Patterns of Vulnerability in the Forestry, Agriculture, Water, and Coastal Sectors of Silago, Southern Leyte, Philippines

On behalf of

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

Patterns of Vulnerability in the Forestry, Agriculture, Water, and Coastal Sectors of Silago, Southern Leyte, Philippines

Manila Observatory
Gemma Teresa T. Narisma, May Celine T.M. Vicente, Emmi B. Capili-Tarroja, Faye Abigail T. Cruz, Rosa T. Perez, Raul S. Dayawon, Julie Mae B. Dado, Ma. Flordeliza P. Del Castillo, Marcelino Q. Villafuerte II, Leonard Christian G. Loo, Deanna Marie P. Olaguer, Ma. Antonia Y. Loyzaga

World Agroforestry Centre
Ma. Regina N. Banaticla-Altamirano, Lawrence T. Ramos, Christine Marie D. Habito, Rodel D. Lasco

Edited by: Joel T. Maquiling

LUMEN DE LUMINE
MANILA OBSERVATORY

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

giz

The **Manila Observatory (MO)** is a scientific research institution established by the Jesuit order in the Philippines with over a hundred forty-five years of service in the fields of atmospheric and earth science. It advocates a science-based approach to sustainable development and poverty reduction through its principal focus on the areas of climate change and pre-disaster science. The Observatory actively confronts these challenges through investments and partnerships in scientific research which must inform and guide a safe and sustainable future for humankind.

The World Agroforestry Centre (ICRAF) is part of the alliance of the Consultative Group on International Agricultural Research (CGIAR) centres dedicated to generating and applying the best available knowledge to stimulate agricultural growth, raise farmers' incomes and protect the environment**.** ICRAF combines excellence in scientific research and development (R&D) to address poverty, hunger and environmental needs through collaborative programs and partnerships and is proud to be part of a multi-sector effort to promote agroforestry in the Philippines, especially among swidden agriculturists (slash-and-burn farmers) and upland farmers.

The **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)**, is a federally-owned enterprise that supports the German government in the field of international development cooperation. For more than 30 years now, GIZ has been cooperating with Philippine partners in strengthening the capacity of people and institutions to improve the lives of Filipinos in this generation and generations to come. Together we work to balance economic, social and ecological interests through multi-stakeholder dialogue, participation and collaboration.

Cover Photo: Emmi Capili-Tarroja

This study has been financed by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) through the Project 'Adaptation to Climate Change and Conservation of Biodiversity in the Philippines (ACCBio)' with funding from the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The International Climate Initiative is based on a decision of the German Bundestag, the German Parliament. For more information, log on to http://www.bmu klimaschutzinitiative.de/en/about_the_ici

ISBN: **978-971-94565-1-3**

ACKNOWLEDGEMENTS

A number of people and institutions have made this book possible. First, we would like to thank Mr. Friederike Eppen, from GIZ, for providing comments and inputs on the draft report.

Furthermore, we would like to express our gratitude to the following institutions for helping us in gathering the necessary data to complete this book:

Municipality of Silago

- Municipal Planning and Development Coordinator's Office (MPDC)
- Municipal Agricultural Office (MAO)
- Municipal Environment and Natural Resources Office (MENRO)
- Municipal Health Office (MHO)

Regional Offices

- National Economic and Development Authority (NEDA)
- Department of Agriculture – Bureau of Agricultural Statistics (DA-BAS)
- Department of Agriculture - Bureau of Fisheries and Aquatic Resources (DA-BFAR)
- Department of Environment and Natural Resources (DENR)

GIZ

- Regional Environment Information System (REIS)
- Environment and Rural Development Program (EnRD)
- Program for Sustainable Management and Natural Resources

Province of Southern Leyte

- Provincial Planning and Development Office (PPDO)

Academe

- Visayas State University – Institute of Tropical Ecology
- University of the Philippines Visayas Tacloban Campus
- Southern Leyte State University

FOREWORD

It is often said that climate change is an issue that requires global solutions and local actions. The Philippine Strategy on Climate Change Adaptation (PSCCA) picks up this principle by calling for an enabling environment for mainstreaming climate change adaptation based on a decentralized framework of good governance. It also calls for the establishment of credible science-based information linked to community knowledge on climate change and climate change adaptation at scales relevant to decision-makers and practitioners. The National Framework Strategy on Climate Change likewise gives a policy directive of building the adaptive capacity of communities and resilience of ecosystem to climate change.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) advocates the mainstreaming of climate change adaptation in development processes. Part of that is the integration of adaptation into local development planning by using and enhancing existing planning instruments and frameworks with a perspective of climate change. Through the Department of Environment and Natural Resources and GIZ joint project "Adaptation to Climate Change and Conservation of Biodiversity (ACCBio)," we had the opportunity to work together with local government units in mainstreaming climate change adaptation in the Comprehensive Land Use Plan (CLUP) prepared by municipal governments. The CLUP guides the growth and sustainable development of municipal governments by considering all sectors significant in the development process within the territorial jurisdiction. As a tool that reflects the development goals of the local community, the CLUP is a key instrument for analysis of local development policies and programs with regard to the risks and opportunities that climate change poses, and identifying measures to tackle these changes. The opportunity to support the Municipality of Silago, Southern Leyte in updating its CLUP presented an exceptional and welcome prospect for integrating CCA in the local development context. This provided the link to the local level of the mostly national-level interventions of the ACCBio Project through the introduction of the instrument of 'Climate Proofing for Development' developed for the Philippine context with the Environmental Management Bureau of DENR.

This publication is a contribution to action at the level of governance where impacts of climate change and the need for adaptation are inseparable. It presents the results of the impact analysis and vulnerability assessment to climate change of the forestry, water, agriculture and coastal sectors of the Municipality of Silago, Southern Leyte, as an input to the sectoral studies of the CLUP. The Manila Observatory and the World Agroforestry Center ICRAF with contributions from the State Universities in the region and the regional government agencies provided the science on which adaptation planning can be based. The Municipality of Silago, with the assistance of the DENR-GIZ ACCBio Project and the Environment and Rural Development (EnRD) Program, then took on the challenge of integrating this in the revision of the CLUP.

The goal of the PSCCA is to build the capacity of communities to adapt to climate change and increase the resilience of natural ecosystems to climate change. We hope to have contributed a small but significant part to this endeavor.

MABUHAY TAYONG LAHAT!

DR. BERND-MARKUS LISS
Principal Advisor, ACCBio Project

MESSAGE FROM THE MAYOR OF SILAGO

Silago has observed the changes in climate in recent years, being subject to unpredicted weather extremes that triggered damages in the productive sectors and threatened the livelihoods and well-being of our local communities.

In order to address the challenges presented by a changing climate and prepare for adaptation to the impacts of climate change, we have taken the opportunity offered by GIZ to support the Municipality in the development of a climate proof Comprehensive Land Use Plan (CLUP). With the assistance of the ACCBio Project in coordination with the ENRD Program, we were in a position to assess our water, agriculture, forestry and coastal sectors with regard to climate change impacts, to analyze the vulnerabilities and to elaborate options for improved resilience and adaptation to climate change at the local level and integrate them into our CLUP. This report documents the scientific inputs of Manila Observatory and ICRAF, PIK in this process to integrate climate change adaptation into our local development planning.

