenarios is presented in Table 3-8 and the projection of area change by land cover types for the five scenarios is presented in Figure 3-18.

Table 3-7 Assumption used for the five scenarios

Land Use	Criteria	Commodity	Baseline	Government	Mitigation A	Mitigation B	Maximum
Settlement	Population		Medium projection, The land demand for settlement will increase as the population increase and calculated following the Indonesian standard (SNI 03-1733-2004)				
Secondary forest	Amount of wood		With the increase in number of buildings, the amount of wood use will increase and also the area of secondary forest will decrease and Firewood consumption will also increase and will affect area				
Agriculture	Area (ha)	Rice	Follow historical trend	Increase 40% by the year 2020[1]	Follow historical trend	Same as Government scenario	Same as Government scenario
		Maize	Follow historical trend	Increase 5% by the year 2020 and 14% by the year 2030[1]	Follow historical trend	Same as Government scenario	Same as Government scenario
		Other Crop	Rehabilitate 40,000 ha of coffee plantations by 2020 and average area for other crop [o]				
	Yield (t/ha)	Rice	2.45[2]	Increased to 4.5 t/ha by the year 2030[1]	Increased to 3.0 t/ha by the year 2030[3]	Same as Government scenario	Same as Government scenario
		Maize	1.94[2]	Increased to 2.5 t/ha by the year 2030[1]	Increased to 2.0 t/ha by the year 2030[3]	Same as Government scenario	Same as Government scenario
		Other Crop	Average yields of green bean will increase from 150-200k g/ha to 650 kg/ha by the year 2020 and average yield increased by 20% for other crop by the year 2020 [o]				
	Planting Index	Rice	0.9[2]	Increase to 1.7 in the year 2030[1]	Increase to 1.2 in the year 2030[3]	Same as Government scenario	Same as Government scenario
		Maize	0.8[4]				
		Other Crop	-				
	Storage losses (%)	Rice	13.7%[2]	Decrease to 5% by the year 2030[1]	Decrease to 10% by the year 2030[3]	Same as Government scenario	Same as Government scenario
		Maize	26.1%[2]	Decrease to 5% by the year 2030[1]	Decrease to 15% by the year 2030[3]	Same as Government scenario	Same as Government scenario
		Other Crop	-				
	Rice Consumption (kg/cap/yr) **	Rice	106				
		Maize	67				
		Other Crop	-				
	Target	Rice	Rice self-sufficiency in the year 2020				
		Maize	-				
		Other Crop	Substitute at least 50% of imported fruit and vegetables by 2020				
Savana and agriculture mix shrubs		livestock	livestock number will increase 20% in 2030				
Shrubs and Swampy Shrubs	Reforestation		0%	Remaining unproductive land by 2030 will be 40%	Remaining unproductive land in 2030 will be 85%	Remaining unproductive land in 2030 will be 70%	Remaining unproductive land in 2030 will be 10%

Note: [1]Follows the National strategic development plan 2011-2030; [2]Assumed based on current condition as defined in Timor Leste Food Security Bulletin 2012 & 2013; [3]Assumed based on historical trend and expert judgement; [4] Assumed based on historical trend and expert judgement taking into account the current condition.

Table 3-8 Land area used for mitigation measures (Ha)

Land cover categories	Area technically available in 2015	Total area required for mitigation scenario	Total area required for mitigation scenario	Total area required for mitigation scenario
		(2016-2020)	(2021-2025)	(2023-2030)
	Baseline			
Shrubs	559,086	0	0	0
Teak		0	0	0
Sandalwood		0	0	0
Rosewood		0	0	0
Mahogany				
Swampy Shrubs	9,903	0	0	0
Mangrove rehabilitation		0	0	0
Reforestation		72.66	72.66	72.66
Coffee		29.07	29.07	29.07
Sandalwood		43.60	43.60	43.60
	Government Scenario			
Shrubs	559,086	**100,635**	**100,635**	**100,635**
Teak		13,022	13,022	13,022
Sandalwood		33,538	33,538	33,538
Rosewood		9,074	9,074	9,074
Mahogany		16,697	16,697	16,697
Agroforestry (Coffee)		13,317	13,317	13,317
Agroforestry (Candlenut)		170	170	170
Bamboo		14,817	14,817	14,817
Swampy Shrubs	9,903	**1752**	**1752**	**1752**
Mangrove rehabilitation		1752	1752	1752
	Mitigation Scenario			
Shrubs	559,086	**50,318**	**50,318**	**50,318**
Teak		6,511	6,511	6,511
Sandalwood		16,769	16,769	16,769
Rosewood		4,537	4,537	4,537
Mahogany		8,349	8,349	8,349
Agroforestry (Coffee)		6,659	6,659	6,659
Agroforestry (Candlenut)		85	85	85
Bamboo		7,408	7,408	7,408
Swampy Shrubs	9,903	**876**	**876**	**876**
Mangrove rehabilitation		876	876	876
	Maximum Scenario			
Shrubs	559,086	**167,726**	**167,726**	**167,726**
Teak		21,703	21,703	21,703
Sandalwood		55,896	55,896	55,896
Rosewood		15,123	15,123	15,123
Mahogany		27,829	27,829	27,829
Agroforestry (Coffee)		22,195	22,195	22,195
Agroforestry (Candlenut)		284	284	284
Bamboo		24,695	24,695	24,695
Swampy Shrubs	9,903	**2920**	**2920**	**2920**
Mangrove rehabilitation		2920	2920	2920

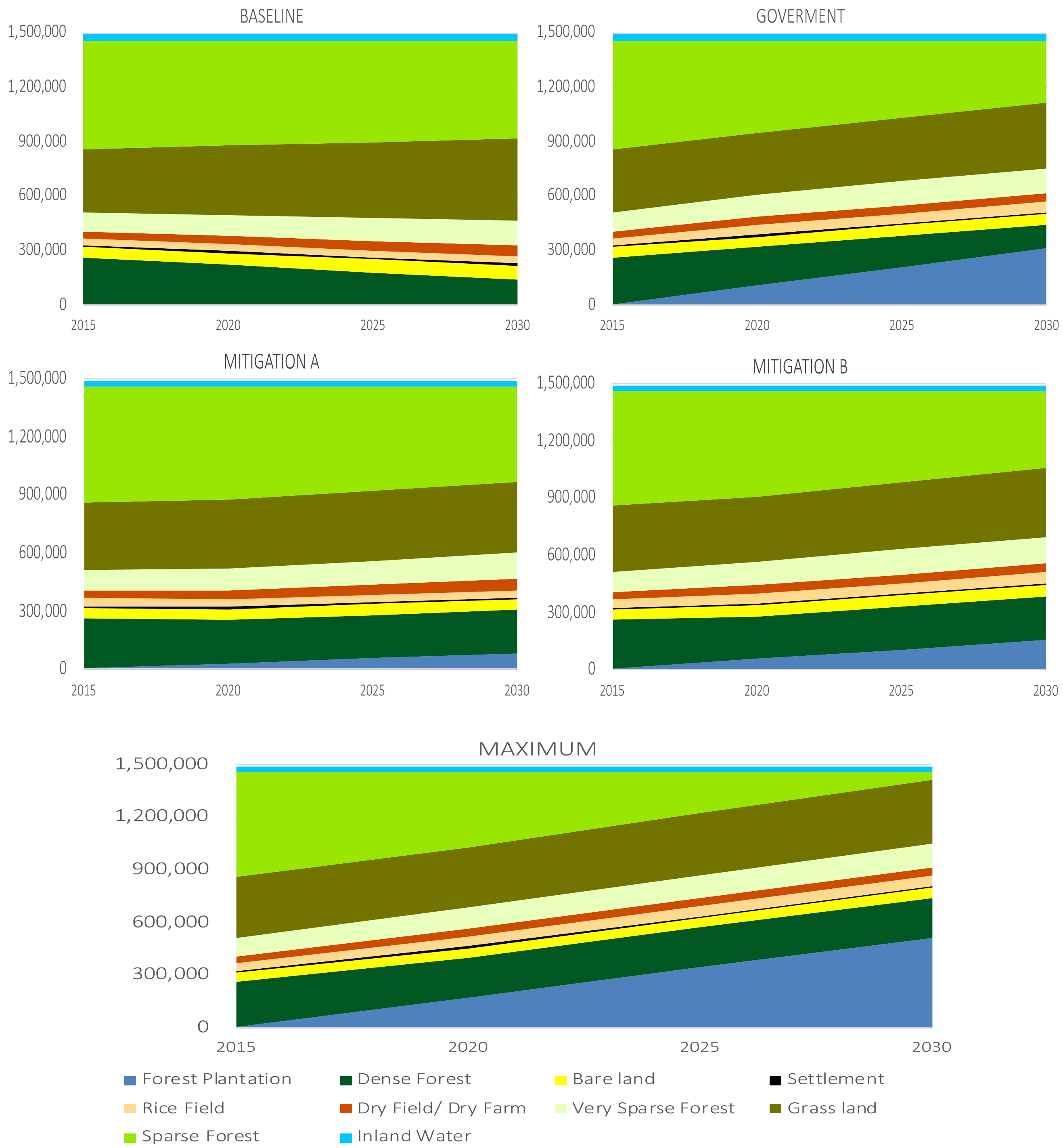
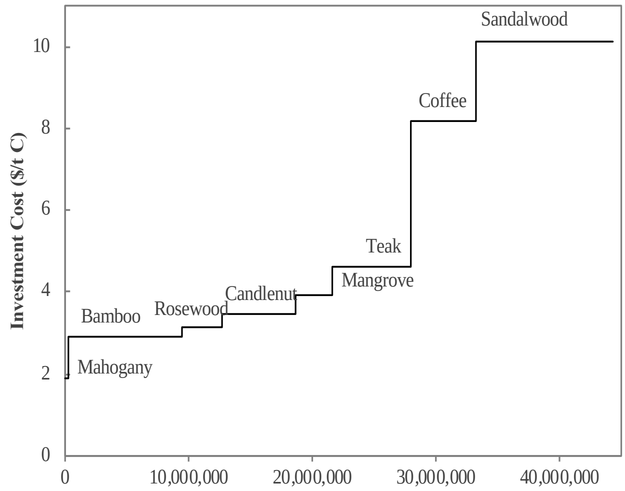


Figure 3-18 Projection of area changes of land cover from 2015-2030 under the five scenarios

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 43,966,667 Tons of C with a total investment of about 242 million USD and a total life cycle cost of around 542 million USD (Figure 3-19; Table 3-9).



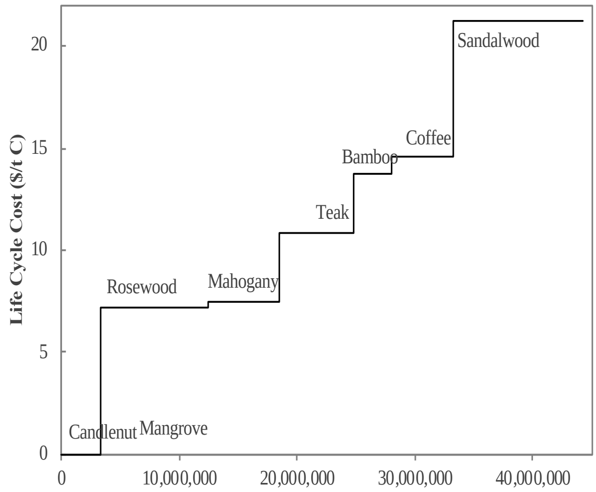


Figure 3-19 Abatement cost and potential emissions reduction from the implementation of the five mitigation measures

Table 3-9 Total investment and life cycle cost required for the implementation of mitigation measures in all available lands

Options	Potential Area (ha)	Investment Cost (US$/ha)	Total Investment Cost (US$)	Life Cycle Cost (US$/ha)	Total Life Cycle Cost (US$)
Teak	72,345	401.05	29,013,762	942.51	68,185,986
Sandalwood	186,320	601.57	112,084,683	1265.39	235,766,702
Rosewood	50,412	372.07	18,756,731	889.91	44,861,855
Mahogany	92,762	187.33	17,377,124	711.11	65,964,242
Coffee	73,984	578.26	42,782,212	1036.89	76,713,950
Candlenut	947	1480.29	1,401,231	8.84	8,372
Mangrove	9,734	1060.24	10,319,910	8.84	86,088
Bamboo	82,316	124.87	10,279,072	614.48	50,581,961
			242,014,725		**542,169,156**

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

Under the baseline scenario, the national carbon pool tends to decrease continuously through 2030 (Figure 3-19). 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 decreases 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 3-9. 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.

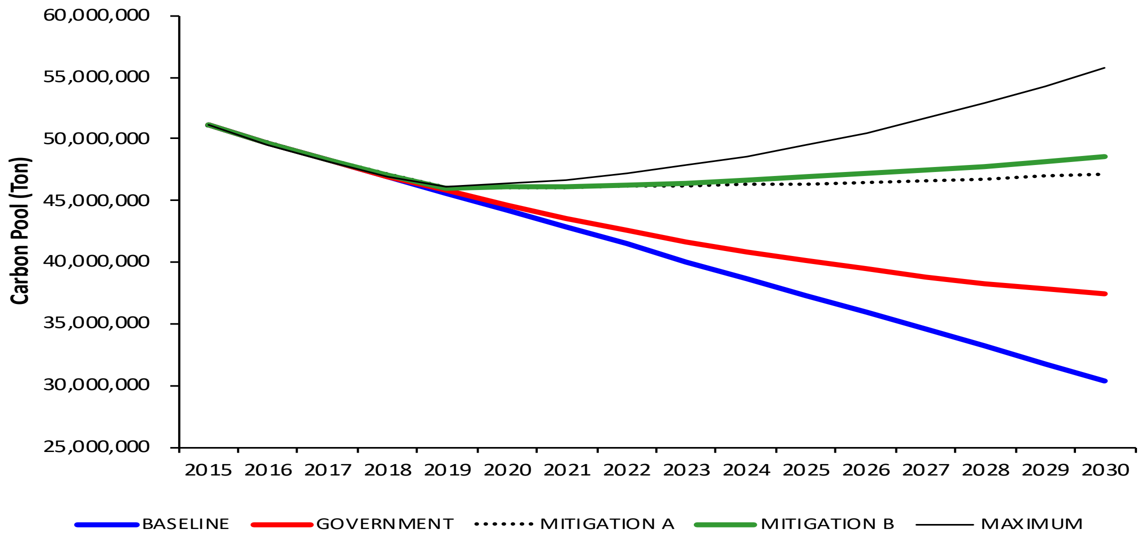


Figure 3-20 Change in carbon pool under baseline and mitigation scenario (ton of Biomass)

3.1.3 Assessment of Mitigation Potential for Waste Sector

As the INDC of Timor-Leste (submitted to UNFCCC in 2016) has not determined the target of GHG emissions reduction in waste sector, the potential of GHG emissions reduction from mitigation actions in this sector is assessed based on identified mitigation options and programs that either are already being implemented or still under planning. The assessment is carried out through discussion with Working Group on the Waste Sector, in which government programs and plans are also uses as the basis in identifying the potential mitigations. The mitigation options and programs are identified based on the key sources with high GHG emissions level. Key category analysis is used in determining the key sources of GHG emissions.

In the waste sector, municipal solid waste (MSW) management is considered as the key sources of GHG emissions. As there are several activities and policies implemented as MSW management, the mitigations assessed in this report only cover activities related to the MSW management that lead to GHG emission reduction. In Timor-Leste, the MSW management is implemented under Law No.2/2017 about municipal solid waste (MSW) management system. Referring to this law, the MSW have to be managed in a proper way so that the MSW is to be reduced, 3R, composted, and disposed in a managed landfill. The implementation of this Law is varied depend on the readiness of MSW system in each districts. To meet this Law, Dili as the capital city of Timor-Leste will have better management system compared to other Districts (Table 3-10 and 3-11). Since the Law is implemented in 2017 and beyond, while 2010 is determined as the base year of mitigations under the INDC of Timor Leste, the MSW management under this Law that lead to the reduction of GHG emissions will be included in the development of mitigation scenarios.

The baseline is developed based on existing condition of MSW management in 2010 and will be projected until 2030 with the same management system. The MSW management considered as assumptions in developing GHG emissions projection under the baseline and mitigation scenarios for Dili and other districts are presented in Table 3-10 and 3-11.

Table 3-10 Mitigation measures for GHG emission reduction in Waste Sector in Dili

Waste Management	Baseline	Mitigation	Remarks
Open Burning	32%	32% (2016-2019) 0% (2020-2030)	No more open burning beyond 2020
3 R and composting	3%	23 % (2016 – 2019) 5% (2020 – 2030)	Targeted for plastic and bottle/can recycling and composting
Waste to SWDS	45%	45% (2016-2019) 95% (2020-2030)	Starts from 2020
a. Un-managed-shallow	100%	30%	
b. Controlled Landfill	-	70%	Starts from 2020
Land Fill Gas (LFG)	LFG is not managed	20% of generated LFG	Starts in 2026

Table 3-11 Mitigation measures for GHG emission reduction in Waste Sector in Other districts

Waste Management	Baseline	Mitigation	Remarks
Open Burning	86%	86% (2016-2020) 84% (2021-2025) 83% (2023-2030)	Gradual reduction until 2030
3 R and composting	1%	1%	Targeted for plastic and bottle/can recycling and composting
Waste to SWDS	3%	3% (2016-2020) 5% (2021-2025) 6% (2023-2030)	Increase in period 2021-2025 and 2026-2030
a. Un-managed-shallow	100%	100%	
b. Controlled Landfill	-	-	
Land Fill Gas (LFG)	LFG is not managed		

Referring to Table 3-10 and 3-11, most of urban's MSW in Dili and other districts in the future will still rely on open burning. To meet the Law No.2/2017, Dili has set that their MSW has to be disposed in the existing landfill (un-managed landfill without LFG recovery) while in other Districts the MSW is mostly treated as open burning due to limited access to landfill facilities. The identified mitigation activities in Dili and other Districts are:

- reducing 'open burning' practices through the implementation of Law no. 2/2017 regarding Urban Solid Waste Management, i.e. 3R, composting, and increasing the MSW disposal into existing landfill as well as new landfill
- implementation of controlled landfill for new landfill in Dili and other Districts with and without LFG recovery systems.

The reduction of open burning practice is also being focused in Dili on the basis of the availability of better alternative, i.e. collection for management in SWDS. The increase of 3R activities is aimed to treat the untreated portion of MSW and contribute to the reduction of open burning as well. However, the 3R is still targeted mainly on plastic and bottle components, so that it will not contribute to the reduction of GHG emissions from MSW management. For other districts, improvement of municipal waste management is conducted through addition of waste truck for collection to SWDS in 2021 and 2026. It is assumed that this additional collection capacity will reduce volume of waste treated by open burning in the area.

Although GHG emission from domestic WWT is the second largest of GHG emissions sources, there are no planned mitigation activities in wastewater treatment as Timor-Leste is still in the process of increasing access to sanitation facilities, particularly in rural areas outside Dili. Thus the category is not included in SNC. By implementing all of the potential mitigation measures described in Table 3-10 and Table 3-11, the resulting cumulative emissions reduction between 2016 and 2030 is about 171.53 Gg CO_2e (Table 3-12). The projection of emissions under the Baseline and Mitigation Scenarios is given in Figure 3-21.

Table 3-12 Potential GHG emission reductions resulting from mitigation actions in the waste sector

Year	**Emissions (in Gg CO2e)**		
	Baseline	**Mitigation**	**Reduction**
2016	183.93	183.93	-
2017	187.32	187.32	-
2018	190.63	190.63	-
2019	193.85	193.85	-
2020	196.96	185.15	11.81
2021	201.02	186.88	14.14
2022	216.22	202.30	13.91
2023	220.32	206.62	13.71
2024	224.36	210.85	13.52
2025	228.33	214.98	13.35
2026	232.25	214.15	18.10
2027	236.16	218.02	18.15
2028	240.06	221.85	18.21
2029	243.93	225.65	18.28
2030	247.76	229.39	18.36

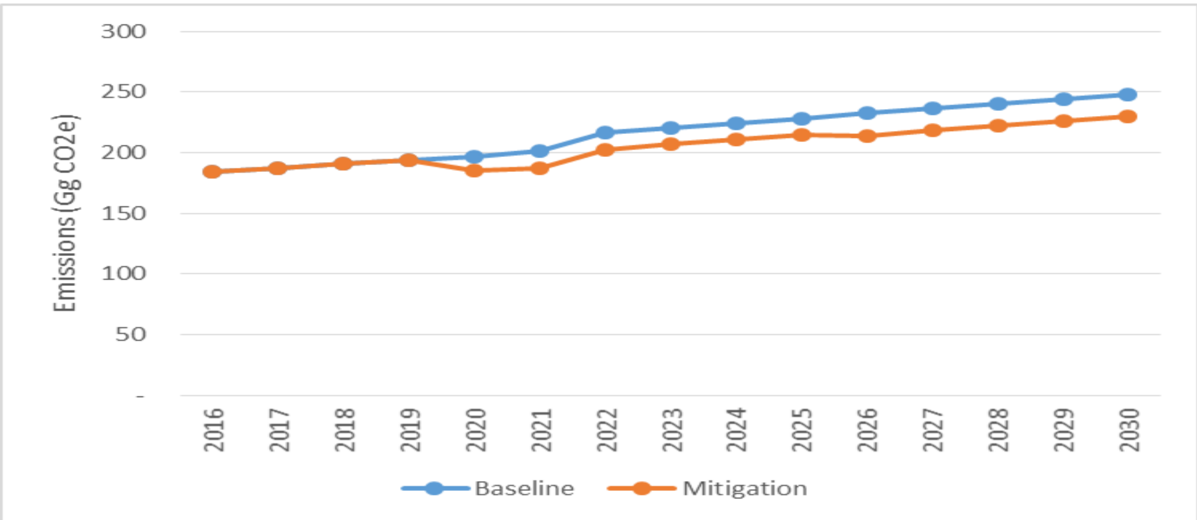


Figure 3-21 Projection of CO_2e under baseline and mitigation scenarios

The increase volume of waste collected in SWDS in correspond increase the generation of methane, and thus create a negative emission reduction for sub category of CH_4 From Municipal Solid Waste at Disposal Sites. However, since the increase in waste collected also reduce the number of waste being treated with open burning practice, net emission reductions from waste sector in this scenario remains positive. Moreover, landfill gas capture and flaring will be operated starting in 2026 and it will add to the reduction of emissions from MSW at SWDS (Table 3-13).

Table 3-13 Emission reductions by category

Year	MSW at SWDS	Incineration	Open burning	Domestic WWT
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	11.81	-
2021	-0.34	-	14.48	-
2022	-0.77	-	14.68	-
2023	-1.18	-	14.88	-
2024	-1.57	-	15.08	-
2025	-1.93	-	15.28	-
2026	1.28	-	16.82	-
2027	1.10	-	17.04	-
2028	0.94	-	17.27	-
2029	0.79	-	17.49	-
2030	0.65	-	17.71	-

Table 3-14 Waste Stream for baseline and mitigation scenario in Dili

Year	Waste Generation (Gg)		Waste Stream in Dili - Baseline								Waste Stream in Dili - Mitigation							
	Dili	Other Districts	Waste to SWDS		Open burning		3R		Untreated		Waste to SWDS		Open burning		3R		Untreated	
			%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg
2016	72	240	45%	32.3	32%	23.0	3%	2.2	20%	14.4	45%	32.3	32%	23.0	3%	2.2	20%	14.4
2017	73	244	45%	32.8	32%	23.3	3%	2.2	20%	14.6	45%	32.8	32%	23.3	3%	2.2	20%	14.6
2018	74	248	45%	33.4	32%	23.7	3%	2.2	20%	14.8	45%	33.4	32%	23.7	3%	2.2	20%	14.8
2019	75	252	45%	33.9	32%	24.1	3%	2.3	20%	15.1	45%	33.9	32%	24.1	3%	2.3	20%	15.1
2020	76	256	45%	34.4	32%	24.4	5%	3.8	18%	13.7	95%	72.5	0%	-	5%	3.8	0%	0.0
2021	77	259	45%	34.8	32%	24.8	5%	3.9	18%	13.9	95%	73.6	0%	-	5%	3.9	0%	0.0
2022	79	263	45%	35.3	32%	25.1	5%	3.9	18%	14.1	95%	74.6	0%	-	5%	3.9	0%	0.0
2023	80	267	45%	35.8	32%	25.5	5%	4.0	18%	14.3	95%	75.6	0%	-	5%	4.0	0%	0.0
2024	81	270	45%	36.3	32%	25.8	5%	4.0	18%	14.5	95%	76.7	0%	-	5%	4.0	0%	0.0
2025	82	274	45%	36.8	32%	26.2	5%	4.1	18%	14.7	95%	77.7	0%	-	5%	4.1	0%	0.0
2026	83	277	45%	37.3	32%	26.5	5%	4.1	18%	14.9	95%	78.7	0%	-	5%	4.1	0%	0.0
2027	84	281	45%	37.8	32%	26.9	5%	4.2	18%	15.1	95%	79.7	0%	-	5%	4.2	0%	0.0
2028	85	285	45%	38.3	32%	27.2	5%	4.3	18%	15.3	95%	80.8	0%	-	5%	4.3	0%	0.0
2029	86	288	45%	38.7	32%	27.6	5%	4.3	18%	15.5	95%	81.8	0%	-	5%	4.3	0%	0.0
2030	87	292	45%	39.2	32%	27.9	5%	4.4	18%	15.7	95%	82.8	0%	-	5%	4.4	0%	0.0

Table 3-15 Waste Stream for baseline and mitigation scenario in Other districts

Year	Waste Generation (Gg)		Waste Stream in Dili - Baseline								Waste Stream in Dili - Mitigation							
	Dili	Other Districts	Waste to SWDS		Open burning		3R		Untreated		Waste to SWDS		Open burning		3R		Untreated	
			%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg
2016	72	240	3%	8.4	86%	205.5	1%	2.4	10%	24.0	3%	8.4	86%	20.5	1%	0.2	10%	2.4
2017	73	244	3%	8.4	86%	209.0	1%	2.4	10%	24.4	3%	8.4	86%	20.9	1%	0.2	10%	2.4
2018	74	248	3%	8.4	86%	212.5	1%	2.5	10%	24.8	3%	8.4	86%	21.3	1%	0.2	10%	2.5
2019	75	252	3%	8.4	86%	215.9	1%	2.5	10%	25.2	3%	8.4	86%	21.6	1%	0.3	10%	2.5
2020	76	256	3%	8.4	86%	219.2	1%	2.6	10%	25.6	3%	8.4	86%	21.9	1%	0.3	10%	2.6
2021	77	259	3%	8.4	86%	222.4	1%	2.6	10%	25.9	5%	12.5	84%	21.8	1%	0.3	10%	2.6
2022	79	263	3%	8.4	86%	225.6	1%	2.6	10%	26.3	5%	12.5	84%	22.1	1%	0.3	10%	2.6
2023	80	267	3%	8.4	86%	228.8	1%	2.7	10%	26.7	5%	12.5	84%	22.5	1%	0.3	10%	2.7
2024	81	270	3%	8.4	86%	232.0	1%	2.7	10%	27.0	5%	12.5	84%	22.8	1%	0.3	10%	2.7
2025	82	274	3%	8.4	86%	235.2	1%	2.7	10%	27.4	5%	12.5	84%	23.1	1%	0.3	10%	2.7
2026	83	277	3%	8.4	86%	238.4	1%	2.8	10%	27.7	6%	16.7	83%	23.0	1%	0.3	10%	2.8
2027	84	281	3%	8.4	86%	241.7	1%	2.8	10%	28.1	6%	16.7	83%	23.3	1%	0.3	10%	2.8
2028	85	285	3%	8.4	86%	244.9	1%	2.8	10%	28.5	6%	16.7	83%	23.7	1%	0.3	10%	2.8
2029	86	288	3%	8.4	86%	248.2	1%	2.9	10%	28.8	6%	16.7	83%	24.0	1%	0.3	10%	2.9
2030	87	292	3%	8.4	86%	251.5	1%	2.9	10%	29.2	6%	16.7	83%	24.3	1%	0.3	10%	2.9

4. MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

4.1 Introduction

Timor-Leste is considered to be vulnerable to the impact of climate change. Many sectors are seriously affected by climate extreme events. Based on data from the last 17 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). Based on data from the Disaster Information Management System for the region of Timor-Leste, the number of the hazard events recorded during the period 1992-2017 for strong wind, flood and landslide that occurred once in a day reached 404, 119 and 45 events respectively. Drought also has serious impacts on communities. The drought event that occurred in 2003 impacted about 8502 households.

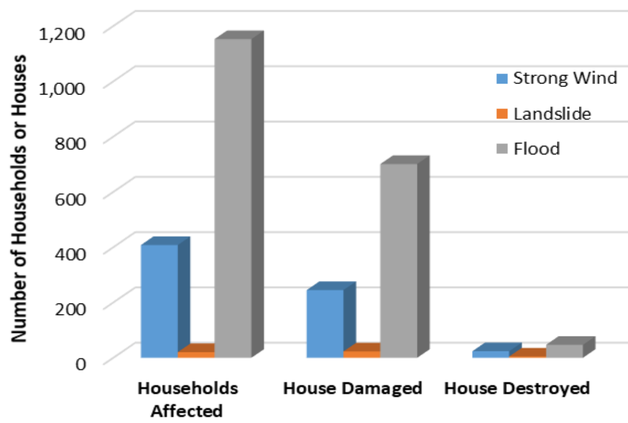


Figure 41 Annual average number of households or houses impacted by the three main climatic hazards in Timor-Leste (2001-2017) Source: Disaster Information Management System (desInventar.net)

Without developing capacity to manage the climate risk, and increasing climate variability in the future, Timor-Leste will be exposed to higher 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. Timor-Leste has submitted the previous INC to the UNFCCC in 2014. This document provide the updated modelling results and analysis as the science of climate change projection and impact assessment modeling have considerably improved. It involves modelling and analysis on the current and future climate change trends and scenarios based on the recent CMIP5 datasets under the RCP scenarios.

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. The map of the administrative area at municipality level is shown in Figure. There are thirteen municipalities registered in Timor-Leste, i.e. Aileu, Ainaro, Ambeno, Baucau, Bobonaro, Covalima, Dili, Ermera, Lautem, Liquica, Manatuto, Manufahi, Viqueque Municipality. Those areas lie on various terrain from a very low altitude in the coastal areas up to the high mountainous region reaching more than 2000 m above sea level (Figure 4-3). Various terrain contour could contribute the characteristics of its climate, but regional and global climate phenomena due to climate change are the most driver factor in affecting the local climate characteristics.

Historical climate data is very important in conducting historical climate analysis and future climate change scenarios. The data with higher spatial and temporal resolutions will provide better information of climate variability and change in the region. For climate variables such as mean temperature, a long-term grid data from University of East Anglia Climate Research Unit (UEA CRU) TS3.22 dataset (Harris *et al*. 2013) is used for this analysis. Meanwhile for rainfall analysis, a gridded daily and monthly precipitation data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) are mainly used which has 5 km x 5 km grid resolution starting from January 1981 to present (Funk *et al*. 2014).

Figure 4-2 Municipalities in Timor-Leste.

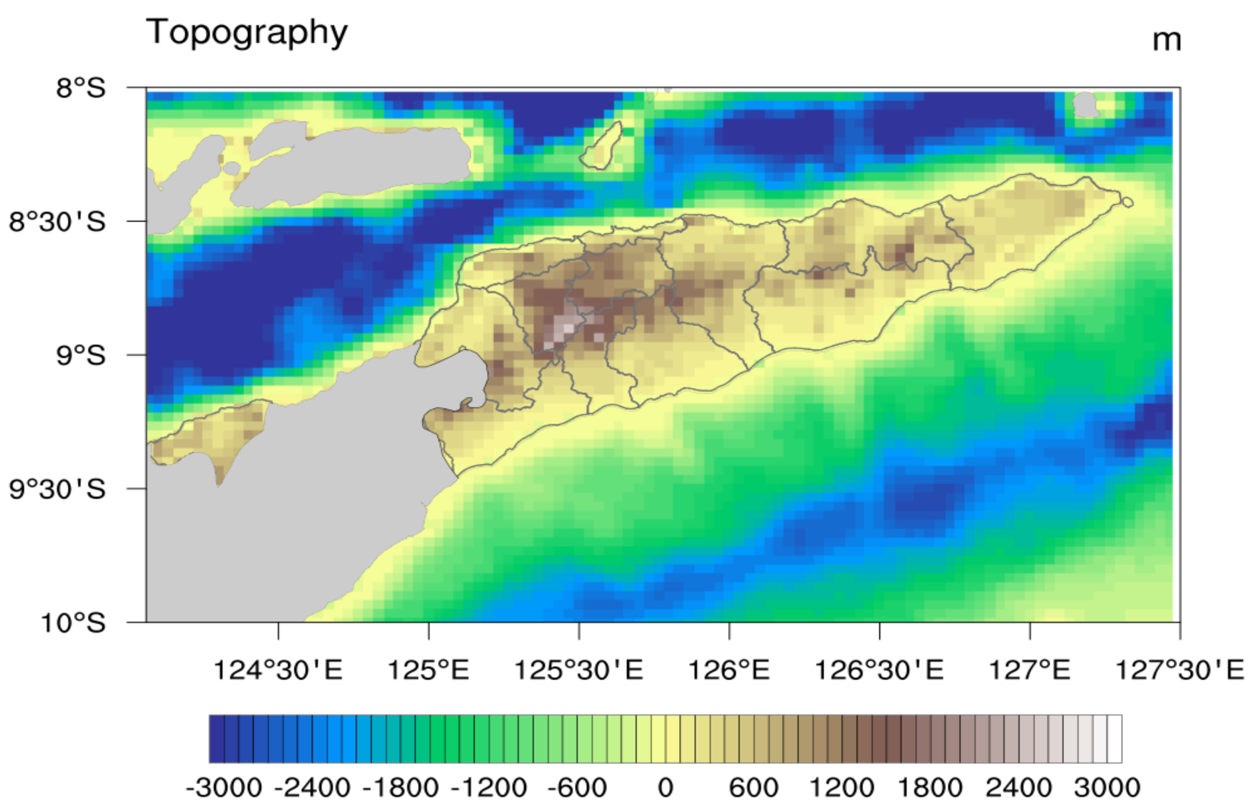


Figure 4-3 Topography map of Timor-Leste

4.2.1 Temperature

4.2.1.1 Temperature Pattern and Climatology

The climatology of monthly mean temperature in Timor-Leste varies across different areas (Figure 4-4). Based on the climatology of mean temperatures of 13 municipalities 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. The area-averaged value of monthly mean temperature climatology (dash-red line) is ranging from 23 to 25.9 °C, with the highest value occur in December and the lowest happen in August. Based on the mean temperature data on every municipality, several municipalities have temperature climatology that is passing over the mean value, such as Dili, Liquica, Manatuto, Manufahi, Oecussi, and Viqueque (mostly located in the low land). Meanwhile, other municipalities that have high topography in their region are being under the mean temperature.

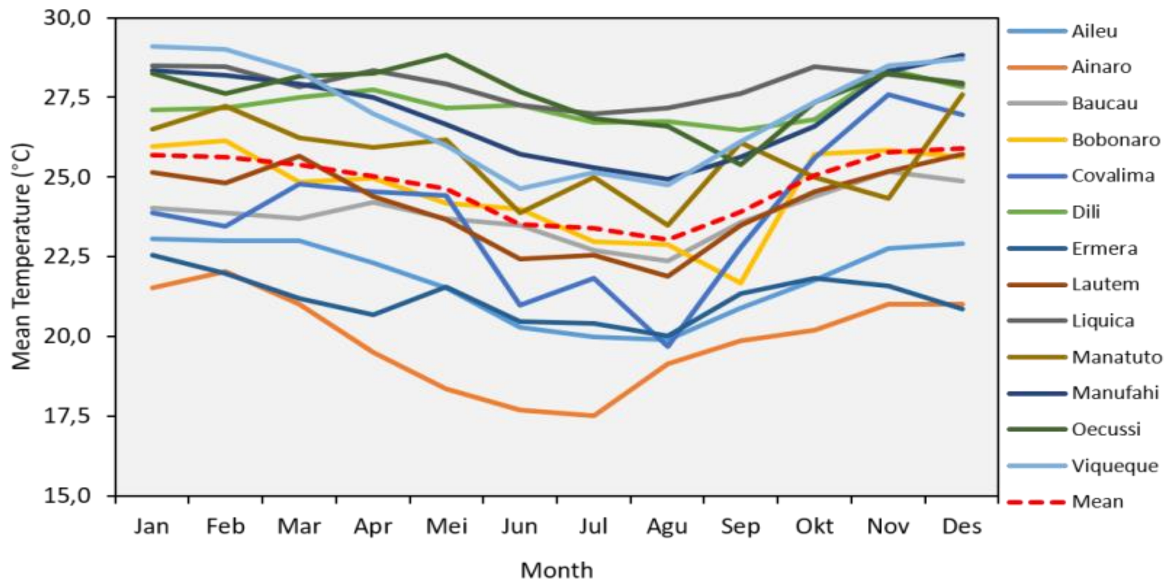


Figure 4-4 Monthly climatology of mean temperature over Timor-Leste based on observation data during 2008-2017. Red-dashed line is the mean values of all stations

The spatial mean temperature is shown in figure 4-5 for monthly climatology and figure 4-6 for seasonal climatology. These spatially reconstructed mean temperature data is produced to generate a high-resolution data with 5 km x 5 km resolution. It has been analysed from gridded global data and topography (CRU TS3.22 dataset) which has a quite low spatial resolutions, continue with building statistical models to estimate and interpolate mean temperature data. Correction of estimated data is performed that it could fit with the observation dataset. Figure 4-5 shows different value of monthly mean temperature. The lowest value mostly occurs in July and August in the mountainous area. Similar result is also found from the seasonal maps where the lowest occurs in JJA period. There is a clear difference from both maps that the coastal region tends to have higher temperature than in the region at high topography. The differences of temperature between the coastal and mountainous area are higher than 5 °C.

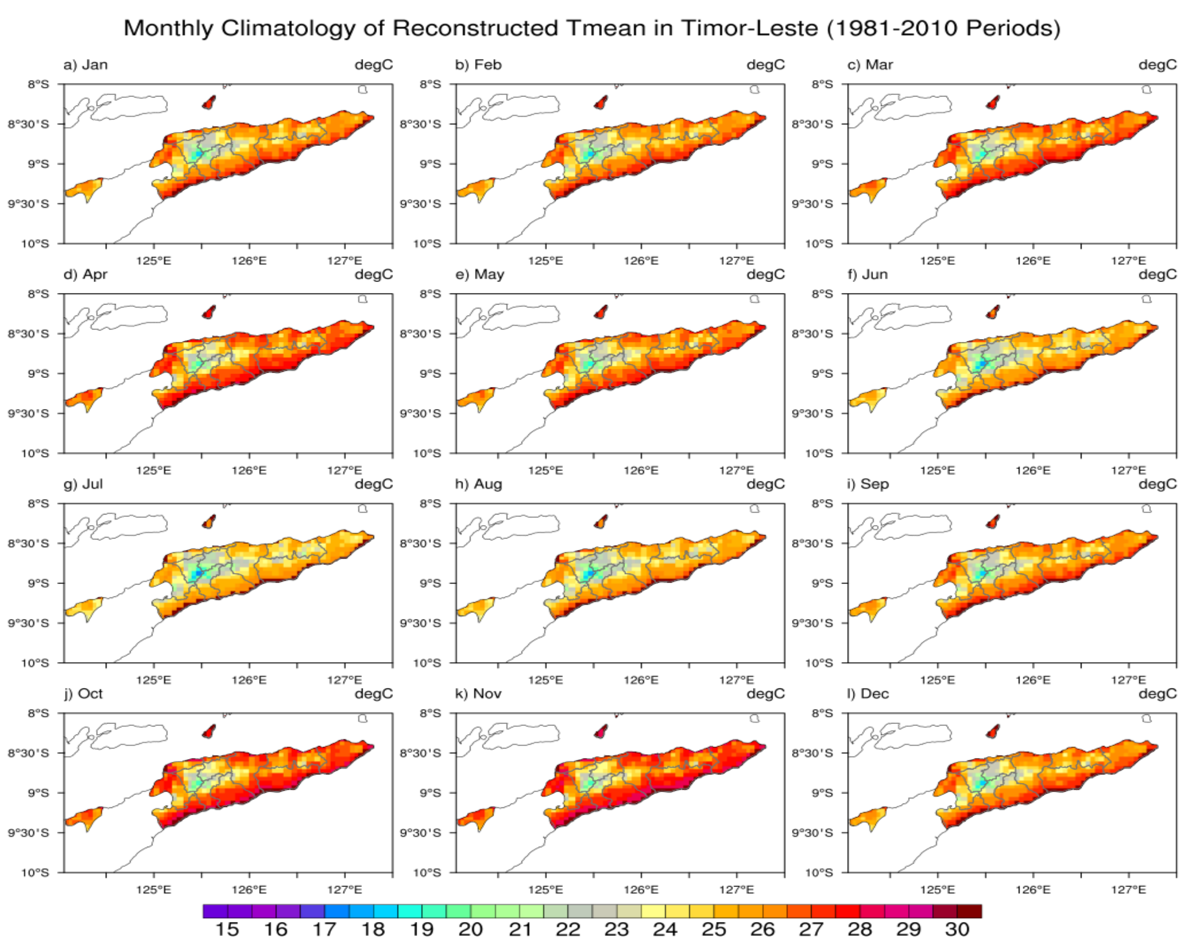


Figure 4-5 Climatology of monthly mean temperature in Timor-Leste (1981-2010 periods) calculated from reconstructed dataset

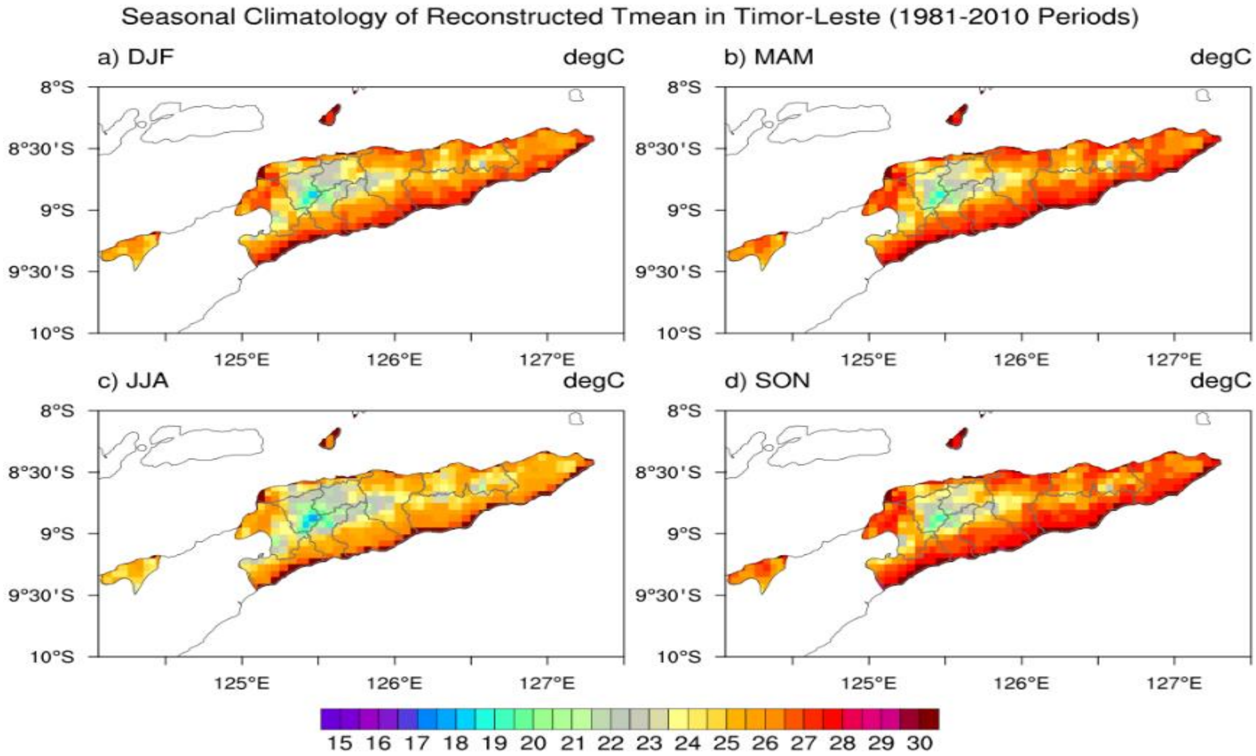


Figure 4-6 Climatology of seasonal mean temperature in Timor-Leste (1981-2010 periods) calculated from reconstructed dataset

Temperature Trends

Observed temperature data of minimum temperature (Tmin), mean temperature (Tmean), and maximum temperature (Tmax) during 2008-2017 periods from 13 stations are used to see the temperature trends (Figure). The plot shows upward trends of the temperature with the rate value of Tmin, Tmean and Tmax during that period is 0.023, 0.106 and 0.104 °C per-year, respectively. The length of this period is inadequate to study the trends related to climate change, but the information could help in understanding the current condition of temperature trends in the country.

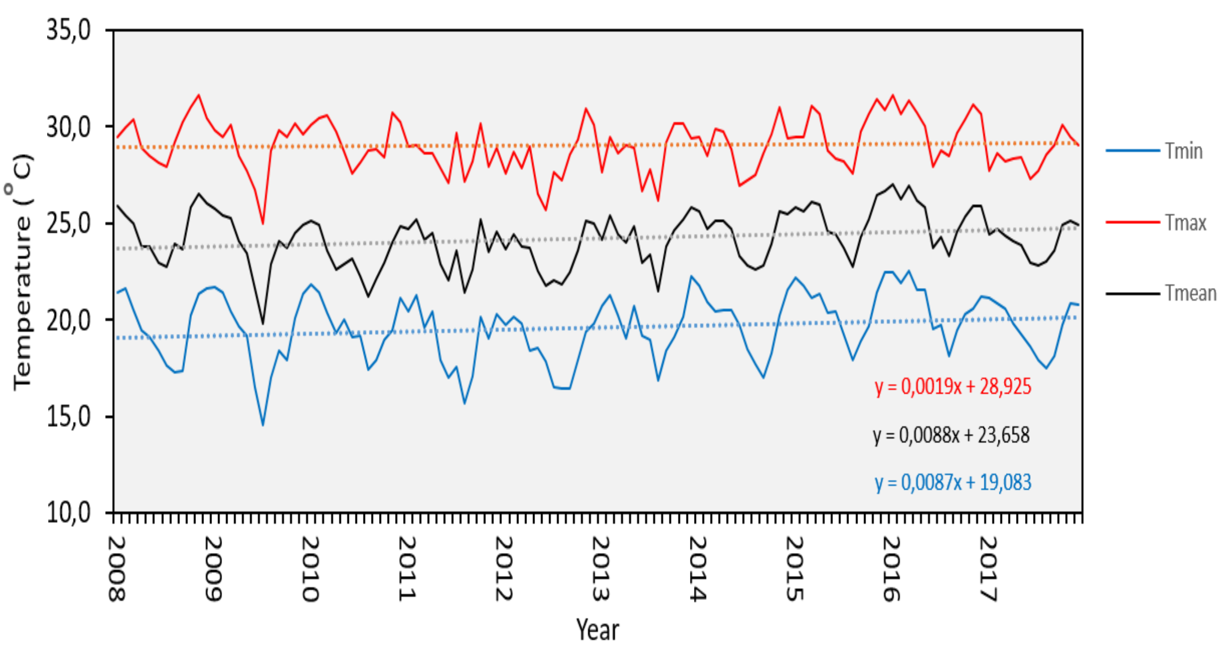


Figure 4-7 Timeseries of Monthly Temperature over Timor-Leste based on observation data during 2008-2017. The trend units are in °C per-month

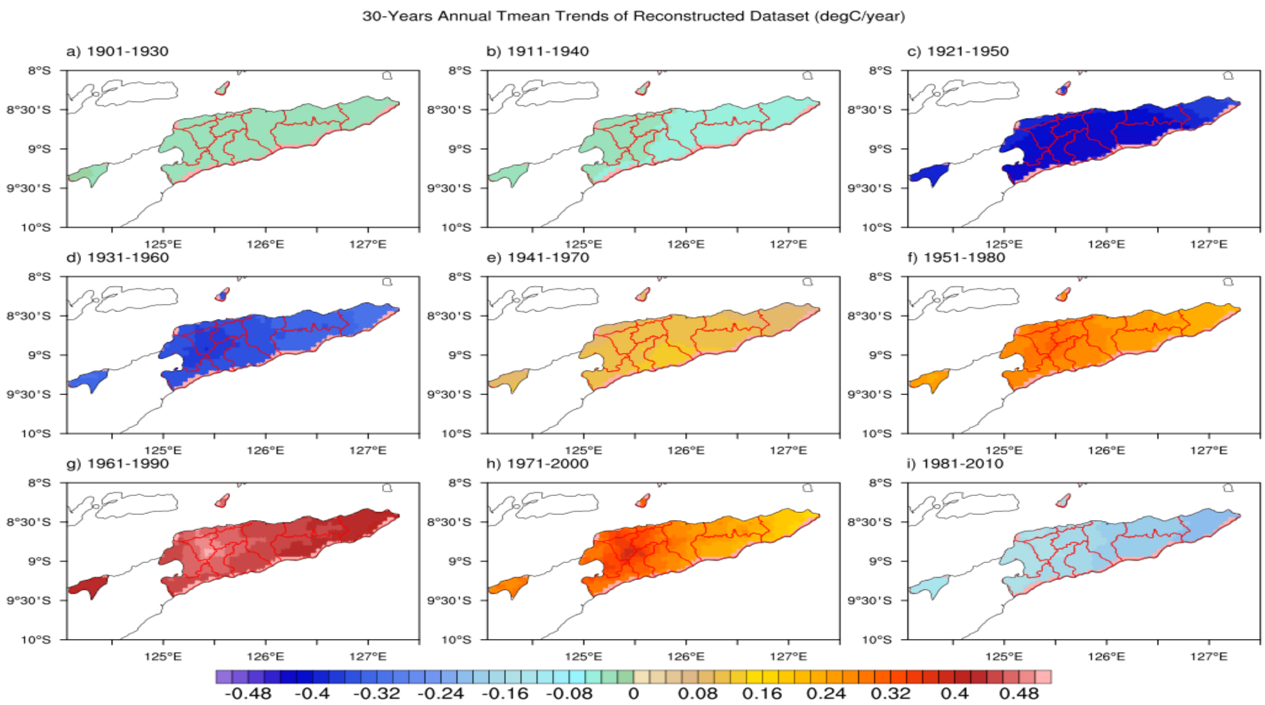


Figure 4-8 Decadal trends of annual mean temperature in Timor-Leste calculated from the reconstructed historical data

The decadal trends calculate the annual rainfall trend in every 30-year periods with 10-year distance, starting from year 1901 to 2010. Figure depicts the value of decadal trends of mean temperature using the reconstructed data. All periods are not consistently showing the increased trends, the upward trends are shown during the second half of the 20th century (1941-1970, 1951-1980, 1961-1990, and 1971-2000), while other periods indicate small decreasing trends of mean temperature. The highest increasing trend occurred in 1961-1990 period especially in the mountainous area with the rate of around 0.4-0.5 mm/year. This high rate of trends is mostly due to decadal variability of the temperature data.

4.2.2 Rainfall

4.2.2.1 Rainfall Pattern and Climatology

The rainfall pattern in Timor-Leste is strongly characterized by the Australian Monsoons in general. During the Australian Summer Monsoon, most of Timor-Leste region experience wet condition where it occurs mostly during December to April. Meanwhile the dry season usually stays for several months, from May to November based on the climatology of historical climate observation data. Figure presents the patterns of monthly rainfall climatology calculated from the area-averaged of long-term observed meteorological stations in each municipality area. The peak of the wet seasons have around 250 mm of monthly rainfall climatology in average, whilst the lowest average value is not exceeding 50 mm.

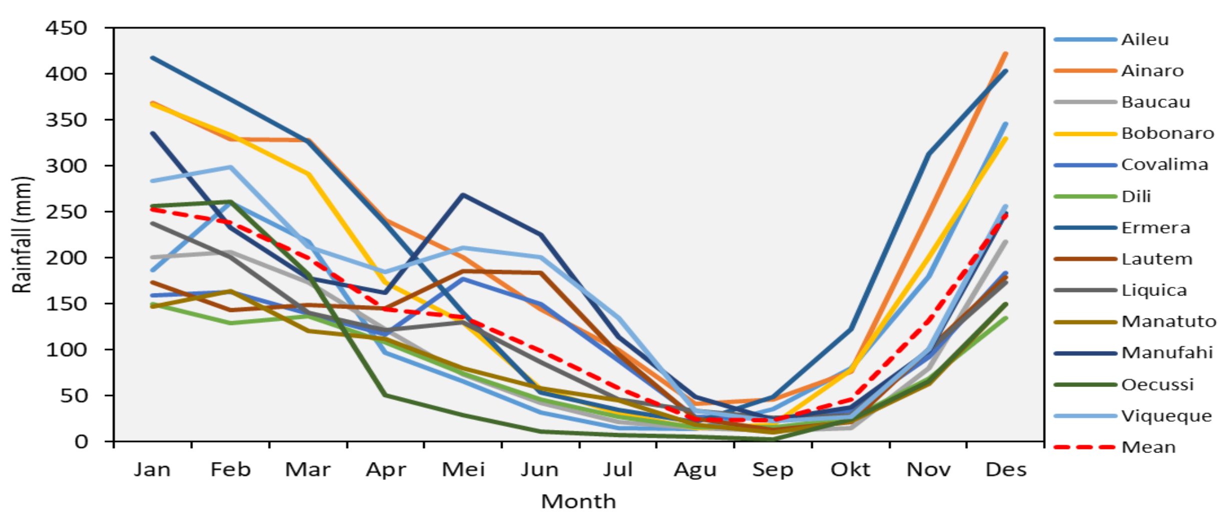


Figure 4-9 Rainfall characteristics over Timor-Leste based on rainfall observation data during 1952 – 2017. Red-dashed line is the mean values of all stations

The spatial maps of the monthly climatology in Figure 4-10 shows that several municipalities which located at high terrain (Aileu, Ainaro, Bobonaro, Manufahi and Ermera) have the regions with relatively high rainfall records. Meanwhile, other areas that are located in the coastal areas tend to have less rainfall, especially in the northern part of the region. Northern part of Manatuto seems to have low mean rainfall almost along the year since its monthly climatological value is not exceeding 150 mm/month. The peak of rainfall mostly occurs in December, where in the mountainous region – based on the climatology during 1981-2015 periods – could reach more than 500 mm/month. The spatial maps of seasonal rainfall climatology in Figure 4-11also shows that the peak is also occurred during the active period of the Australian Monsoon in DJF season and getting less during the transition period from wet season to dry season in MAM period. In contrast, low rainfall amounts are found in dry season, especially in JJA and extent to the transition period from dry season to wet season in SON period.

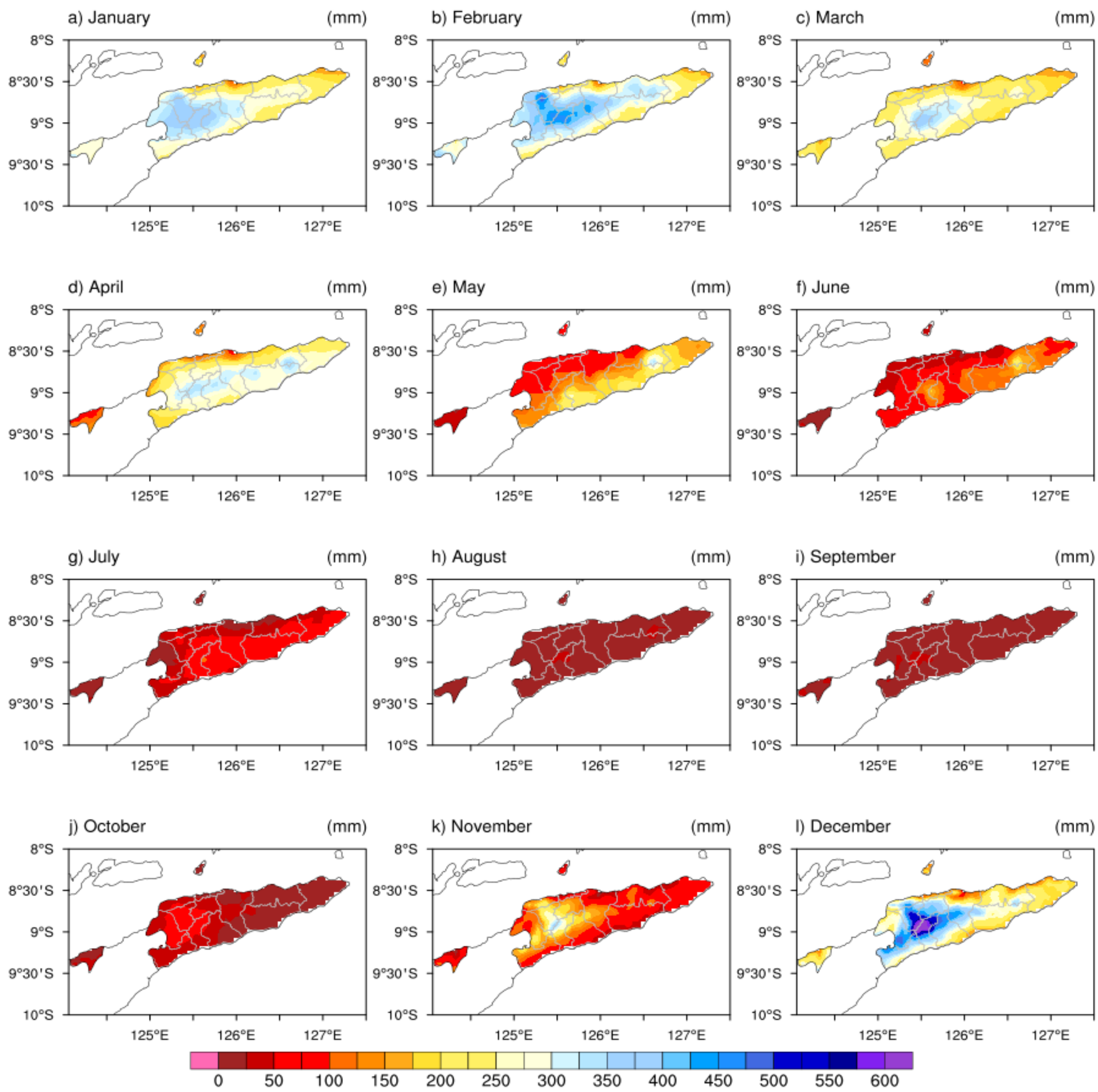


Figure 4-10 Monthly rainfall climatology in Timor-Leste calculated using grid data during 1981-2015 periods

The seasonal patterns of rainfall are spatially drawn using both the land-based in-situ data (Figure 4-10) and from the blended rainfall from satellite and stations products to get the grid rainfall data (Figure 4-11). Although it is technically incomparable due to differences in data sources and in the calculations of spatial rainfall, but in general there are some similarities between the two figures. High rainfalls during the wet season are found in the municipalities in the mountainous area, such as Aileu, Ainaro, Bobonaro and Manufahi.

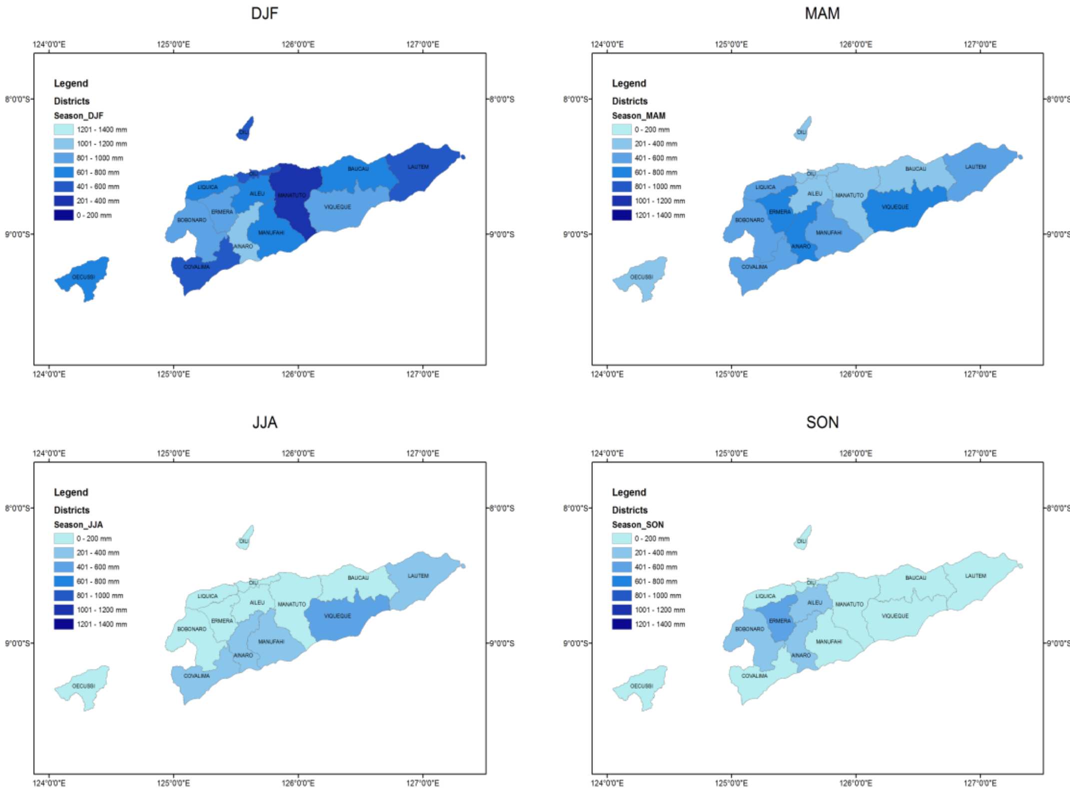


Figure 4-11 Seasonal rainfall characteristics over Timor-Leste based on rainfall observation data during 1981 – 2015

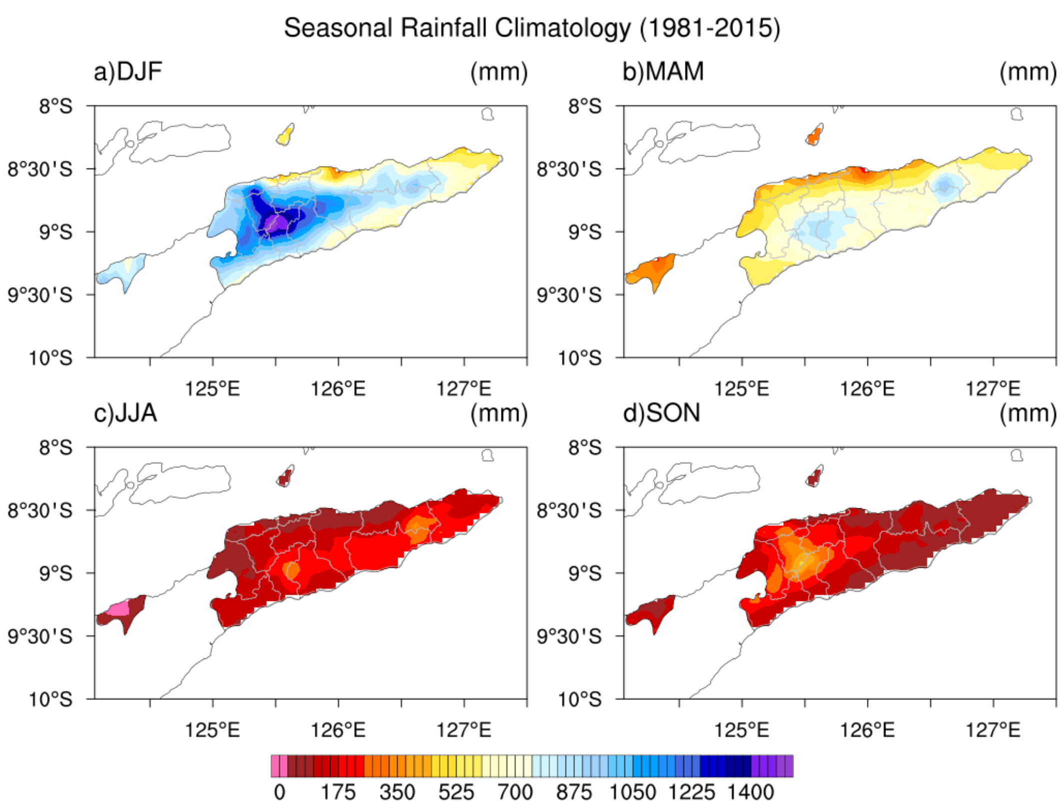


Figure 4-12 Observed seasonal rainfall climatology in Timor-Leste based on grid rainfall data (1981-2015 periods)

4.2.2.2 Rainfall Trends

Long-term rainfall variability in Timor-Leste contributes to the change in rainfall climatology over different periods. Rainfall trends are analysed in Figure 4-16 using several sources of datasets from the land-based observation records and global gridded data of global database. Based on trend analysis of area-averaged annual rainfall in 13 municipalities using observed data from stations, most municipalities indicate a decreasing trend of annual rainfall, except in Baucau, Lautem and Oecussi (Table). The largest rainfall decrease is found in Manufahi municipality (-10.8 mm/year), followed by Ermera municipality (-8.8 mm/year) and Ainaro municipality (-7.2 mm/year).

Table 4-1 Linear regression coefficients for trend analysis of area-averaged annual rainfall data in 13 municipalities in Timor-Leste

No.	Municipality	Trend (mm/year)
1	Aileu	-5.2
2	Ainaro	-7.2
3	Baucau	2.8
4	Bobonaro	-1.2
5	Covalima	-3.2
6	Dili	-1.1
7	Ermera	-8.8
8	Lautem	3.8
9	Liquica	-3.0
10	Manatuto	-2.6
11	Manufahi	-10.8
12	Oecussi	1.0
13	Viqueque	-1.6

The observed data are available from 1952 to 2017, but there are some missing values in 1970s, 1980s and 1990s for analysing the trend from stations in 13 municipalities (Figure 4-13). Therefore, it has been combined with other datasets that are adjusted based on the annual mean of the observed data. Visualizing and analysing the trends using this data could be misleading if it is not taken very careful, since it could provide different results when compared with a good, complete and quality-controlled data. Nevertheless, it is still important to use the result in this report for comparison with other data.

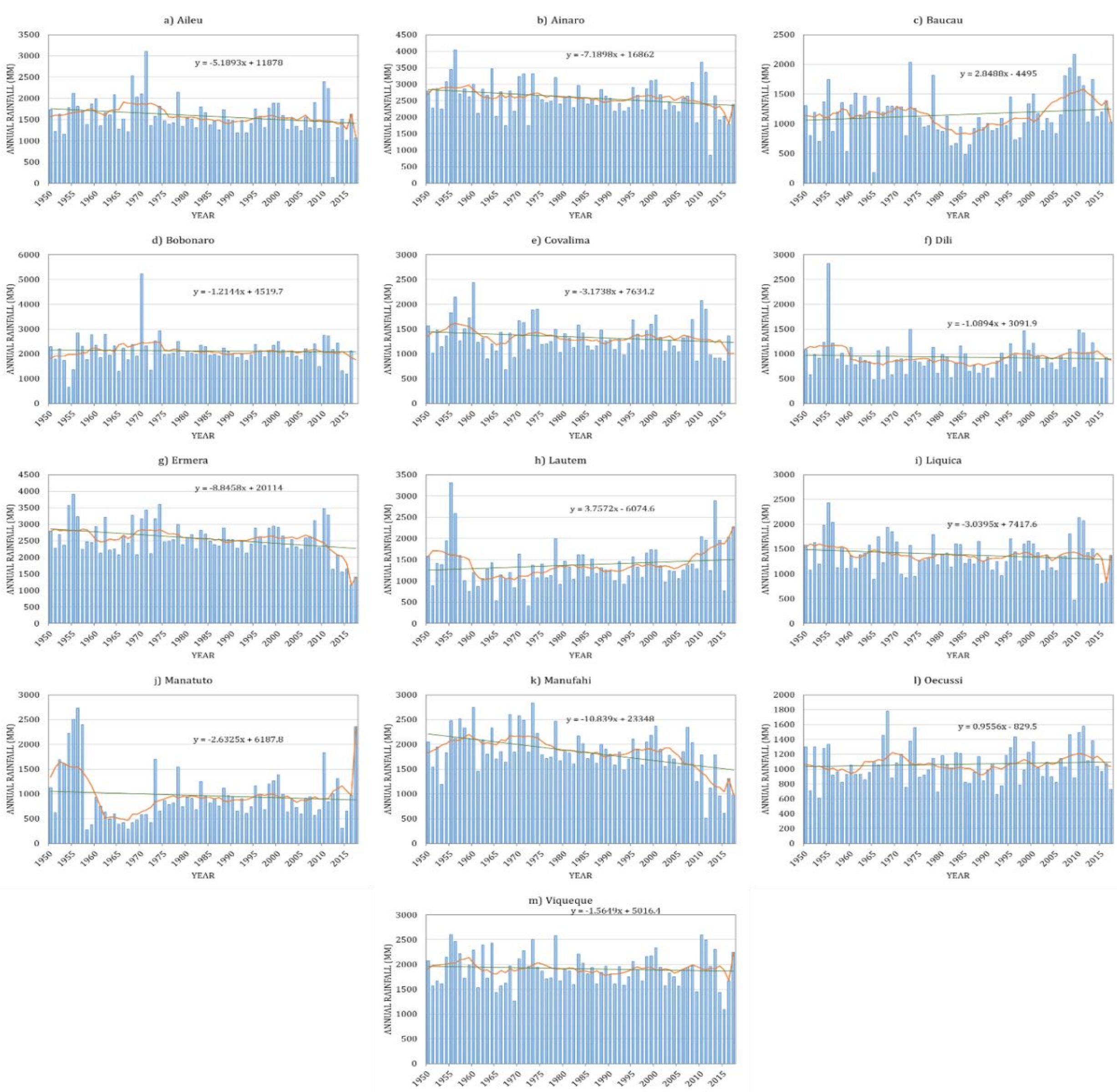


Figure 4-13 Annual trend of rainfall over Municipality of Timor-Leste based on rainfall observation data during 1952-2017

Decadal trends which are seeing the changes of rainfall every 30 year periods depict inconsistent directions of trends over different periods (Figure 4-14). The downward trends of annual rainfall are predominantly found in 1901-1930, 1961-1990 and 1971-2000. Meanwhile the upward trends indicated in most part of the region are evidently found during 1911-1940 and 1981-2010. For other periods (1921-1950, 1931-1960, 1941-1970, 1951-1980), there are contradicting trends across different regions in Timor-Leste.

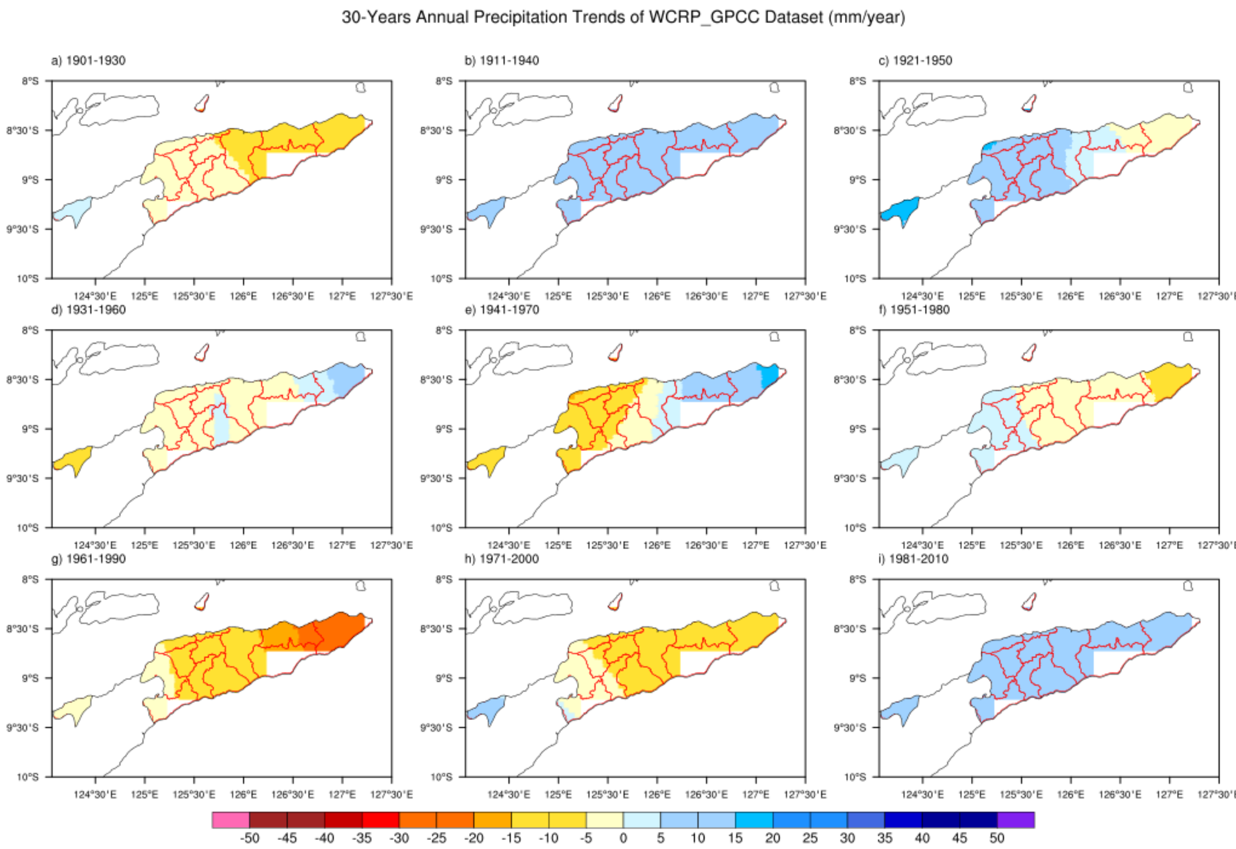


Figure 4-14 Change in decadal trends of annual rainfall in Timor-Leste based on the WCRP GPCC precipitation data calculated for every 30-year period with 10-year distance between calculation : a) 1901-1930, b) 1911-1940, c) 1921-1950, d) 1931-1960, e) 1941-1970, f) 1951-1980, g) 1961-1990, h) 1971-2000, and i) 1981-2010. The white colored grid indicates missing value.

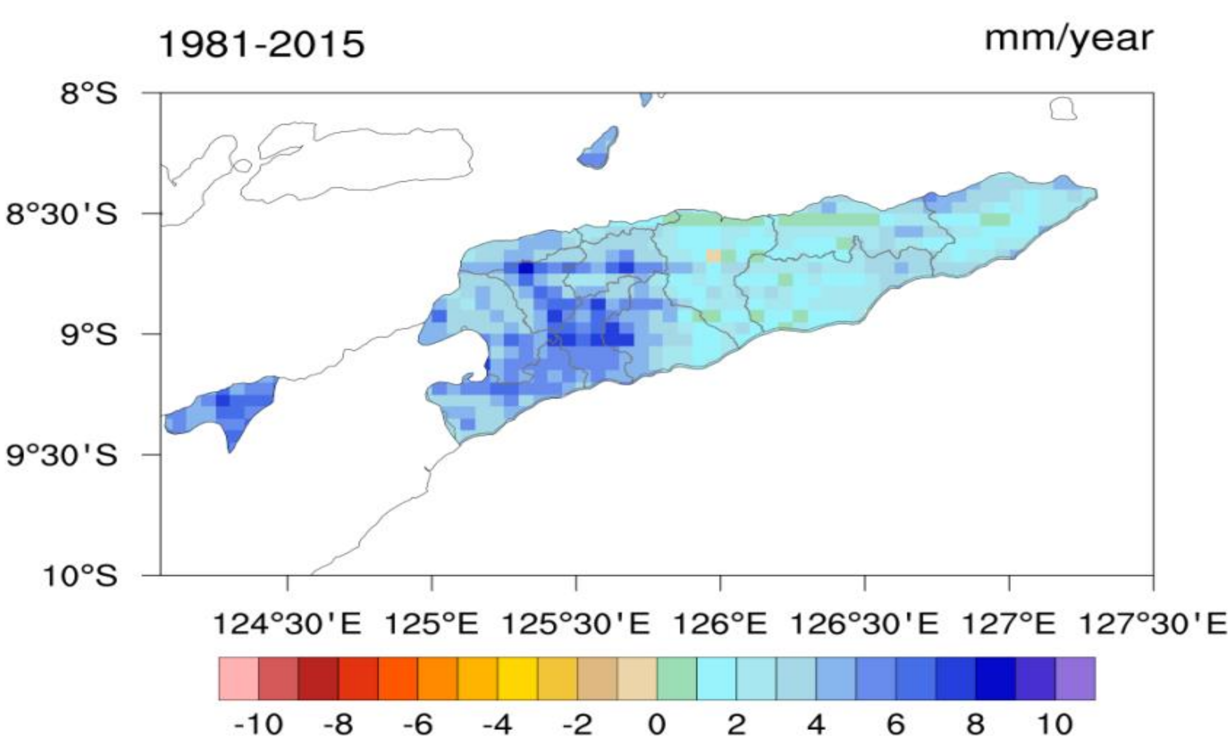


Figure 4-15 Spatial trends of annual rainfall in Timor-Leste calculated using gridded rainfall data in 1981-2015 periods

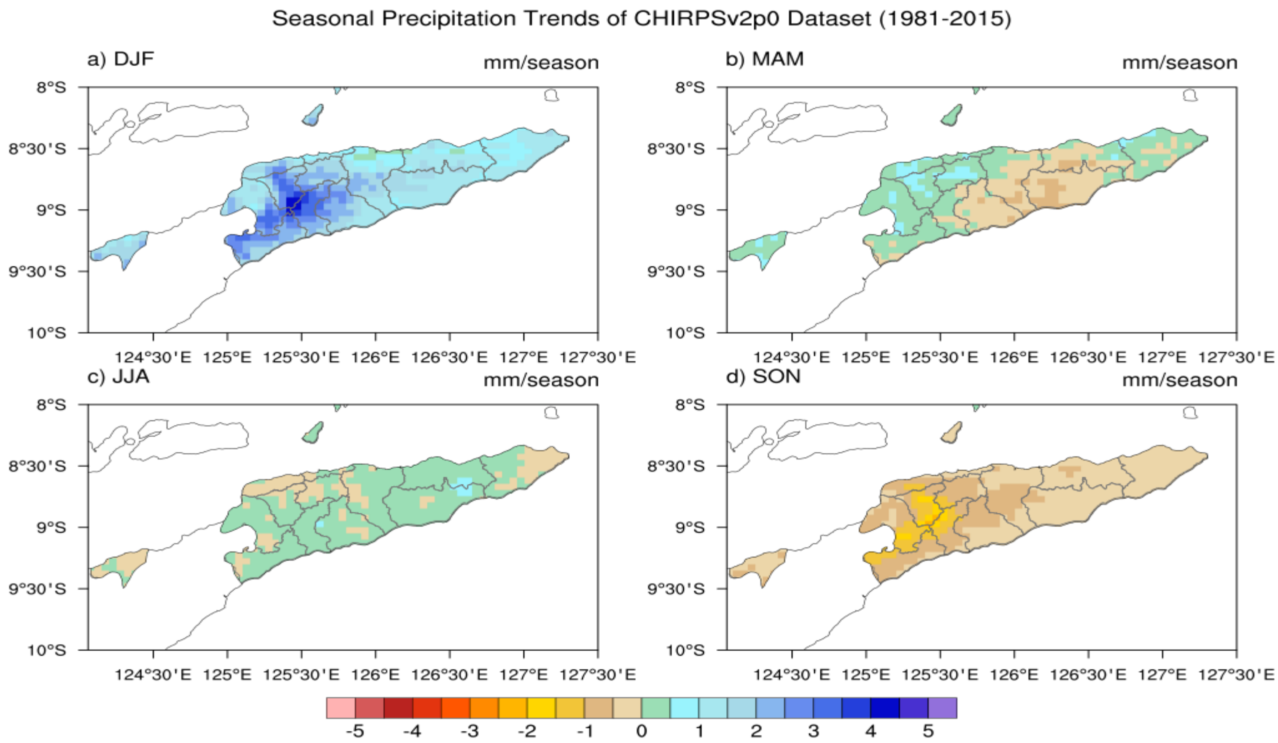


Figure 4-16 Spatial trends of seasonal rainfall in Timor-Leste calculated using data in 1981-2015 periods, a) DJF, b) MAM, c) JJA and d) SON season.

Almost all the region of Timor-Leste has quite significant upward trends of annual rainfall especially during 1981-2010. In order to get better understanding on the result as well as to check the consistency of the trends, a different source of rainfall data is used (using CHIRPS v2.0 data in 1981-2015 periods in Figure 4-15). It shows consistent results with the decadal trend in 1981-2010 as shown in Figure 4-14, where most of the region indicates upward trends of annual rainfall with rate less than 10 mm/year. The increasing trends of annual rainfall during this period are mostly contributed by the increase of seasonal rainfall during DJF or wet season.

4.2.2.3 Rainfall Variability

The differences in each year of the annual rainfall amounts in Timor-Leste show strong inter-annual rainfall variability associated with annual increase or decrease of rainfall that links to possible extreme climate events such as drought and flood. Rainfall variability with long-term trends are shown in the seasonal rainfall time series in Figure 4-17. It could be affected by the climate variability of both Timor-Leste's neighboring countries, Indonesia and Australia. Many studies have identified that various climate drivers or phenomena in sub-seasonal, interannual and interdecadal time scales could contribute in the climate pattern of the region.

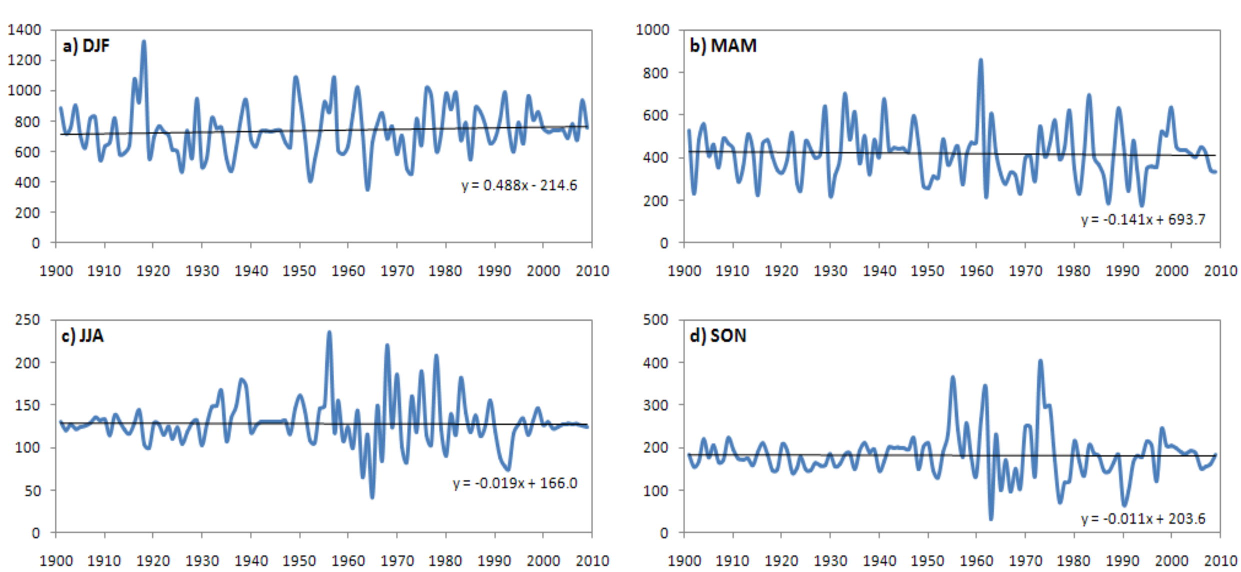


Figure 4-17 Time series of seasonal rainfall over Timor-Leste taken from CRU TS3.1 (1901-2009 periods)

There are many climate drivers that could affect the climate variability. Madden-Julian Oscillation (MJO) is the most notorious phenomena in sub-seasonal or intra-seasonal time scale affecting rainfall variability and extremes (Jones et al 2004; Wheeler and Hendon 2004; Madden and Julian 1971; Madden and Julian 1972). On interannual time scale El Nino-Southern Oscillation (ENSO), many studies have shown that 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) besides another familiar phenomenon known as Indian Ocean Dipole (IOD) mode (Ihara et al. 2008;Saji et al. 1999).

4.2.2.3.1 Impact of Madden-Julian Oscillation (MJO)

MJO is well-known to impact the sub-seasonal rainfall variability in the Maritime Continent region strongly. The phenomenon could sometime be used to explain the occurrences of several days of daily rainfall during dry season or several days of extreme rainfall during wet season. The sub-seasonal rainfall variability in the country can be related to the active MJO phases in phase 3, 4 and 5 by referring to the location of each phases shown in the all-season real time multi-variate MJO (RMM) diagram (Wheeler and Hendon 2004). Those three phases are when MJO is located at the eastern Indian Ocean, and also the west and east part of the Maritime Continent.

Table 4-2 provide the summary of the ratio (in %) of daily rainfall above certain threshold that occurred during active phase of MJO located in Phase 3, 4 and 5. The ratio is calculated using area-averaged daily rainfall data in Timor-Leste during 1981-2015 periods. It shows similar percentages of MJO influence on daily rainfall in the region at different phases where the percentages at 1, 5 and 10th percentiles are around 7.5-8 %. Combining the percentages from those three phases, the daily rainfall variability in Timor-Leste affected by MJO could reach around 22.8-25.2%. It means around a quarter of daily rainfall occurrence in the country during 1981-2015 periods were affected by the MJO events, especially when they are active in phase 3, 4 and 5.

Figure 4-18 presented an example of how the active MJO during phase 3, 4 and 5 affect the daily rainfall and the extreme value in the country. The daily rainfall data during 2013 are used, especially during the selected months when the active MJO are located in one or more of those three phases, i.e. in February, June, September, and December. The daily rainfall data during those months, each of them, are compared with the RMM diagram during the same dates as highlighted in light transparent boxes in the figure.

Table 4-2 Ratio of daily rainfall in Timor-Leste exceeding different thresholds of rainfall percentiles (RT) affected by active MJO during phase 3, 4 and 5. The calculation of ratio is relative to the number of rain days of daily rainfall data during 1981-2015 periods

Rainfall Percentile	Phase 3		Phase 4		Phase 5		Phase 3,4,5	
	R_T (mm)	MJO Influence (%)	R_T (mm)	MJO Influence(%)	R_T (mm)	MJO Influence (%)	R_T (mm)	MJO Influence (%)
1%	0.1	8.3	0.1	8.1	0.1	8.8	0.1	25.2
5%	0.5	8.3	0.5	8.1	0.5	8.8	0.5	25.2
10%	1	7.5	1	7.3	1	8	1	22.8
90%	19	1	19	1.6	19	1.5	19	4.1
95%	24.5	0.5	24.5	0.8	24.5	0.9	24.5	2.2
99%	37.3	0.1	37.3	0.2	37.3	0.2	37.3	0.5

In February 2013, the rainfall above 10 mm from February 15th to 23rd are strongly linked with active MJO phases, mainly in phases 3 and 4 (Figure 4-18a). The recorded area-averaged rainfall reach more than 20 mm per day in several days during those dates. Different condition appears during MJO event in June 2013 (Figure 4-18b). Weak MJO signals during the first 10 days of the month occurred at the same time with some rainfall events in the region. It is not clear whether the extreme rainfall in June 7th, 2013 is closely related to the MJO signal, which was very weak. However, several days of low rainfall (<10 mm) around June 11-18th could be linked with the MJO signals found in phase 4 and 5 during the same dates. For the example of MJO event in September 2013, several days of low rainfall (> 5 mm) are found to occur at the same time with the MJO signal in phase 5 at the end of the month (Figure 4-18c). It seems that not all daily rainfall recorded in December 2013 is related to MJO (Figure 4-18d). The effect of the Australian Monsoons could be the dominant factors of rainfall during that month, while the active MJO may only link to several daily rainfall occurrences.