In this regard, let me thank and congratulate all local government agencies and key stakeholders for their commitment and tireless efforts towards a local planning that responds to the challenges of climate change. Thanks to the support of GIZ, we are now confident that our CLUP will provide a good basis for future development of the Municipality of Silago to make our programs and projects more adaptive to the impacts of climate change, thus more sustainable.

DAGHANG SALAMAT KANINJONG TANAN! Mabuhay!

HON. MANUEL A. LABRADOR, SR.
Municipal Mayor
Silago, Southern Leyte

MESSAGE FROM THE EXECUTIVE DIRECTOR OF THE MANILA OBSERVATORY

On behalf of the Manila Observatory, I wish to extend our sincerest congratulations and deep appreciation to all who have been part of this breakthrough work on patterns of vulnerability. This work is intended to enhance the capacities of coastal communities, as politico-ecological units, in confronting the unique challenges and opportunities posed by climate change. This publication represents a milestone in the achievement of our shared objective, namely, to address vulnerability by establishing the foundation for evidence-based policies in local governance.

The Manila Observatory wishes to thank the Municipality of Silago, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the World Agroforestry Center (ICRAF) for the privilege of being able to work on this unique collaborative opportunity. In particular, we wish to extend a special thanks to Hon. Manuel A. Labrador, Sr., his hospitality and the generosity of time and spirit he showed our teams during the course of the project. Moreover, we wish to express our sincerest appreciation to Dr. Bernd-Markus Liss and Ms. Agnes Balota of GIZ for their unwavering support, and to Dr. Rodel Lasco for contributing his valuable time and expertise. Lastly, I wish to acknowledge the hard work and leadership of Dr. Gemma T. Narisma and the vital contributions provided by Ms. Deanna Marie Olaguer and the entire Manila Observatory team.

It is hoped that Silago, the Province of Southern Leyte and other coastal communities may use this results of this collaboration in their search for ways to significantly overcome these patterns of vulnerability and achieve resilience in response to our changing climate.

MS. MA. ANTONIA YULO LOYZAGA
Executive Director
Manila Observatory

MESSAGE FROM THE DIRECTOR OF THE WORLD AGROFORESTERY CENTER (ICRAF)

The World Agroforestry Centre (ICRAF) exists to help smallholder farming communities develop their crops and manage their agricultural landscape in a more sustainable way. Being largely dependent on natural ecosystems and climate conditions for productivity often leaves these communities vulnerable to the brunt of climate variability and extremes which are expected to intensify as the climate changes. Thus, they are among the sectors who require locally-suited adaptation and climate-proofing mechanisms with minimal investment costs.

ICRAF and its partners like GIZ and the Manila Observatory have in many occasions echoed the need to come up with locally-suited climate change adaptation interventions. This document is an instance of that call. It examines the vulnerability patterns in the forestry, agriculture, water and coastal sectors in the Municipality of Silago, Southern Leyte with the end aim of providing guidance to policy makers in the drafting of an updated and climate-informed Comprehensive Land Use Plan (CLUP).

The CLUP is a key instrument with how good governance, land use and natural resources are interfaced with climate. With a CLUP designed with climate vulnerability in mind, we hope that the local government of Silago would be in a better position to address its climate-related problems.

Well wishes to a more sustainable Silago!

DR. RODEL D. LASCO
Director
World Agroforestry Centre

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Study

For developing countries that are highly vulnerable to climate change such as the Philippines, sound information on climate and its potential impacts need to be made available in a timely manner to enable decision- and policy makers to formulate the appropriate adaptation measures to climate risks. The Potsdam Institute for Climate Impact Research, PIK, in cooperation with the German Technical Cooperation, GTZ, developed an interactive web-based platform called CI:Grasp (**C**limate **I**mpact: **G**lobal and **R**egional **A**daptation **S**upport **P**latform), which provides information on climate change, its physical and socio-economic impacts, and adaptation options and experiences from across the world. The objective of the study is to conduct a case study on the patterns of vulnerability and impacts of climate change on the forestry, water, agriculture and coastal sectors of Silago, Southern Leyte, Philippines.

The process involved: 1) the identification and definition of impacts and typical patterns of vulnerability of the four identified sectors to climate change and climate change variability; 2) regional climate modeling to provide background and future climate profiles for Silago, Southern Leyte, 3) identification of crucial data and information for each sector for impacts and vulnearbility analysis, and 4) identification of the different physical and socio-economic variables that affect vulnerability, visualized through influence diagrams and impact chains. Consultations with local stakeholders in the municipality of Silago were conducted to validate the identified patterns, which could serve as basis for the formulation of appropriate adaptation options for each sector in the municipality's Comprehensive Land Use Plan.

The Study Area

The 4th class Municipality of Silago is one of the nineteen municipalities of Southern Leyte, located on the eastern side of Region VIII (Eastern Visayas). Climate is classified as Type II, characterized by no distinct dry season and a very pronounced maximum rainfall period from November to February. The municipality is generally mountainous in the hinterlands and plain to sloping near the coasts. The 15 barangays that make up the municipality are largely rural, with fishing and agriculture as the major source of livelihood, and rice and coconut as the major products. Included in the Municipality's identified development needs are insufficient social services (health, education and access to safe water), low income and few livelihood opportunities, and low agricultural productivity. Recently land transportation has improved significantly with the construction/paving of a national road which now directly links the municipality to the provincial capital.

Climate Projections

Climate projections for Silago were done using a regional climate model that downscaled the A1B scenario of the ECHAM5 global climate model to a resolution of 20km. Modeled historical climate was validated using ground observation data and results showed that the model was able to capture observed historical trends and seasonal variability. Projected climate changes for Silago indicate: a) a slight increase in mean rainfall for the dry season of 2020s and a decrease for all the other seasons. By the 2050s, mean rainfall is projected to decrease throughout the year with up to 25% decline in the dry season; b) as much as 2.2 deg Celsius increase in average temperature which may be expected during the warm dry months (of April & May) during the 2050s; c) warmer days and warmer nights are anticipated in the 2020s and 2050s. This is indicated by the rightward shifts, i.e. shifts into higher values, in the extremes (the lower and upper tails) of the probability distribution functions of the daily minimum and maximum temperatures; d) extremely high maximum and minimum temperatures (90th Percentile of the baseline period: 1961 to 1990) could last throughout the year in the 2050s; and e) consecutive dry days can occur for more than two months with fewer instances of month-long consecutive wet days in the future.