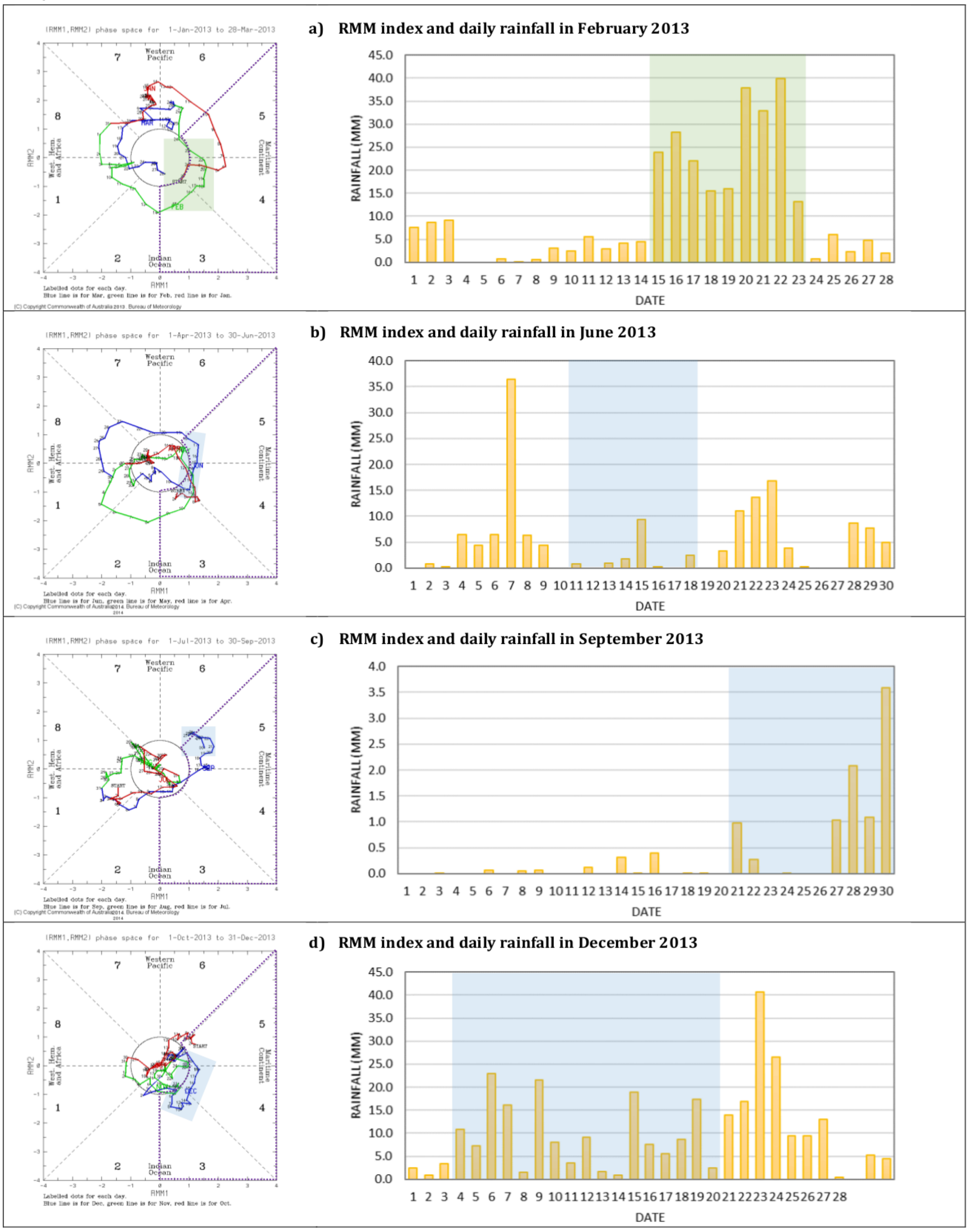


Figure 4-18 The influence of MJO on rainfall variability and extremes in Timor-Leste as indicated by the RMM diagram (left) and area-averaged daily rainfall (right), taking examples from the data records in 2013. The focus of the selected rainfall is when the MJO is located in Phase 3, 4 or 5. Four different months in 2013 are selected as examples: a) February, b) June, c) September, and d) December. The green or blue shaded-area in both figures (left and right) is used to indicate the same timing of RMM index and daily rainfall, when the MJO is active during one of the three phases.

4.2.2.3.2 Impact of El Nino-Southern Oscillation (ENSO)

ENSO is one of dominant factors affecting interannual climate variability over many areas in global. The phenomenon is an air-sea coupled interaction sourced in the tropical Pacific Ocean and has two coined phases of activities. The 'warm' phase of ENSO usually known as El Nino is signified by the increase of sea surface temperature anomalies (SSTA) – usually above 0.5 °C threshold – in the eastern and central tropical Pacific that last for more than five months. During this phase, the shifting of warm water area to the east is causing the Indonesian Maritime Continent and its surrounding areas including Australia and Timor-Leste to experience drier condition than the normal condition. The manifestation of this event is mostly related to prolonged drought, water shortage, forest fire, crop failure and many other drought-related conditions.

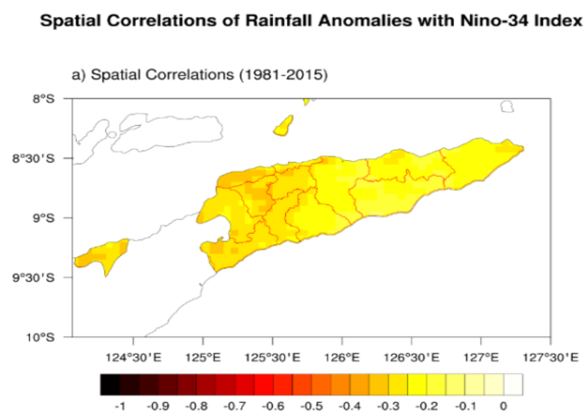


Figure 4-19 Relationship between ENSO and spatial rainfall anomalies in Timor-Leste as shown by a) spatial correlation and b) spatial regression values calculated using 35 years monthly data (1981-2015 periods). The index of ENSO is represented by SST anomalies in the Nino-3.4 region calculated by using ERSST version 4 data.

Figure 4-19 shows the spatial correlations and regressions coefficients between SST anomalies in Nino-3.4 region with the rainfall anomalies in Timor-Leste. The correlations between the two are mostly negative, meaning that the increase/decrease in the SST in Nino-3.4 indicating the occurrence of El Nino/La Nina could lead to the decrease/increase of rainfall anomaly in Timor-Leste. The correlation values vary from the lowest (around 0.2) in the eastern part into the highest (more than 0.4) in the western part. The spatial regression coefficients (slope, ***b***) also show negative values, explaining that the average decreased/increased of rainfall anomaly in every 1 °C will increase/decrease SST anomaly in Nino-3.4 region during El Nino/La Nina event (Figure 4-19b).

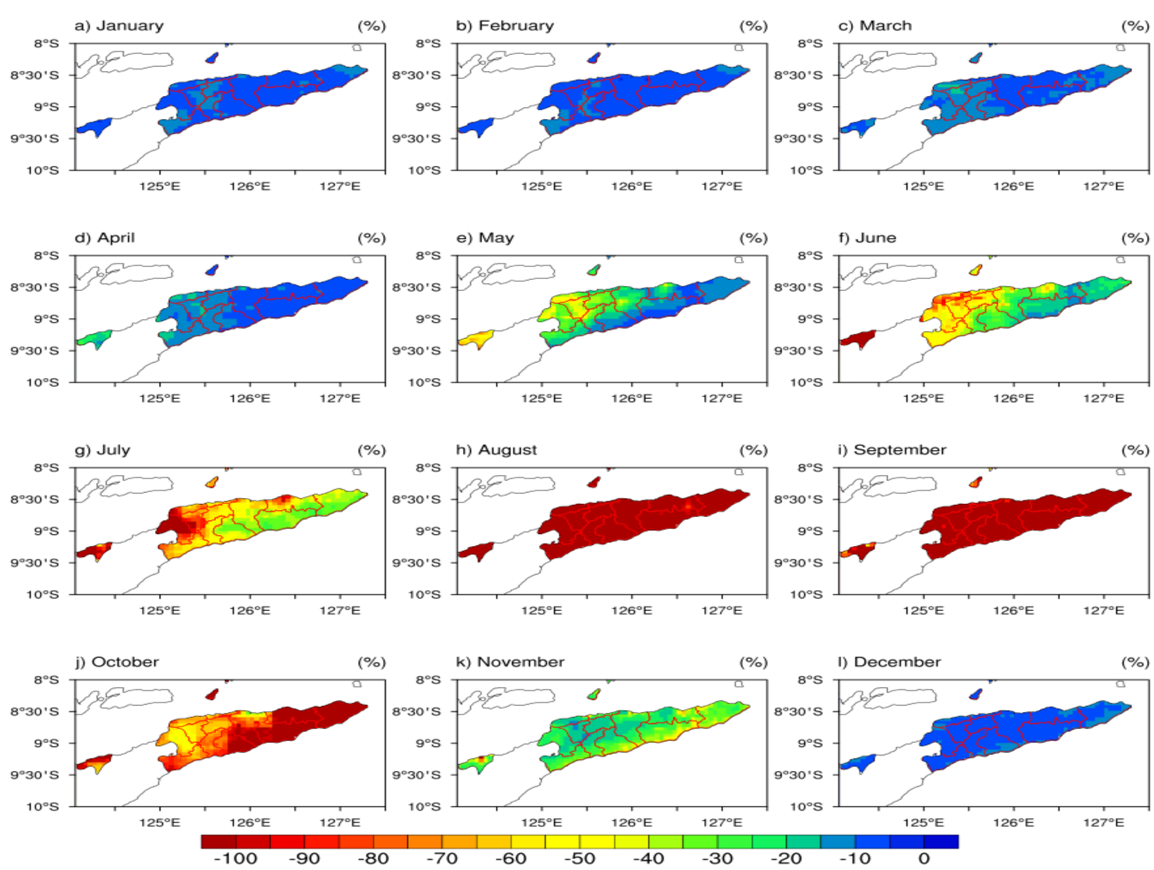


Figure 4-20 El Nino impacts on monthly rainfall anomalies in Timor-Leste (a-j) shown by the percentage of rainfall decrease (%) per 1 °C increase of SST anomaly in the Nino-3.4 region.

The percentage of rainfall anomalies affected by the event of SST anomaly (increase per 1°C) in the Nino-3.4 are revealed in Figure 4-20 for each month. The highest percentage of rainfall anomaly mostly found during dry season, especially in August and September which could reach 100% or more of percentage. This is mostly possible due to little amount of rainfall climatology during dry season. During the wet season, the percentage of rainfall affected by ENSO reaches only up to around 20% from its climatological value. However, only 10-20% rainfall decrease/increase during El Nino/La Nina, where the climatology during December or January could reach more than 300 mm for certain region, is a quite big deviation. During La Nina, the increase of rainfall during the rainy season could lead to the increase of the frequency and intensity of extreme rainfall.

Figure 4-21 shows the spatial correlations between 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 significant correlation between SSTA and rainfall anomalies could exist until 4 months lead time, allowing the condition to be used for developing seasonal climate forecast for the ENSO-related impacts up to 4 months ahead.

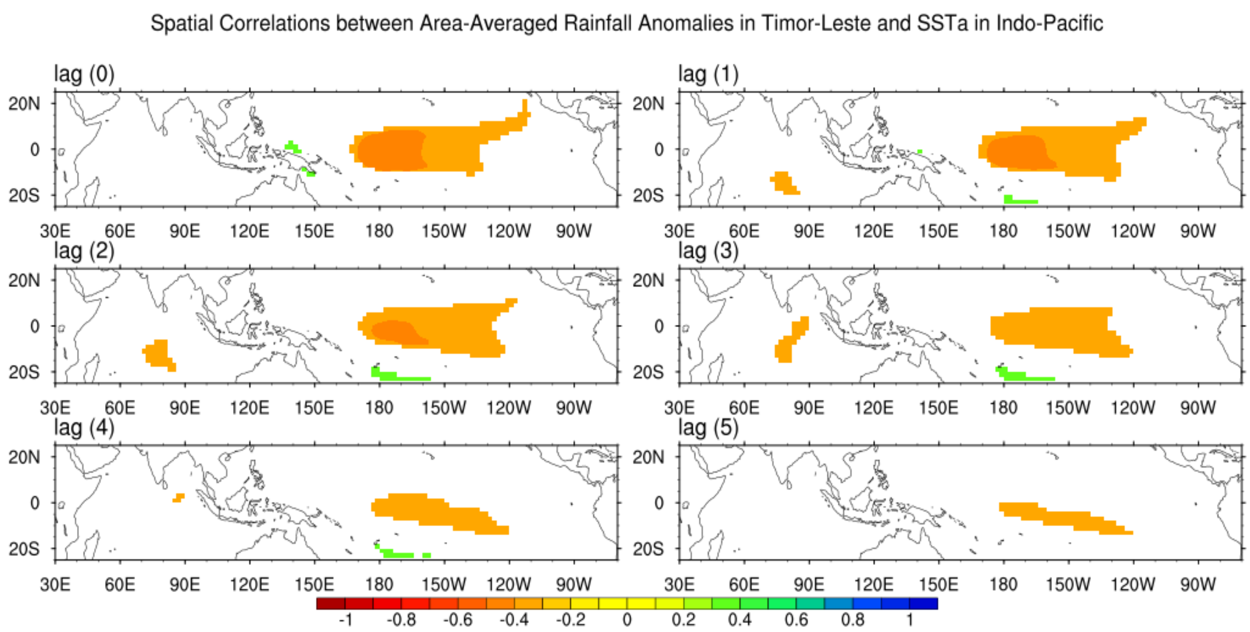


Figure 4-21 Time-lagged relationship between area-averaged rainfall anomalies in Timor-Leste and spatial SST anomalies in the tropical Indian and Pacific Oceans. Colored contours represent significant correlation values at 95% significant level (α=5%).

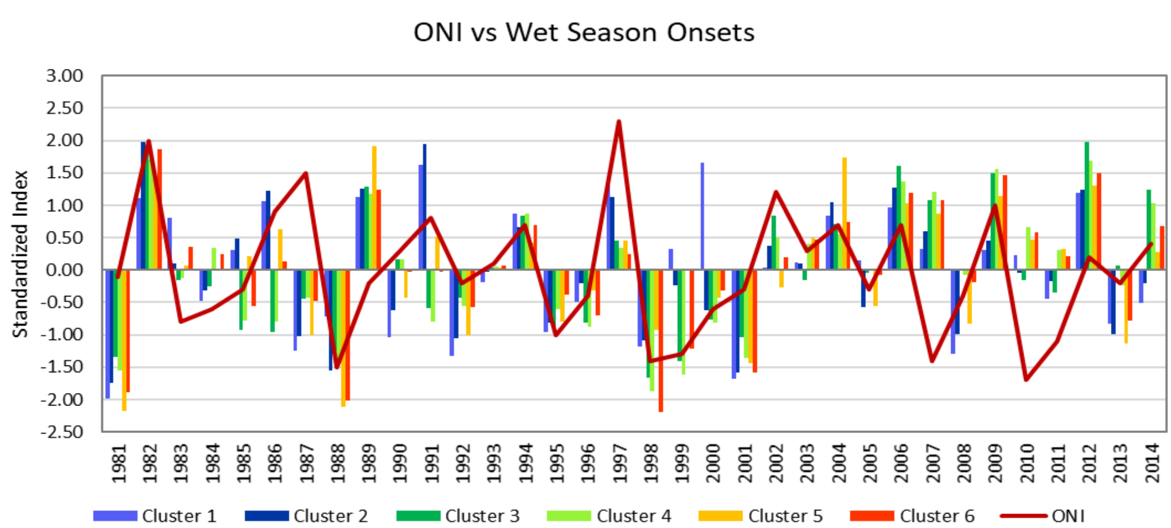


Figure 4-22 Comparison of Ocean Nino Index (ONI) time series – as one of the ENSO index – with the wet season onset anomalies in Timor-Leste. Positive onset anomaly indicates a delay of the onset, while negative shows the onset comes earlier than normal.

The impact of El Nino has been identified to cause severe drought condition to the country and leading into serious impact on agriculture. In 2016, there were about 78% of households are impacted by drought, with more than 62 thousands households experienced food shortages during El Nino, especially between December 2015 to March 2016 (The Ministry of Agriculture and Fisheries 2016). However, variability of the wet season onset in the country could also be affected by other factors besides ENSO. The comparison of time series between Oceanic Nino Index (ONI) and wet season onset anomalies in Figure 4-22 shows that the increase of the standardized ONI index is mostly followed by the increases of wet season onset anomalies at different clusters. Furthermore, it is also shown that not all the increase/decrease of the ONI index are always followed by the increase/decrease of the onset values.

4.2.2.3.3 Impact of Indian Ocean Dipole (IOD)

Another phenomenon that is known to be a driving factor in affecting rainfall variability in the Maritime Continent region is Indian Ocean Dipole (IOD). IOD is a coupled ocean-atmosphere interaction besides ENSO that also works on interannual time scale. The main location of IOD is found in the tropical Indian Ocean. It is different with ENSO that identified in the tropical central and eastern Pacific. The phenomenon is firstly identified in 1999 (Saji et al. 1999) and the index to measure and monitor the IOD events is called Dipole Mode Index (DMI). Strong positive DMI is usually linked with drought occurrence in Maritime Continent, especially in the western part of the region. In contrast, strong negative DMI is associated to more rainfall occurrence leading to many flood events in the region.

The IOD event could also potentially cause a delay on wet season onsets in some areas within the Maritime Continent, including in Timor-Leste. Figure 4-26 shows the comparison between time series of DMI and wet season onsets in Timor-Leste. The figure shows that some of the events on the delay of wet onsets in Timor-Leste are due to IOD event rather than due to El Nino. This can be seen for example in 2007, where the ONI index shows negative while the onset anomalies are positive (Figure 4-23). This opposite direction between the two indicate that the delay of the wet season onset during that year was not caused by El Nino but more due to IOD event as shown by the positive DMI index during that year.

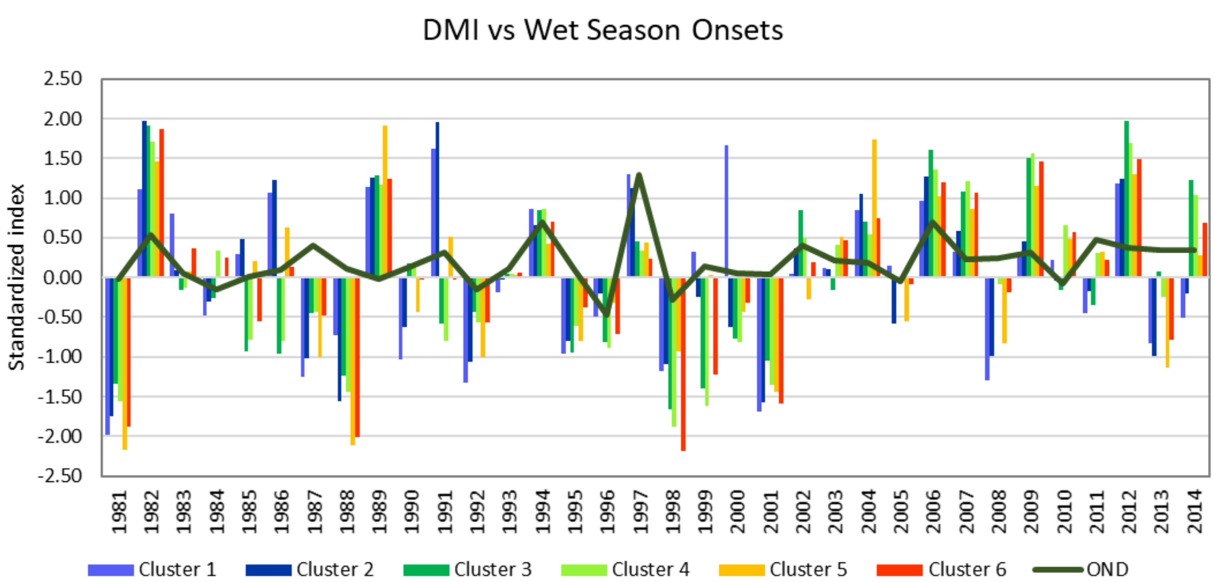
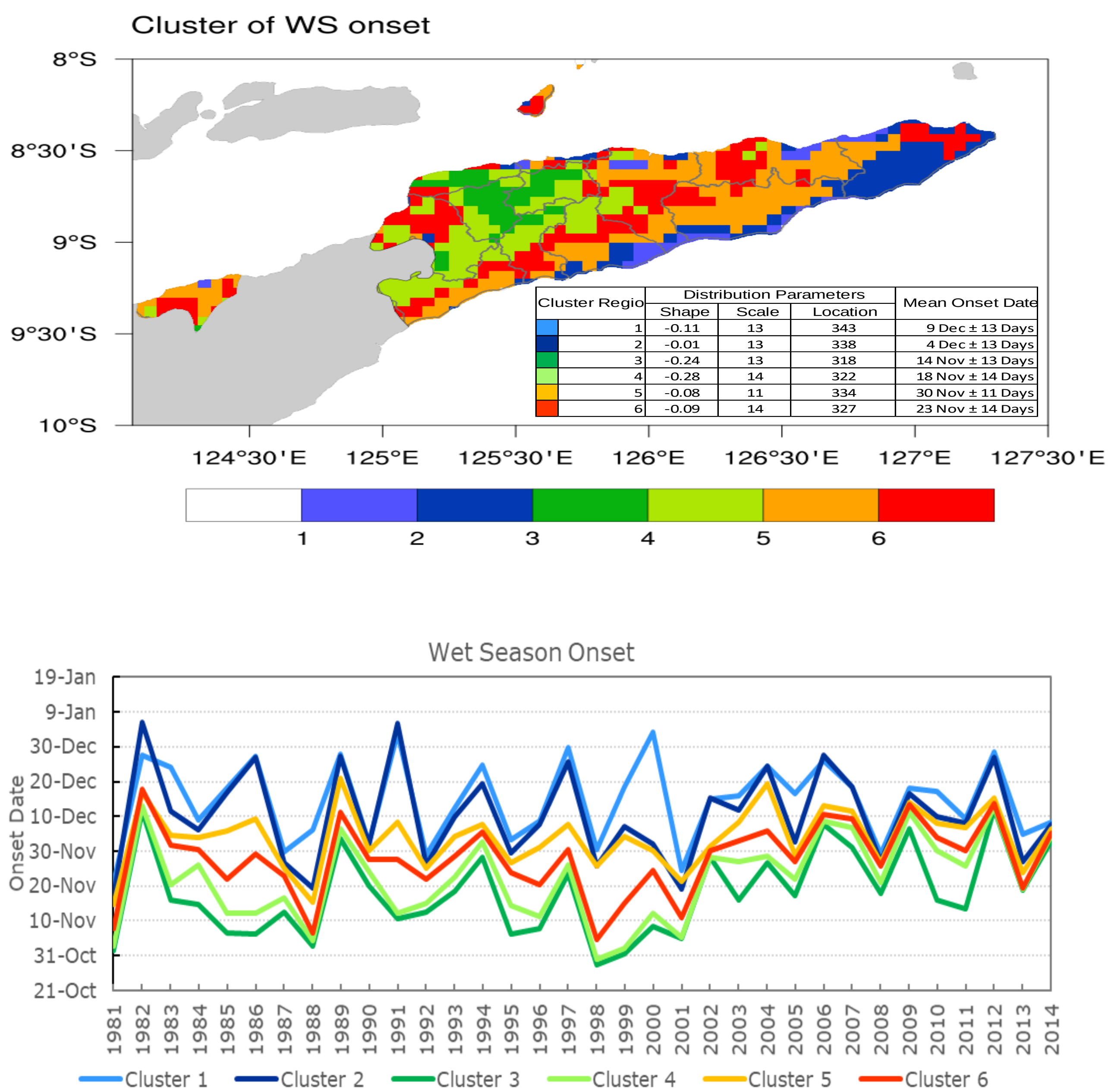


Figure 4-23 Comparison of Dipole Mode Index (DMI) time series – an IOD monitoring index – with the wet season onset anomalies in Timor-Leste. Positive onset anomaly indicates a delay of the onset, while negative shows the onset comes earlier than normal.

4.2.2.3.4 Onset, End and Length of the Seasons

The season onsets are important especially for agricultural and water resource managements. The wet season onsets in Timor-Leste usually occur in mid-November to early December with different timing across different regions. The advance or delay of the onset could reach around 14 days in respective of the mean onset date. Figure 4-24 shows the spatial pattern for the average timing of the wet season onset across different areas in Timor-Leste. For the dry season onsets, the usual timing is found in early April to early May each year. However, due to the impact of climate drivers affecting climate variability, the dry season onsets could shift earlier or later with standard deviations up to 35 days from the mean onset date (Figure 4-25). The calculation of the onsets was based on the meteorological approach through the calculation of cumulative daily rainfall anomalies using daily rainfall from CHIRPS datasets during 1981-2015 periods (5 km x 5 km grid resolution).



Cluster Regio	Distribution Parameters			Mean Onset Date
	Shape	Scale	Location	
1	-0.11	13	343	9 Dec ± 13 Days
2	-0.01	13	338	4 Dec ± 13 Days
3	-0.24	13	318	14 Nov ± 13 Days
4	-0.28	14	322	18 Nov ± 14 Days
5	-0.08	11	334	30 Nov ± 11 Days
6	-0.09	14	327	23 Nov ± 14 Days

Figure 4-24 Cluster of wet season onsets (1981-2015 periods): Spatial area (top) and averaged-time series of each cluster (below).

Figure 4-24 demonstrates the spatial characteristic of wet season onsets based on cluster analysis of the distribution parameters of onset time series calculated in every grid. In general, the average timing of the onsets starts from mid-November to early December. Considering the spatial distribution of the clusters, the timing of wet season onset starts from the areas with higher topography to other areas, away from the mountainous area to the coastal region. This is shown by the timing sequence of the onsets between clusters, i.e. cluster 3 (14 Nov ± 13 days), cluster 4 (18 Nov ± 14 days), cluster 6 (23 Nov ± 14 days), cluster 5 (30 Nov ± 11 days), cluster 2 (4 Dec ± 13 days), and cluster 1 (9 Dec ± 13 days). Cluster 3 is located in the mountainous area in some parts of Ermera, Aileu and Liquica municipalities, while cluster 1 in the south coast of the country.

The cluster analysis for dry season onsets is shown in Figure 4-25. This study identified 5 clusters, showing different characteristics of the onsets in Timor-Leste. Similar to the sequence of the wet season onsets between clusters, the area with higher topography is normally expected to experience earlier dry season onsets. In this case, the area is represented by cluster 4 region with mean onset date on 3 April ± 21 days. The east and southeastern regions covering municipalities such as Viqueque and Lutem, as well as some parts of Ainaro, Manufahi, Manatuto and Baucau are experiencing lattes dry season onsets that normally occurred in early May. These can be seen from cluster 2 and 5 regions with mean onset dates are in 6 May ± 35 days and 8 May ± 41 days, respectively.

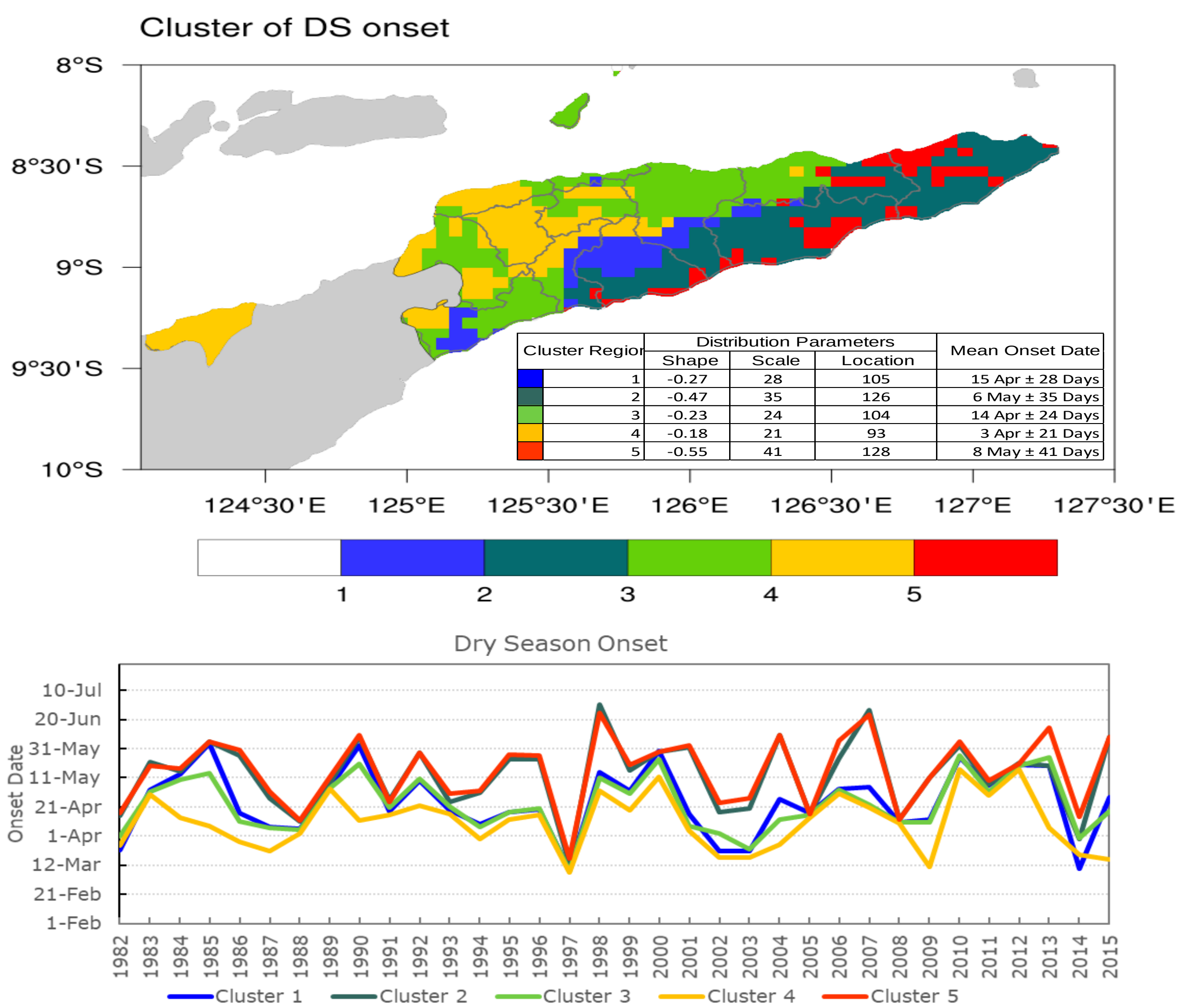


Figure 4-25 Cluster of dry season onsets (1982-2015 periods): Spatial area (top) and averaged-time series of each cluster (below)

Figure 4-26 performs the correlations between SSTA and onsets of the wet seasons (left figures), ends of the wet seasons (or onsets of the dry season; middle figures) and the length of the wet seasons (right figures) in Timor-Leste. The maps are created separately for five different months of SSTA as predictors (June to October). It is shown that the onsets are strongly correlated with SSTA both in local (negative correlations) and in remote area in the central tropical Pacific Ocean (positive correlations). Negative correlations over the local sea indicates 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 earlier/delay time of the wet season onset in the country. In contrast, positive correlations found in the central Tropical Pacific Region leads to an indication where warm/cold SSTA in the region associated with the El-Niño/La-Niña event is associated with the onsets of the dry and wet seasons.

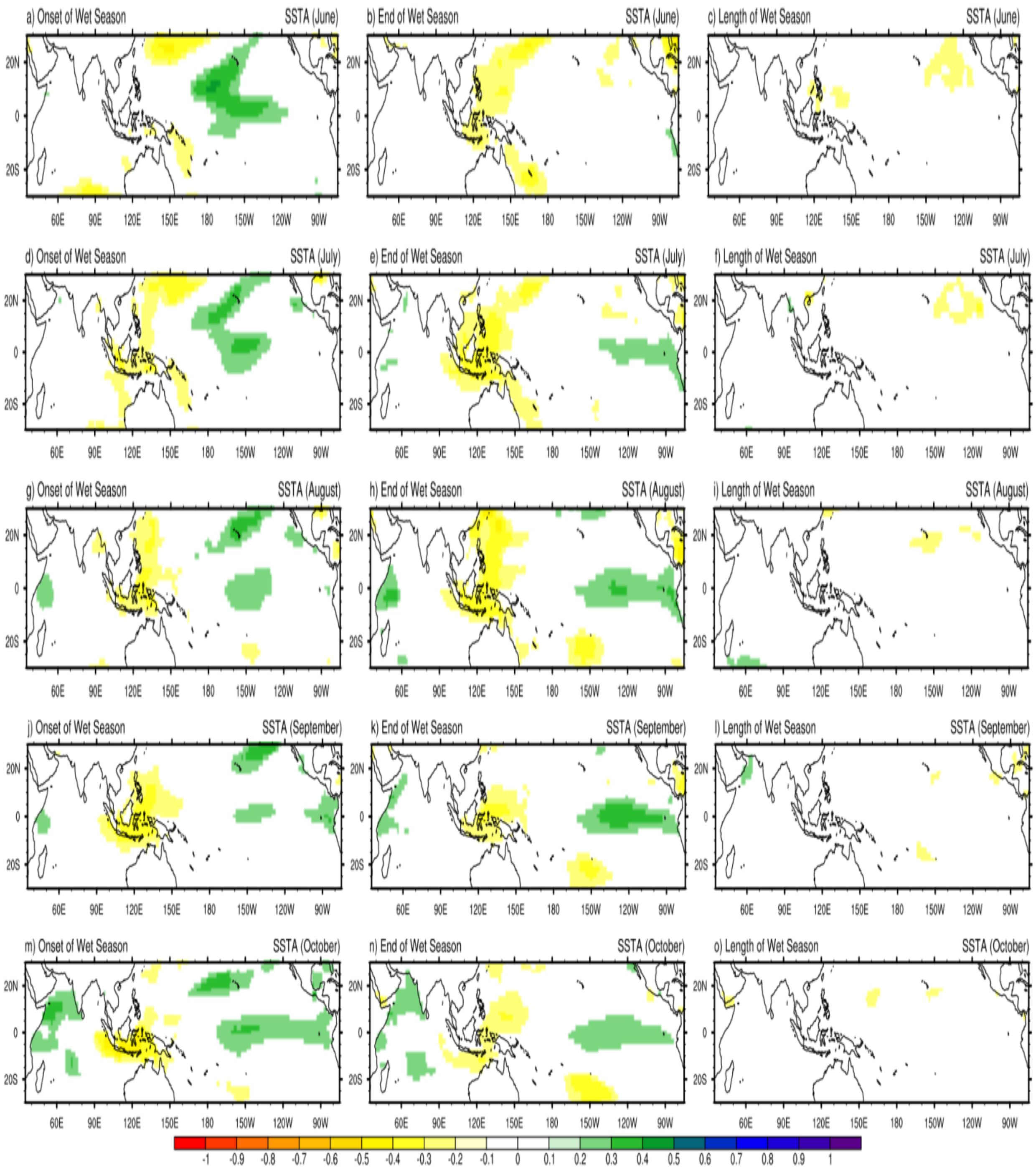


Figure 4-26 Spatial correlations of onset, end and length of wet seasons in Timor-Leste with SSTa in Indo-Pacific in a-c) June, d-f) July, g-i) August, j-l) September, and m-o) October

The areas of local SSTA that are significantly correlated with the onsets are clearly shown in July, followed in 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 (July, August and September). The correlations become higher again for SSTA in October, but with significant correlations in area that shift from the central to the eastern part of the Tropical Pacific Oceans. Based on this finding, it can be concluded that the lengths of the wet seasons are not significantly correlated with the SSTA in the Tropical Pacific Oceans, but the onsets are significantly correlated.

4.2.2.4 Trends of Extremes

Extreme climate events related to rainfall play significant role in water availability as well as disaster-related impacts on society in the country. *CCl/WCRP/JCOMM Expert Team on Climate Change Detection and Indices* (ETCCDI, http://www.wcrp-climate.org/etccdi) has developed 27 cores of climate indices that can be used to identify and monitor extremes (*see* http://etccdi.pacificclimate.org/list_27_indices.shtml). Therefore, only six indices are suitable to represent extreme climate in Timor-Leste for the region that are selected for the trend analysis (Table 4-3).

Table 4-3 Selected ETCCDI indices for the INC study

No.	Index	Definition	Calculation
1	Rx1day	Monthly maximum 1-day precipitation	Let RRij be the daily precipitation amount on day i in period j. The maximum 1-day value for period j are: Rx1dayj = max (RRij)
2	Rx3day*	Monthly maximum consecutive 3-day precipitation	Let RRkj be the precipitation amount for the 3-day interval ending k, period j. Then maximum 3-day values for period j are: Rx3dayj = max (RRkj)
3	Rx5day	Monthly maximum consecutive 5-day precipitation	Let RRkj be the precipitation amount for the 5-day interval ending k, period j. Then maximum 5-day values for period j are: Rx5dayj = max (RRkj)
4	R20mm	Annual count of days when PRCP≥ 20mm	Let RRij be the daily precipitation amount on da in period j. Count the number of days where: RI ≥ 20mm
5	CWD	Maximum length of wet spell, maximum number of consecutive days with RR ≥ 1mm	Let RRij be the daily precipitation amount on day i in period j. Count the largest number of consecutive days where: RRij ≥ 1mm
6	CDD	Maximum length of dry spell, maximum number of consecutive days with RR < 1mm	Let RRij be the daily precipitation amount on day i in period j. Count the largest number of consecutive days where: RRij < 1mm

Annual maximum 1-day precipitation (RX1day) index is analysed in this study and mostly shows some decreases in most part of Timor-Leste with the rate of the decrease around 1 mm/year. In contrast, some areas especially in the high topography region experience increasing trend, such as in the municipality of Liquica, Ermera, Aileu, Ainaro and Bobonaro (Figure 4-27a). Trend of another index, annual maximum consecutive 3-day precipitation (RX3day) is also investigated (Figure 4-27b) which shows considerable downward trends of most area in the central of the country. Meanwhile, the area in the eastern and some in the western part demonstrate increasing trends of extreme. The upward trends of extreme index in the east and west are getting higher and stronger based on the calculation result using annual maximum consecutive 5-day precipitation (RX5day) index (Figure 4-27c). The downward trends in the central to south area of the country, such as over Manufahi, Manatuto, and Viqueque are also getting stronger compared to the trends of RX3day.

Trend analysis of annual count of days when precipitation ≥ 20mm (R20mm) is also conducted (Figure 4-27d). The result shows that most of the area in Timor-Leste experience increasing trends the frequency of daily rainfall above 20 mm/day. The increase in the frequency of extreme rainfall above the threshold could impact on the increase of climate-related disasters affecting many sectors in the country. Based on the analysis of index using historical climate data, it is found that the country is not only experiencing the increase in the frequency and intensity of extreme rainfall but also the increase of climate impact related to prolong and intense drought. This is shown by the result of spatial trends of maximum length of dry spell, maximum number of consecutive days with daily precipitation for 1 day < 1mm (CDD), where most areas of the country show increasing trends, especially in the municipality located in the middle and south of the country, such as over Cova-Lima, Manufahi, Manatuto, Viqueque, Baucau and Ailue (Figure 4-27e). In contrast, trend analysis of Maximum length of wet spell, maximum number of consecutive days with daily precipitation for 1 day ≥ 1mm (CWD) shows no considerable trends in Timor-Leste (Figure 4-27).

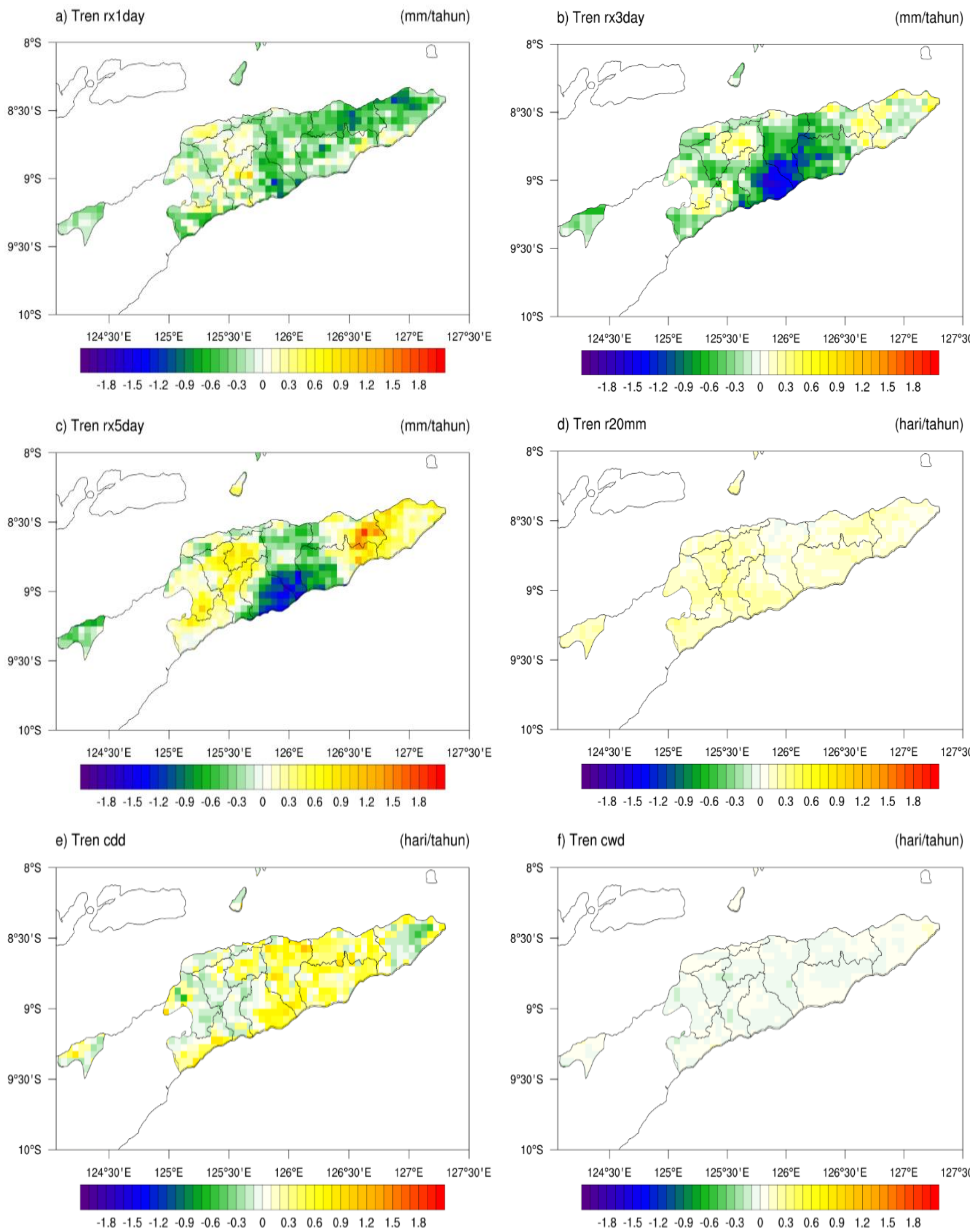


Figure 4-27 Trends of six selected ETCCDI indices: a) Rx1day, b) Rx3day, c) Rx5day, d) R20mm, e) CDD and f) CWD. Trends are calculated using 35 years historical data of CHIRPS v2.0 daily rainfall datasets during 1981-2015 periods.