Forest Sector Climate Impacts and Key Vulnerabilities

The municipality has high forest cover relative to other parts of the island; dipterocarp forest remnants are now generally found in localities where large-scale logging was not profitable and where access was hampered by the difficult terrain. Deforestation in recent years can be attributed to the clearing of forests for commercial and marginal upland agriculture, and non-timber plantation establishment. Coconut plantations dominate low-lying areas and are the usual end land use to forestlands after clearing and annual crop cultivation. Five out of the 15 barangays of the municipality are situated in the hilly to mountainous interior where these forest remnants are found. Currently, four barangays are involved in a community –based forest management (CBFM) program. Forest cover loss over the last decade based on land cover change analysis using remotely-sensed data is considered minimal. There is evidence of increasing fragmentation, giving way to islands of scrubland and urban areas. Among the current important drivers of deforestation and degradation are the expansion of farming activities in forest lands; the current scarcity of timber in the region in the face of increasing demands for wood which could drive illegal logging activities, and road construction. A better understanding of how these threats operate at the local scale is needed.

Future changes in climate could induce productivity gains in forest areas where water is not limiting, and increases in productivity are not offset by deforestation or novel fire regimes. Strong warming, on the other hand (the trend predicted for Silago) and its accompanying effects on water availability could potentially induce drought conditions and negatively affect vegetation. A warming trend is also predicted to increase the likelihood of more fire disturbances. For Silago, climate change projections include a greater warming inland, where most of the forest land are located; these would have important implications to forest protection and production activities. While CBFM project sites will be among the areas that will be strongly affected by these changes in temperature and rainfall, attention should also be given to forest edges where most disturbances are occurring. Communities situated in the forest lands are vulnerable to the impacts of climate due to their poverty and high degree of dependence on forests for livelihood.

Water Sector Climate Impacts and Key Vulnerabilities

Silago`s forests provide important hydrological services availed not only by local residents but by adjacent municipalities. Hydrological analysis shows that the Municipality's river systems under average rainfall conditions can very well supply irrigation needs. There is a potentially large supply of water .In the context of the Municipality`s dependence on springs for both domestic use and irrigation needs, a continuing decrease in forest cover may result in the long-term to decreased aquifer recharge, spring flow and base flow and instead lead to increased runoff production, erosion and siltation. However, climate-sensitive variables are also present, particularly 1) the incidence of enteric waterborne diseases, and 2) water siltation. Incidence of enteric waterborne diseases can be exacerbated by the presence of favorable climatic (i.e. temperature, moisture) and other environmental conditions. Meanwhile, siltation – although also greatly affected by land use change – is aggravated by climate stimuli such as increase in rainfall, strong winds and occurrence of extreme climate events. An urgent need of the hydro-forest sector is the establishment of an improved distribution network to maximize the use of the currently underutilized water resources.

Agriculture Sector Climate Impacts and Key Vulnerabilities

Agriculture in Silago is extremely vulnerable to the projected negative impacts of climate change. Most of the changes in the different climate variables analyzed, such as changes in minimum temperatures, rainfall decreases especially during the wet season, will have adverse effects on rice yield. More importantly, the adverse effects of global warming on rice production will have serious socio-economic consequences given that rice is the most important food and commodity of the municipality. There are, however, alternative crops that may be more resilient to climate impacts, specifically to the decrease in rainfall. Coconut and abaca appear to be less vulnerable to the effects of the strong 1997-1998 El Nino and cassava is considered to be a drought tolerant crop. Projected warming is higher inland where most of the forest lands are located. In contrast, the decrease in rainfall is more severe along the coastal areas where majority of the rice paddies located. Sea level rise will inundate the rice paddies along the coast and land loss can be as a high as 20% of the total rice paddy areas with a 4 meter increase in sea level.

Coastal Sector Climate Impacts and Key Vulnerabilities

There are about 100 registered fisherfolks as of September 2009 in 12 coastal barangays in Silago and most of the residents in the coastal communities are involved in fishing and aquaculture. Most of the barangays in Silago are also located along the coast, implying a high dependence on the coastal resources by the populace for food consumption, trade, and income. Potential changes in climate that will affect the various ecosystems in the coastal sector, including coral reefs, seagrass and seaweed beds, mangroves, estuaries, and beaches, will hence have corresponding socio-economic impacts on Silago. The projections for temperature in Silago showed increases in temperature in the coastal areas for both 2020 and 2050. These can translate to changes in the SSTs as land and sea temperatures interact. A small increase in SSTs will have big impacts on marine life and processes. It will affect coral reef productivity and will alter the impact thresholds of coastal organisms. The projected changes in rainfall, on the other hand, can affect changes in the fresh and salt water balance thereby affecting salinity and pH of ocean waters, which is a critical part of primary productivity. The compounding effects of temperature and rainfall increase will have impacts on the state of the coastal resources and the sustainability of the coastal communities in the municipality.

Risk Implications of Future Climate Changes in Silago

The risk to the impacts of global warming is not solely dependent on the exposed sectors and the climate hazards. It is also very much affected by social vulnerabilities and the capacity to adapt to the adverse impacts of climate change change. A qualitative assessment of the overall risks to climate change that Silago may face in the future was made based on available indicator data. The barangays of the municipality were categorized according to climate change impact, sectoral impact due to climate change and vulnerability/exposure indicators. The barangays that are found to be more at risk to the projected impacts of climate change are Hingatungan, Salvacion, Lagoma, Poblacion District 2 (Pob Dist 2), Poblacion District 1 (Pob Dist 1), and Katipunan. Hingatungan, which is a coastal barangay, is particularly at risk because of very high- and high climate change impacts on rainfall decrease and sea level rise, respectively; very high climate impacts on rice production, and high population density. The inland barangay of Katipunan on the other hand is more at risk due to very high increase in temperature, very high impacts on rice (given the proportion of non-irrigated rice and the combined impacts of warming and decrease in rainfall), high temperature impacts on forest, and high percentage of malnourished children. The relatively high risk to climate change in Pob Dist 2 is mainly due to exposure/vulnerability indicators. Pob Dist 2 has a very high population density and very high cases of malnourished children and these combined with high rainfall impacts on rice, and high climate hazards in terms of sea level rise and rainfall decrease puts the barangay at a relatively greater risk compared with the other barangays. These assessments, though are qualitative and are very much reliant on 1) the projected climate changes using a particular regional climate model and scenario and 2) on the available data obtained for this study.

I. INTRODUCTION

A. THE PHILIPPINES AND CLIMATE IMPACTS

Climate change literature consistently emphasizes that countries located in tropical areas are among the most susceptible to the impacts of climate change. Southeast Asia, in particular, with its fast-growing population and increasing dependence on natural resources and agriculture, has already been experiencing climate change-induced phenomena, aside from pre-existing climatic conditions and events (Lasco et al., 2011). The Intergovernmental Panel on Climate Change (IPCC) noted in its Fourth Assessment Report (AR4) that Southeast Asia has experienced an increase in average temperature by 0.1 to 0.3°C every decade between 1951 to 2000 (Cruz et al., 2007). Conversely, precipitation in the region has exhibited a generally decreasing trend between 1961 and 1998, with a decline in the number of rainy days.

The Philippines is an archipelagic country in Southeast Asia (Figure I.1) made up of over 7,000 islands and 36,289 kilometers of coastline (CIA, 2009). It is located in the western Pacific Ocean and along the Pacific Ring of Fire, making it highly vulnerable to both earthquakes and volcanic eruptions. Its location along the west Pacific Typhoon Belt also places the Philippines in a collision course with an average of 20 tropical cyclones each year, of which 8 or 9 make landfall (Cruz et al., 2007). The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has established that between 1951 and 2006, there have been an increasing number of hot days and warm nights, and a decreasing number of cold days and cool nights (Hilario et al., 2009). In addition, between 1971 and 2000, there was an observed increase in mean annual, maximum and minimum temperatures in the Philippines by 0.14°C every year (Cruz et al., 2007).

Climate-related disasters in the Philippines are on the rise, with losses affecting the national economy dependent on natural resources. Since 1990, the frequency of tropical cyclones entering the PAR has increased by 4.2 (Cruz et al., 2007). The two largest calamities of 2009 combined – Tropical Storm Ketsana ("Ondoy") and Typhoon Parma ("Pepeng") – resulted in agricultural losses worth PhP 10 billion (Go, 2009). In October 2010, Super Typhoon Megi ("Juan") devastated 19 provinces from four regions, claiming 36 lives and resulting in agricultural losses amounting to over PhP 8 billion. Climate change impacts are foreseen to worsen poverty, further increasing the vulnerabilities of about a third of the population still living below the poverty line and heavily dependent on natural resources for subsistence. It will also derail the country's efforts to achieve its full development potential due to the economic impacts of climate-related disasters.

B. THE CI:GRASP PROJECT

For developing countries that are highly vulnerable to climate change such as the Philippines, sound information on climate and its potential impacts need to be made available in a timely manner to enable decision- and policy-makers to formulate the appropriate mitigation and adaptation measures to climate risks. However such information is available mainly for global trends and developed countries, is scattered across many sources, and is often difficult or cumbersome to access. To address this problem, the Potsdam Institute for Climate Impact Research, PIK, in cooperation with the German International Cooperation, GIZ, developed an interactive web-based platform called ci:grasp *(**C**limate **I**mpact: **G**lobal and **R**egional **A**daptation **S**upport **P**latform)*. The platform contains three main information layers that can be freely accessed and are mainly visualized through maps:

1. Climate change stimuli parameter (like temperature, precipitation, wind, etc.),
2. Physical and socio-economic impacts (e.g. sea-level rise, changes in agricultural production, losses due to extreme events, etc.)
3. Adaptation options and experiences.

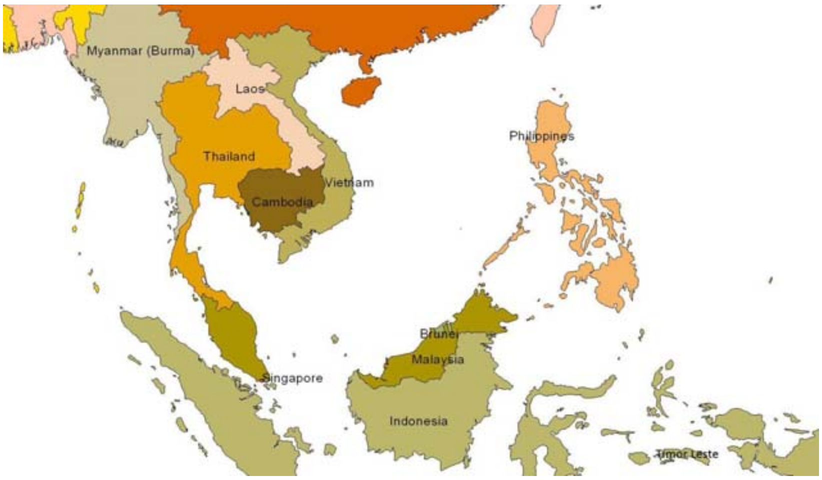


Figure I.1. *Map of Southeast Asia. Map generated by ICRAF.*

Through the latest Web 2.0 applications, adaptation experts and practitioners can provide feedback and add information through pre-structured web forms and geo-tags that will undergo quality control mechanisms.
The objective of the project is to conduct a case study on patterns of vulnerability (archetypes) and impacts of climate change on the forestry and water sectors of Silago, Southern Leyte, Philippines, as an input to CI-GRASP. This report aims to answer the following specific tasks:

1. Identify and define a limited number (2-3) of typical patterns (archetypes) of vulnerability (to climate change and climate change variability) and adverse impacts in the forestry and water sectors;
2. Describe the selected patterns of vulnerability (archetypes), including the impact of climate change, and provide for each archetype influence diagrams of relevant variables.
3. Identify and describe a set of indicators, which is capable of serving as proxies to the variables to quantify a given/defined archetype and its internal dynamics.
4. List possible data sources for the indicators and means of access to the data.

II. THE STUDY AREA: SILAGO, SOUTHERN LEYTE

A. *BIOPHYSICAL PROFILE*

The 4th class Municipality of Silago is one of the nineteen municipalities of Southern Leyte, located on the eastern side of Region VIII (Eastern Visayas) at coordinates 10°31'56" N and 125°9'56" E (Figure II.1). According to a recent perimeter survey conducted by the local government, Silago has a total land area of 21,995.13 hectares (ha)[1] and is bounded by the municipalities of Abuyog, Libagon and Hinunangan in the north, west and south, respectively (Figure II.2) (Draft CLUP, 2011). In the east, Silago is bounded by the Gulf of Leyte and the islands of Homonhon and Dinagat.