4.2.3 Sea Level Rise

Based on the trends of sea level obtained from satellite altimetry data (referred to as multi-mission, see Figure 4-28), there were increasing trends of sea level rise surrounding Timor-Leste. It is similar with the study for Pacific Climate Change Science Program (2011) as the ocean water become warmer and causing the sea level to rise. 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 4-28; left). In 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 500 mm 2100 (Figure 4-28; right).

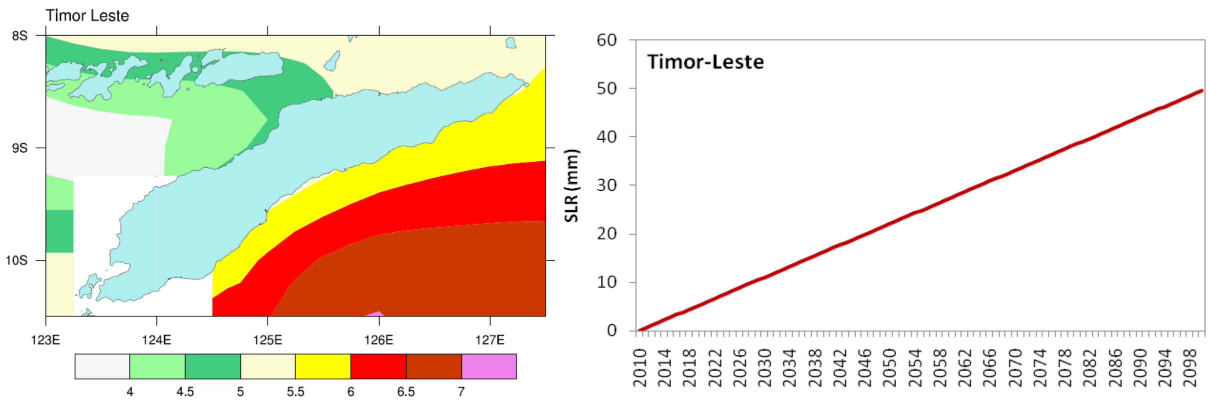


Figure 4-28 Trend of mean sea level rise from observed multi-mission satellite altimetry during October 1992 – November 2009 (units in mm/year; left), and projected increase of sea level based in the future based on the average of current trends (units in mm; right). *Source:http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/altimetry-data-and-images/index.html*)

4.3 Future Climate Change

During the past few years, the science of climate change projection modeling and impact assessment modeling has considerably improved. IPCC has produced their Fifth Assessment Report (AR5), and the use of SRES scenarios has been replaced by the next generation climate change scenarios known as the Representative Concentration Pathway (RCP). The study of climate change projection scenarios for Timor-Leste is conducted using multi-model ensemble (MME) of CMIP5 GCMs under different RCP scenarios. The RCP scenarios are the recent climate change scenarios that were defined based on the pathways of radiative forcing until 2100 (Moss *et al.*, 2008: Moss *et al.*, 2010). It consists of four scenarios, describing from the lowest scenario represented by RCP2.6, moderate scenarios shown by RCP4.5 and RCP6.0 and the highest scenario represented by RCP8.5. Information regarding those RCPs is listed in Table 4-4. The ideal target is at scenario RCP2.6 in which under this scenario, the probability of global temperature to increase beyond 2°C will be less than 50%. However, considering the capacities of the various nations, this target may not be achievable and the pledge may follow RCP4.5. 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).

Table 4-4 The four RCPs used in the new climate change scenarios (Source: Moss et al. 2008)

Name	Radiative Forcing	Concentration (p.p.m)	Pathway	Model providing RCP
RCP8.5	>8.5 Wm^{-2} in 2100	>1,370 CO_2-equiv. in 2100	Rising	MESSAGE
RCP6.0	~6 Wm^{-2} at stabilization after 2100	~850 CO_2-equiv. (at stabilization after 2100)	Stabilization without overshoot	AIM
RCP4.5	~4.5 Wm^{-2} at stabilization after 2100	~650 CO_2-equiv. (at stabilization after 2100)	Stabilization without overshoot	GCAM
RCP2.6	Peak at ~3 Wm^{-2} before 2100 and then declines	Peak at ~490 CO_2-equiv. before 2100 and then declines	Peak and decline	IMAGE

4.3.1 Temperature

The latest IPCC AR5 report has strongly emphasized the contribution of anthropogenic factor in enhancing global warming and climate change. It is projected that the temperature will continue to increase in the future. The projection results based on the outputs of CMIP5 GCMs under the RCP scenarios shows that the temperature for 2081-2100 will increase around 0.3°C to 1.7°C in RCP2.6, 1.1°C to 2.6°C in RCP4.5, 1.4°C to 3.1°C in RCP6.0, 2.6°C to 4.8°C in RCP8.5 scenario. It is suggested that the change in the mean surface temperature will not be regionally identical (IPCC 2013). Therefore, more analysis on the regional or national level for the future mean temperature projections is needed.

In general, the country has experienced and increase of mean annual temperature with an annual rate of increase of 0.016 °C per year. The projection result between global mean temperature resulted in the IPCC AR5 and mean temperature in Timor-Leste based on multi-model ensemble analysis is shown in Figure 4-29. It is shown that the mean temperature projection in Timor-Leste will continue to increase in the future consistent with the increase of global mean temperature. However, the rate of the increase will be slightly different. The raise of mean temperature in the country is expected to be lowering than in global. This can be seen from the graph especially in the year of 2100, where the ensemble mean for Timor-Leste is around 3.4 °C under the highest RCP scenario (RCP8.5). The value is more than half degrees lower than the value projected in global mean temperature under the same time and scenario. Nevertheless, looking from the values of uncertainties from the models, the maximum increase of temperature between Timor-Leste and global in 2100 will be similar around 4.8 °C.

a) Global Mean Temperature [5] **b) TL Mean Temperature**

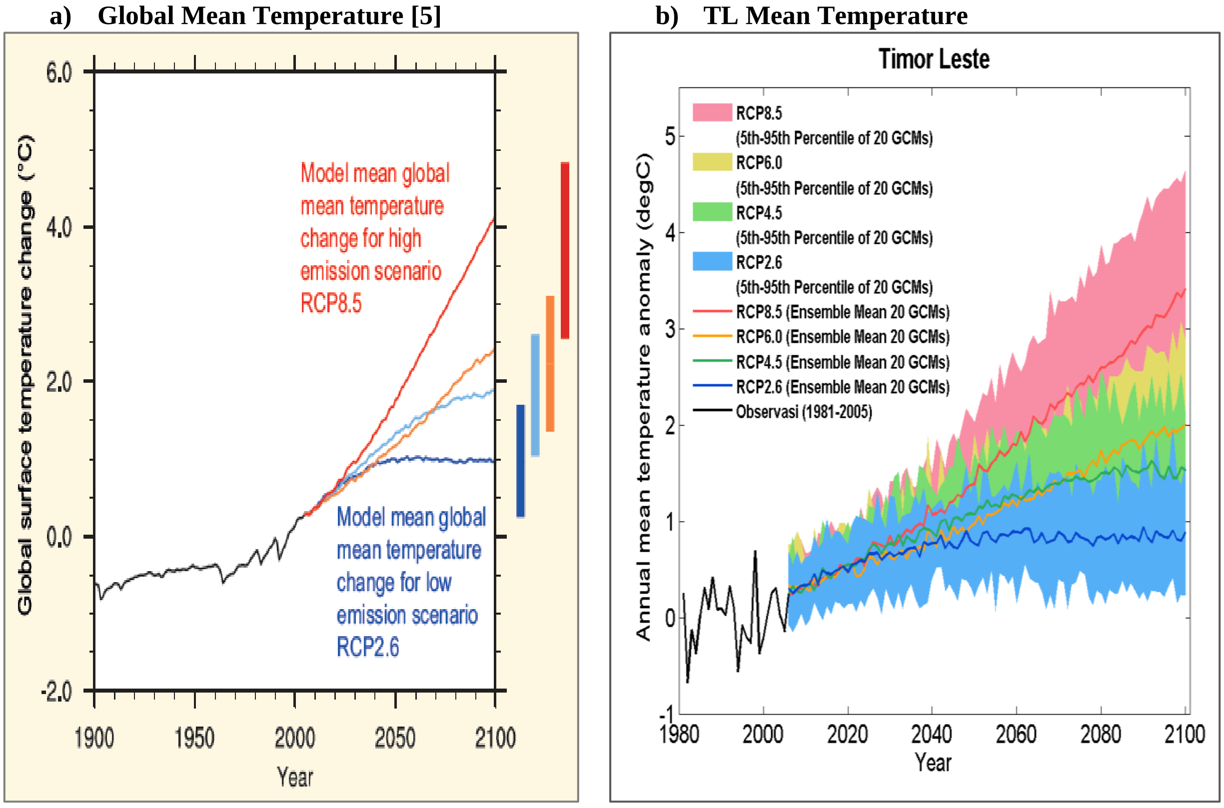


Figure 4-29 Projected annual mean temperature anomaly in Timor-Leste based on the ensemble mean of 20 GCMs. The uncertainty range of each scenarios were calculated based the range of 5th to 95th percentiles of the models.

Spatial analysis of mean temperature anomalies in Timor-Leste based on the outputs of RCM simulations under moderate scenario (RCP4.5) and extreme scenario (RCP8.5) is shown in Figure 4-30. The spatial temperature anomaly in the country will consistently to increase in the future. In year 2030, the terrestrial temperature anomalies are projected to be around 1.1-1.3 °C under RCP4.5 and slightly lower under RCP8.5, i.e. around 0.9-1 °C. In 2050, the RCP 8.5 projects higher temperature anomalies compared to RCP4.5, and this continues to the next following years, including in 2070. RCP4.5 projects an increase of temperature anomalies around 1.6-1.8 °C, while RCP8.5 around 1.8-2 °C. For the year 2070, the difference between temperature anomalies projected by RCP4.5 and RCP8.5 are large. RCP4.5 project temperature increase around 2.0-2.1 °C and RCP 8.5 projects the temperature anomalies to be above 3 °C from the climatological values during baseline periods. More detail maps on the projected temperature result can be seen in Climate Change Trend and Scenario Analysis for the Second National Communication of Timor-Leste 2018.

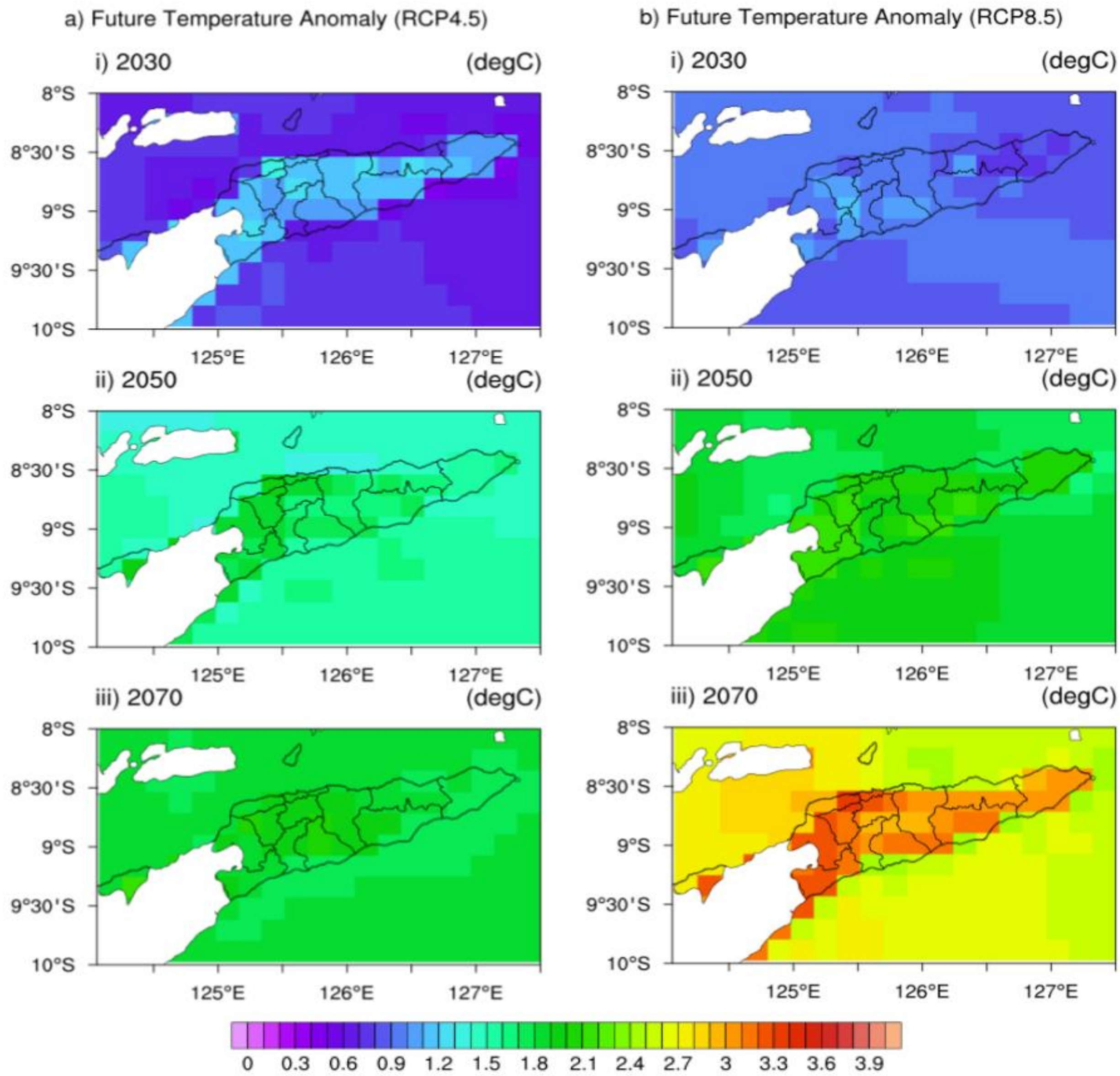


Figure 4-30 Future annual temperature anomalies in year: i) 2030, ii) 2050, and iii) 2070, projected under: a) RCP4.5 and b) RCP8.5. The anomalies are calculated relative to the annual mean of 1981-2005 baseline periods. The scenario data were resulted from RegCM4.5 simulation using ICBC from HadGEM2-ES GCM data outputs.

4.3.2 Rainfall

Rainfall Projections

Future rainfall projections are investigated using statistical and dynamical downscaling approaches. The future changes of seasonal rainfall climatology are projected by using downscaled rainfall data from 20 GCMs under four RCP scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5). The projections are divided into three periods in the future, i.e. 2006-2030, 2026-2050 and 2051-2075 and the calculation refers to the reference data in 1981-2005 periods. The seasonal maps are presented in separately for DJF, MAM, JJA and SON seasons as respectively displayed in Figure 4-31 to 4-34.

The climatology of rainy season in DJF in Timor-Leste is projected to be mostly decrease in the future (Figure 4-31). This is based on the projections performed under different scenarios at three different periods. From 12 combinations of the scenarios and periods, 8 projections show agreements on this condition, while 3 others are showing possible increase of rainfall, i.e. in RCP4.5 (2006-2030 periods), RCP8.5 (2006-2030 periods), and RCP6.0 (2026-2050 periods). All scenarios for 2051-2075 agree to project possible rainfall decrease in the future.

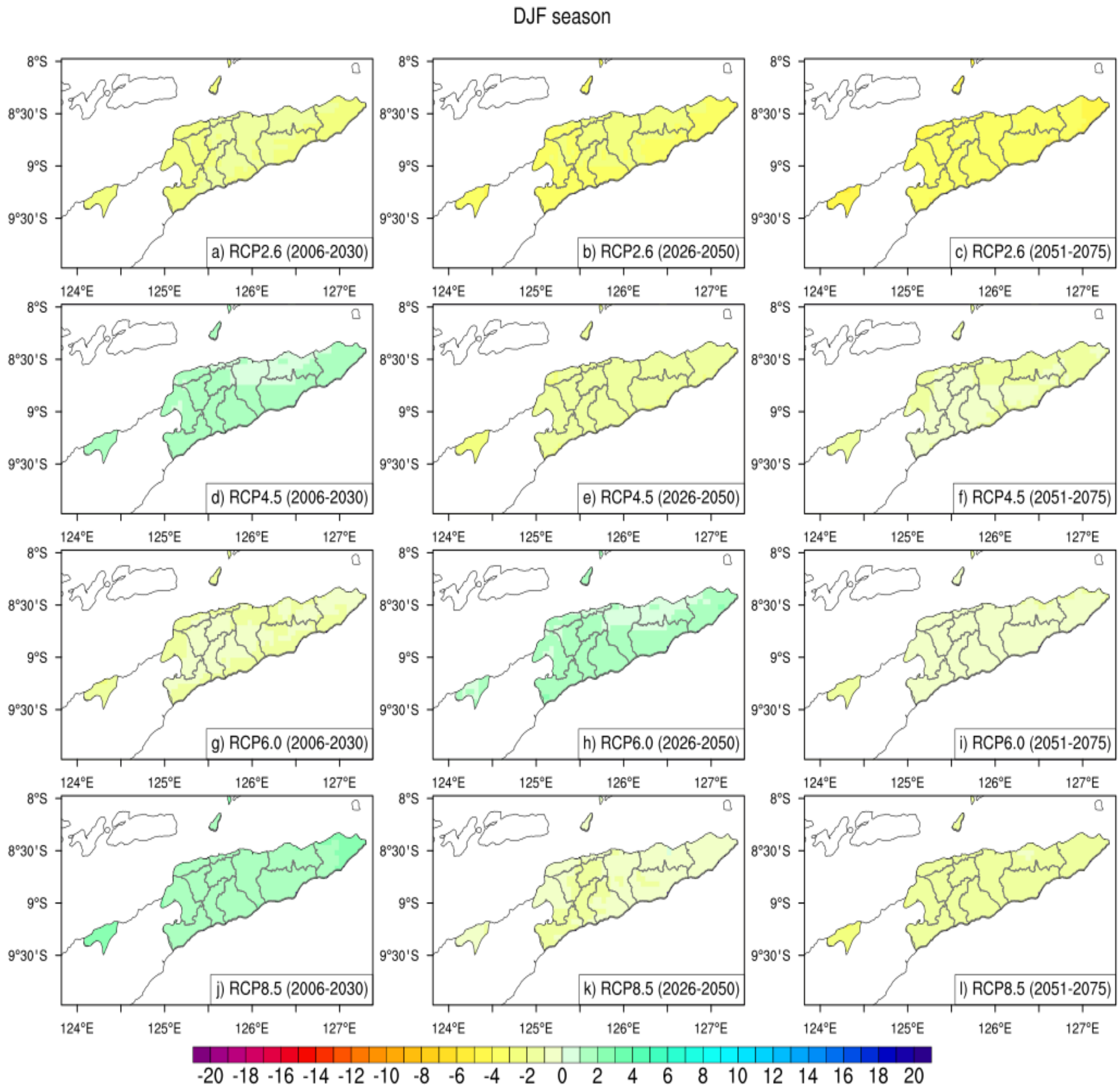


Figure 4-31 Projected rainfall changes in DJF season from the multi-model ensemble mean of 20 GCMs downscaled using bias correction method

Unlike in DJF, the seasonal rainfall in transition period from rainy season to dry season (MAM) is projected to increase (Figure 4-32). All scenarios at different periods show that rainfall during this season will increase in the future. Agreement of all scenario and period combinations is also found in dry season (JJA) in Figure 4-33. For this season, the future rainfall will decrease compare to the rainfall in the reference period. The sign of decrease of rainfall during this dry season may lead to possible increase on the drought-related impacts.

During the transition from dry to wet seasons in SON, the projection result indicates inconsistent rainfall change between different scenario and period combinations. Nevertheless, there is a clear indication from those projections that the further the period projected, lead to dried condition in the future. However, it is not necessarily related to the more extreme RCP scenario (Figure 4-34). Additional result from projections resulted by the dynamical downscaling results under a single GCM input and two scenarios (RCP4.5 and RCP8.5) are shown in annexes of Climate Change Trend and Scenario Analysis for the Second National Communication of Timor-Leste. Please note that the results from a single model obtained from RCM simulation may not be comparable with the results obtained from the multi-model ensemble mean of downscaled 20 GCM model outputs. The result from RCM driven by a single model is likely to be inside the uncertainty ranges resulted from the multi-model ensemble analysis.

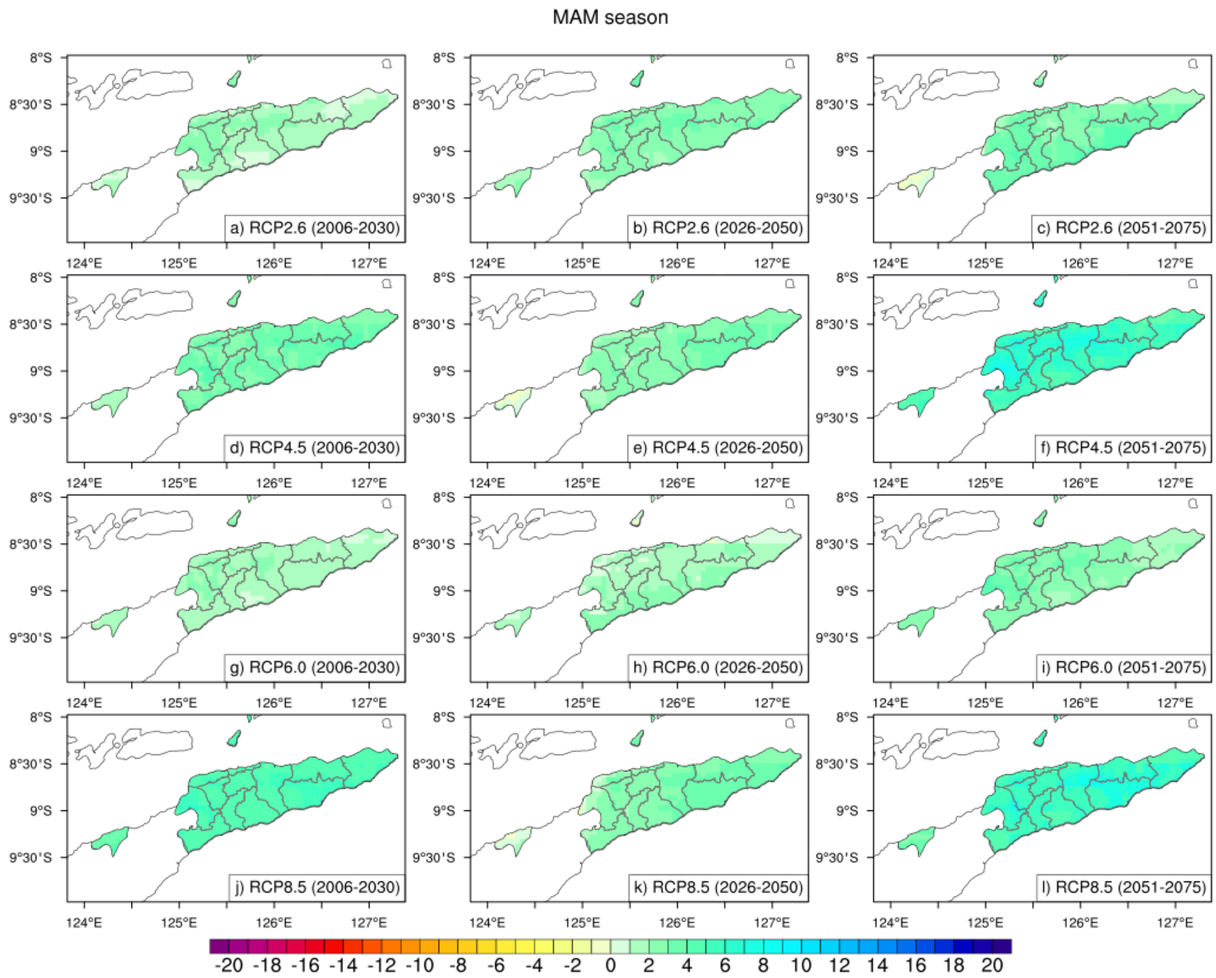


Figure 4-32 Projected rainfall changes in MAM season from the multi-model ensemble mean of 20 GCMs downscaled using bias correction method.

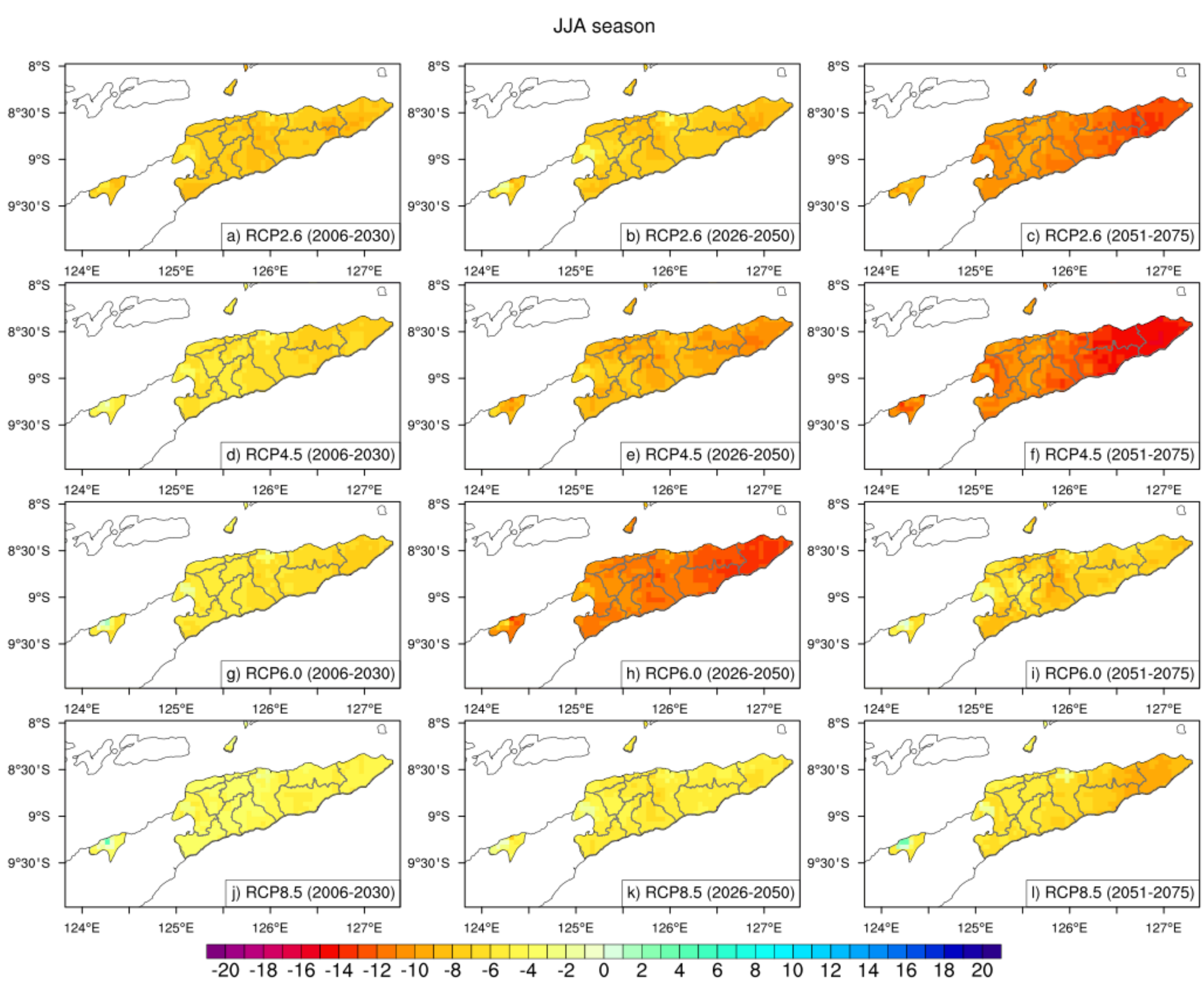


Figure 4-33 Projected rainfall changes in JJA season from the multi-model ensemble mean of 20 GCMs downscaled using bias correction method.

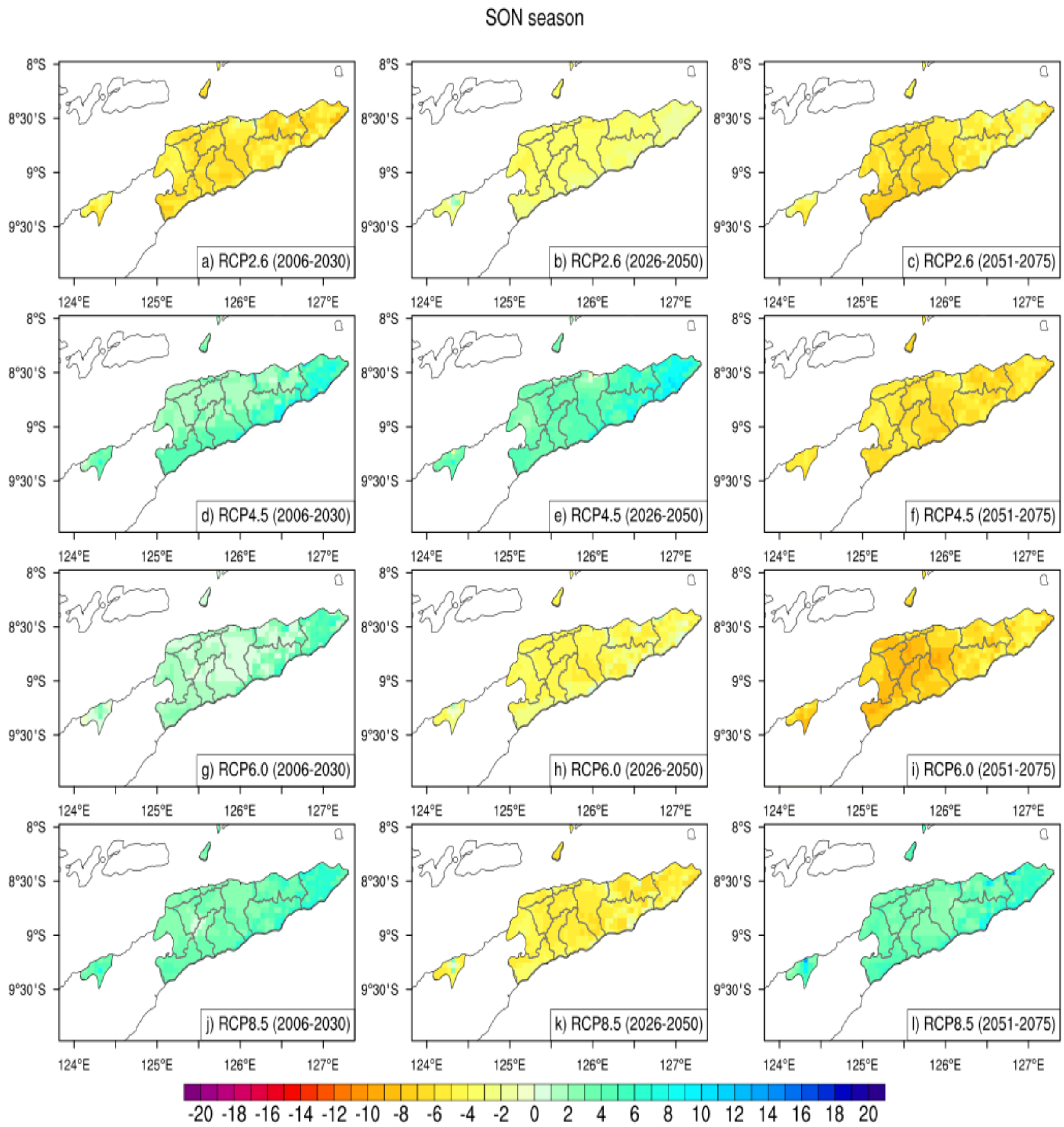


Figure 4-34 Projected rainfall changes in SON season from the multi-model ensemble mean of 20 GCMs downscaled using bias correction method.

Changes of Rainfall Types

The rainfall patterns in Timor-Leste are ranging from driest area in the northeastern part to wet area in the western part of the country. 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 4-35 and 4-36. 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.

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 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 rainfalls.

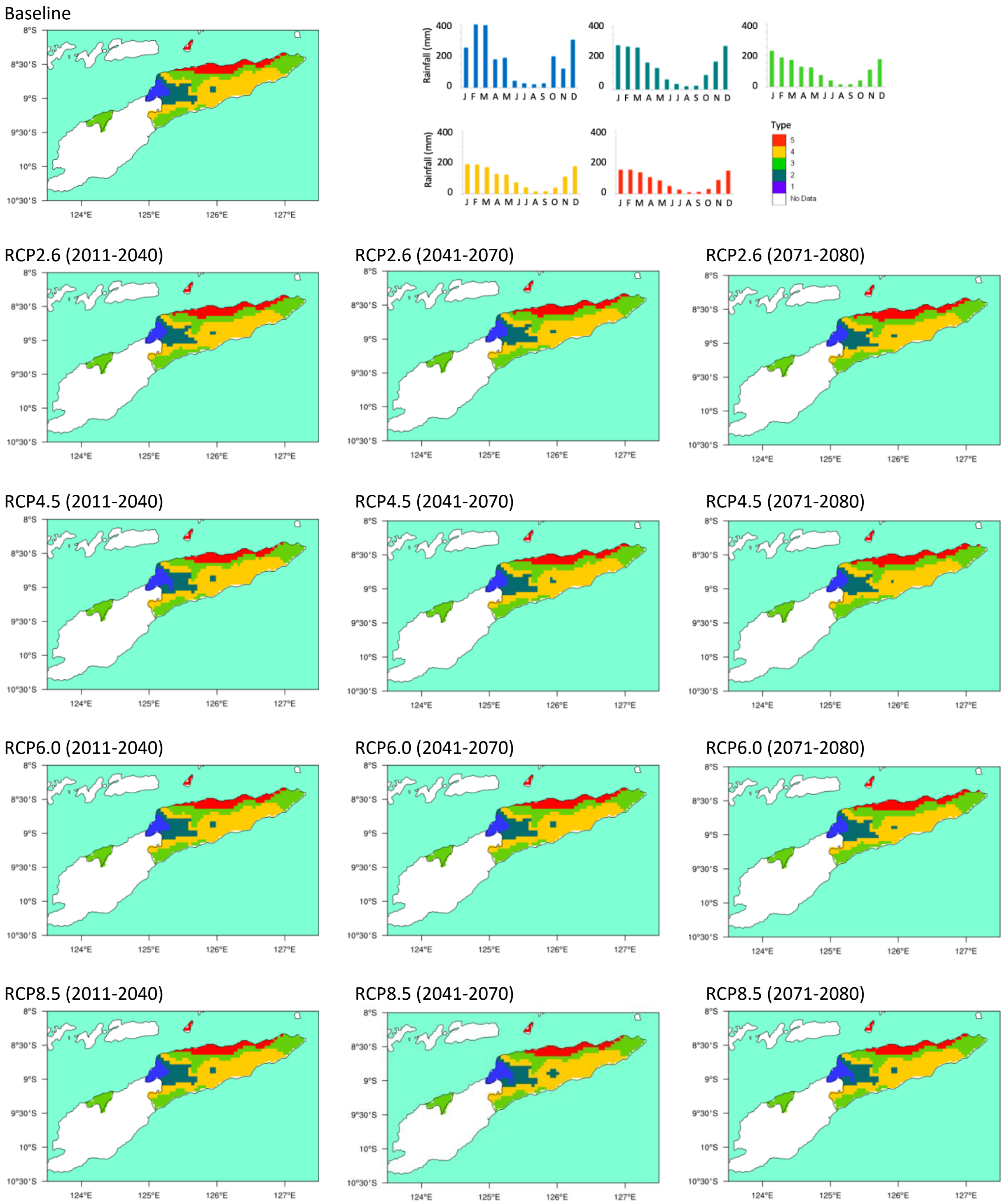


Figure 4-35 Changes in the spatial patterns of rainfall types in Timor-Leste based on the 20 GCMs multi-model ensemble projection under four RCP scenarios at three different future periods, i.e. in 2011-2040, 2041-2070 and 2071-2100.

Figure 4-36 Projected changes of total area at different rainfall types

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 4-14 and 4-15). 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 more expected to occur in the dry season and 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 4-37).

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 show that the wet season rainfall in the DJF season are 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 of 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 4-38).

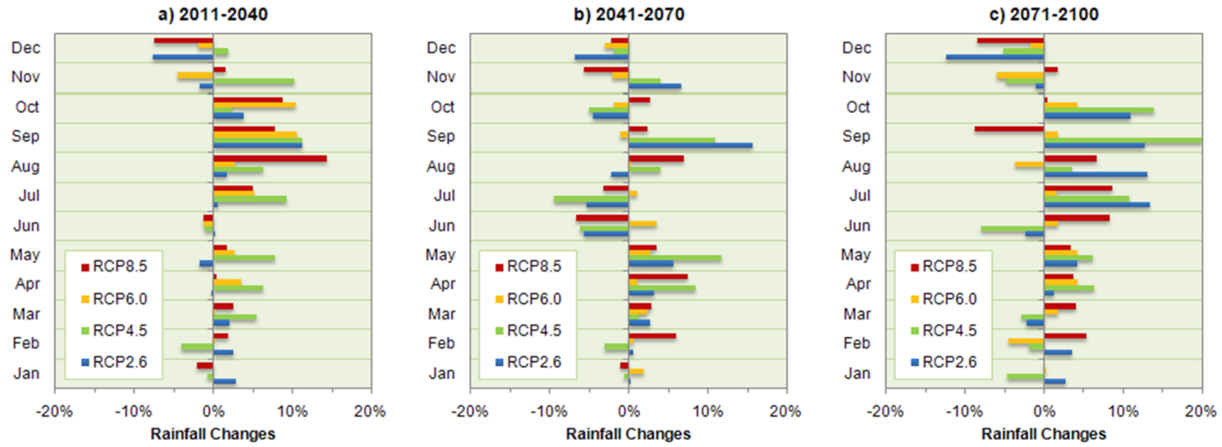


Figure 4-37 Changes of monthly rainfall climatology in Timor-Leste as projected by the median of 20 CMIP5 GCMs based on four RCP scenarios

Under the RCP4.5 scenario, different projections results on future rainfall are shown (Figure 4-39). Unlike in 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 4-40), where most models show that the season will experience a rainfall decrease over some areas in the country. Especially for this season and time periods, instead, most models under the RCP6.0 scenario project an increase of rainfall. Under the highest range scenario (RCP8.5 in Figure 4-41), the models mainly show a very low consensus in projecting future seasonal rainfall in Timor-Leste. This is similarly found in other RCP scenarios which projected an increase of future rainfall in Timor-Leste under the RCP8.5 for the MAM season during the 2011-2040 and 2041-2070 periods.

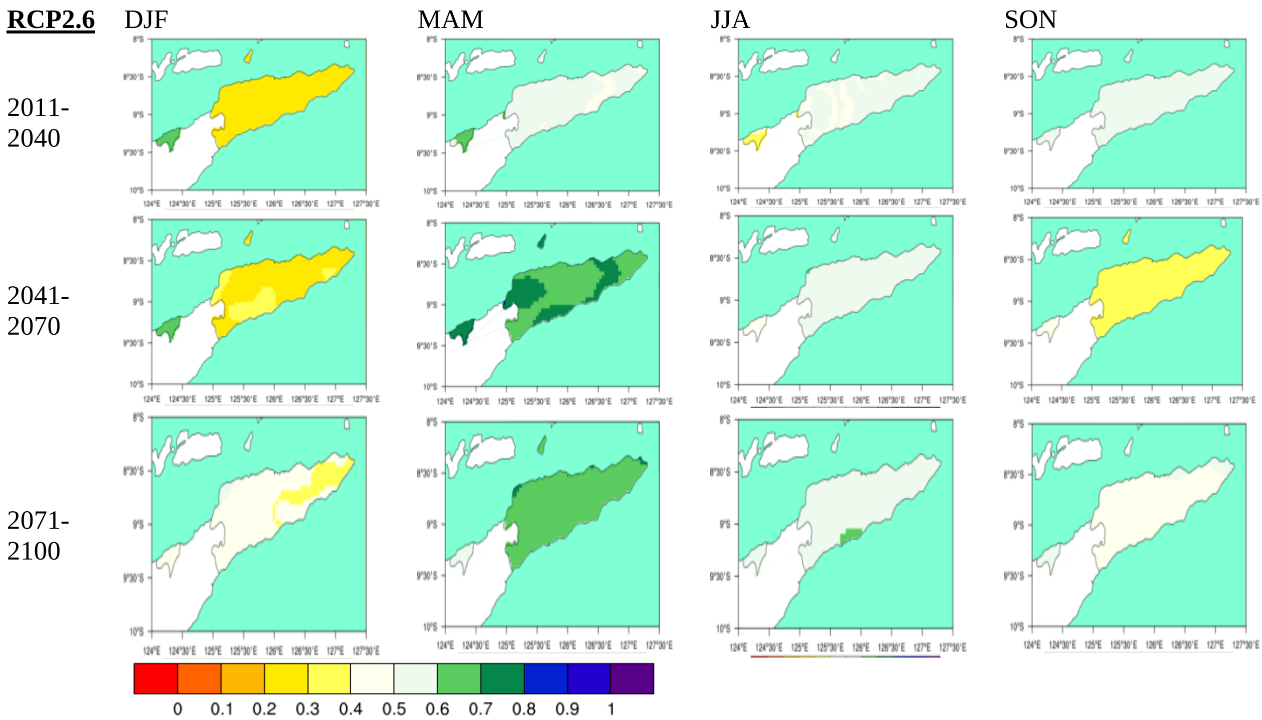


Figure 4-38 Level of probability of 20 CMIP5 GCM models under the RCP2.6 scenario in projecting seasonal rainfall increases in Timor-Leste

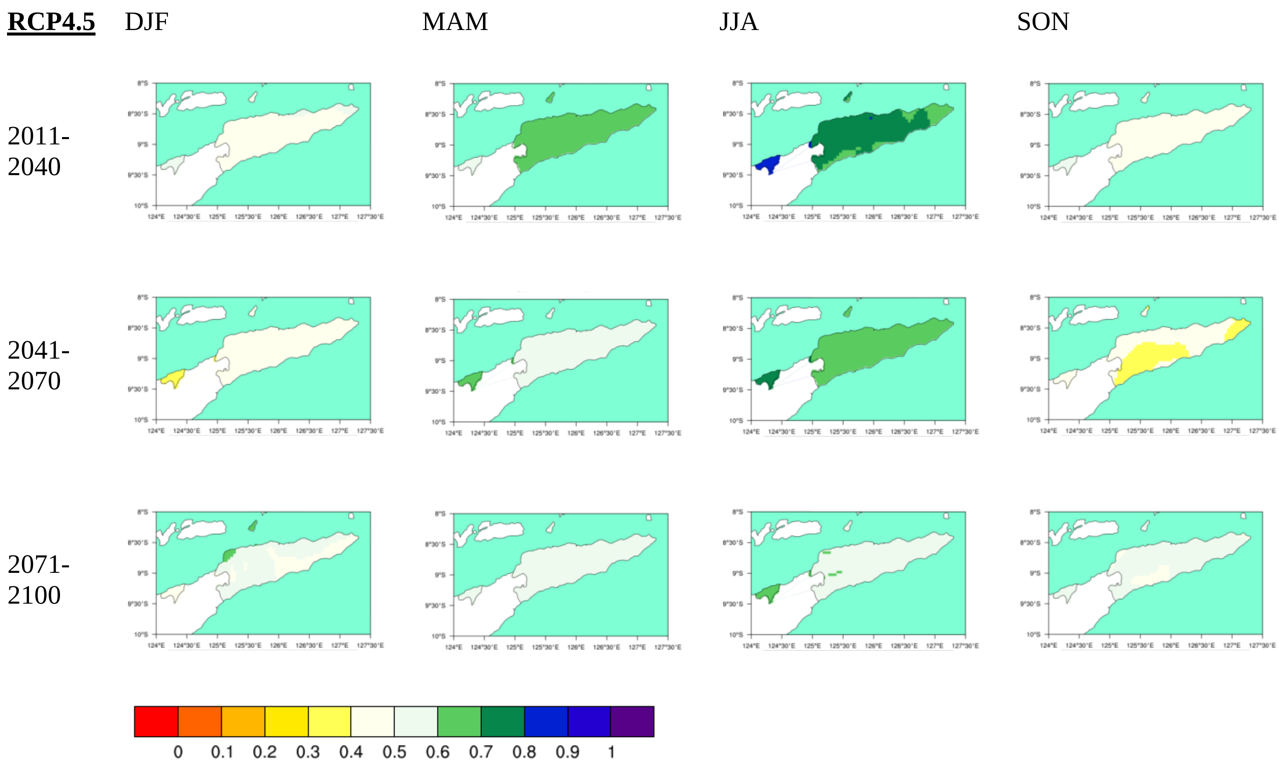


Figure 4-39 Level of probability of 20 CMIP5 GCM models under the RCP4.5 scenario in projecting seasonal rainfall increases in Timor-Leste

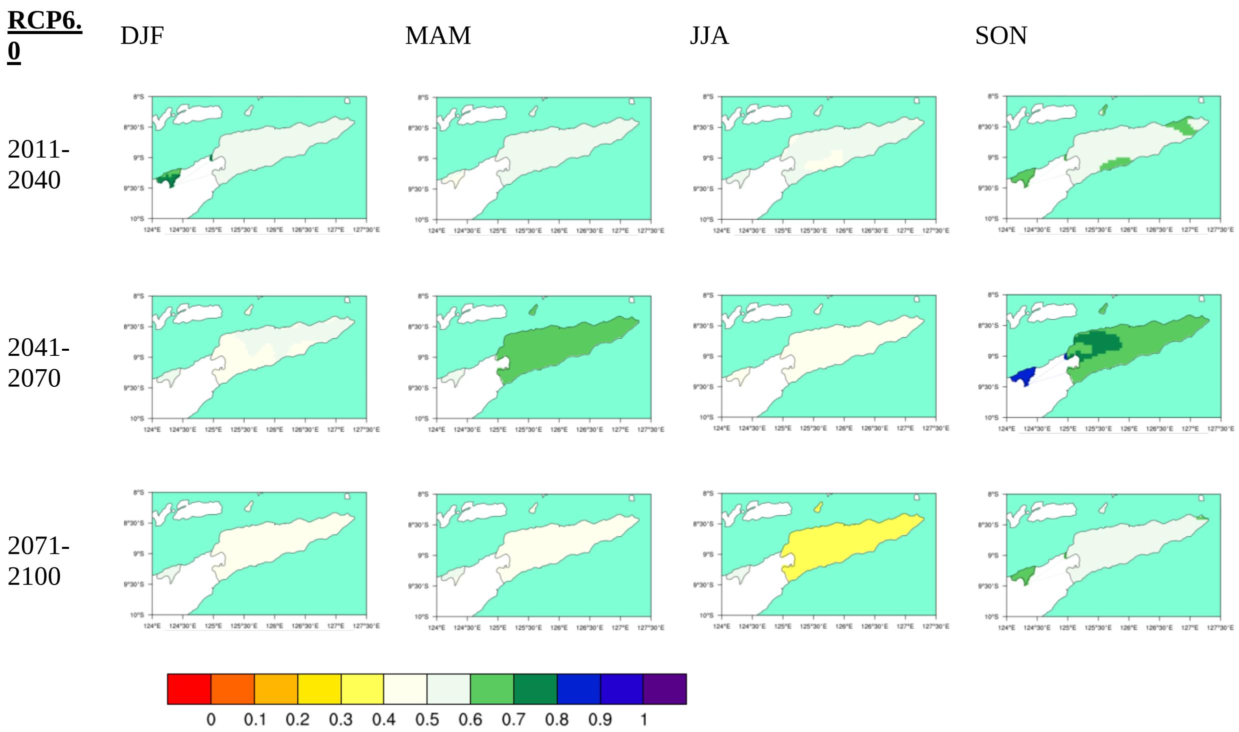


Figure 4-40 Level of probability of 20 CMIP5 GCM models under the RCP6.0 scenario in projecting seasonal rainfall increases in Timor-Leste

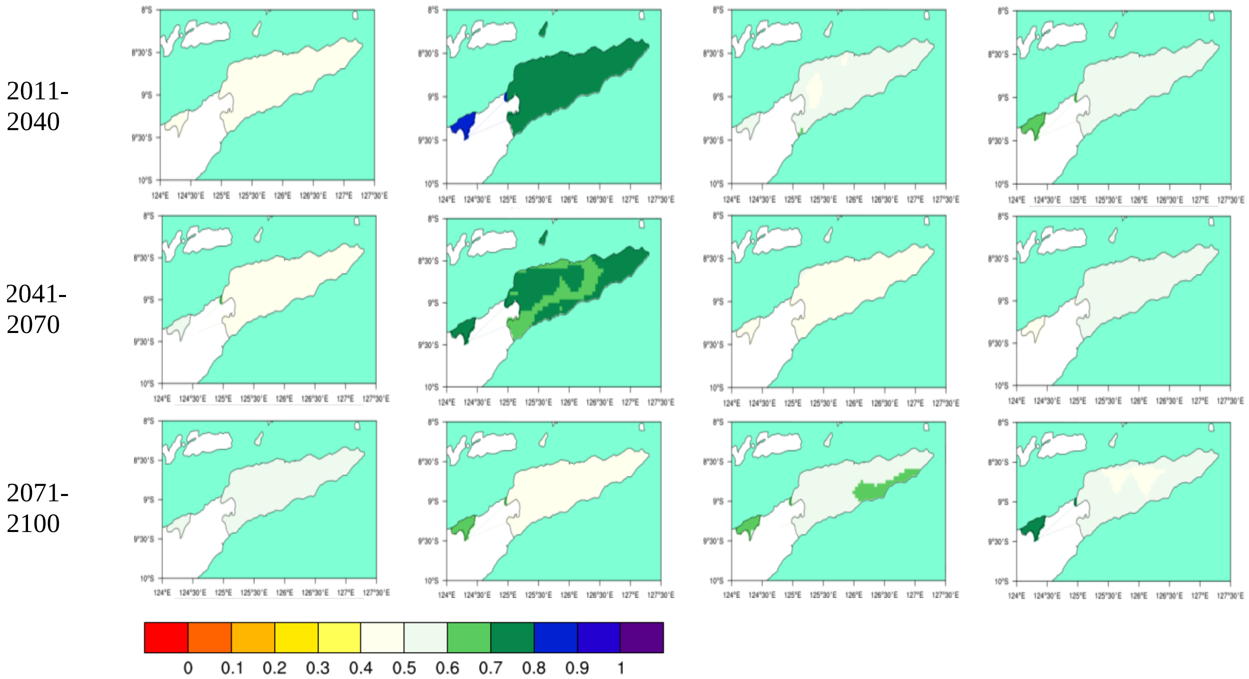
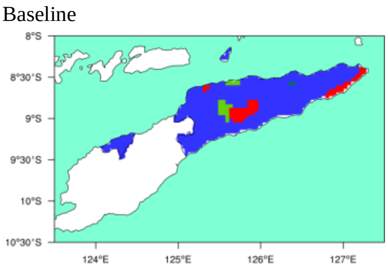


Figure 4-41 Level of probability of 20 CMIP5 GCM models under RCP8.5 scenario in projecting seasonal rainfall increases in Timor-Leste

Changes of the Dry and Wet Season Onsets

Based on the projections of the future dry and wet season onsets using statistical downscaling methods, Timor-Leste is projected to experience some changes to the average timing of the season onsets in the future. Figure 4-42 indicates that most of the timing of the dry season onsets in the country will be shifted. In the current period, most of the regions in Timor-Leste experienced 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 which could reach around 28 days of advance and delays of the onsets 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 onsets, the changes to the wet season onsets in Timor-Leste are expected to be consistent across different periods and scenarios (Figure 4-43). 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.



Cluster Region		Distribution Parameters: Shape	Distribution Parameters: Scale	Distribution Parameters: Location	Onset Date
	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

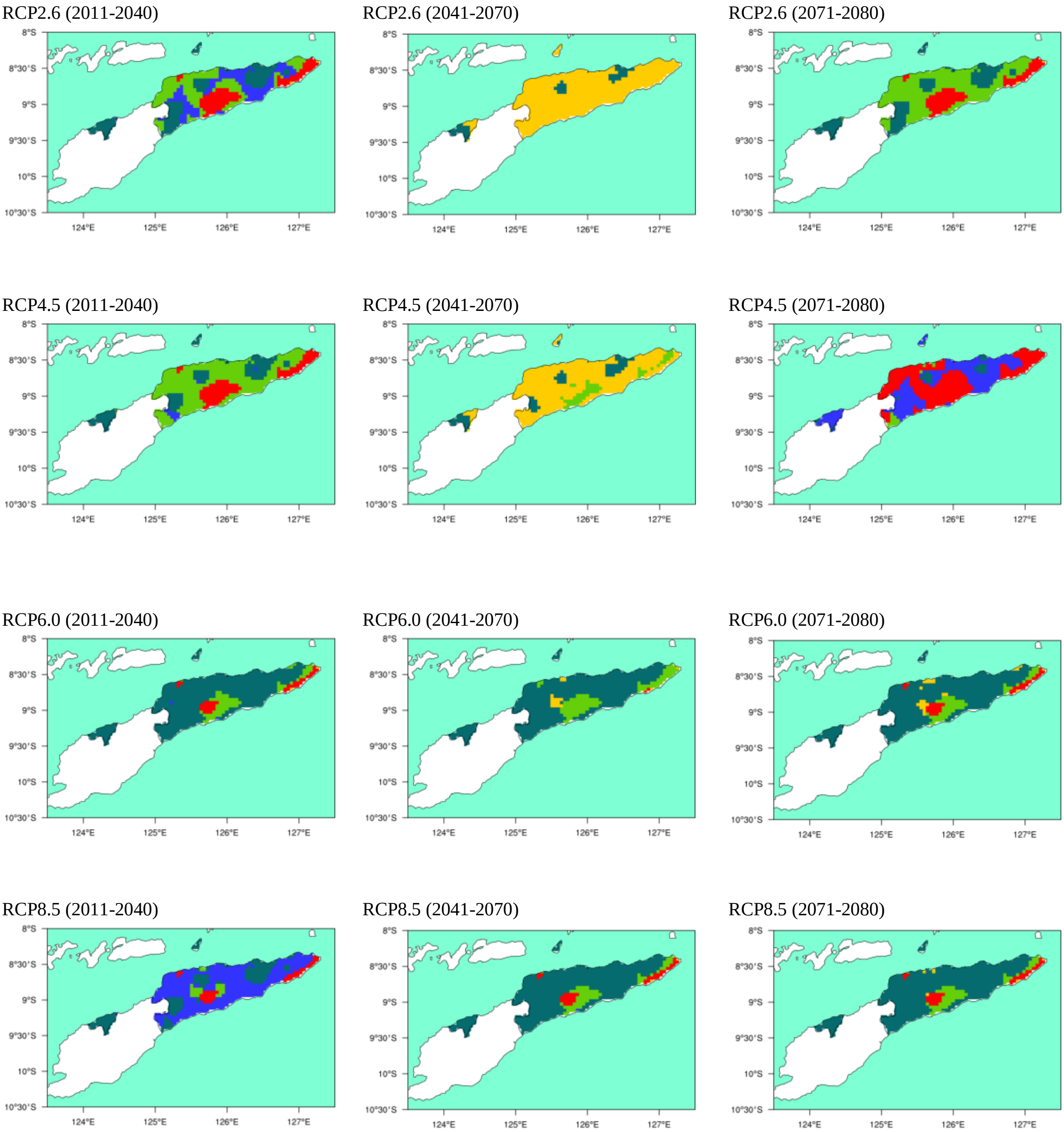
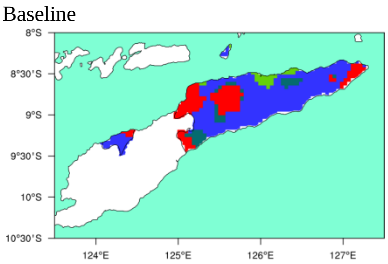


Figure 4-42 Projected changes of dry season onsets from 20 GCMs CMIP5 in Timor-Leste compared to the current baseline



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

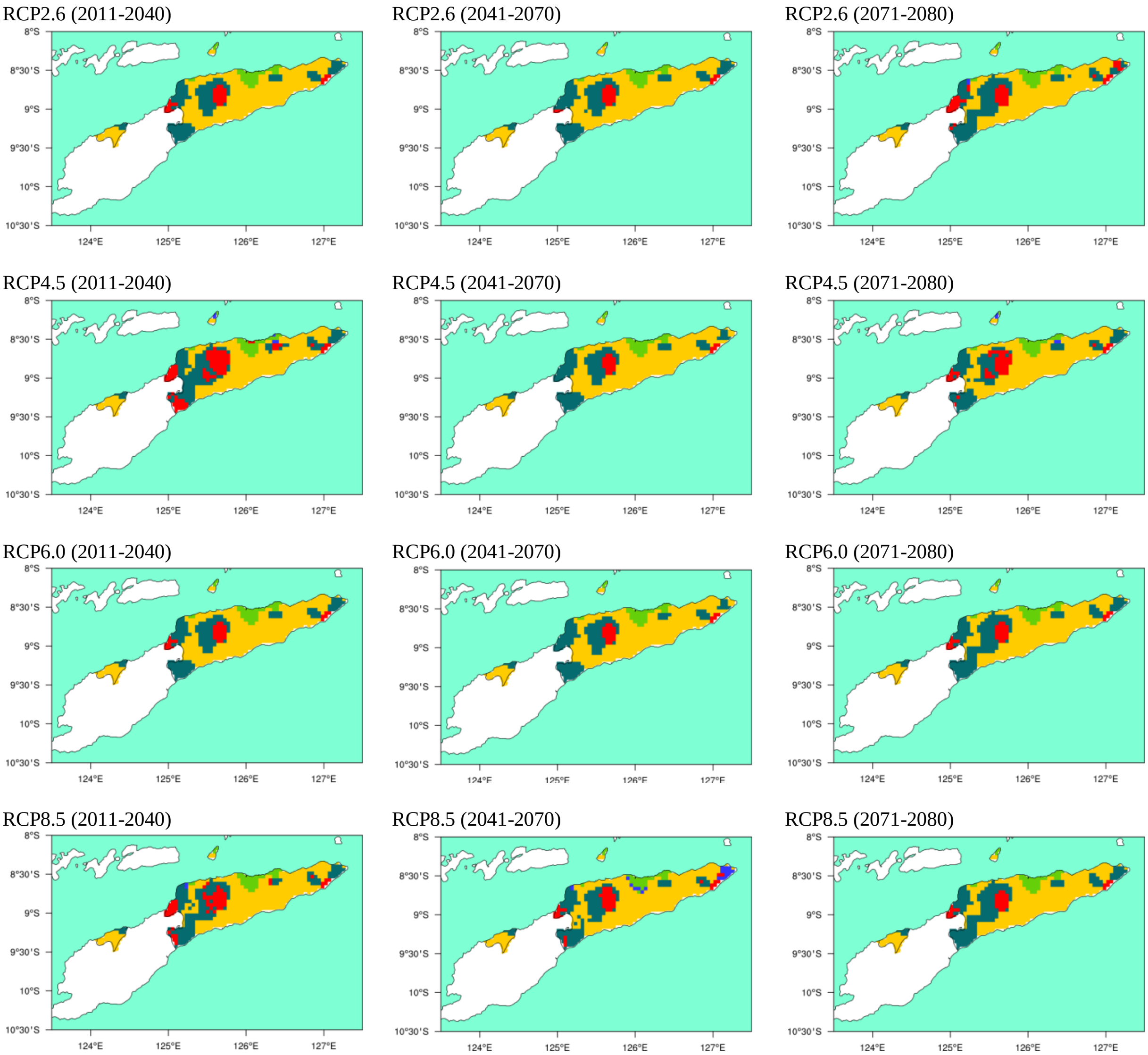


Figure 4-43 Projected changes of wet season onsets from 20 GCMs CMIP5 in Timor-Leste compared to the current baseline

4.3.3 Extreme Indices Projection Scenarios

Five ETCCDI extreme indices are selected to be projected for this study. The projections are conducted by performing downscaling on the outputs of 14 GCMs for multi-model ensemble (MME) analysis. The analysis will be based on trend and time series analysis of the MME based on spatial mapping and time series plot, respectively. For the time series plot will be summarized for every municipality located in the country. Spatial trends are calculated using the data from the combination of baseline and future periods (1981-2100).

4.3.3.1.1 Annual Maximum 1-day Precipitation (RX1DAY)

Spatial trends of RX1day indices from the reference and projected data obtained from 14 GCMs MME mean are shown in Figure 4-44. It is projected that the future rainfall extreme defined by the RX1day index will increase in the future. Considerable increase is mostly shown in the southern/south eastern part of the country, where the highest upward trends are resulted by RCP8.5 scenarios. The RCP 4.5 is the scenario that could probably produce the least upward trends of the index.

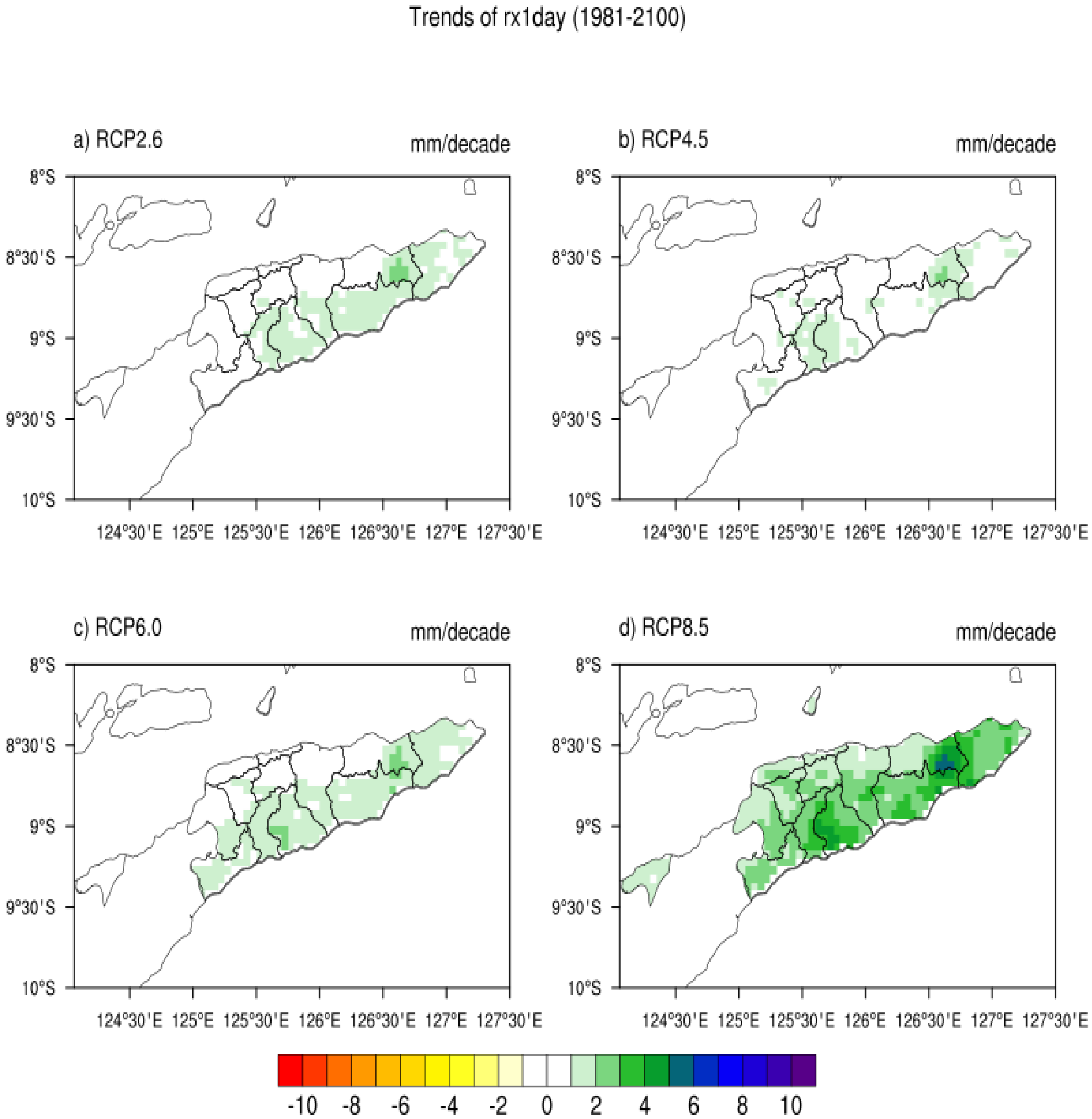


Figure 4-44 Spatial trends of RX1DAY in Timor-Leste based on ensemble median of bias-corrected outputs of 14 CMIP5 GCMs unde 4 RCP scenarios: a) RCP2.6, b) RCP4.5, c) RCP6.0 and d) RCP8.5. Trends were calculated using long term data in 1981-2100 periods.

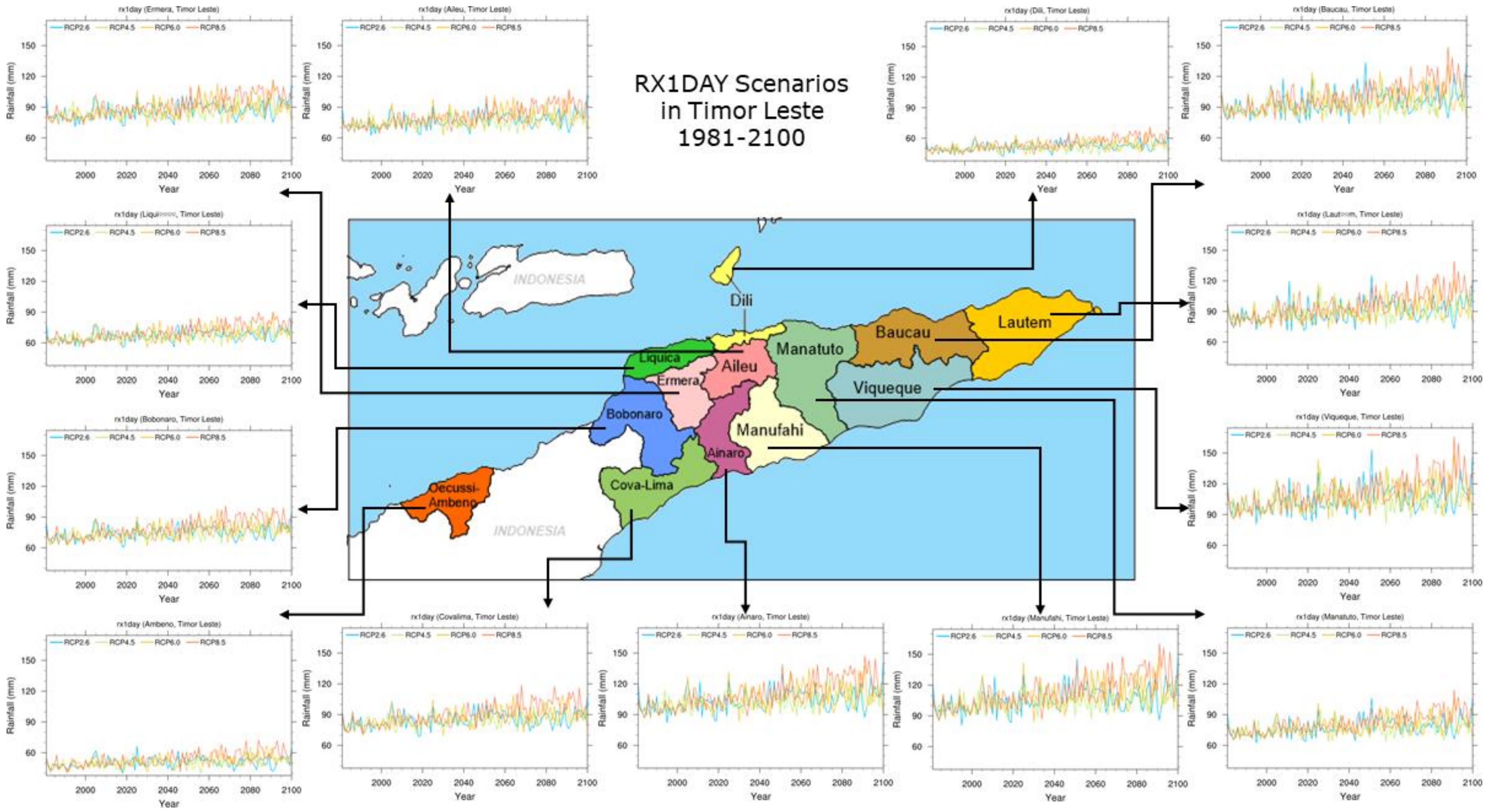


Figure 4-45 Scenario and trends of RX1DAY in each of 13 municipalities in Timor-Leste. The time series were calculated from the ensemble median of the bias-corrected outputs of 14 CMIP5 GCMs. It is based on the area averaged index within the area of the selected municipality.

Figure 4-45 provides more detail analysis of the RX1day projections based on the MME mean. Based on the results, several municipalities are identified to have large variability and intensity of the RX1day index, such as Baucau, Lautem, Viqueque, Manufahi, and Ainaro. In general there is tendency that the trend will increase in the future with RCP8.5 producing highest upward trends compare to other scenarios.

4.3.3.1.2 Annual Maximum 5-days Precipitation (RX5DAY)

Similar to the results in RX1day, the spatial trends of RX5day indices are also projected to increase in the future (Figure 4-46). The trends are expected to be increase at most of the main area of the country at all RCP except RCP4.5. The RCP 4.5 is the scenario that could probably produce the least upward trends of the index. Considerable increase is mostly shown in the southern/south eastern part of the country, where the highest upward trends are resulted by RCP8.5 scenarios. This is similar to the projection result of the RX1day index.

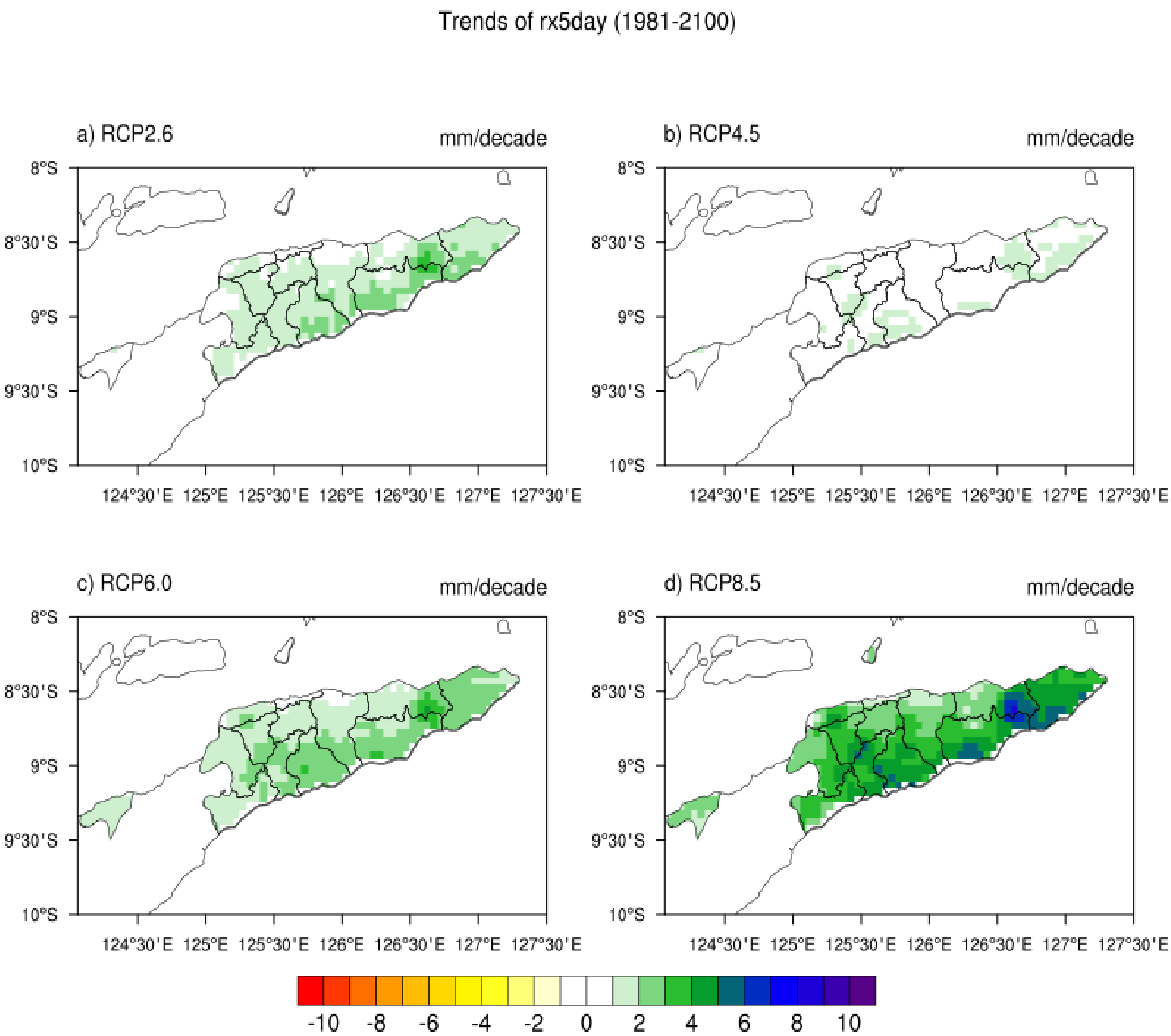


Figure 4-46 Spatial trends of RX5DAY in Timor-Leste based on ensemble median of bias-corrected outputs of 14 CMIP5 GCMs unde 4 RCP scenarios: a) RCP2.6, b) RCP4.5, c) RCP6.0 and d) RCP8.5. Trends were calculated using long term data in 1981-2100 periods.

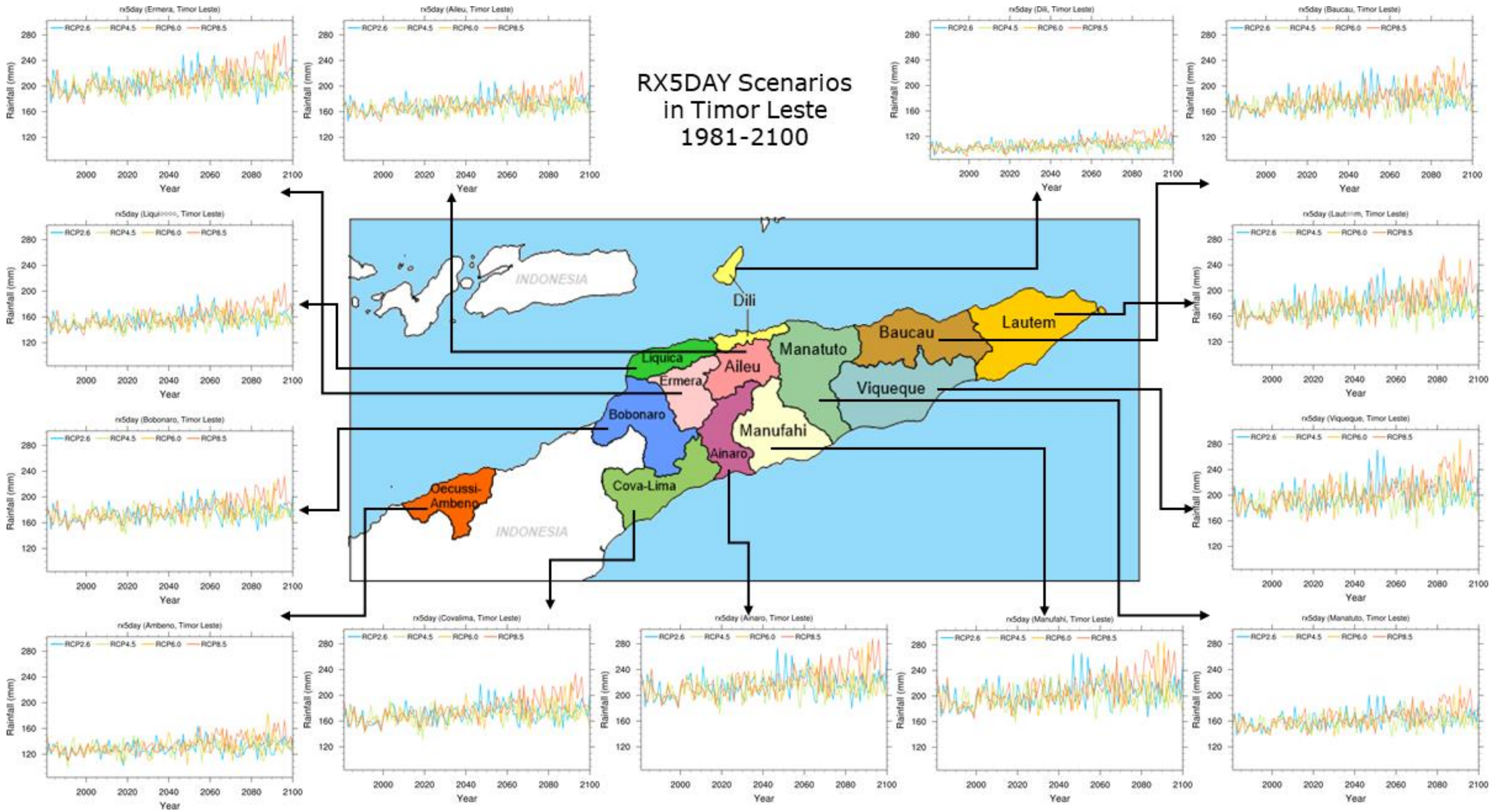


Figure 4-47 Scenario and trends of RX5DAY in each of 13 municipalities in Timor-Leste. The time series were calculated from the ensemble median of the bias-corrected outputs of 14 CMIP5 GCMs. It is based on the area averaged index within the area of the selected municipality.

Based on the results in Figure 4-47, several municipalities are identified to have large variability and intensity of the RX5day index, such as Baucau, Lautem, Viqueque, Manufahi, and Ainaro. This is similar with the result shown in RX1day index. However, there is also another municipality that show considerable increase in the future projection in term of the index's variability and intensity. The RCP8 is identified to be potentially producing highest upward trends compare to other scenarios.

4.3.3.1.3 Precipitation Exceeding 20 mm Per-day (R20MM)

Rainfall extreme could be source of climate-related disasters. The projection analysis of rainfall extreme exceeding certain threshold is needed in order to understand their potential change in the future. Figure 4-48 depict the trends R20MM index of MME mean of 14 GCMs under different scenarios. It is indicated that almost all scenarios are projecting the index to be increase in the future, except under moderate RCP4.5 scenario that produce different trend direction. Under this scenario, almost all areas in the country are projected to experience downward trend of R20MM index. Nevertheless, the slope resulted from both upward and downward trends are relatively small.

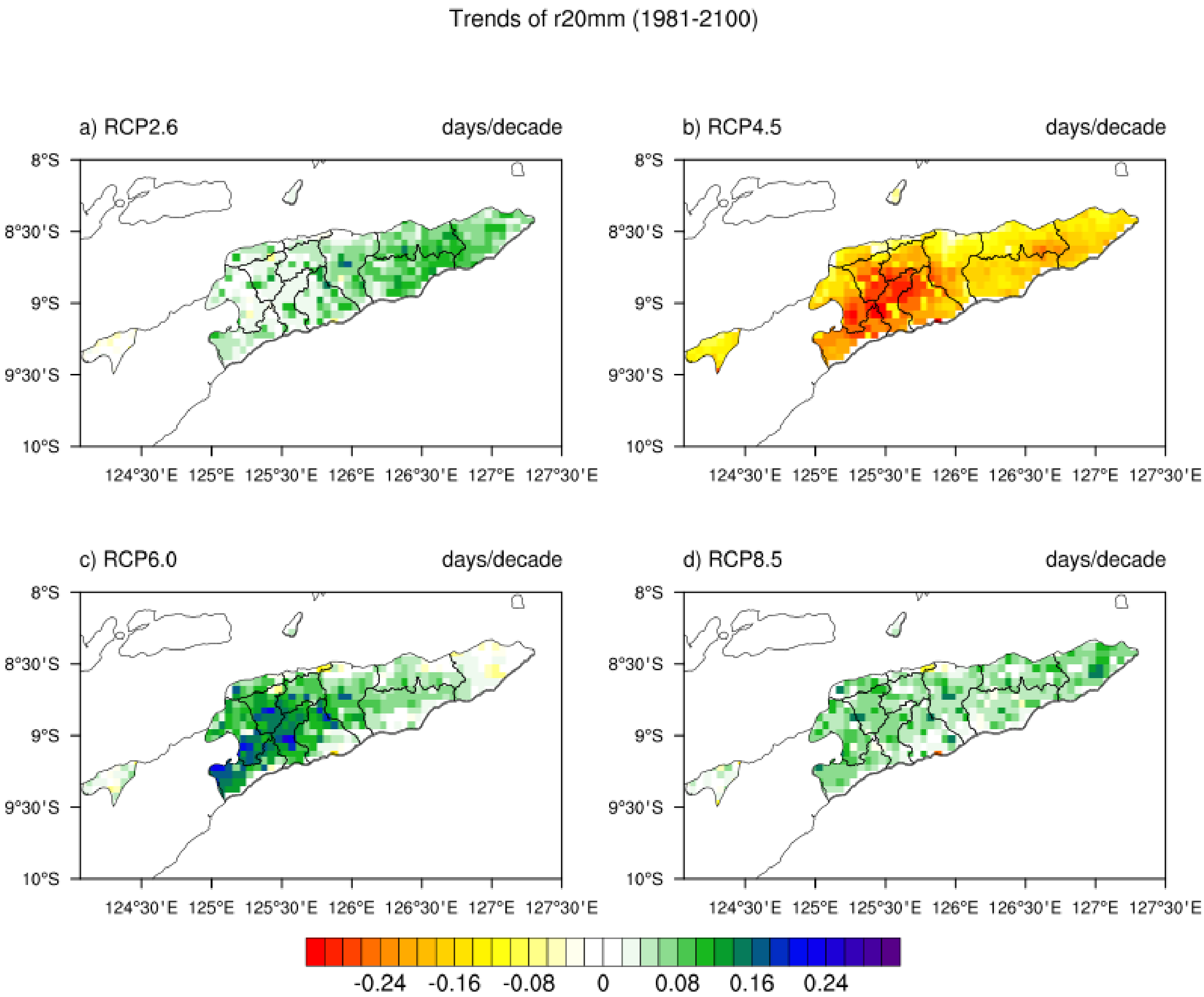


Figure 4-48 Spatial trends of R20MM in Timor-Leste based on ensemble median of bias-corrected outputs of 14 CMIP5 GCMs under 4 RCP scenarios: a) RCP2.6, b) RCP4.5, c) RCP6.0 and d) RCP8.5. Trends were calculated using long term data in 1981-2100 periods.

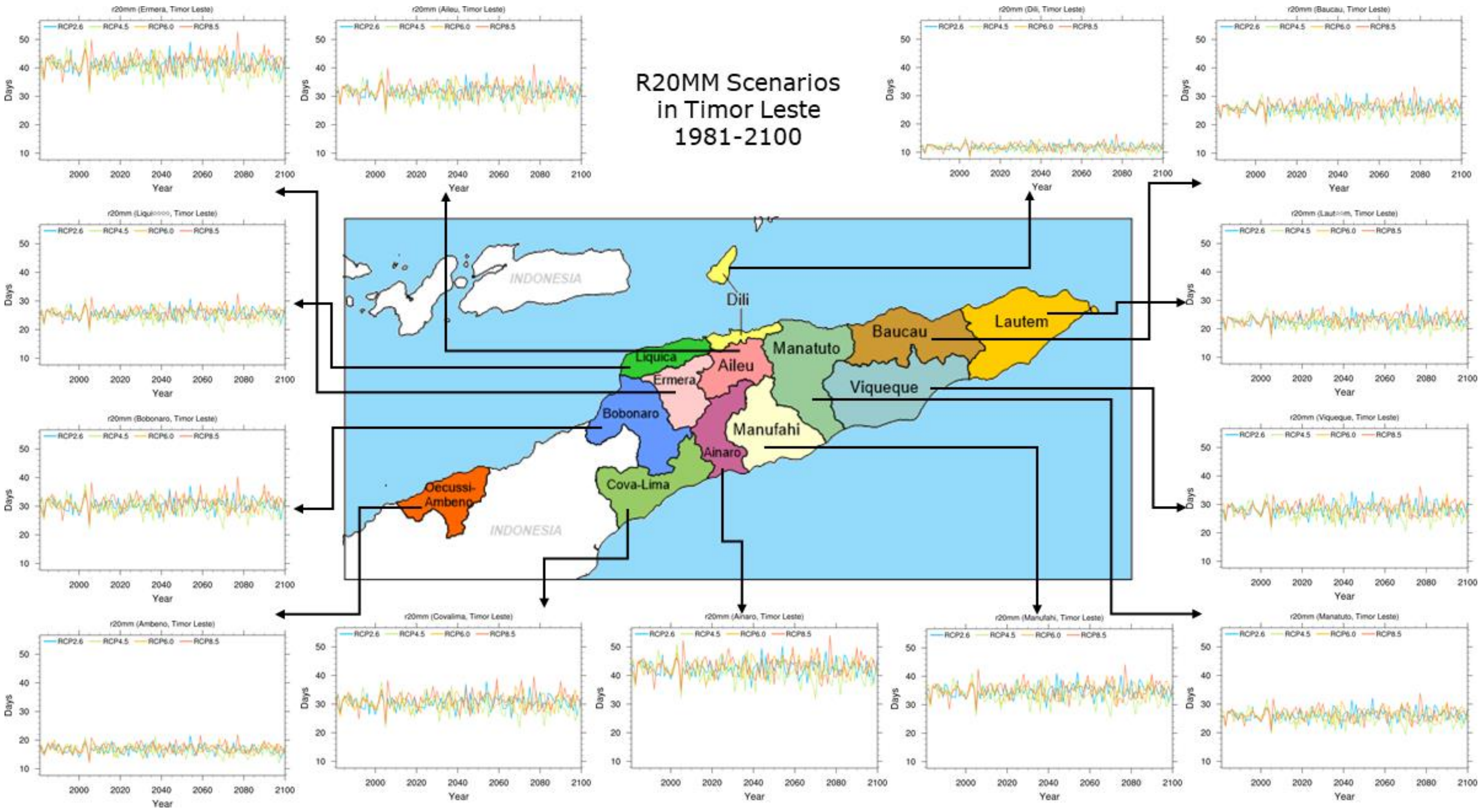


Figure 4-49 Scenario and trends of R20MM in each of 13 municipalities in Timor-Leste. The time series were calculated from the ensemble median of the bias-corrected outputs of 14 CMIP5 GCMs. It is based on the area averaged index within the area of the selected municipality.