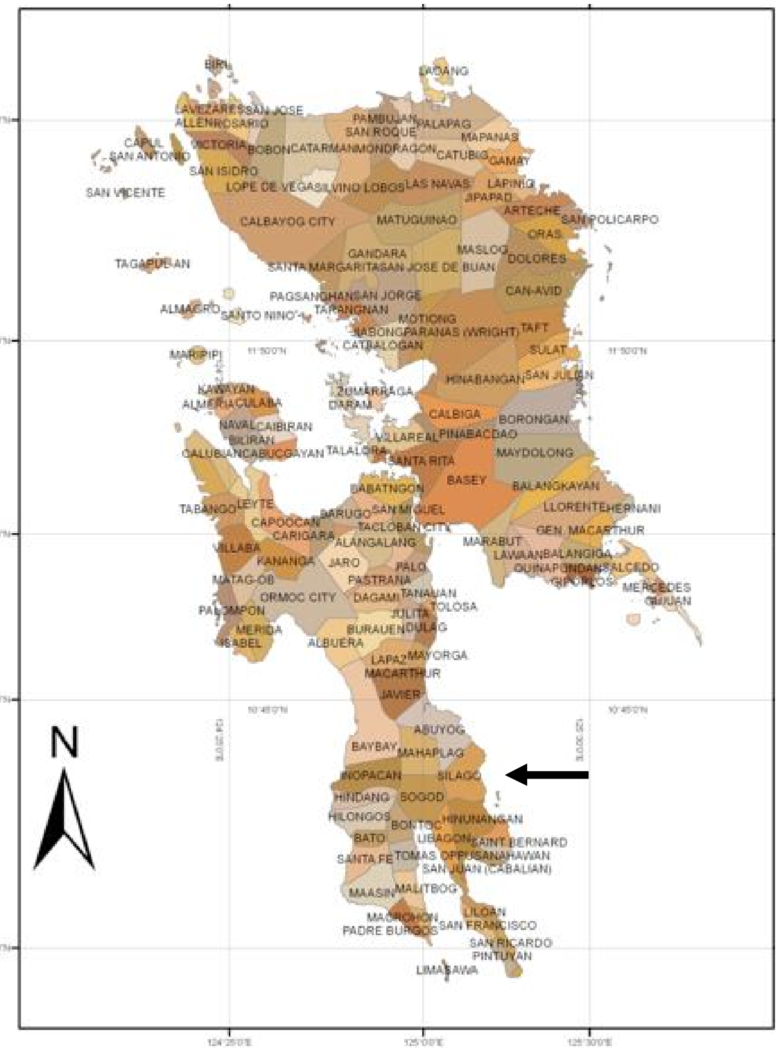


Figure II.1. *Map of Region 8 – Eastern Visayas, Philippines. Map generated by ICRAF.*

[1] As of March 28, 2011, draft CLUP (2011) released by the MENRO states that the total land area of Silago is 21,995.13 ha, with 14,653.22 hectares (66%) determined for forest purposes, based on an actual perimeter survey conducted by the Municipal Implementing Team (MIT). However, data on land use classification are still to be reconciled with DENR official estimates before they can be considered final and authoritative.

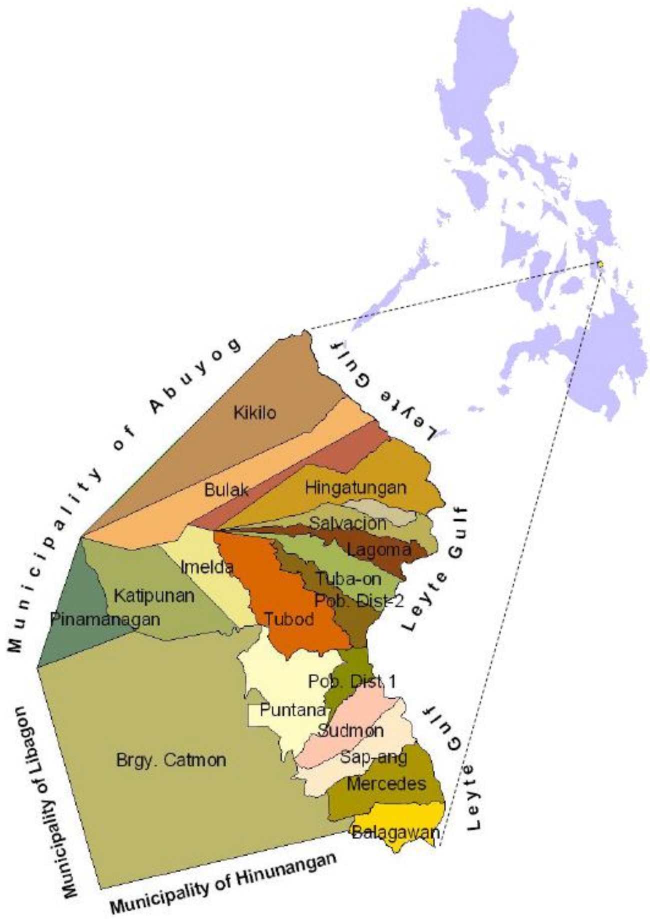


Figure II.2. *Map of the Municipality of Silago, Southern Leyte. Map generated by ICRAF.*

B. GEOLOGY, CLIMATE AND TOPOGRAPHY

The earth layers of Silago are made up of sedimentary and metamorphic rocks (Recent and Pliocene to Pleistocene) and igneous rocks (Miocene and older). About 84%of the municipality's total land area is made up of Miocene and older rock systems. Meanwhile, Plio-Pleistocene series can be found in the south-west portion of the municipality, occupying about 15% of the municipality's total land area. Recent deposits (Holocene series) cover the smallest amount of total land area (1%) concentrated in Poblacion Districts I and II, and are made up of unconsolidated fine sand, silt, clay with minor gravel-rich tuffaceous sediments.

Climate in Silago is classified as Type II. This climate type does not have a distinct dry season and experiences maximum rainfall in the period between November to February.

The topography of Silago is generally rolling to mountainous in the hinterlands and plain to slightly sloping near the coasts. The largest proportion of land is described as rolling to moderately steep, comprising 33% of Silago's total land area (Table II.1).

Table II.1. *Land area by slope classification in the Municipality of Silago*[2].

Percent Slope (%)	Description	Land Area (ha)	Percent of total (%)
0-3	Level or nearly level to gently sloping	1,052	5%
3-8	Gently sloping to undulating	1,178	5%
9-18	Undulating to rolling	2,823	13%
18-30	Rolling to moderately steep	7,144	33%
30-50	Moderately steep to very steep	3,877	18%
>50	Very steep to precipitous	5,436	25%
	TOTAL	21,510	100%