The small value of the slope resulted by the analysis can be clearly seen in the time series plots in Figure 4-49. Most of the time series from different municipality show a relatively flat or stationary data. Therefore, it can be suggested that the future change of R20MM index in Timor-Leste in terms of their mean values would not really considerable. However, the change could be more substantial when it is related to the variability of the index. From the figure, there are two municipalities that are identified to have high value of R20MM, i.e. Ermera and Ainaro municipalities.

4.3.3.1.4 Consecutive Wet Days (CWD)

CWD is defined as maximum length of wet spell, maximum number of consecutive days with daily rainfall ≥ 1mm. The higher the CWD value indicates longer consecutive daily rainfall to occur. Based on the projection results shown in Figure 4-50, all scenarios agree that there will be downward trends on the CWD index in the future. The largest downward trend is projected by RCP8.5 and the lowest is produced by RCP6.0. The region with high topography seems to have the largest the decreasing trend compare to the region located in coastal area.

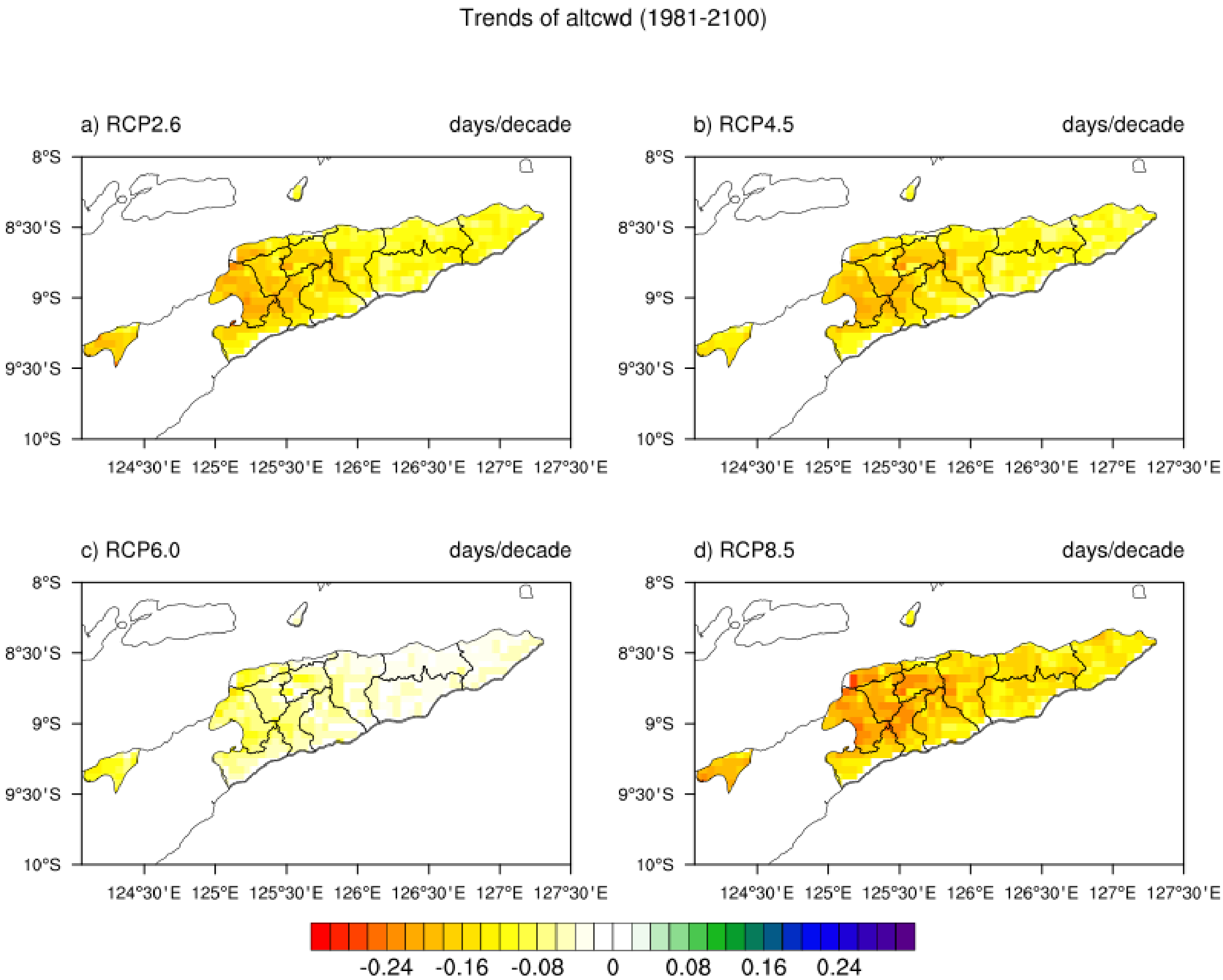


Figure 4-50 Spatial trends of CWD in Timor-Leste based on ensemble median of bias-corrected outputs of 14 CMIP5 GCMs under 4 RCP scenarios: a) RCP2.6, b) RCP4.5, c) RCP6.0 and d) RCP8.5. Trends were calculated using long term data in 1981-2100 periods.

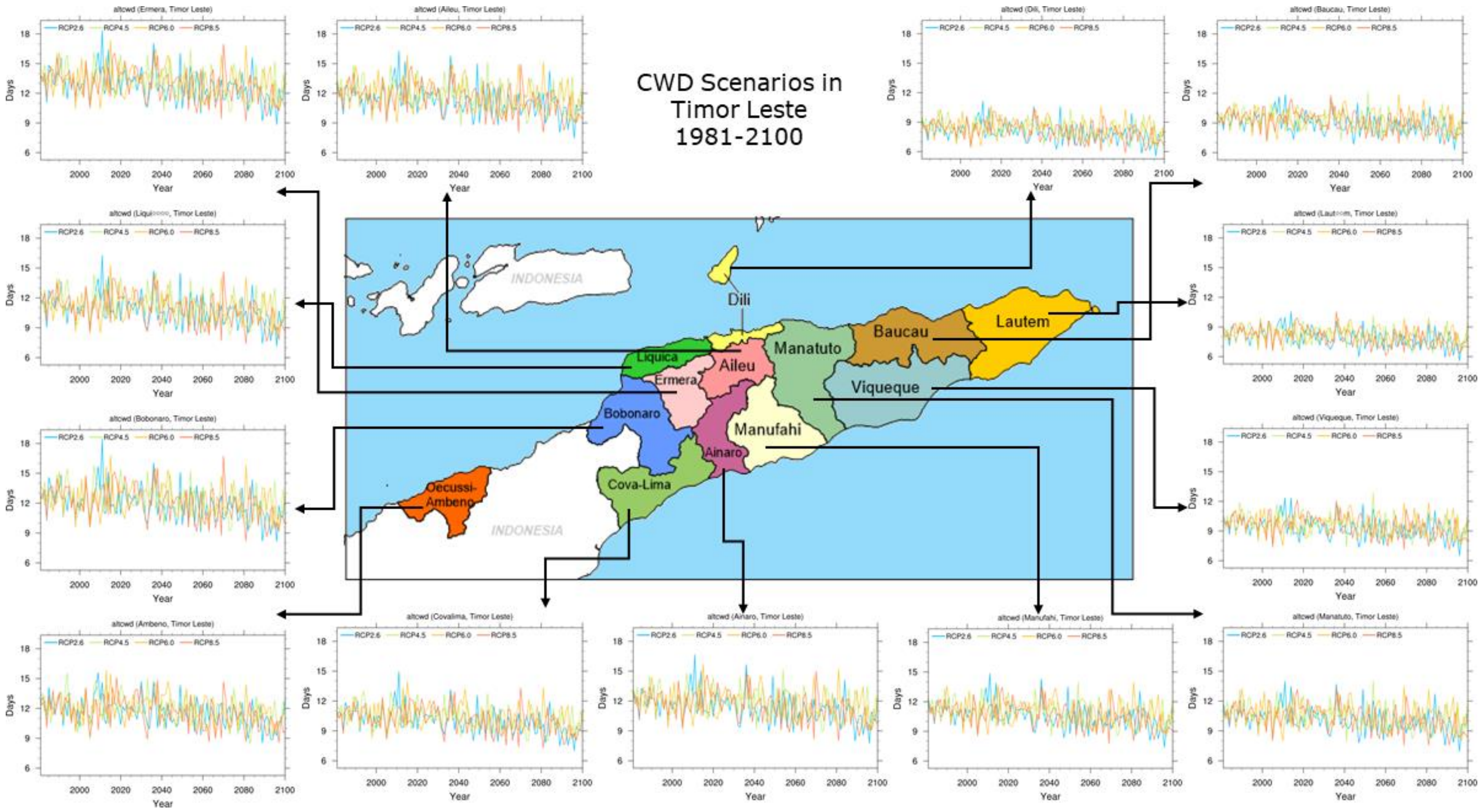


Figure 4-51 Scenario and trends of CWD in each of 13 municipalities in Timor-Leste. The time series were calculated from the ensemble median of the bias-corrected outputs of 14 CMIP5 GCMs. It is based on the area averaged index within the area of the selected municipality.

All municipalities in Timor-Leste is projected to experience a decreasing trend of CWD index. This is clearly shown by the timeseries plots depicted in Figure 4-51. In addition, although the trends are expected to decrease, there is a possibility in the increase of intensity represented by the change of variability of the index. This for example can be seen from the time series plots in several municipalities, such as Ermera, Liquica, Bobonaro, Covalima, Ainaro, Aileu, and Manufahi.

4.3.3.1.5 Consecutive Dry Days (CDD)

CDD defined as maximum length of dry spell, maximum number of consecutive days with daily rainfall < 1mm can be used as a proxy of drought. The projections of CDD trends based on the MME mean are shown in Figure 4-52. The CDD in Timor-Leste is expected to increase in the future with a rate could be up to 2 days per-decade in several locations, such as in the western part of Oecussi as projected under RCP8.5. In general, both RCP4.5 and RCP8.5 project higher upward trend compares to other two scenarios, i.e. RCP2.6 and RCP6.0. The RCP6.0 is expected to produce the lowest upward trends of the CDD index.

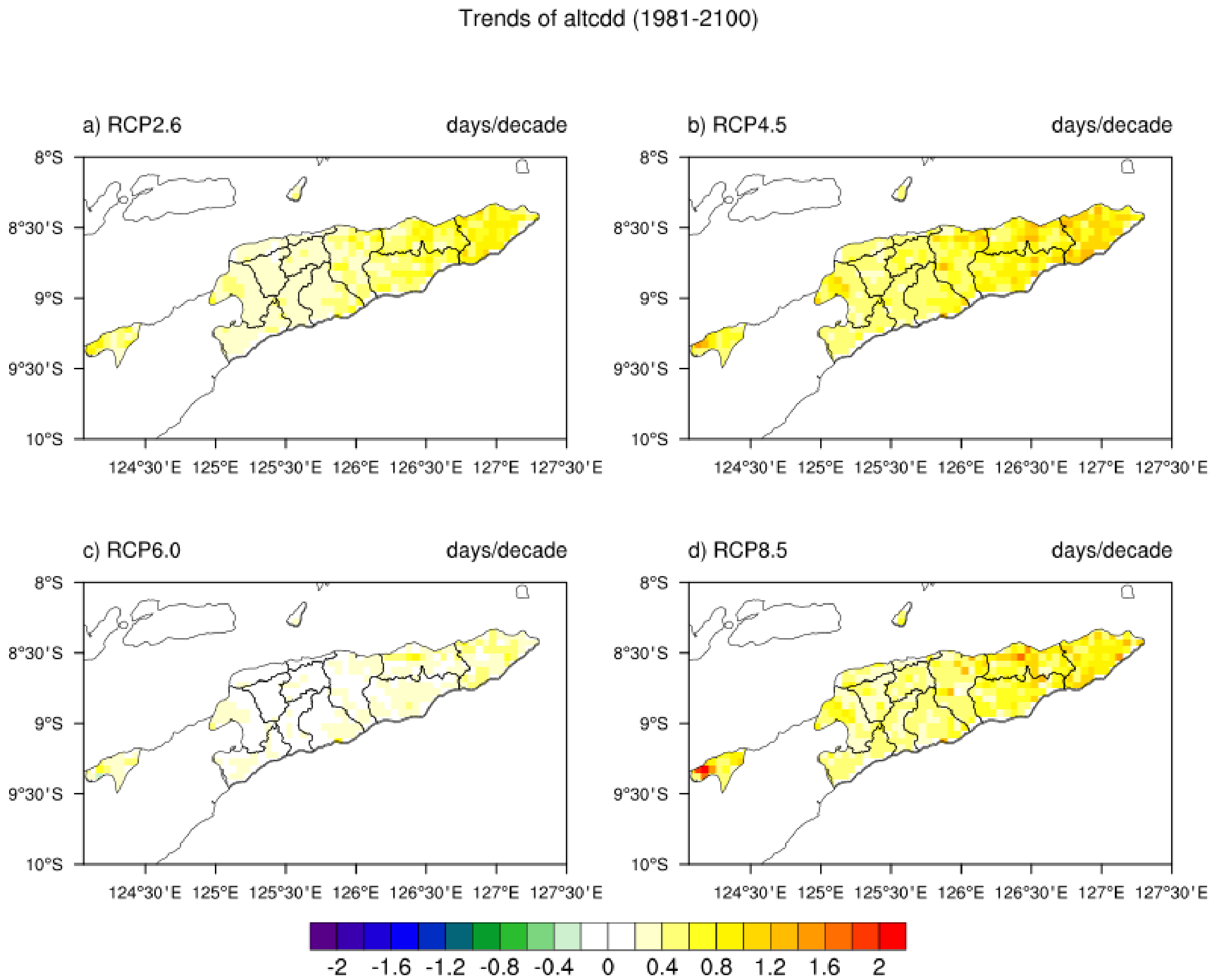


Figure 4-52 Spatial trends of CDD in Timor-Leste based on ensemble median of bias-corrected outputs of 14 CMIP5 GCMs under 4 RCP scenarios: a) RCP2.6, b) RCP4.5, c) RCP6.0 and d) RCP8.5. Trends were calculated using long term data in 1981-2100 periods.

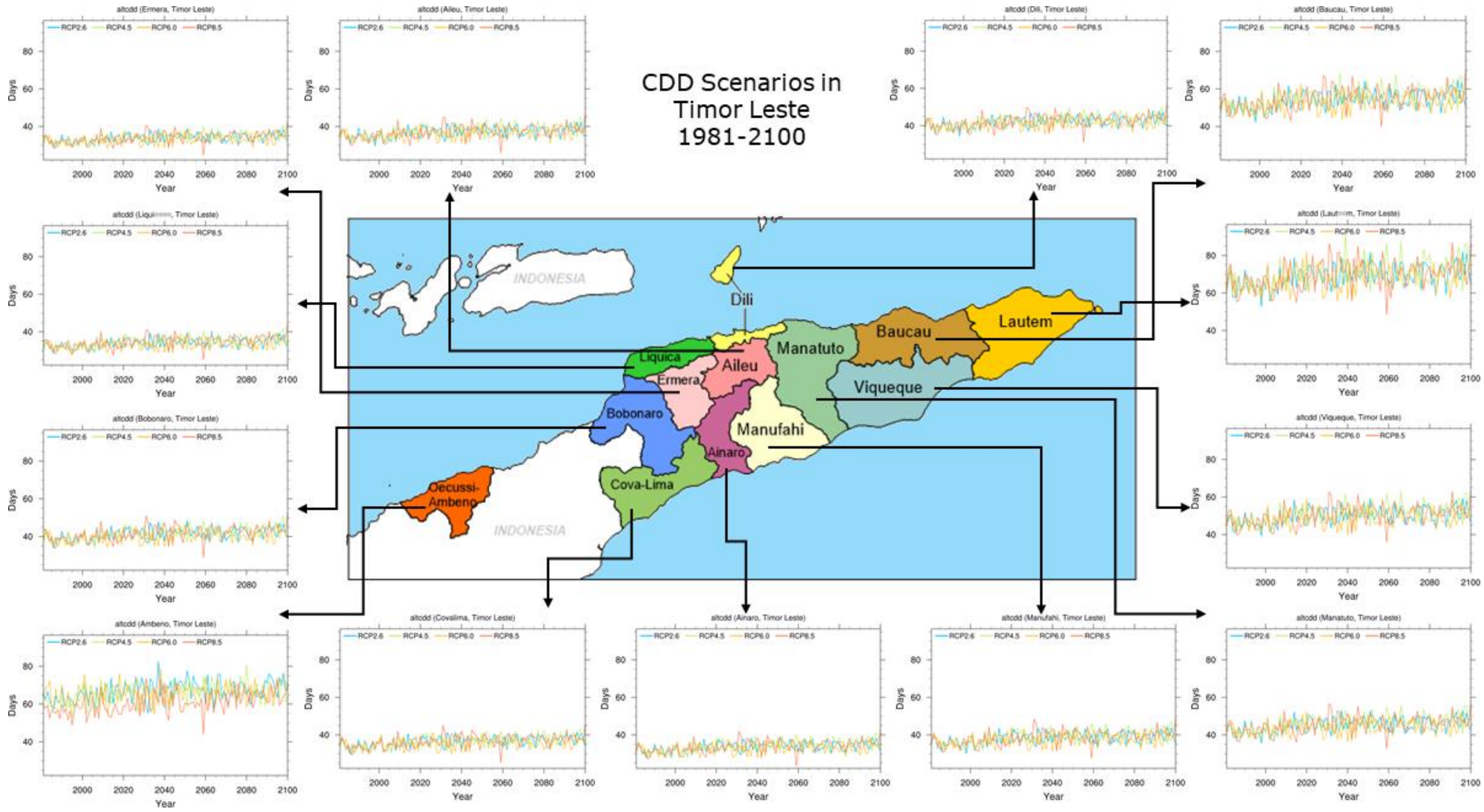


Figure 4-53 Scenario and trends of CDD in each of 13 municipalities in Timor-Leste. The time series were calculated from the ensemble median of the bias-corrected outputs of 14 CMIP5 GCMs. It is based on the area averaged index within the area of the selected municipality.

The characteristics of CDD in every municipality are different as can be seen in Figure 4-53. Several municipalities have relatively high CDD value compare to other municipalities, such as in Oecussi, Lautem and Baucau. The time series plots also show clear upward trends of CDD in the future. The potential increase of CDD may be used as a signal of possibly more severe drought condition in the future.

4.4 Vulnerability Assessment

Currently Timor-Leste has been considered as one of top 10 countries in the world in terms of their vulnerability to the impact of climate change (UNU-EHS, 2011). Timor-Leste along with three island nations, Vanuatu, Tonga and the Solomon Islands and also Philippines, Bangladesh, Cambodia, Guatemala, Costa Rica, and El Salvador have the highest world risk index (Figure 4-54 left). The risk index was calculated by combining the 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 being one of the top ten countries with highest risk index are mainly due to high exposure to hazards, and relatively high vulnerability and susceptibility and lack of coping capacity and adaptive capacity (Figure 4-31 right).

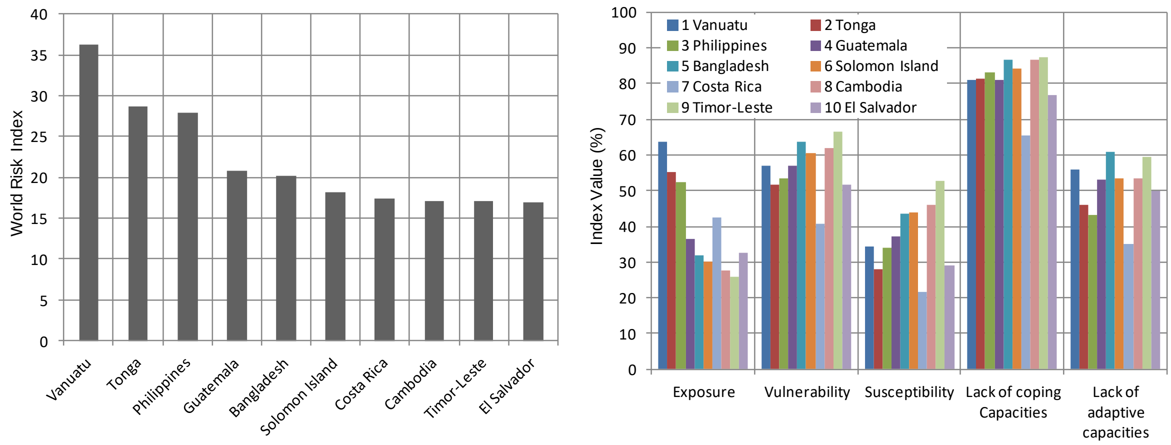


Figure 4-54 World Risk Index of the top ten countries (left) and factors causing the countries to be high risk (right)

The INC undertook further vulnerability assessment at the village ('suco') level by adopting the IPCC approach (IPCC 2001 and 2007) where the vulnerability is measured using three dimensions, namely level of exposure, level of sensitivity and adaptive capacity. Vulnerability is defined (IPCC 2001, 2007) 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 capacityô*.

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 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 the most vulnerable system while those with a low level of exposure and sentivity with high adaptive capacity will be considered as the least 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 level of exposure and sensitivity and low adaptive capacity are considered as the most vulnerable villages, while those with low level of exposure and sensitivity and high adaptive capacity are not vulnerable sucos. Sucos with low exposure, sensitivity and adaptive capacity are considered as vulnerable sucos, 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.

Base on biophysical, social and economic data of 2010, most of the sucos in Timor-Leste could be categorized as quite vulnerable 44.7%, and about 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 4-55). The impact of climate change is expected to be high in the vulnerable sucos and therefore, this sucos should be prioritized for the implementation of adaptation actions. Improving capacity of the sucos to manage climate risk in key sectors such as agriculture and water sector is very important as part of the effort to reduce the vulnerability of the sucos. Inability of the sucos to manage the impact of climate change on these key sectors will bring the sucos to be more vulnerable. Huge loss in agriculture production due to climate change for example will increase poverty rate of the sucos and this will contribute to the increase of the vulnerability. Therefore, assessment of climate change impact on the key sectors sector is crucial to assist in identifying adaptation options.

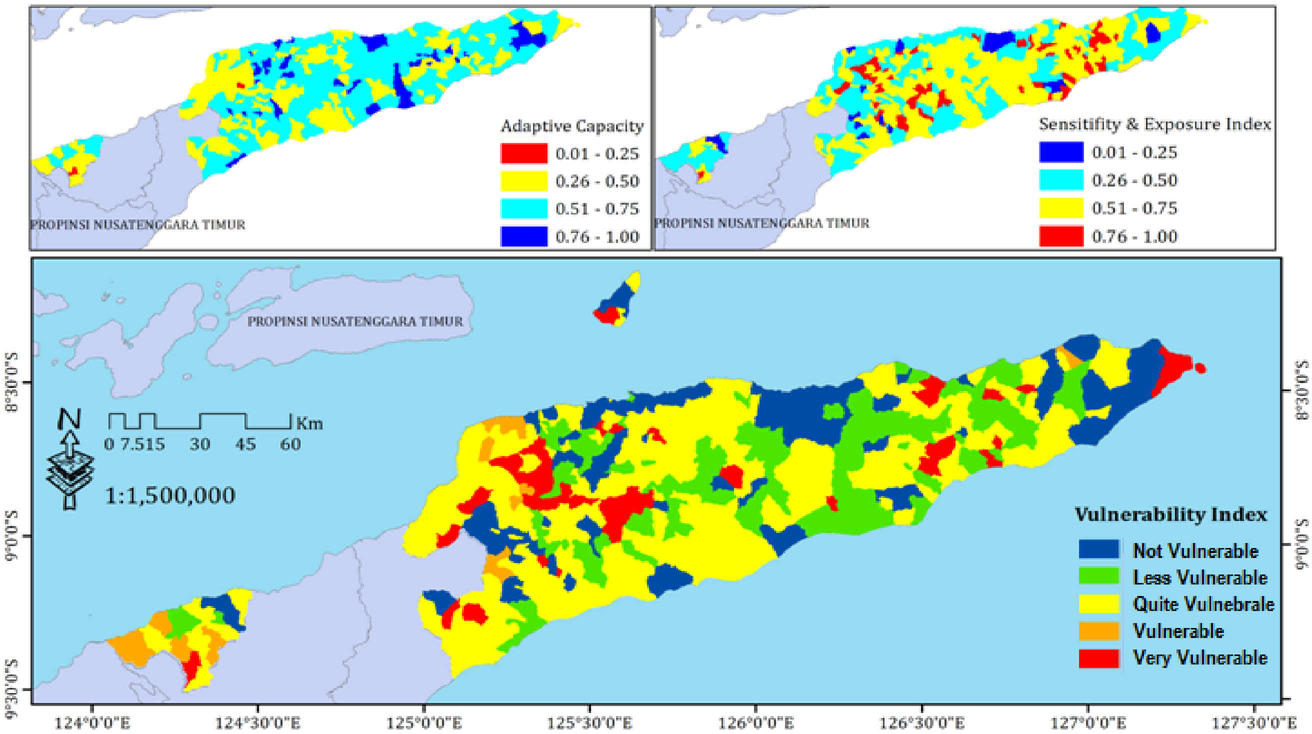


Figure 4-55 Vulnerability index of Timor-Leste by Village or ''Suco'' in 2010

4.5 Climate Change Impacts Assessment

The country has experienced warming air temperature with an annual rate of increase of 0.016°C per year. The Pacific Climate Change Science Programme (PCCSP) states that air temperature records from Dili are missing but it is probable that there has been a warming air temperature trend over the last fifty years, in line with regional and global trends. This is partly due to warming ocean temperatures around Timor-Leste area. It is expected that annual mean temperatures and extremely high daily temperatures will continue to increase (GoAustralia and GoTL 2015).

Satellite data collated by the PCCSP (PCCSP 2011) indicates that sea levels have risen around Timor-Leste by about 9mm per year since 1993, which is higher than the global average of sea levels (2.8mm – 3.6 mm per year.) This may be partly related to natural fluctuations caused by phenomena such as the El Nino-Southern Oscillation. Sea level rise is 5.5mm based on the trends of sea level obtained from satellite altimetry data and found to be higher in the south coast (≥5.5 mm/year) than in the north in (Section 4.2.3). It is predicted to increase between by 5-7mm per year by PCCSP, and a total of 76cm by 2100. The climate change policy expects it to be 6-9 mm. Sea levels will continue to rise as the ocean warms.

Ocean acidification has been slowly increasing in the waters around Timor-Leste since the 18th Century, due to the absorption of carbon dioxide in the oceans, and is expected to continue. This impacts the growth of organisms and corals which rely on the carbonate minerals for the development of their skeletons. Coral bleaching is also expected to increase.

Geographically, Timor-Leste is exposed to several kinds of natural hazards, which include frequent events such as tropical cyclone, drought, riverine flooding, and landslides as well as rarer events such as earthquakes and tsunamis. To date, hazards have been localised and have not caused widespread devastation fortunately. Within the country's most recent history, the most prevalent have been floods, landslides, and drought (Asian Disaster Preparedness Centre 2013).

There are two types of flood in Timor-Leste namely: (1) flash flood that occurs when heavy seasonal rain water in high catchment basins converges in tributaries as it descends downward resulting in the rapid rise of discharge along the water courses and (2) riverine flood that occurs when water accumulates in lowland or upland flood plains and river banks have insufficient capacity to contain the flow resulting in an overflow of the river.

A Country Situation Report undertaken by the Asian Preparedness Centre in 2013 considered the risk of landslides. In terms of earthquake induced landslides, the study found that 50 % of the country falls within medium landslide susceptibility zones, and 29 % falls within high zones. These high susceptibility zones are located along the eastern and northern coast. The second part looked at rainfall induced landslides and found that 33% of the country falls within medium landslide susceptibility zones which are spatially distributed evenly across the country. Other location-specific assessments have been carried out, including a natural hazard risk assessment (RMSI 2015) for the Strengthening Community Resilience Programme in 2015, in order to understand more about the risks of floods, landslides and intense winds at the Suco-level. The analysis and maps were prepared for the four districts in the study (Ainaro, Aileu, Ermera and Manufahi). Strong winds were more prone in Ainaro and (moderate winds) and Aileu. Floods were also more likely in Aileu and Ainaro. It was found that 76% of the total area of the study was susceptible to landslide ranging from very high to low susceptibility.

In term of flood hazard, it is revealed that Liquiçá district is the most likely to be impacted, with the highest percentage (2.6%) of flood inundation area that has a flood depth of over 2 meters. A landslide vulnerability analysis was conducted in two main parts, in earthquake induced landslides as much as 50 % of the country falls within medium landslide vulnerability zones, 1% falls within very high zones and 29% falls within high zones. These very high and high vulnerability zones are located along the eastern and northern coast. Meanwhile at rainfall induced landslides, found that 33 % of the country falls within medium landslide vulnerability zones which are spatially distributed evenly across the country, and about 25% Timor-Leste is prone to very high and high landslides. A coastal erosion hazard assessment also found that the stretches of coast that are highly vulnerable to erosion are concentrated mostly in the south which is exposed to higher waves than the north. The entire coastline of some districts such as Aileu, Manufahi and Viqueque are highly vulnerable to coastal erosion (Asia Disaster Preparedness Centre 2013).

Tropical cyclone numbers are projected to decline in the broad region surrounding Timor-Leste (0–20ºS and 100ºE–130ºE) (moderate confidence). Kirono (2010) concurs that in future the frequency of cyclones and extreme rainfall events in Timor-Leste are likely to decrease, but the intensity of the cyclones (with high wind speeds) and extreme rainfall events will increase.

Other vulnerability analysis of the forest fire found that the majority of forest area in Timor-Leste is highly vulnerable to forest fires. Large area of districts such as Aileu, Ainaro, Baucau, Ermera, Liquiçá, and Viqueque are at high risk while smaller area of some districts such as Dili, Liquiçá and Manatuto have an even greater risk.

The likely most common natural hazards are floods, droughts and landslides. Changes in rainfall pattern could lead to severe water scarcity and water contamination conditions. Sea level rises and inundation is likely to continue to have wide range of effects on coastal processes, including erosion, salt water intrusion and inundation and flooding. Potential impact of climate changes on some sectors are detailed below.

4.5.1 Agriculture

Most commonly crops grown in Timor-Leste are maize, paddy and cassava. Around 81% of the country's population is engaged in maize production, but the yields are relatively low caused by poor quality seeds and poor soil conditions. About 39% of the population are involved in paddy farming. The limited access to improved technologies, use of good quality seeds, fertilizers and limited supply of irrigation also leads paddy farming to low productivity. Coffee is the most common commercial agricultural crop which grown in the mountainous areas of the southern coast as well as in the central highlands. Other commercial crops that are grown are vanilla and coconut, and particularly root crops such as sweet potatoes and peanuts.

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, potential impact of climate change on maize has been assessed using DSSAT (Decision Support System for Agro-technology Transfer) 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 4-55), however future yields may be lower than current yields (Figure 4-56). 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 period 2061-2080, but not for period 2041-2060. Different response of the crop to irrigation application at these two time periods may be due to different level of temperature increase. The temperature increases 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 by around 20%. During La Nina, more rain falls and the wet season can be quite long leading to an increase in rainfall by 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).

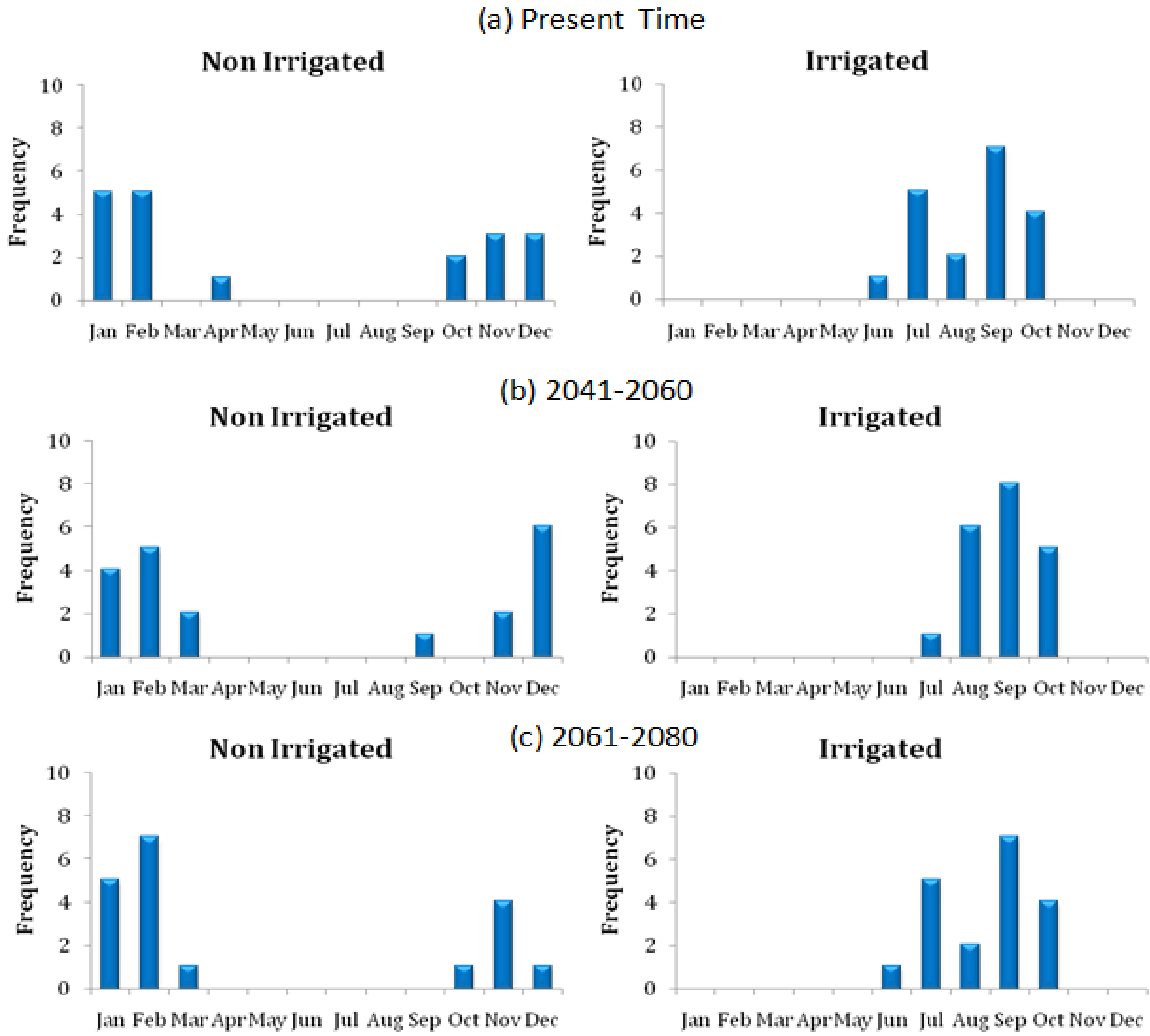


Figure 4-56 Number of years of the 20 years simulation that give the highest yield for each planting month for irrigated and non-irrigated maize at present climate (a) and future climate periods (b) 2041-2060 and (c) 2061-2080

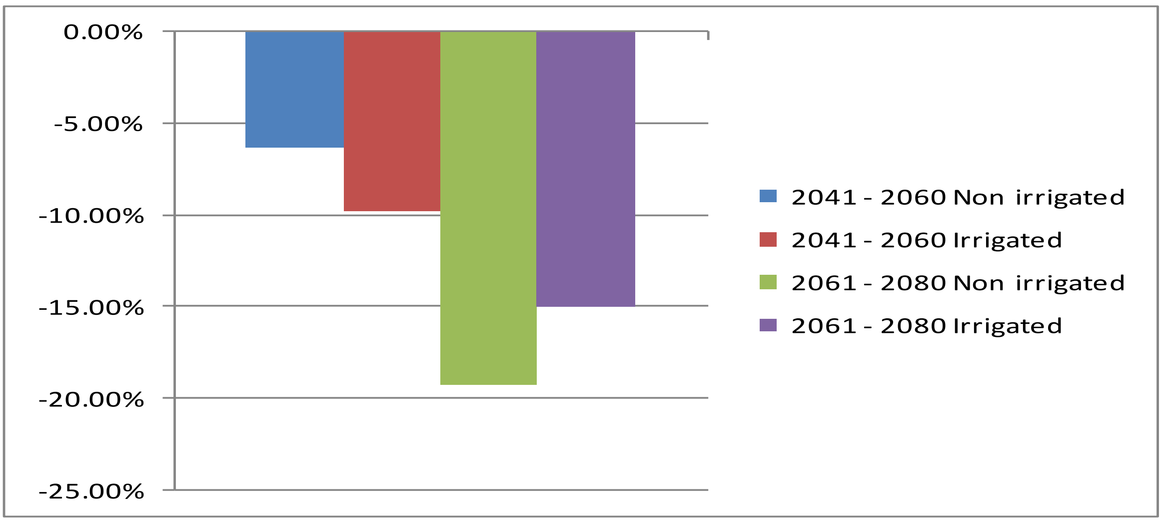


Figure 4-57 Changes in mean crop yield due to climate change in Timor-Leste

Changes in behavior 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.

Considering the impact of drought from El Niño phenomenon, households had to rely mainly on eating less preferred foods from their own production like tubers and root crops, skipping meals and reducing meal portions to cope with food shortages. Considering the effect of drought to farming and livestock the main sources of livelihood of most of the affected families, access to animal protein (i.e. meat, eggs and fish) became intensely challenging, worsening the household food insecurity and undernutrition. About 78 % of the households were negatively impacted by drought through households experiencing delayed planting, crops not growing, or some sick and dying animals due to difficulty in accessing water and fodder. There was a decrease in staple crop production by drought-impacted households (by 3% for rice, 2% for maize compared to last year), with most farmers planted crops not more than a hectare, which could be a cause for concern for agricultural production in the future.

Table 4-5 Potential impact of climate change on agricultural sector

Climate change related phenomena and events	Climate change impacts
Increased air temperature	Warmer condition can reduce crop yields/live stock productivity by preventing pollination Current knowledge and practice may no longer be effective Altered patterns of crop/live stock pests and diseases Increased of water shortages for agriculture as well as rising demand through increased evapotranspiration
Changes in rainfall patterns and intensity	Increased crop loss from floods and droughts Increased damage to agricultural infrastructure and agricultural productivity caused by storm Increased degradation and loss of agricultural land and soil fertility
Sea level rise	Saltwater intrusion and seawater flooding of coastal agricultural lands Rise in food imports to compensate for insufficient domestic production Increased soil erosion, runoff and landslides

4.5.2 Water Resources

Water and sanitation are critical resource in Timor-Leste. Around 300,000 of population do not have access to safe water and 700,000 people don’t have access to adequate sanitation (RDTL 2011). The Government is currently developing a National Water Supply Policy and is engaging with the targets of Sustainable Development Goal 6 which specifically targets water, sanitation and hygiene and water infrastructure. Various government programmes are currently being conducted to improve the water system for example the Urban Services Improvement Sector Project (ADB funded) to foster integrated water resources management and reduce the time spent collecting water, amongst other issues. A challenge to increase rural sanitation is the availability of sanitary products and services, exacerbated by poor roads and transport that makes access difficult and increase price of the goods (Smets 2015).

Assessment of potential impact on climate change on clean water availability is still not available. In the INC, the assessment has been done for soil water balance that 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 4-58). The region with shortest dry period is in the southern part of the country (blue), while the longest is the northern part with a dry period equal to or more 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 4-59). Those with shortest dry period are covered by dense forest.

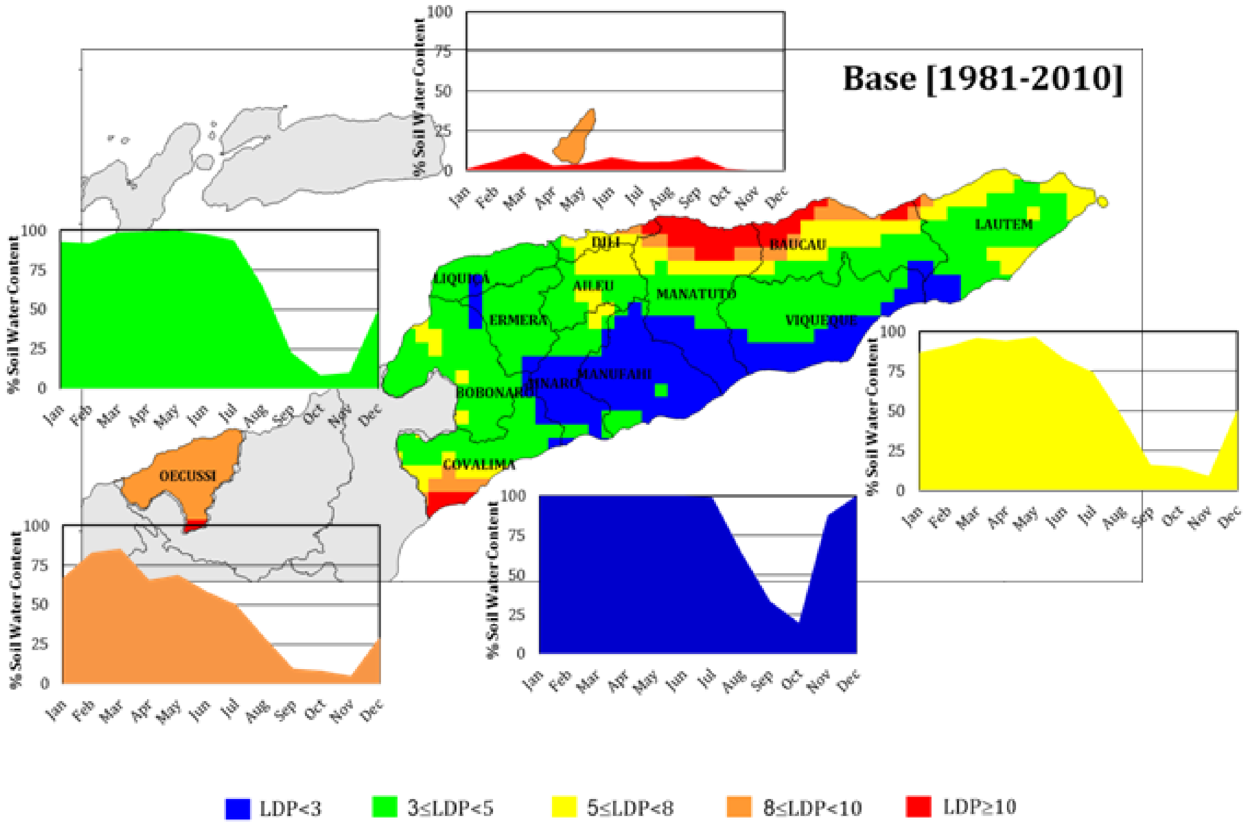


Figure 4-58 Classification of Timor-Leste according to the monthly pattern of Soil Water Content

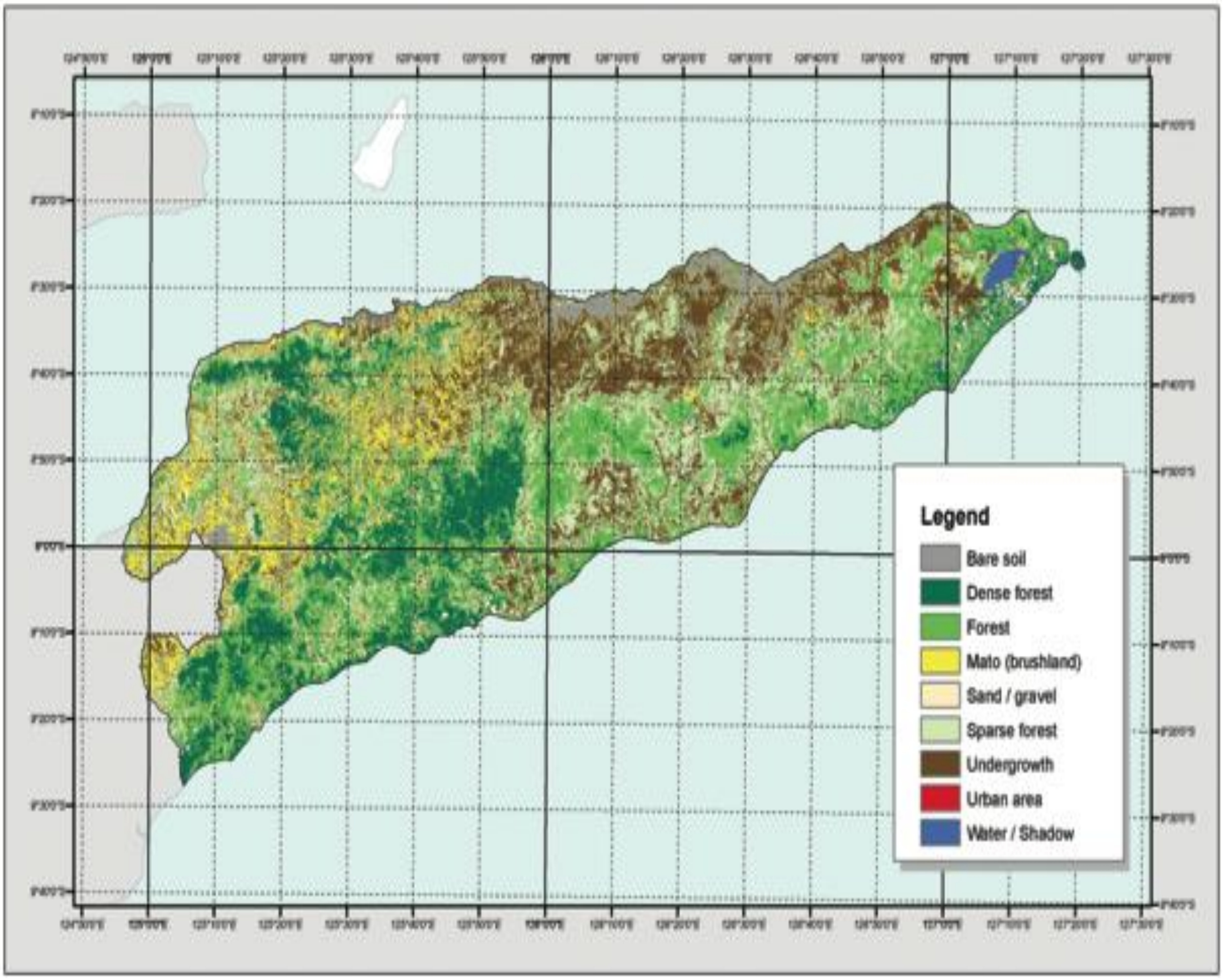


Figure 4-59 Land cover of Timor-Leste in 2010

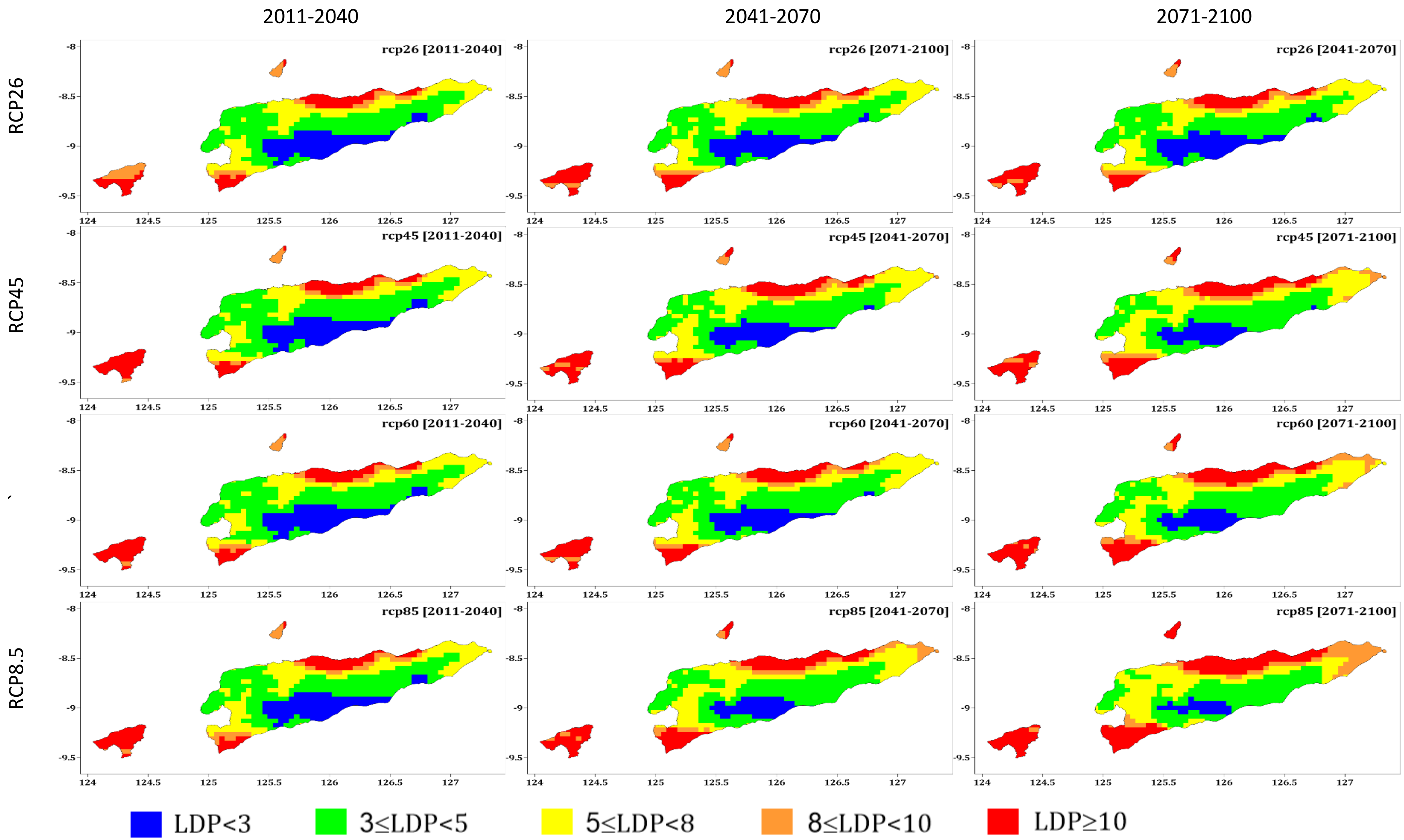


Figure 4-60 Impact of climate change on length of deficit periods in Timor-Leste (in month)

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 4-59). 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.

The significant change in soil water regimes due to changes in rainfall 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.

Table 4-6 Potential impact of climate change on water resource

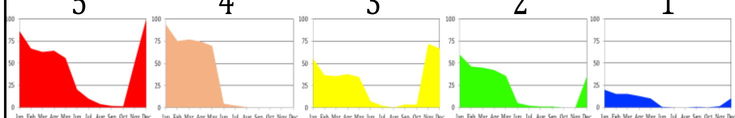
Climate change related phenomena and events	Climate change impacts
Increased air temperature	Increased evaporation of surface water (streams, rivers and lakes) Reduced access to water for agriculture, industry and household use
Changes in rainfall patterns and intensity	Increased rates of runoff due to increased intensity of heavy rainfall leading to reduced groundwater recharge Increased flooding will damage land, crops, infrastructure and irrigation systems
More intense storm activity	Infrastructure damage to bridges, roads, irrigation and sewage systems
Rise in shallow seawater temperatures, rise in sea level and seawater acidification	Salinization of groundwater sources near coasts

4.5.3 Health

Direct impacts of climate change on human health include exposure to thermal extremes and damage to public health infrastructure, increase 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 which in turn disturb child growth and development. Many infectious diseases such as malaria, dengue fever, and 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 malaria and dengue risk. The level of risk is defined by the incidence rate and transmission risk. The incidence rate is classified into five categories. Locations which have an incidence rate 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). 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. 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.

Table 4-7 Matrix of climate risk for Malaria and Dengue Fever

Risk / Incident Rate [/1000] \ 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

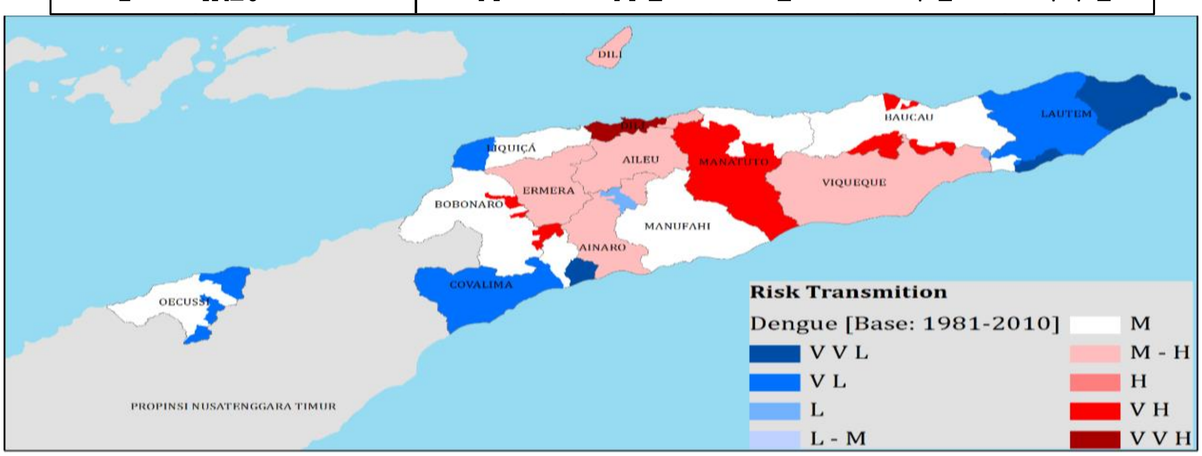


Figure 4-61 Level of risk for dengue fever in Timor-Leste under current climate conditions

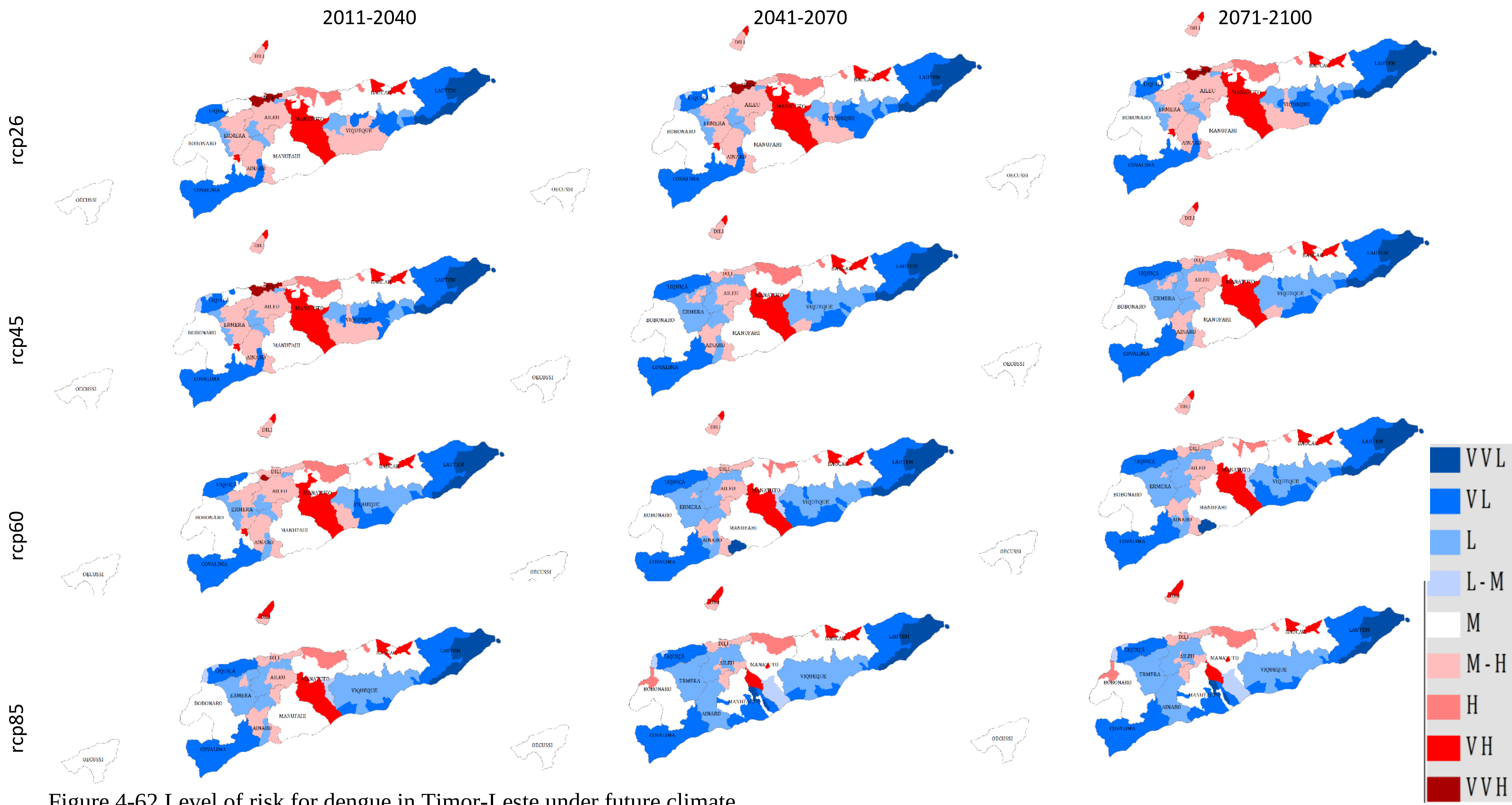


Figure 4-62 Level of risk for dengue in Timor-Leste under future climate

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

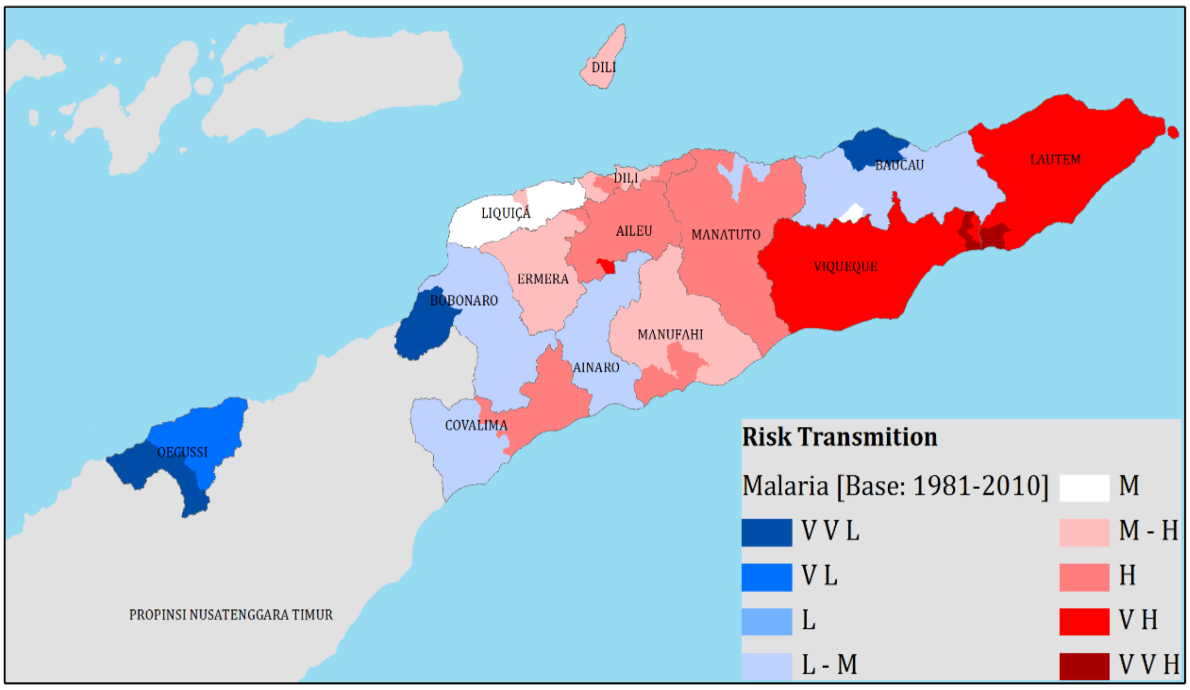


Figure 4-63 Level of risk for Malaria in Timor-Leste under current climate conditions

The results of the analysis indicate that sucos located in Manatuto district are all considered to have high risk to dengue (Figure 4-60). Under the emissions scenarios RCP2.6 to RCP8.0, the risk of dengue may increase in future. The worst conditions will occur under the emissions scenario of the RCP8.0. For malaria, the districts with high risk under the current climate are Viqueque and Lautem (Figure 4-62). In the future the number of districts under high malaria risk will also increase. The worst conditions will also occur when emissions follow the RCP8.0 scenario (Figure 4-63).

Table 4-8 Potential impact of climate change on human health

Climate change related phenomena and events	Climate change impacts
Increased air temperature	Increased incidence of respiratory diseases and associated infections Increased risk of malnutrition, hunger and water shortages Increased risk of eye cataracts and skin cancers Increased incidence of heat stroke, sun-burn, dehydration, heat exhaustion and sun stroke
Changes in rainfall patterns and intensity	Increased landslide and flood-related injury and mortality Increased incidence of waterborne diseases such as diarrhea and typhoid Increased incidence of vector-borne diseases such as malaria and dengue Increased risk of food contamination
More intense storm activity	Crop/livestock loss, leading to food insecurity and malnutrition
Rise in shallow seawater temperatures, rise in sea level and seawater acidification	High sea water temperature leads to toxic algal blooms

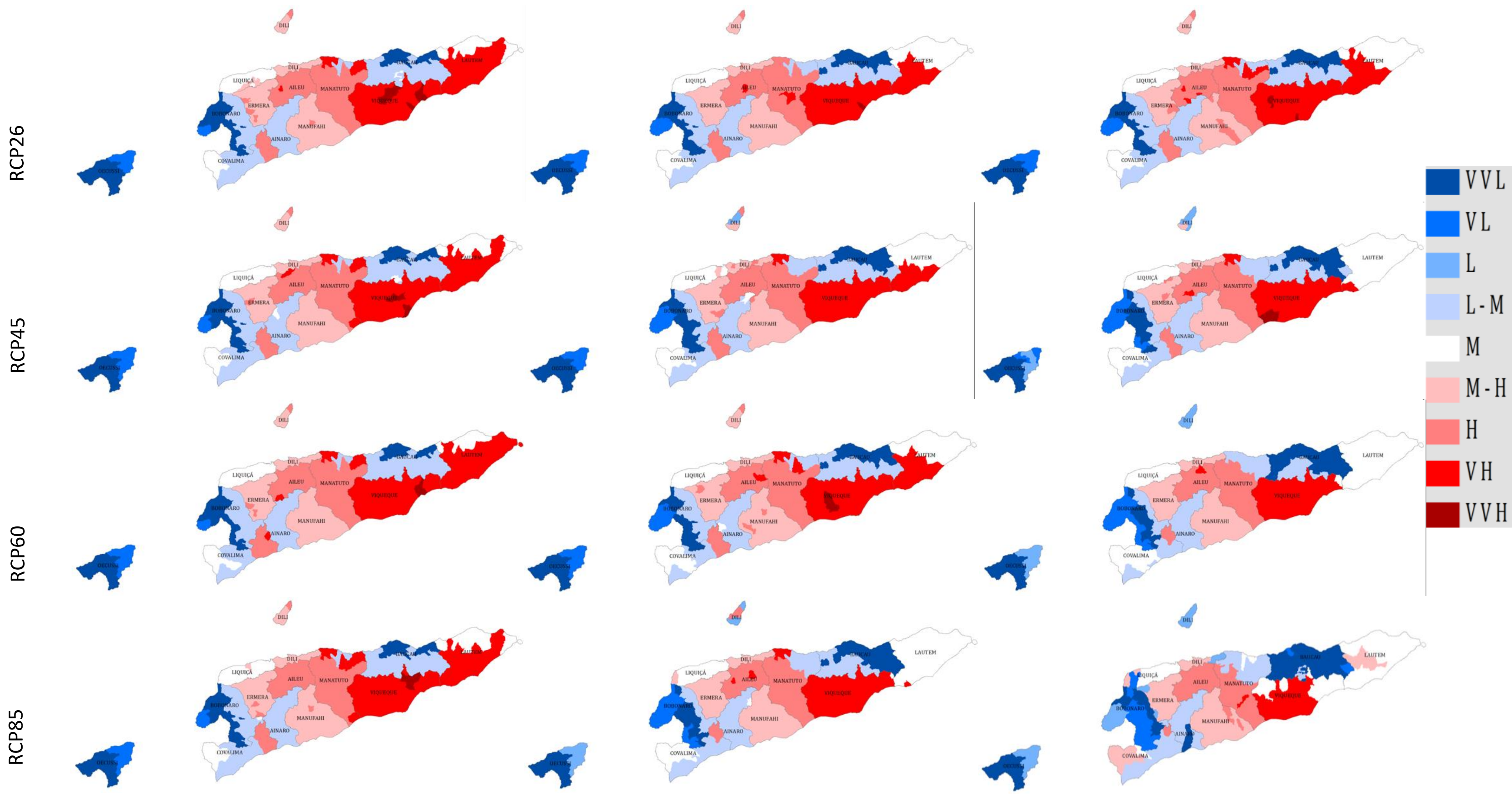


Figure 4-64 Level of risk for Malaria in Timor-Leste under future climate

4.5.4 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 serious impacts 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 4-9.

Table 4-9 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 serious impact on many sectors in Timor-Leste. Agriculture production is likely to be affected by the increase temperature and change of rainfall pattern. Crop loss due to extreme climate events may be more often and the expansion of agriculture area would be confined due to the expansion of drier areas. Risk of health may also increase. Coastal and marine sector will also be seriously affected. Developing capacity to adapt the potential impact of climate change in the various sectors is very important.

4.6 Climate Change Adaptation

Climate change will have serious impact on many sectors in Timor-Leste as described above. Developments of adaptation action plans are urgently needed. There are many actions that have been implemented in Timor-Leste involving the various actors (communities, government and NGOs). Communities are undertaking some short-term coping or adaptive strategies toward the climate change impact such as collecting water from elsewhere, consuming different food, and making sand bags to stop erosion. Meanwhile, the longer-term approaches are planting trees, conserving soil and water, and plans to build retaining walls by sending a proposal to the government. These strategies showed the awareness of people about climate change adaptation which need the continued support from government.

The GoTL has endorsed the Intended Nationally Determined Contribution (INDC) document and the Paris Declaration about climate change adaptation and mitigation. Timor-Leste adopted the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) in 2015, including Goal 13: To take urgent action to combat climate change and its impacts. The key national policy documents referring to climate change to date have been the National Strategic Development Plan (2011-2030) and a Basic Environmental Law (Decree Law No.26/2012). Table 4-10 shows the different areas of work that are being carried out for adaptation across different sectors which produced for the Climate Change Policy.

Table 4-10 Adaptation of Different Sectors in Tackling Climate Change

Sector	Nature of Impact	Adaptation	Agencies Involved
Agriculture	Droughts; floods; strong winds; landslides erosion; soil desertification	Distribution and promotion of climate resilient seed varieties to the local farmers (Seeds of Life/MAF)	VMHSPE,MAF (Forestry), Infrastructure (irrigation), Food production and Horticulture, MSS, CCCB, Health
Fisheries	Sea level rise; Coastal erosion; Sedimentation; Ocean acidification; Increase in sea temperature: Loss of marine and coastal biodiversity	Protection of mangroves creating a Green belt; in the coastal areas; Education & public awareness on the sustainable harvest, conservation of marine diversity; Stone wave breakers in order to lessen coastal erosion	VMHSPE ,MAF (Forestry), Community leaders & local government
Livestock	Drought; Flooding; inundation; Increase in temperatures	Create & enhance water harvesting (capture and storage), to avoid water shortages during dry season. Develop climate proofed and environmentally sustainable infrastructure to protect water sources (springs, streams & wells) in order to provide safe water	MAF (Livestock & Forestry) VMHSPE, NGOs and Community leaders
Infrastructure & Transportation	Land-slides; Erosion; Flooding	Climate resilient infrastructure, bioengineering	VMHSPE, local government, MSS, MSA, MAF (Forestry) and community leaders in corporation with UNDP

Sector	Nature of Impact	Adaptation	Agencies Involved
Forestry	Forest fire; Landslides and erosion;	Promotion of agro-forestry & community forestry on degraded lands to reduce landslides/erosion, watershed management	VMHSPE, MoPTC, Agriculture (Forestry), local government and community leaders
Health	Floods and long dry season has caused malnutrition, more frequent occurrence of vector borne diseases as well as increase in the risk of respiratory diseases	Address outbreaks of diseases e.g. malaria & dengue, provide safe water & improve sanitation to lessen occurrence of diarrhoeal disease & continuously conduct health surveillances	VMHSPE, Water and Sanitation, Education and Environmental Health
Water Sources	Water contamination and scarcity due to floods and droughts, drying up of aquifers, diminishing ground water table and saltwater inundation	Integrating climate change adaptation measures into current water management programs. Rain water harvesting during rainy season, development and rehabilitation of water sources	Forestry, VMHSPE, MoH and MoPTC, local leader and communities
Tourism	Sea level rise, coastal erosion, deforestation, droughts, land degradation and floods	Incorporating a range of possible climate change adaptation measures into eco-tourism development in all tourism destination areas.	VMHSPE, MoPTC, MoE, MoH, MAF, NGOs and local communities
Education	Flooding, sea level rise, strong winds	Evacuate all school children during floods, windstorms and sea level rise/inundation	VMHSPE, MoE, UNTL and Ministry of Social and Solidarity
Disaster Risk Management	Landslides, flooding, strong winds Inundation	Assist, encourage and alarm people who are at risks from natural disaster, Promote early warning systems, Education and public awareness	MoE, MAF, MoPWTC MCIA, and communities leaders at local level
Natural Resources & Biodiversity	Temperature rise; Strong winds; Ocean acidification; Forest fires; Prolonged droughts;	Promote mangrove rehabilitation and awareness raising to protect coastal habitats, and other natural resources from coastal erosion, inundation and other related risks, Integrated coastal zone management, Enforcement of existing laws & regulations including local bylaws to protect and conserve environment and natural resources	MAF (Fisheries & Forestry), NGOs, MoPWTC, MoE, local leaders and communities

A National Adaptation Programme of Action (NAPA) was developed in 2010 by the State Secretariat for Environment located within the Ministry of Economy and Development (MED), Government of the Democratic Republic of Timor-Leste. It provides a national vision to work towards more resilience to climate change. Nine priority areas are proposed with the summary of adaptation options in Timor-Leste's NAPA as shown in Table 4-11.

Table 4-11 Priority adaptation options

Rank	Adaptation Options	Activities
1	Food security: Reducing vulnerability of farmers and pastoralists to increased drought and flood events.	Integrated agro-forestry and watershed management Integrated sustainable land management Reforestation of degraded land Improvement of physical infrastructure, civil engineering and natural vegetation methods to prevent landslides. Education and awareness raising on sustainable agriculture and forest management
2	Water resources: Promotion of Integrated Water Resource Management (IWRM) to guarantee water access in a climate change context.	Building infrastructure to protect water sources Enhancement of government and community strategies on drought response Creation and enhencement of the waterharvesting model and distribution system Control of the quantity of water used by industry and water pollution
3	Human health: Enhancing capacity of health sector and communities to anticipate and respond to changes in distribution of endemic and epidemic climate-sensitive diseases, and reduce vulnerability of population to infection in areas at risk from expansion of climate related diseases.	Strengthening of integrated community health services Strengthening of ithe integrated early warning system at the community level Review of existing guidance and standards issued by the Ministry of Health on respiratory, airborne and vector diseases.
4	Natural disasters: Improving institutional and community (including vulnerable groups such as women and children) capacity to prepare for and respond to climate change induced natural disasters.	Establishment of early warning systems Integration of climate risk information into raditional DRR and disaster risk management
5	Forests, Biodiversity and Coastal Ecosystems Resilience: Maintain and restore mangrove and forests and promote awareness raising to protect coastal ecosystems and forests from climate change impacts.	Maintenance of mangrove plantations and awareness raising to protect coastal ecosystems Inclusion of ecosystem management in national planning
6	Livestock Production: Improve planning and legal framework for promoting sustainable and balanced food for livestock production.	Improvement of planning and the legal framework to promote sustainable and balanced food for livestock production
7	Physical Infrastructure: Improved regulations, standards and compliance for climate-resilient infrastructure.	Review of existing laws, regulatoins and standards to enhance resilience of critical infrastructure Passing of new legilation to strengthen and guarantee national development through improved regulations
8	Oil and Gas Production: Support to the ambitious national poverty reduction target 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.	Protection of offshore infrastructure against strong wave damage that could affect the distibution of gas and oil, and a reduction accidents and destruction of offshore oil and gas infrastructure
9	National Institutional Capacity Development for Climate Change: Overarching programme level coherence will be ensured.	Strengthening of the mandate of the cross-sectoral national climate change team to improve coordination and engagement Establishment of the climate change unit Capacity development support for key non-governmental institutions Development of a national climate change strategy and action plan Promotion of sub-national capacity development for improved adaptation planning and implementation Strengthening of the hydro-meteorological department to collect, compile, analyse and disseminate climate-related data

Table 4-12 NAPA Projects, Budgets, and Implementing Agencies

NAPA Implementation Project	Funding	Implementer
Food Security and Agriculture	EY/ IFAT (USD4,000,000)	MAP
Small Scale Rural Infrastructure (SSRI)	GEF/ LCDF under the UNFCCC (USD 4,600,000)	UNDP
Disaster Risk Reduction (Dili-Ainaro Corridor)	GEF/ LDCF-UNFCCC (USD 5,250,000)	UNDP
(Manatuto-Natarbora Corridor)	GEF-LDCF-UNFCCC (USD 4,500,000)	ADB
Mangrove and coastal zone management	GEF/LDCF (USD 7,000,000)	UNDP
Community Based Adaptation	AUSAID (USD 1,700,000)	Oxfam, CRS, CARE, CONSORSIUM
Community Based Adaptation (water supply)	EU (USD 203,000)	USP and SEMA
Forestry, agriculture and land use information system	EU (USD 4,000,000)	GIZ and Camoes Institution
Securing clean water for a climate resilience future	EU-GIZ (around USD 500,000)	National Directorate for Climate Change
Integrated action for resilience and adaptation (IA4RA) to climate change in the Rumoco Watershed	EU-GIZ (around USD 500,000)	MAF and Hivos Stitching, Dili

Other unlisted adaptation projects in table 4-12 are capacity need assessment (EU-GCCA) of USD 30,000, establishment of Center for Climate Change and Biodiversity (CCCB) under the National University of Timor Lorosa'e to address adaptation research, climate change vulnerability assessment for Hera Village and Pantai Kelapa Beach by CCCB (financed by GoTL via MCIE) of USD 7,000, and capacity building for adaptation researchers such as climate change analysis and modeling by CCCB with support from the MCIE of USD 2,000.

Box 4-1. Adaptation technology and/or practices adopted in Timor-Leste

Conservation Agriculture (CA) is an approach to managing agro-ecosystems and expected to increase farmers' efficiency in crop production as well as their capacity to adapt to variable climatic conditions. The technology is progressively being adapted and adopted in Timor-Leste and has shown significant impact on crop yields and agricultural productivity. CA increased crop productivity by 70% and reduced labour and inputs by 50% (FAO, 2018).

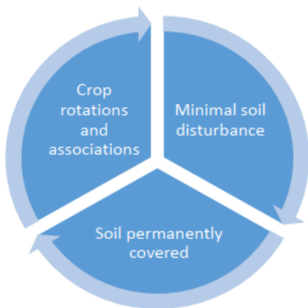


Figure 4-65 Principles of CA (*Source: adapted from www.act-africa.org*)

The successful tested five technologies and/or practices in CA are:

1. No burning of crop residues and weeds;
2. The use of organic mulches, leguminous cover crops, and green manures;
3. Hand jab planters, li seeders and rolling injector planters, long-handled sickles, and hand crimpers;
4. Two-wheel tractor-drawn roller/crimpers, no-till rippers and direct seeders;
5. Liquid organic fertilizers, knapsack sprayers and wheelbarrow-sprayers.

Further programmes at the local level are managed by multilaterals and NGOs in conjunction with government ministries. Meteorological data system and weather stations is GIZ supporting within the Directorate of Research, Statistics and Geographic Information in data collection and analysis from 46 weather stations (feeds into tl.agromet.org). It is trying to enhance capacity. National information and Early Warning System carried by FAO in conjunction with the Ministry of Agriculture is to provide information regarding food stability (influenced by disasters, pests and diseases, and areas affected), food availability (maize and rice prices, livestock, fluctuation of prices), and food production. Data is submitted and compiled in a national database by a District Food Security Officer. The Ministry of Health have also create a health management system that use to complement it. Mercy Corps is undertaking a programme (funded by USAID) that addresses seed system insecurity and food insecurity in Timor-Leste to mitigate post-harvest storage losses of farm-saved seeds and also helps maintain better quality seeds to reduce underlying risk factors of availability, accessibility and utilization of productive seeds. Mercy Corps and FAO are conducting a programme that focuses on Conservation Agriculture in areas of drought, using adaptive research in 6 municipalities. About the deforested areas, a Farmer Managed Natural Regeneration (FMNR) is being used by World Vision to encourage the systematic re-growth of existing trees or self-sown seeds. Mercy Corps also is working to build resilience to natural hazards and incentivising Disaster Risk Reduction (DRR), through bio-engineering crops, and states that they work with the most vulnerable in 31 communities in Dili, Ermera and Ainaro. Some cross-sectoral location-specific programmes are also being undertaken including a programme by CARE and Water Aid carried out a community-based programme in 33 villages in Liquica. It promoted climate-resilient livelihoods, through crop dive rsification, enhancing the access to safe drinking water and improved sanitation, reducing the risk from erosion and landslides, and enabling broader village plans for climate change adaptation. It ran for two years and was completed in 2015.

The projects are already implemented and need further assessment to develop in achieving the expected outputs. Other examples of climate change-related programmes that are being implemented in Timor-Leste programmes are better food better health (about nutrition sensitive agriculture limited on climate change) from World Vision, Climate Smart Agriculture System by Mercy Corps and funded by USAID, improving resilience (disaster risk reduction in community planning and agriculture) through practicing conservation agriculture by FAO (Box 4-1), zero hunger challenge (developing action plan about sustainable foods) by FAO and others, and post seeds of life by MAF Directorate of Research, Statistics and Geographical Information.

Climate change will impact heavily in the region that dependent on natural resources. It has fewer assets and less access to adapt with the climate risks. Ensuring the policies and programmes which are designed to be integrated thinking around the linkages between climate change and vulnerability is important, especially in integrating a social perspective into climate change adaptation policies and integrating consideration of climate change to develop policies and programme. Further assessment of the most vulnerable area or people that have been impacted by climate change is needed as the budget allocation within relevant Ministries should reflect to the more vulnerable populations and be included as allocated budget lines. Some of the climate change adaptation activities in the three main sectors that have been implemented in Timor-Leste by the the government are described below.

4.6.1 Agricultural Sector

The Ministry of Agriculture and Fisheries (MAF) has been actively promoting the 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 GIZ, the MAF 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, MAF implemented other activities which 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 seeds storage and post-harvest management, (iv) improving crop management systems (Box 4-2), (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.

Box 4-2. Adaptation Activity in Timor-Leste

A study about adaptation strategy of Conservation Agriculture (CA) in Timor-Leste is comparing maize yield using CA and conventional farming (control). The treatments for the control are burning the organic matter and ploughing the soil with a tractor and discs, while the CA has minimum tillage. CA performed better than the control which has higher maize yield (Figure 4-65). It is more efficient as CA has a lower amount of labour employed and the fuel used. Many farmers are speculating that implementing CA technologies can also improve crop resilience to variable weather events (Urdín and Nabais, 2016).

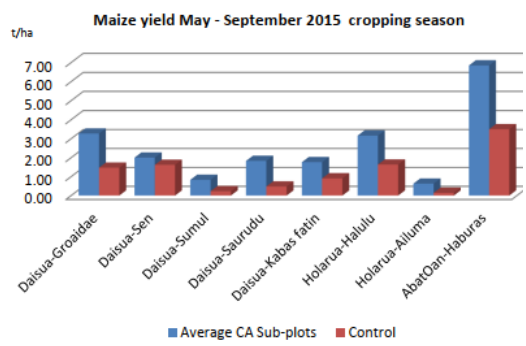


Figure 4-66 Comparison of maize yield in CA vs control
(*Source: Urdín and Nabais 2016)*

Due to the impact of El Niño 2015/2016 leading Timor-Leste into the drought hazard, many farmers managed to help their m aize perform better by keeping a layer of crop residue on the soil surface as a part of CA (FAO 2018). After four years using CA, the report shows that 74% of the CA field has more rapid soil water infiltration rates compared than conventional practices. CA is a solution for reducing soil degradation, conserving water and boosting yield stability, and limiting the risks connected to droughts.

4.6.2 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 of adaption actions in the water sector have been practiced by Timorese communities for a long time, 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 of the above mentioned adaptation activities, the government of Timor-Leste through the NDWCQ in collaboration with international development agencies have conducted studies such as a vulnerability assessment of groundwater resources to climate change, and also produced a hydro-geological map of Timor-Leste. This directorate has drafted a water resource policy and law to be taken to the Council of Ministers for the 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, and the last section of the draft focuses on water resource disasters. In addition, the National Directorate for Forestry, Watershed Management and Reforestation (NDFWNR) has also taken serious steps towards conserving forests which can be seen to directly contribute positively to water source conservation. From 2014 to 2023, the NDFWNR 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 which 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.

4.6.3 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 household own at least one mosquito net, and 42% of these nets are insecticide treated nets. The programs conducted proved to be effective in reducing the incidence of malaria in the country. 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: 1) improving case management through early detection of infection and delivery of effective anti-malarial therapies; 2) application of integrated vector management systems; 3) epidemic preparedness and outbreak responses; 4) 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 the 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 Of Timor-Leste 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. The implementation of these programs Timor-Leste will require funding of about 32.353 million USD as the result of the climate change adaptation progress in Timor-Leste workshop by UNFCCC in 2015. The duration of such a program range would range from 2-5 years. Some projects have been finished, but still have to be monitored by the government and need more development.

5. OTHER INFORMATION

5.1 Technologies on Mitigation and Adaptation

Timor-Leste, like many other Least Developed Countries (LDCs), is considered as countries most vulnerable to the impact of climate change due to its low capacity for adapting to climate variability and change. Majority of Timor-Leste population is highly dependent on natural resources coming from agriculture, forest and fisheries as a source of living. In addition, the country is also very susceptible to natural disasters. Timor-Leste's economic and social development is being threatened by climate change and the threats can be even more serious in the future if no effort is made to manage it. Under the Fourth Constitutional Government of Timor-Leste, the government has acknowledged that one of the greatest challenges to the sustainable development in the country is Climate Change and therefore they are making steps to address the challenges.

One of the key components need to be considered in order to adequately respond to the threat of climate change in Timor-Leste is technological innovation and implementation. It is no doubt that development and transfer of technology for mitigation and adaptation to climate change is essential. The development and implementation of such technologies must be in place quickly and perform continuously to reduce the vulnerability of the country to climate variability and climate change as well as to participate and contribute to the stabilization of the concentration of greenhouse gas concentration in the atmosphere. Those technologies for mitigating and adapting to climate change should be environmentally sound technologies (EST) that supports sustainable development.

In order to have a better understanding on the development and implementation of the local and transfer of EST and other related information such as the status of Research and Systematic Observation (RSO) in Timor-Leste, a survey on EST was conducted as part of the development of Timor-Leste's Second National Communication (SNC) on Climate Change.

This survey covered the following aspects: methodology used for assessment of technology needs, analysis of survey responses including; technology needs, enabling conditions for technology transfer, the needs for capacity building for technology transfer, international support for Timor-Leste in technology transfer and the status of RSO in Timor-Leste.

5.1.1 Energy Sector

Timor-Leste has been implemented and replicated environmentally sound technology as part of mitigation activities in sector energy. There are six types of these technologies as shown in Table 5-1, and of the six technologies solar panel is considered to be the most replicated technology in Timor-Leste, followed by biogas, efficient cook stove, micro-hydro and biobricket, consecutively (sources: INC and TWGs, 2017).

Table 5-1 List of Environmentally Sound Technology in Energy Sector

No.	Environmentally Sound Technology	Progress of Implementation	Notes
1.	Wind-Power	Preliminary Study	76.5 MW potential energy from wind power (NDRED, 2012)
2.	Biobricket	Implemented	
3.	Solar panel	Replicated	Most replicated technology in Timor-Leste
4.	Efficient cook stove	Implemented	Promoting Improve Cook Stoves (ICS) through UNDP fund
5.	Micro-hydro	Implemented	Gariwai (320 KW), Loi Hunu (12-15 KW) and Mausiga (15 KW)
6.	Biogas	Implemented	Ainaro (257 KW for 3 household), Manatutu (524 KW for 6 household), Liquica (257 KW for 3 household),

5.1.2 Agriculture Sector

There are 24 initiatives being implemented or planned to be implemented to reduce GHG emission and/or to adapt with the challenges caused by climate change in agriculture sector, list of these initiatives can be seen in Table .

Table 5-2 List of Climate Responsive Activities in Agriculture Sector in Timor-Leste

No.	Climate Responsive Activity	Progress of Implementation	Notes
1.	Develop sustainable land management system by promoting permanent farming, reducing burning, reducing erosion and improving soil fertility	Replicated	
2.	Develop a legal and planning framework for the provision of balanced and sustainable feeding (in order to support livestock production under climate change)	Implemented & replicated	
3.	Terracing (including drainage channels and vegetative reinforcement)	Replicated	
4.	Green/living fence	Replicated	
5.	Seeds storage		
6.	Karabengkuk as green fertilizer	Not yet fully implemented	
7.	Amoniase and Silage (amoniase and silage techniques for feeding)	Not yet implemented	
8.	Hydroponic	Not yet implemented	
9.	Aquaculture	Not yet implemented	
10.	Fish cages	Replicated	
11.	Conservation agriculture	Implemented & replicated	
12.	SALT (Slopping Agricultural Land Technology)	Replicated	
13.	Multistrata/multi-storied agroforestry	Implemented	
14.	Water-saving cultivation (e.g. using gogo rancah)	Implemented	
15.	Organic Agriculture	Implemented & replicated	
16.	Cropping Pattern (rice-rice-other crop, rice-other crop-rice)	Replicated	
17.	Heteroculture system (intercropping)	Replicated	
18.	Innovation in irrigation system (e.g. irrigation management, institution, capacity development)	Replicated	
19.	Integrated agriculture system (by combining food crop, livestock, fishery, forestry, and other agriculture-related activities in a single field / combined-farming)	Implemented	

No.	Climate Responsive Activity	Progress of Implementation	Notes
20.	Development of local potential (protection, development and utilization of local crops and animals to improve food security. This activity could also include hybridization or cross-breeding)	Implemented	
21.	Diversification of food crops	Implemented	
22.	Climate resistant technologies (e.g. water-efficient or salinity-resistant rice varieties, floating rice, etc.)	Implemented	
23.	Lawn cultivation (such as for food plants, livestock, and fish pond)	Replicated	
24.	Livestock-waste utilization	Implemented	

According to the assessment of climate responsive activity in agriculture sector, the practice of sustainable agriculture, through land management system by promoting permanent farming, reducing burning, reducing erosion and improving soil fertility, has been implemented and replicated in many areas in Timor-Leste. Meanwhile, aquaculture is still considered as technology not easily replicated because of lack of human resource competency and financial issues in Timor-Leste.