Source: Silago CLUP, 2000

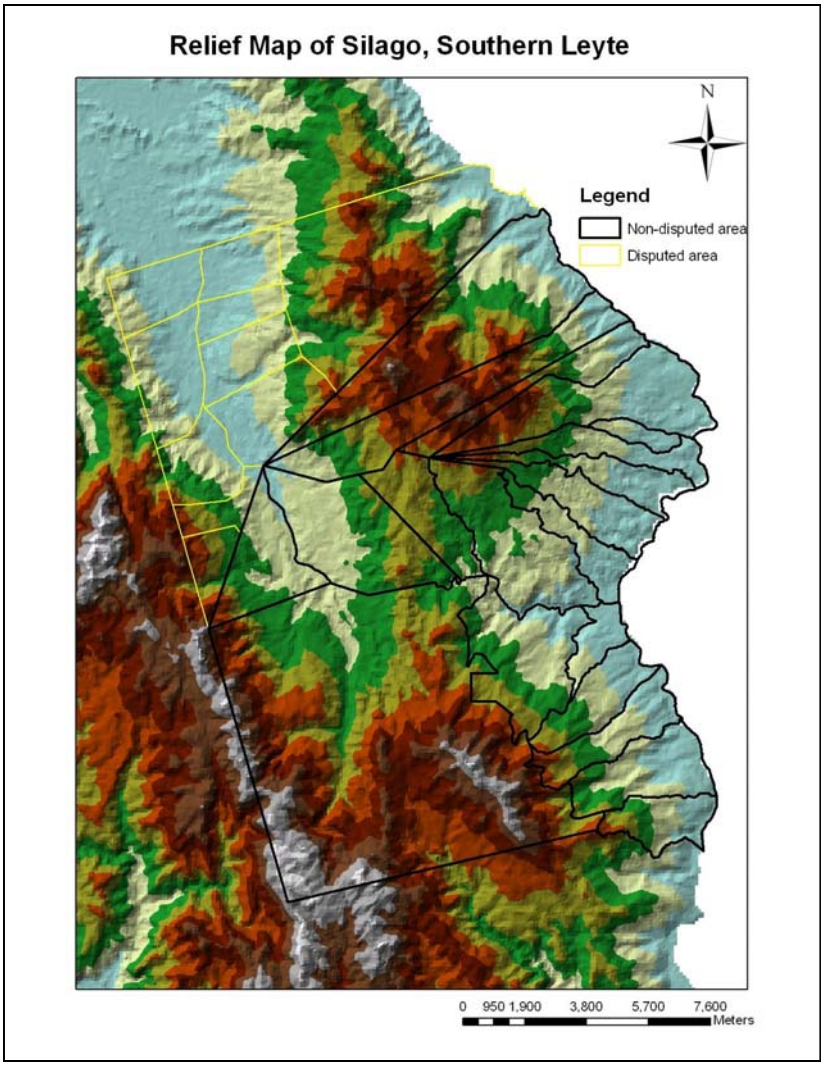


Figure II.3. *Relief map of Silago, Southern Leyte showing non-disputed and disputed land area. Map generated by ICRAF.*

Although anecdotal accounts reveal that the town rarely experiences climate extremes, its coastal barangays directly face the Pacific Ocean and are thus, prone to storm surge, typhoons and tsunami, while barangays in the mountains are prone to landslides and forest and bush fires.

[2] Due to lack of updated estimates, land area by slope classification and total land area presented in the table were taken from the figures in the old CLUP (2000).

Figure II.4. *Boundary map of Silago showing national highway. Map generated by ICRAF.*

C. LAND USE

The Municipality of Silago is made up of 15 barangays, most of which are located along the coast. In terms of land use, more than half of the municipality's total land area is classified as forestland[3] (12,482 hectares) while another 8,363.11 hectares (38.88%) is used for agricultural production (Table II.2). Open grasslands occupy 2.3% of the municipality's land, with another 93 hectares (0.43%) housing the town's built-up areas, inclusive of residential, commercial and institutional areas, parks and open spaces, and transportation utilities. Other existing general land uses within the area are open water spaces, road networks and cemetery/memorial park.

Table II.2. *Land use classification in the Municipality of Silago[4].*

Classification	2009*(ha)
Agricultural land	8,363.11
Forest land	12,482.00
Built-up areas	93.00
Dumpsite	
Grassland/shrubland/pasture land	494.15
Mangroves/NIPA/fish ponds	
Beach sand	
Open water spaces	71.63
Road network	3.12
Cemetery/memorial park	3.00
TOTAL	21,510.00

*Source: *Municipal Ecological Profile, MPDO, 2009*

[3] According to Philippine law, "forestlands" are lands within the public domain with a slope of 18% or higher, including those covering the foothills to the forest zone line, plateaus with elevations greater than 600 meters, and lands with more than 50% slope, which are categorized as protected forest. This definition however, does not distinguish the actual vegetative cover of an area.

[4] Due to lack of updated estimates, land area by land use classification and total land area presented in the table were taken from the figures in the old CLUP (2000) and the Municipal Ecological Profile (MPDO, 2009).

Silago's land resources can be subdivided into three broad land capability classes. Municipal records reveal that 12,197 hectares of land (57%) is classified as good land that is barely level and can be cultivated, but is shallow, drought-prone and has low soil fertility and slight alkalinity (BS) (Table II.3). This type of land is generally suited for legumes and tree crops. Another 5,436 hectares (25%) of land is moderately to very steep and excessively eroded, shallow, rough and dry for cultivation, and is considered best suited for forests (N). This type of land can also be used for grazing. The last 3,877 hectares is classified as very steep and severely to excessively eroded, shallow for cultivation and also best suited for forests (M).

Table II.3. *Land capability classes in the Municipality of Silago, by topographical and soil characteristics*[5].

Land Capability Class	Area (ha)	Percent of total area (%)
BS – Good land, barely level, can be cultivated, shallow, drought-prone and has low soil fertility and slight alkalinity, suited for legumes and tree crops	12,197	57%
N – Moderately to very steep land, excessively eroded, shallow, rough and dry for cultivation, best suited for forests, can also be used for grazing	5,436	25%
M – Very steep to precipitous land, severely to excessively eroded, shallow for cultivation, best suited for forests	3,877	18%
TOTAL	21,510	100%

Source: Municipal Ecological Profile, MPDO, 2009

The 2000 CLUP describes two dominant soil types in Silago based on records of the Bureau of Soils and Water Management: Guimbala-on clay and Laylay. Guimbala-on clay – composed of basaltic and andesite rocks – makes up approximately 99.5% of the total land area, while Laylay makes up the remaining 0.5% and can be found along shorelines bordering the coast of alluvial lands.

D. DEMOGRAPHIC PROFILE

Population

The urban portion of the Municipality of Silago is composed of three barangays: Poblacion Districts I and II, and Poblacion District III (Barangay Tubod). The rest of the barangays are considered rural. As of 2010, the urban population accounts for almost one-fourth of the total municipal population. Among the component barangays of Silago, Hingatungan had the largest population at 2,049, while Catmon had the smallest at 134 (Table II.4). Average annual growth rates from 2007 to 2010 (based on computations for this report) are considerably higher for populations in the barangays located in the mountainous interior.

[5] Land area by land capability classes and total land area presented in the table were taken from the figures in the Municipal Ecological Profile (MPDO, 2009).

Table II.4. *Population by barangay in the Municipality of Silago, 2010 vs 2007.*

Barangay	Urban/ Rural	2010		2007		Average annual growth rate (%)
		Population	Percent of total	Population	Percent of total	
Pob. District I	Urban	1,071	8.50%	1,224	11.00%	-4%
Pob. District II	Urban	1,207	9.60%	1,007	9.00%	7%
Pob. District III (Tubod)	Urban	791	6.30%	839	7.50%	-2%
Balagawan	Rural	724	5.70%	727	6.50%	0%
Catmon	Rural	241	1.90%	134	1.20%	27%
Hingatungan	Rural	2,234	17.70%	2,049	18.40%	3%
Katipunan	Rural	645	5.10%	480	4.30%	11%
Laguma	Rural	781	6.20%	677	6.10%	5%
Mercedes	Rural	2,133	16.90%	1,767	15.80%	7%
Puntana	Rural	289	2.30%	171	1.50%	23%
Salvacion	Rural	610	4.80%	608	5.40%	0%
Sap-ang	Rural	681	5.40%	551	4.90%	8%
Sudmon	Rural	466	3.70%	315	2.80%	16%
Tuba-on	Rural	472	3.70%	438	3.90%	3%
Imelda	Rural	265	2.10%	176	1.60%	17%
TOTAL		12,610	100.00%	11,163	100.00%	

Sources: Silago Draft CLUP, 2011, NSO Census 2007

In 2010, Silago had a population of 12,610 and a land area of 215.10 square kilometers, resulting in an average population density of about 59 per square kilometer. Among all the barangays, Poblacion District I had the highest population density at 315 per square kilometer, followed by Mercedes with 188 per square kilometer (Table II.5).