5.1.2.1 Water Resource Management

Currently, Timor-Leste has implemented several water resource management technologies for combating the impact of climate change. Due to limited information available on the implementation progress, Timor-Leste has conducted a survey to assess the progress of implementation based on the perception of related stakeholder. According the survey, water resource management that have been implemented in Timor-Leste include rain-harvesting technology, development of biopores, water catchment wells, etc. Further details of survey result are shown in Table .

Table 5-3 Assessment of technologies in water resource management system implementation in Timor-Leste

Sector	Type of technology	Progress of implementation	Notes
Water Resource Management	Rain-harvesting technology	Implemented	MAF-TL in collaboration with EU-GIZ
	Biopores	Implemented & replicated	Initiative has not been conducted
	Water catchment wells	Implemented & replicated	Initiative has not been conducted
	Spring protection	Implemented & replicated	It is supported by local regulation *(Tarabandu)*
	Water re-use	Limited progress	More than 50% of activities is still not yet implemented
	Water use limitation	Limited progress	More than 50% of activities is still not yet implemented
	Industrial water use control	Limited progress	More than 50% of activities is still not yet implemented

Most of water resource management technology has been widely implemented in Timor-Leste. Local community in Timor-Leste or *adat* has regulate activities around water sources such as conservation of forest area aiming at accelerating progress of water resource management resource technologies, i.e. spring protection. Several technologies have not been implemented effectively due to lack of human resource capacity in technical aspects e.g. water re-use, water use efficiency and industrial water use control.

5.1.3 Health and Sanitation

Timor-Leste has identified seven activities in health sectors that contribute the increase adaptability of community to climate change (Table **).** Of the seven activities, SISCA (Integrated Community Health Service) is seen as the most replicated activity on adaptation measure in health sector, followed by clean and safe water treatment, mosquito and vector control, early warning and response system for outbreak, environmental improvement, standardization of water pollution control from industrial waste, and efficient waste management.

Table 5-4 List of Technologies and Initiatives in Environmental Health Sector

No.	Climate Responsive Activity	Implementation progress	Note
1.	Mosquito and vector control (e.g. by draining, burying, and closing mosquito nests)	Replicated	Since 2003, program of malaria control has been supported by Global Fund and Ministery of Health Allocation national budget to provide pesticide/insecticide for controlling vector
2.	Environmental improvement (e.g. to prevent flood and puddles)	Implemented	Initiating environmental health education to the community
3.	Early warning & response system for climate-related disease outbreak such as diarrhea, malaria and dengue fever	Replicated	Early warning and response system has been developed
4.	Clean and safe water treatment	Implemented	This service is supported by the MOH through education in clean sanitation, and strengthened by a strong leadership at the municipal/district level.
5.	Efficient waste management (human, livestock and industrial waste)	Implemented	
6.	Standardization of water pollution control from industrial waste	Not yet implemented	
7.	Improvement of SISCA (Integrated Community Health Service)	Replicated	One of successful adaptation measure in health sector

5.1.4 Land and Forestry

Forestry sector has become one of important agendas of Timor-Leste, considering the increase rate of deforestation, i.e. from 1.1% in the period of 1989 until 1999[4] to 1.7% in recent period[5]. Without any significant effort to stop deforestation and to protect forest area, it is estimated in 60 year there will be no forest area left. Deforestation and land degradation have affected the stock of Timor-Leste's indigenous trees, including teak, mahogany and sandalwood. This condition also causes soil degradation, decrease in groundwater, threats to wildlife and decreases in food sources[6]. To reverse this trend, several programs have been developed by the government with or without support from international agencies. A few of them are:

1.) Community based nursery program.
Through this program, 400,000 to 500,000 seedlings of forest plant, fruit and bamboo are produced every year and 800.000 of coffee plant is distributed to the community.

2.) Mangrove restoration and coastal development.
Mangrove degradation has also become of the most important problems in the forestry sector. There were estimated 11,000 hectares of mangrove in 1940, but now only 1,300 hectares left. Government of Timor Leste (GoTL) in collaboration with UNDP under the project of Building Shoreline Resilience of Timor-Leste to Protect Local Communities and Livelihood since 2016 has been trying to rehabilitate mangrove area with a target of 250 hectares of mangrove being planted every year. This project is implemented in the seven

[4] Timor Leste Action Plan to Combat Land Degradation, A draft report, November 2008
[5] Based on discussion with Director General of Forest, Coffee and Industrial Plants, Ministry of Agriculture and Fisheries on 19th September, 2017
[6] Timor-Leste Strategic Development Plan 2011-2030

districts/municipalities, including Bobonaro, Liquica, Dili, Covalima, Manufahi, Manatuto and Viqueque. It is targeted that a total of 1,000 hectares of mangrove are rehabilitated and benefiting at least 1,000 households and empowering women through diversified livelihood and social business.

3.) Watershed Conservation
There are 11 watersheds set by the GoTL as the priority watershed for conservation. These watersheds are chosen based on the characteristic of total area of more than 10,000 hectares and supplying water more than 1,000 hectares of rice field in the downstream area. A project on Community-based Sustainable Natural Resource Management (CB-NRM) phase II 2010-2015, a collaboration between GoTL and JICA, is an example of program focused on critical watersheds in Timor-Leste (Laclo and Comoro).

Progress on the implementation of activities in forestry sector is presented in Table .

Table 5-5 List of climate responsive activity that has been planned in Timor-Leste

No.	Climate Responsive Activity	Implementation progress	Note
1.	Mangrove planting	Replicated	Mangrove restoration and coastal development through collaboration between GoTL and UNDP
2.	Mangrove eco-tourism	Not yet implemented	
3.	Land rehabilitation and reforestation	Implemented	
4.	Fast growing tree planting	Replicated	Community based nursery program
5.	Reforestation of landslide prone areas	Implemented	
6.	Strengthening local wisdom to support forest protection	Replicated	

5.2 Research and Systematic Observation

A number of climate-related research activities have been conducted by both national and international institutions in Timor-Leste. However, there is a need to establish a body that coordinate these research activities and also a clearing house that organizes all the data, information and result of these research activities. The list of climate-related research in Timor-Leste is presented in Table .

Table 5-6 List of Climate-related Research in Timor-Leste

No.	Research Title	Author/ Organization	Year
1.	Selection of drought resistance grain legumes for growing them after rice	Marcal Gusmao	2017
2.	Climate and Health, Timor-Leste	WHO	2015
3.	Community adaptation to climate change: a case study from the sub-districts of Liquidoe and Remexio, District of Aileu, Timor-Leste	Marcal Gusmao, Acacio da Costa Guterres, Tania Paul	2015
4.	Water deficit during reproductive period reduced yields of tomato varies	Marcal Gusmao and Sabino Henrique	2013
5.	Water deficit during the reproductive period of grass pea (*Lathyrus sativus L.*) reduced grain yield but maintained seed size	M. Gusmao, K. H. M. Siddique, K. Flower, H, Nesbitt, and E. J. Veneklaas	2012
6.	Vulnerability Assessment related to Sea Level Rise in Pantai Kelapa	CCCB – UNTL	n/a
7.	Vulnerability, Risk and Needs Assessment in Hera	CCCB – UNTL	n/a
8.	Research on Adaptive Commodities under Climate Pressures (rice, corn/maize, sweet potato, cassava)	National Directorate for Research, Statistics and Geography Information, MAF	n/a

In order to support the research activities in Timor-Leste, the availability of climate and weather observation system is essential. Up to now, there are only four weather stations in Timor-Leste that are registered in the World Meteorological Organization (WMO). These four weather stations are located in Oecusse, Dili, Baucau and Suai. Based on the information from the National

Directorate for Meteorology and Biophysics (NDMB) of Timor-Leste, there is a need to increase the number of weather station in Timor-Leste to least one in each district, or in other words, minimum 13 weather stations in total.

For the purpose of agricultural activity, there are 58 manual weather stations built since the occupation of Portuguese in Timor-Leste. These weather stations provide information related to rainfall and are managed under the authority of MAF. Data related to sea tides are not yet available, but the plan to install tidal gauges is in place.

To provide related data for various research on climate change, Timor-Leste have been collaborating with overseas agency such as Indonesian BMKG and Australian Bureau of Meteorology. However, according to the National Directorate for Research, Statistics and Geography Information and the National Directorate for Meteorology and Geophysics, it was found that the involvement of Timor-Leste to the Global Climate Observation System is still very minimal due to limited data that can be provided within the country.

5.3 Information on Education, Training, and Public Awareness

The effort to integrate environment and health issues in the education system has been done by the Ministry of Education as a mean to improve students' awareness to the changing environment. In the curriculum for primary education climate change is addressed implicitly, while in secondary education it is addressed explicitly as seen in the document of *Plano Curricular do Ensino Secundário Geral, Ministério da Educação 2011*. Environmental problems, including climate change, have also been addressed in the subject of natural science at the primary education and the subject of integrated science system at the secondary education. Awareness rising through practical environmental education has become a part of the subject of art and culture through the project of school garden.

5.3.1 Education

Formal education institutions (schools) in Timor-Leste often organize trainings for students such as training for organic and inorganic waste recycling, plant cultivation, tree planting and land rehabilitation, prevention and management of climate-related disaster such as landslides, flood and drought. Many schools have also implemented climate change adaptation/mitigation initiatives whilst rising student's awareness to climate change, such as building water catchment well and living/green fence. The concept of green school has been implemented in two schools, Esperansa da Patria and SMA (upper middle school) of Cristal, under a collaboration with Japan International Cooperation Agency (JICA).

Dissemination of information on climate change and health for schools and villages all around Timor-Leste is done by SISCA and Ministry of Health. To improve the knowledge and awareness of education personnel on the issue of climate change and health, in 2013 Ministry of Health organized a training on climate change and health. In 2015, a National Workshop on Climate Change and Health was also conducted and modules from WHO were disseminate. However, these modules produced by WHO are still in English and there is an urgent need to translate these modules into Tetun so that trainings on climate change and health for teachers, health personnel and public can be conducted more effectively.

As an attempt to integrate climate change and disaster risk management into the development plan, National Institute for Public Administration (NIPA) in collaboration with Center for Climate Change and Biodiversity, National University of Timor-Leste (CCCB-UNTL) conducted a training on Integrating Climate Change Adaptation and Disaster Risk Management to the Development Plan for government officials at the district/municipality level from June to August 2017. List of education activities that have been conducted in Timor-Leste is shown in Table .

Table 5-7 List of education activities in Timor-Leste

No.	Activities	Coordinated by	Document/Reference/Note
1.	Integration of environmental issue in the primary education	Ministry of Education	*Currículo Nacional Do Ensino Básico do Primeiro e Segundo Ciclos de 2014*
2.	Integration of climate change issue in the secondary education	Ministry of Education	*Plano Curricular do Ensino Secundário Geral, Ministério da Educação 2011*
3.	Climate change and health education for schools and villages	SISCA and Ministry of Health	Incidentally
4.	Climate Field School for Farmers	Ministry of Agriculture of Timor Leste and Indonesian BMKG	Started in 2016 in Ainaro, Baucau, Ermera and Lautem District

5.3.2 Training

Several trainings have also been coordinated by the NDCC. Every year, NDCC organizes a workshop to rise climate change awareness of local authorities and community at the district/municipality level. The details of training activities that have been conducted in Timor-Leste will be shown in Table .

Table 5-8 List of training activities in Timor-Leste

No.	Activities	Coordinated by	Document/Reference/Note
1.	Students training for organic and inorganic waste recycling, plant cultivation, tree planting and land rehabilitation, prevention and management of climate-related disaster such as landslides, flood and drought.	Ministry of Education	Incidentally
2.	Workshop of climate change awareness in each district for local authorities, community, students.	NDCC, DGE, Ministry of Commerce, Industry and Environment	Annually, since 2012
3.	Training on Climate Change and Health for Teachers and Education Personnel	Ministry of Health	2013
4.	National Workshop on Climate Change and Health	WHO and Ministry of Health	2015
5.	Training on Integrating Climate Change Adaptation and Disaster Risk Management to the Development Plan for Government Officials at the District/Municipality Level	National Institute for Public Administration (NIPA) and Center for Climate Change and Biodiversity, National University of Timor Leste (CCCB-UNTL)	1.) 19-23 June 2017 for Baucau, Viqueque, Manatuto, Lautem Districts 2.) 3-7 July 2017 for Aileu, Ainaro, Cova Lima, Manufahi Districts 3.) 29-31 July 2017 for Oecusse District 4.) 22-24 August 2017 for Dili, Bobonaro, Luquica, Ermera Districts/Municipalities

5.3.3 Public Awareness

To raise farmers' awareness to the changing climate, as well as to improve their knowledge and capacity to manage the risk, Ministry of Agriculture of Timor-Leste in collaboration with the Indonesian BMKG (Meteorological, Climatological, and Geophysical Agency) has launched a program on Climate Field School. As it has been mentioned in the previous sub-chapter, this program has been implemented since 2016 in several areas in Ainaro, Baucau, Ermera and Lautem District. The summary of activities related to public awareness for climate change can be seen in Table .

Table 5-9 List of public awareness activities in Timor-Leste

No.	Activities	Coordinated by	Document/Reference/Note
1.	Website of Climate Change Information Center	NDCC, DGE, Ministry of Commerce, Industry and Environment	https://ccb-tl.org/45-untl
2.	Workshop of climate change awareness in each district for local authorities, community, students.	NDCC, DGE, Ministry of Commerce, Industry and Environment	Annually, since 2012
3.	Campaign on environment and climate change awareness in district and villages	NDCC, DGE, Ministry of Commerce, Industry and Environment	Annually, since 2001

5.4 Efforts to Promote Information Sharing

Efforts to disseminate climate change adaptation and mitigation information in Timor-Leste are conducted among others through participations in various regional and international meetings. The list of international/regional meeting participated by government officials of Timor-Leste is presented in Table .

As the center for online information on climate change, National Directorate of Climate Change (NDCC), Directorate General of Environment (DGE), Ministry of Commerce, Industry and Environment (MCIE) have developed a website that can be accessed at https://ccb-tl.org/45-untl.

Table 5-10 List of International/Regional Meeting Participated by Government Officials of Timor Leste

No.	Meeting	Hosting Country	Year
1.	COP23: The 23rd session of the Conference of the Parties (COP 23) to the UN Convention on Climate Change (UNFCCC)	Bonn, Germany	2017
2.	Regional Meeting on Agricultural Biotechnologies in Sustainable Food Systems and Nutrition in Asia-Pacific	Kuala Lumpur, Malaysia	2017
3.	Southeast Asia Pacific (SEAP) Regional Network Meeting	Phuket, Thailand	2017
4.	The 9th International Forum for Sustainable Asia and the Pacific (ISAP)	Yokohama, Japan	2017
5.	39th Open- Ended Working Group (OEWG)	Bangkok, Thailand	2017
6.	*IV Congresso Internacional de Educação Ambiental* / The Fourth International Congress of Environmental Education	Portuguese Association of Environmental Education (ASPEA)	2017
7.	The 29th meeting of the LEG (Least Developed Countries Expert Group)	Timor Leste	2016
8.	Southeast Asia Pacific (SEAP) Regional Network Meeting	Suva, Fiji	2016
9.	38th Open-Ended Working Group (OEWG) and ExMOP 3	Vienna, Austria	2016
10.	28th Meeting of the Parties to the Montreal Protocol	Kigali, Rwanda	2016
11.	COP 22: The twenty-second session of the Conference of the Parties (COP 22) and the twelfth session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP 12)	Marrakesh, Morocco / UNFCCC Secretariat	2016

Timor-Leste also participate actively in the regional/international programs that facilitate sharing of information. The program include the following:

1.) Coral Triangle Initiatives (CTI)
2.) Pacific Island Development Forum (PIDF)
3.) Southeast Asia Pacific (SEAP) Regional Network
4.) Least Developed Countries (LDC) Expert Group
5.) Small Island Developing States (SIDS)

5.5 Gender

As described in the INC of Timor-Leste, the country has made significant efforts to improve gender equality and women's empowerment. Based on ADB study on Timor-Leste Country Gender Assessment[7], GoTL has developed systems for gender mainstreaming and coordination. The voice of Timorese women is one of the gender equality frameworks that have been implemented in Timor-Leste and it is represented through national women's congress being held every 5 years. This activity encourages government to produce a platform for addressing gender issues in Timor-Leste.

There are also 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. SEPI in particular supports the implementation of gender equality program though gender working groups at district and cross-ministerial levels.

Timor-Leste's future plan for achieving gender equality will be implemented through invigorate systems for gender mainstreaming and policy practice, and development of concrete guideline for government official and other stakeholder and monitoring & evaluation of government program that related to gender equality.

[7] Timor-Leste Country Gender Assessment, 2014

6. OBSTACLES, SHORTAGES AND NEEDS RELATED TO FINANCE, CAPACITY BUILDING AND TECHNOLOGY

6.1 Financial

Funding is considered as the main obstacles to implement climate change mitigation and adaptation in Timor-Leste due to limited government budget and also less attractive country's circumstances for foreign investment that might facilitate technology transfer. In addition, other obstacle is lack of private sector involvement. Government of Timor-Leste has developed NAPA and submitted NDC to the UNFCCC. In order to implement all of this plan, Timor-Leste government needs assistance from international supports, especially on financial issues. The GoTL has been working with development partners in urban and rural development projects, i.e. ADB, AusAID, DFAD, EU, UK DFID, GIZ, JICA, World Bank, UNDP and other UN Agencies.

According to the OECD DAC Reporting system[8], Timor-Leste has received financial support about US$102.5 million during 2010 – 2014 for the implementation of climate actions. These supports were mainly used for adaptation (68%), and then for mitigation (30%) activities. A few activities were integration of mitigation and adaptation (Figure). In addition, Timor-Leste proposed Official Development Aid (ODA) for US$128.5 million for to support the implementation of climate actions.

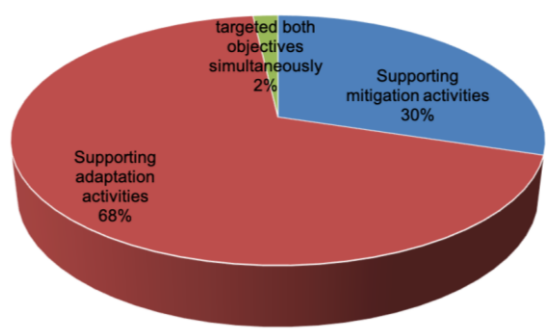


Figure 6-1 Proportion of climate finance during 2010-2014 by type of climate actions

Based on donor countries, Japan was the biggest source of finance in Timor-Leste, particularly for supporting irrigation projects, and then followed by Australia and the Least Developed Countries Fund that supported water & sanitation and environmental policy (Figure 6-2).

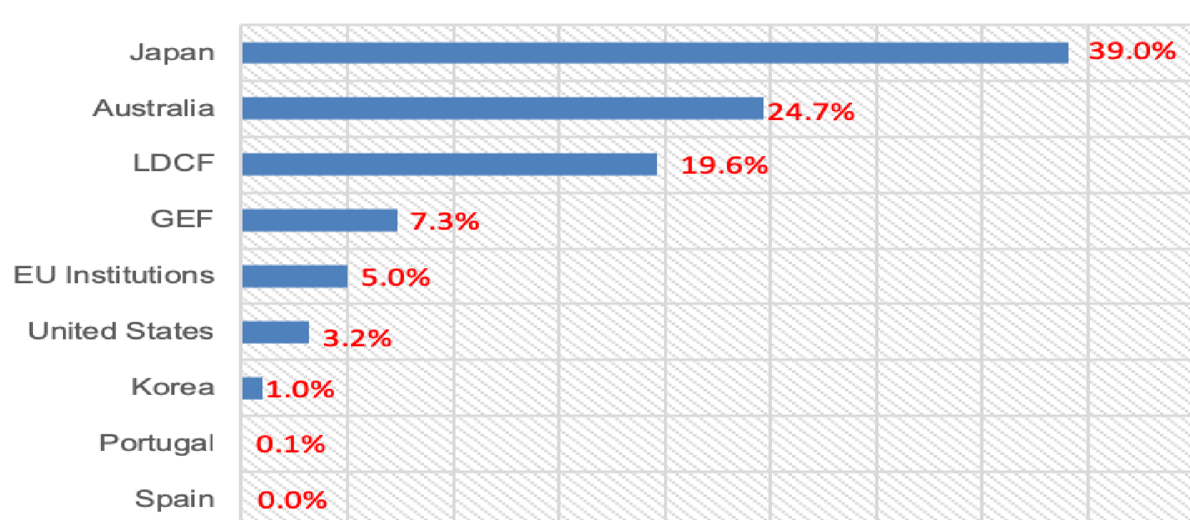


Figure 6-2 Source of finance and sectoral distribution in Timor-Leste

[8]Climate finance in the pacific: An overview of flows to the region's Small Island Developing States, SEI working paper, 2017

Currently, UNDP with funds from the GEF is implementing several projects that contribute to National Adaptation Plan of Action (NAPA) and Timor-Leste SDP 2011 – 2030. These activities are consisting of Building Coastal Resilience Project with the Ministry of Agriculture, Strengthening Resilience Along the Dili-Ainaro Road with Ministry of Social Solidarity and SSRI Project – Rural Infrastructure and Local Governance Support Systems with Ministry of State Administration and Ministry of Environment.

In the future, Timor-Leste government required additional funding to meet the gap between what is needed in National Development Plan and the level of funding that already received and implemented. Beside the support from financial sector, the Timor-Leste Government also need support for building their capacity and technology transfer.

6.2 Technology Transfer

Timor-Leste has collected information related to technologies needed for addressing climate change. The information was obtained based on the perception of working group and key resource person from different sectors, i.e. energy, agriculture, water resource management, waste, health & sanitation and land & forestry. Results of the survey indicate that Timor-Leste's still required financial and technical supports as well as human resources for the implementation of ESTs in all sectors.

6.2.1 Energy sector

As mentioned in previous chapter, there are six environmentally sound technology that have been implemented in Timor-Leste, namely wind-power, bio-bricket, solar panel, efficient cook stove, micro hydro and biogas. Renewable energy is considered as potential energy source. The main objective of the Government of Timor-Leste in increasing the use of renewable energy is for energy diversification to improve energy security. By 2017, electrification ratio is targeted to reach 85% with two main energy sources including from Hera and Betano power plants. Considering that most regions currently have access to national grids, the future of technology transfer in the energy sector needs to be supported by the formulation of energy development plan focusing on the transfer and re-allocation of both fossil-based and renewable-based energy.

According to the preliminary study led by State Secretariat for Energy Policy with a support from Martifer Renewables (2009), the potency of wind power in Timor-Leste reaches 72 MW. Government targeted the use of wind energy of 42.6 MW by 2017. However, this has not been implemented since more in-depth feasibility study is still needed.

Directorate of Research and Development under the Ministry of Public Works, Transport and Communications have also identified 21 hydropower energy potential. Some of which have been implemented, namely:

1.) Mini-hydro pilot project at Gariwai, with a capacity of 320 KW, installed in 2008 with a support from Norway. This project stopped after 3 years of operation due to less favorable geological conditions and land movements.
2.) Micro-hydro in Loi Hunu, Ossu, Viqueque District, with a capacity of 12-15 KW. This project faced an obstacle related to calcareous water that affected the engine (technical obstacle). As the community in the area has obtained national grid access, attempts to re-operate the micro-hydro are minimal.
3.) Micro-hydro in Mausiga, Ainaro District, with a capacity of 15 KW. Constraints of this project were related to small runner and a lack of community's effort to re-operate this micro-hydro as they now can access electricity from the national grid.

In addition, Biogas utilization for home cooking stoves and electricity has been implemented quite successfully in many areas of Timor-Leste. Among others are:

1.) Biogas plant in Ainaro with a capacity of 10 m^3 and is capable of producing 257 KW electrical energy for 3 households.
2.) Biogas plant in Manatutu with a capacity of 20 m^3 and is capable of producing 524 KW of electric energy for 6 households.

3.) Biogas plant in Liquica with a capacity of 10 m^3 able to produce 257 KW electrical energy for 3 households.

One of the obstacles in the implementation of biogas is a lack of management capacity at the community level, mainly maintenance system. Business model training for the biogas has been conducted, but it is not yet sufficient to sustain the practice.

Among the six types of ESTs, technology that needs high support for its implementation is wind power, and that needs low support is solar panel. In general, the main challenge for the implementation of these technologies is the human resource.

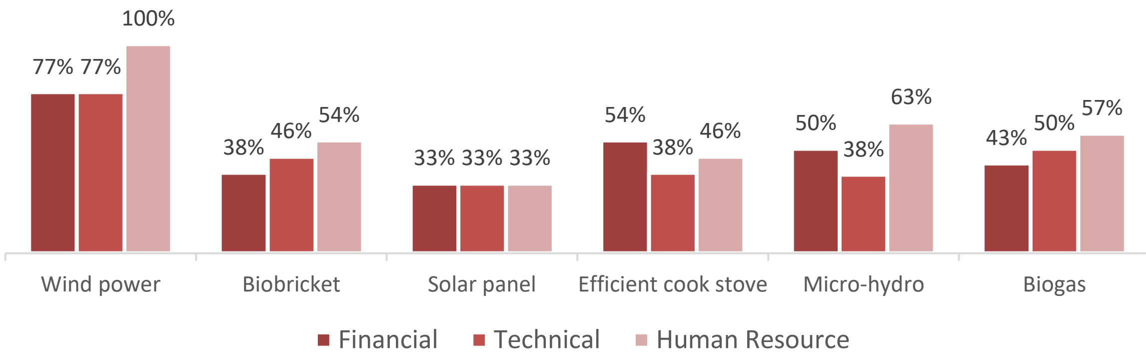


Figure 6-3 Support required for the Implementation of Environmentally Sound Technologies in Energy Sector

6.2.2 Agriculture sector

The agriculture sector has identified at least 24 climate responsive activities as shown in Figure . Main support needs for the implementation of sustainable agriculture, karabengkuk as green fertilizer, hydroponics, fish cages, conservation agriculture, water saving cultivation, and cropping pattern are technical and human resource, while for sustainable feed, green/living fence, seeds storage, aquaculture, multi-storeys agroforestry, hetero-culture system, integrated agriculture, development of local potentials, diversification of food crops, and livestock-waste utilization is mainly technical support. For the implementation of terracing, amoniase and silage, salt mining, and organic agriculture, the main support needs is human resource, while for the implementation of lawn cultivation the main support is financial.

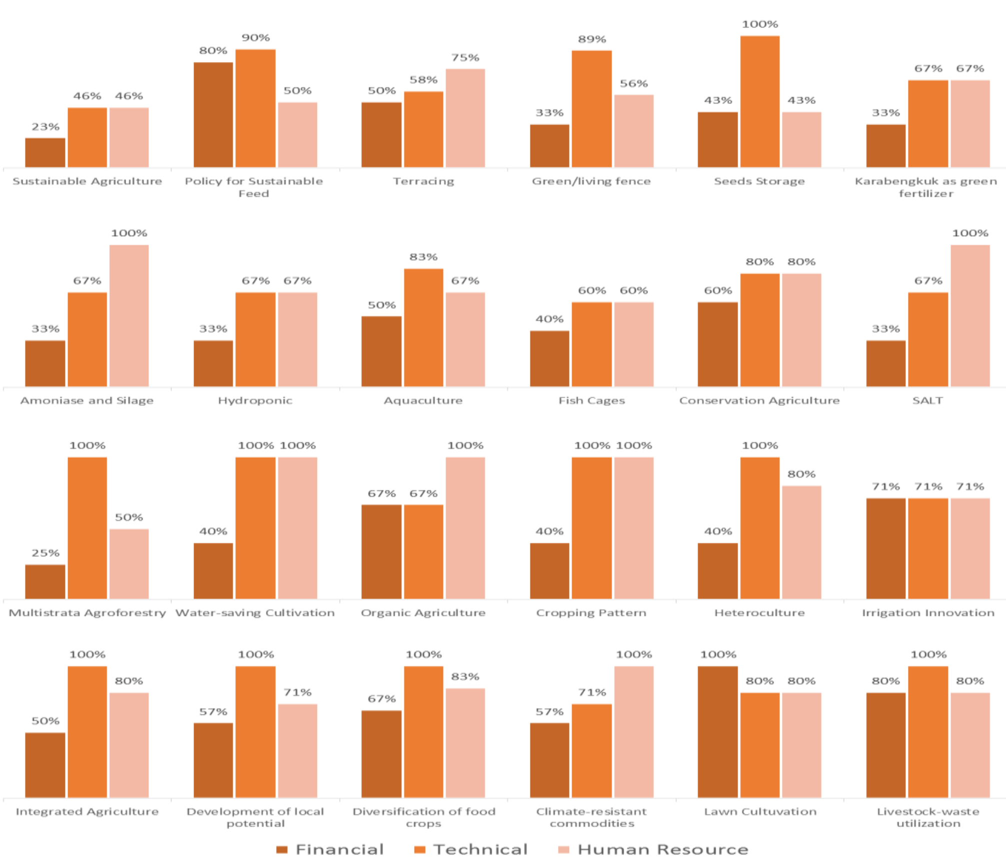


Figure 6-4 Support needs for the Implementation of Climate Responsive Initiatives in Agriculture Sector

6.2.3 Water Resource Management

In water resource management, there are at least eight activities considered important to be implemented, i.e. rain harvesting, biopore, water catchment wells, spring protection, infrastructure for springs protection, restoring water catchment areas by planting trees around springs, local institutional for protecting springs, water recycle, water use efficiency and industrial water use control (Figure 6-5). The main obstacle in water resource management is human resource capacity, except for rain harvesting, water catchment well and industrial water-use control. For these technologies the main support required is technical.

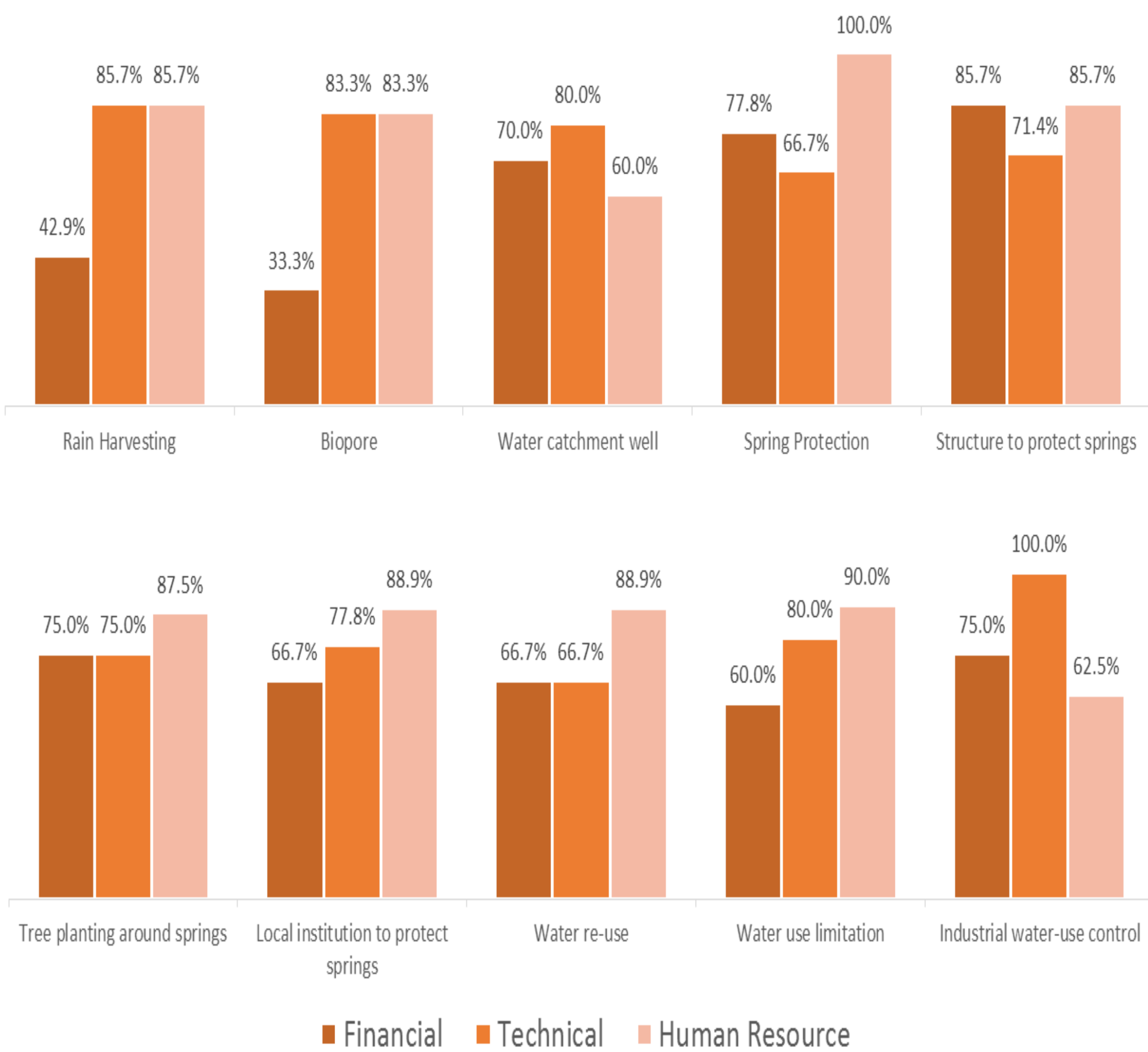


Figure 6-5 Support needs for the Implementation of Initiatives in Water Resource Management

6.2.4 Health and Sanitation

In health and sanitation sector, technologies being considered to be important are mosquito and vector control, environmental improvement, clean and safe water treatment and improvement of SISCA (Figure **).** Human resource capacity for implementing these technologies is still lacking. Meanwhile, technical support is more required for the implementation of efficient waste management and standardization of water pollution control from industrial waste.

On the other hand, primary health care, including environmental health, is still facing financial problem. National budget allocated for each municipality/district each year is still very limited, i.e. 3,000 USD/year. Agencies that have contributed financially for the development of health sector in Timor-Leste are the Global Fund (malaria), WHO (water safety plan, food safety program, control vector dengue), UNICEF and PHD[9] (sanitation and hygiene).

[9] Partnership Human Development by Australian Government

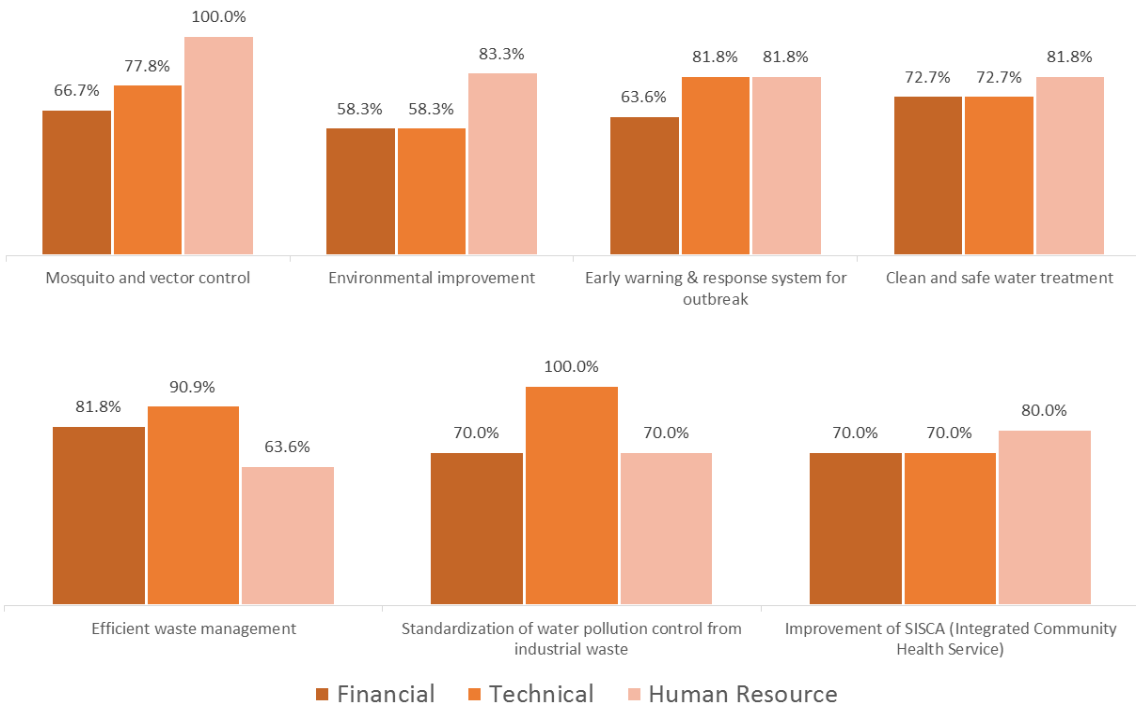


Figure 6-6 Support needs for the Implementation of Technologies and Initiatives in Environmental Health Sector

6.2.5 Land and Forestry

According to the information collected by Timor-Leste Government, implementation of technologies and initiative in forestry sector needs technical support particularly for mangrove rehabilitation, and financial support is also needed for the development of mangrove eco-tourism (Figure 6-7). The technical support is mostly needed for the implementation of land rehabilitation and reforestation, fast-growing tree planting, and reforestation of land-slide prone areas.

Figure 6-7 Support needs for the Implementation of Technologies and Initiatives in Forestry Sector

6.2.6 Transfer of Technology in Solid Waste Management

There are at least three initiatives implemented in Timor-Leste for the management of solid waste, namely organic household waste processing, agricultural waste processing, and inorganic waste processing. MAF in collaboration with FAO has promoted to reduce waste from agriculture sector, i.e. post-harvest waste. Support needs for further implementation of this initiative is related human resource as awareness of local community on this technology is still lacking (Figure 6-8).

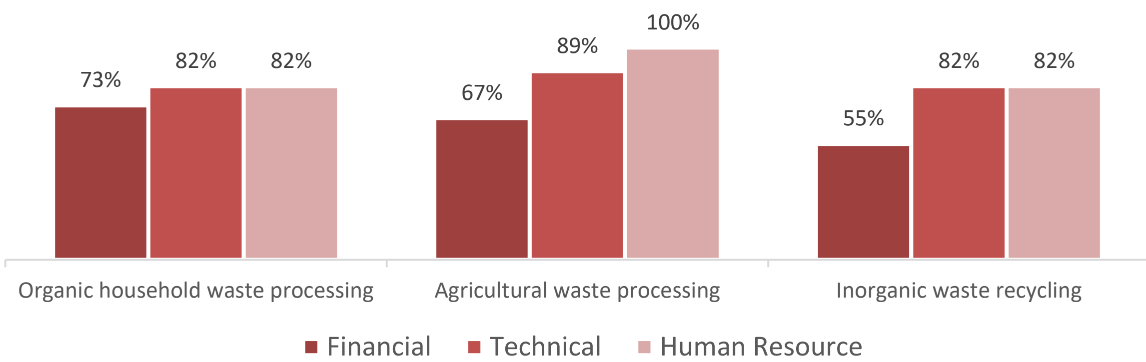


Figure 6-8 Support needs for the Implementation of Solid Waste Management

6.2.7 Transfer of Technology in Prevention and Management of Climate-Related Disaster

Timor-Leste exposes to high risk of climate hazards. The characteristics of climate in Timor-Leste are heavy monsoonal rain and strong winds. As many of the areas in Timor-Leste has steep topography and prevalent deforestation, these areas are very prone to floods, landslides, river shifts and erosion[10]. Landslides and flash floods are the most common natural hazards in Timor-Leste. These hazards often destroy bridges and wash out roads and disrupt the land transport system[11]. Transfer of technology related to prevention and management of climate-related disaster is important in Timor-Leste.

Government of Timor-Leste has implemented a number of activities for managing the climate disaster. National Directorate for Disaster Management, Ministry of Social Solidarity (DDM-MSS) is implementing a project on strengthening community resilience to climate-induced disaster along with the implementation of Dili-Ainaro climate-resilient road project. Other activities that are implemented by the DDM-MSS in collaboration with other line ministries and stakeholders are as follows[12]:

1.) Development of training manual for disaster risk reduction/management (DRR-DRM) and climate change adaptation (CCA), as well as implementation of disaster risk management training in Baucau, Manufahi, RAEOA-Oecusse and Bobonaro in collaboration with National Institute for Public Administration (NIPA) and Center for Climate Change and Biodiversity, National University of Timor-Leste (CCCB-UNTL)
2.) Promotion of community-based reforestation and infrastructures along the road to reduce the vulnerability of local communities, in a close collaboration with MAF.
3.) Establishment of four nurseries, planted 16 hectares and constructed a check dam land along the project corridor.
4.) Development of early warning system based on the risks assessment in the project areas.
5.) Other related activities such as reforestation, community mobilization and awareness campaign in Ainaro, in a collaboration with Maharu (local NGO).

Views from DDM-MSS, and CCCB-UNTL indicates that other activities needed to increase resilience to climate hazards include construction of dams and reservoirs, development of flood embankment, and flood warning system, flood control water pump, rehabilitation of water catchment area, early warning system for hurricanes, drought prevention strategies, and efforts to elevate building structure. The financial support is critical for the implementation of the first three activities, and technical support, and enhancement of human resource capacity for the rest.

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[10]Disaster needs analysis: Preparedness Timor-Leste, September 7, 2012. https://www.acaps.org/sites/acaps/files/products/files/timorleste_2012.pdf

[11] Timor-Leste Disaster Management Reference Handbook. 2016. Center for Excellence in Disaster Management and Humanitarian Assistance

[12] DARDC Project Fact Sheet, May 2017. http://www.tl.undp.org/content/dam/timorleste/docs/Projects/DARDC/Factsheet/DARDC%20Project%20Facksheet%20May%202017-ENGLISH_edited.pdf

6.3 Capacity Building

A number of capacity building activities have been participated by the government representatives of Timor-Leste, both at the national and international level. Some capacity building activities participated by the government officials of Timor-Leste in the period of 2016-2017 is presented in Table .

Table 6-1 List of Capacity Building Activities Participated by Government Officials of Timor-Leste

No.	Title	Hosting Country / Organizing Committee	Year
1.	Adapting to Climate Change: Facing the Consequence	Thailand / TICA (Thailand International Cooperation Agency)	2017
2.	Regional Capacity-building Workshop on the Measurement, Reporting and Verification (MRV) Framework under the United Nations Framework Convention on Climate Change (UNFCCC)	Singapore / Cooperation between Government of Australia and Singapore, UNDP/UNEP, Global Support Programme/GSP	2017
3.	Strengthening Community Climate and Disaster Resilience, ADB Regional Consultation Workshop	Manila, The Philippines / ADB Manila	2017
4.	Product Knowledge and Installation of Air Conditioner	Jakarta, Indonesia / PT. Panasonic Manufacturing Indonesia	2017
5.	Workshop on Flammable Refrigerants in the Room Air Conditioner (RAC) and Field Trip to RAC and Compressor Manufacture Plant	Shenzen, Guangdong Province, China / UNEP	2016
6.	On-Job Training for NOU (National Ozone Unit) Professional Staff	Jakarta, Indonesia / NOU Indonesia (South-South Cooperation)	2016
7.	LDCs (Least Developed Countries) Climate Change Negotiators Training Workshop	Ethiopia / Joint UNEP and UNDP collaboration UNITAR and IIED	2016
8.	Asia Pacific Regional Workshop on Integrating Market Mechanism to the Implementation of INDCs/NDCs	Kingdom of Thailand	2016
9.	25th Asia-Pacific Seminar on Climate Change Implementation of Intended Nationally Determined Contributions (INDCs) and Post-2020 Enhanced Transparency Framework	Kingdom of Thailand	2016

In GHG Inventory, the Timor-Leste Government still requires capacity building especially in data collection and estimation of emissions. For mitigation, capacity building is needed for development of baseline, in addition to financial support needs. Support in conducting impact analysis is also required along with method to prioritize and design adaptation actions.

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