Table II.5. *Population, land area and population density by barangay in the Municipality of Silago as of 2010.*

Barangay	Population	Land area		Population density (persons/km^2)
		ha	km^2	
Pob. Dist.I	1,071	340	3.4	315
Pob. Dist.II	1,207	710	7.1	170
Pob. Dist.III (Brgy. Tubod)	791	1,740	17.4	45
Balagawan	724	1,095	10.95	66
Catmon	241	8,475	84.75	3
Hingatungan	2,234	1,555	15.55	144
Katipunan	645	960	9.6	67
Laguma	781	580	5.8	135
Mercedes	2,133	1,135	11.35	188
Puntana	289	804	8.04	36
Salvacion	610	900	9	68
Sap-ang	681	740	7.4	92
Sudmon	466	885	8.85	53
Tubaon	472	575	5.75	82
Imelda	265	1,016	10.16	26
TOTAL	12,610	21,510	215.1	59

Sources: Silago Draft CLUP, 2011, MPDO, 2009

Households

Actual data gathered for the 2011 CLUP indeed revealed an increase in number of households in the Municipality, from 1,661 households in 1995 to 2,892 in 2010. Average household size in 2010 has remained constant relative to 1995 data, indicating that the increase in population was from the formation of new households rather than expansion of existing ones (Table II.6).

Table II.6. *Population, number of households and average household size in Silago by barangay, as of 2010.*

Barangay	Population	No. of Households	Average household size
Pob. District I	1,071	278	4
Pob. District II	1,207	304	4
Pob. District III (Brgy. Tubod)	791	212	4
Balagawan	724	210	3
Catmon	241	36	7
Hingatungan	2,234	465	5
Katipunan	645	113	6
Laguma	781	157	5
Mercedes	2,133	496	4
Puntana	289	76	4
Salvacion	610	151	4
Sap-ang	681	155	4
Sudmon	466	96	5
Tubaon	472	94	5
Imelda	265	49	5
TOTAL	12,610	2,892	4

Source: MPDO, 2010

E. SOCIOECONOMIC PROFILE

Local Economy and Business

Agriculture and fisheries

Agricultural and fisheries activities are the main sources of livelihood and income in Silago. According to the CBMS Survey (2006), 1,317 individuals were engaged in agricultural activities. This translates to just under half of the employed members of Silago's labor force numbering 2,771 people (CBMS Survey, 2006). The major agricultural crops in the Municipality are coconut, rice, corn, sweet potato (kamote), cassava, taro (gabi), and other assorted crops (i.e. vegetables). Coconut is the dominant agricultural product, covering slightly over 5,200 hectares of land area, with yield of about 1,000 kilograms per unit of land. Rice production occupies the next largest area of agricultural land, with 480 hectares cropped (Table II.7).

Table II.7. *Comparative agriculture areas and production in Silago, 2008, 2009 and 2010.*

	Area (ha)			Yield (tons/ha)		
	2008	2009	2010	2008	2009	2010
Rice	480.00	480.00	480.00			
Irrigated	477.00	477.00	477.00	5.1	5.0	5.2
Hybrid	60.00	40.00	110.00	4.0	4.2	4.54
Good Seeds	379.50	421.00	367.00	3.8	3.9	4.0
Certified seeds	37.50	16.00	0.00	4.0	4.1	4.2
Non-Irrigated	3.00	3.00	3.00	3.6	3.8	3.9
Coconut	5,247.00	5,269.00	5,269.00	0.83	0.9	1.0
Cassava	27.00	27.00	27.00	10	11	12
Taro (kamote)	17.00	17.00	17.00	10	11	12
Banana	25.00	25.00	25.00	2.0	2.2	2.4
Pineapple	28.75	28.75	28.75	7.5	8.75	10
Vegetable	21.43	21.43	21.43	2.8	3.0	4.0
Abaca	9.75	9.75	9.75	1.30	1.35	1.37
TOTAL	5,855.93	5,877.93	5,877.93			

Source: Municipal Data

The fisheries and aquaculture industry of Silago employs an estimated 117 people out of the 2,771 employed members of Silago's labor force (CBMS Survey, 2006). Over 1,100 hectares was reported under fisheries and aquaculture activities, including marine fishing grounds and inland tilapia and bangus aquaculture ponds. Latest available production data show that the local fisheries and aquaculture industry is valued at roughly PhP 17 million per year, assuming an average selling price of PhP 100.00 per kilogram of fish (Table II.8).

Coastal resources

With the majority of its barangays lining the coast, Silago is rich in coastal resources. Coral reefs can be found in the sea of barangays Balagawan, Mercedes, Sap-ang, Sudmon, Tubaon, Laguma, Salvacion, Hingatungan and Poblacion Districts I & II. Sea grass communities are spread across all 10 of Silago's coastal barangays, while mangrove forests can be spotted in barangays Hingatungan, Laguma, Tubaon and Sudmon. Marine protected areas have also been designated in barangays Hingatungan, Laguma and Sudmon.

Table II.8. *Existing fishing grounds and aquaculture production.*

Barangay	Fishing Ground	Area (ha)	Production	
			Volume (kg)	Value (PhP)
A. MARINE				
Hingatungan	1st Mabaw (1st Reef)	121.76	18,263.25	1,826,325.00
	Mabaw Tunga	55.27	8,290.16	829,015.50
	Mabaw Dako	100.47	15,070.61	1,507,060.50
	Mabaw Sa Lawaan	69.38	10,406.67	1,040,667.00
Salvacion	Labohan	20.92	3,138.56	313,855.50
Laguma	Mabaw sa batong Dako	363.66	54,548.82	5,454,882.00
	Mabaw sa Bulhang	26.98	4,047.51	404,751.00
Tubaon	Mabaw sa Matal –ay	87.34	13,100.78	1,310,077.50
	Batong Diyoy	44.12	6,617.61	661,761.00
	Lawis	13.88	2,081.67	208,167.00
	Lagubo	29.45	4,417.35	441,735.00
	Kapignis	0.71	106.92	10,692.00
Pob. Dist. II	Bato sa Tabon Tabon	0.82	123.54	12,354.00
Pob. Dist. I	Bato sa Simbahan	2.42	362.30	36,229.50
	Kaimog	0.45	66.96	6,696.00
Balagawan	Burawan	38.46	5,768.94	576,894.00
	Balagawan Reef	150.62	22,593.47	2,259,346.50
Sub-total		*1,126.70*	*169,005.12*	*16,900,509.00*
B. INLAND (AQUACULTURE)				
Puntana	Tilapia	0.09	60.00	6,000.00
Pob. Dist. II	Tilapia	0.25	250.00	25,000.00
Mercedes	Tilapia	0.18	120.00	12,000.00
Balagawan	Tilapia	0.06	30.00	3,000.00
Hingatungan	Bangus	0.25	550.00	66,000.00
Sub-total		0.83	1,010.00	112,000.00
	TOTAL	1,127.53	170,015.12	17,012,509.00

Source: Agriculture and Fisheries, Economic Sector, Municipal Data

F. BASIC SOCIAL SERVICES

Education

Day care centers are present in all barangays except Catmon and Puntana. There are 14 public and 1 private elementary schools in the Municipality, along with 4 high schools located in Poblacion District I, Hingatungan, Mercedes and Katipunan. As for school year 2009-2010, enrolment in Silago's primary schools was 950 male and 893 female students, totalling 1,843 elementary school students.

Enrolment in secondary schools during school year 2009-2010 was 1,049, with almost equal participation from male and female students. Based on Department of Education (DepEd) standards, Silago's national high schools have “manageable” conditions, with all 4 schools exhibiting ratios well below the ideal of 1 teacher for every 46 students.

Health facilities and situation

Silago has 1 rural health unit (RHU) which serves as the main health office of the Municipality. There are also 4 barangay health stations located in Hingatungan, Lagoma, Mercedes and Katipunan. Latest available data revealed that the leading causes of morbidity in the Municipality were hypertension, bronchitis and diarrhea (MPDO, 2010). Meanwhile, the leading causes of mortality were pneumonia, hypertension and drowning.

Electric power supply

Electric power supply is provided by the Southern Leyte Electric Company (SOLECO). Based on municipal data, 2,258 households in Silago have availed of electrical connections through SOLECO.

Water supply

According to consultations with local government officials and resource persons, the Municipality of Silago has an abundant supply of water. However, this supply is largely underutilized due to lack of necessary infrastructure and equipment, such as irrigation systems, filtering instruments and metering devices. Based on climate projections for the Eastern Visayas region, mean seasonal rainfall is expected to increase during wet months and decrease during summer (dry) months (Hilario et al., 2009).

Agricultural and support infrastructure

Communal irrigation systems (CIS) are installed in barangays Hingatungan, Sudmon, Salvacion and Lagoma. Meanwhile, there were 3 communal irrigation projects (CIP): Poblacion District II CIP, Sap-ang CIP and Mag-matal-ay CIP. Consultations revealed that the major development need for Silago’s agriculture sector is the development/upgrade of irrigation facilities. Although this concern is commonly flagged as a pitfall of the sector’s productivity, correspondence with local government officials and extension personnel established that there is currently no endeavor to address this concern.

Transportation and communication

Provincial buses pass through the Municipality providing transportation service to Manila, Maasin and Tacloban. Air transportation services can be availed in Tacloban City only. There are also no ports within Silago, but there is a wharf for small boats in barangay Hingatungan.

Land transportation in Silago has improved significantly since the construction/paving of the Junction Pan Philippine Highway (PPH) Himayangan-Silago-Abuyog Junction PPH Road commenced in 2004. The project was funded through the Japan Bank for International Cooperation (JBIC) 23rd Yen Loan Package as a subproject of the Arterial Road Link Development Project (ARLDP), Phase IV (Maris, 2006). The road is classified as a national road spanning 113.4 kilometers. Aside from serving as a provincial link, it is also an alternate route from the Pan Philippine Highway when roads in disaster prone areas are closed (Maris, 2006). Travel time from Tacloban to Silago has been reduced from 6 to 2 hours with the paving of the national road (Figure II.5).

The road traverses the coastal towns of St. Bernard, San Juan, Anahawan, Hinundayan, Hinunangan, and Silago in Southern Leyte. After Silago, the road alignment shifts toward the interior of the island along the provincial boundary (Maris, 2006).

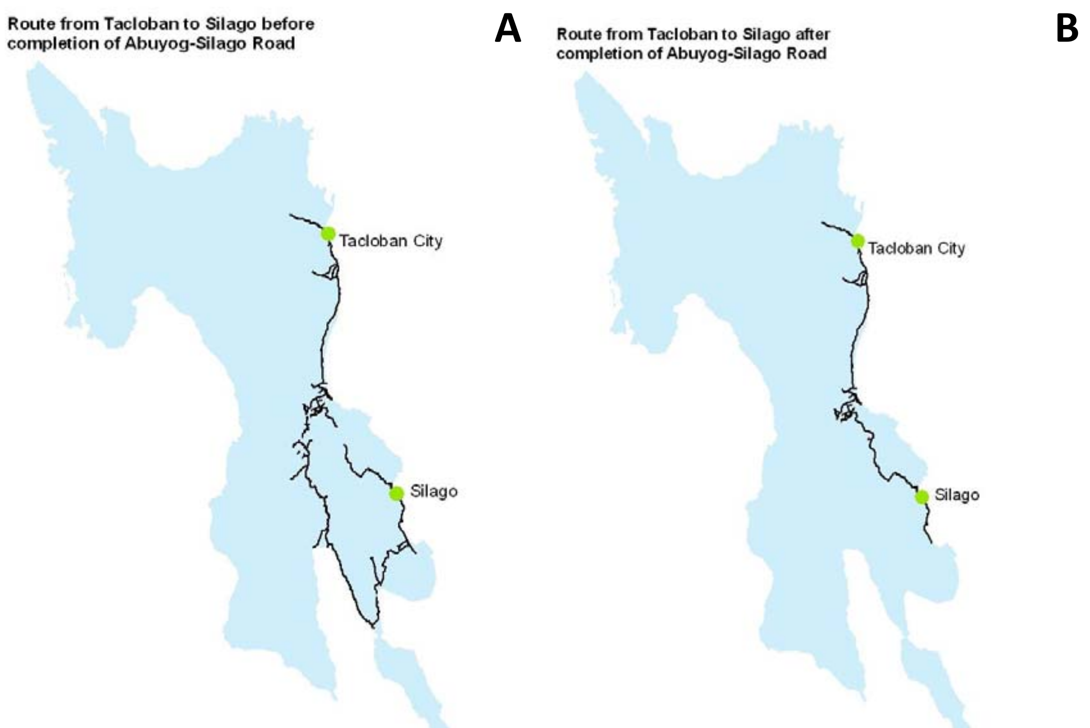


Figure II.5. *Route from Tacloban to Silago (A) before and (B) after the completion of the Junction PPH-Himayangan-Silago-Abuyog Junction PPH Road. Map generated by ICRAF.*

The two major telecommunications companies in the country – Globe Telecom and Smart Communications – provide wireless signal for cellular/mobile phones in Silago. Landline connections are also available via Globe Lines, a brand of Globe Telecom. The town's Bureau of Post (Postal Office) handles the mail and money order services of the community.

Employment and Income

Table II.9. *Labor force population by sex and employment status, as of 2010.*

	Population (15 yrs and over)	Employed	%	Unemployed	%
Male	3,661	1,663	45	1,998	55
Female	3,380	1,108	33	2,272	67
TOTAL	7,041	2,771	39	4,270	61

Source: Municipal estimates as of 2010 based on 2006 CBMS Survey(2006)

The most recent data from the local government shows that about 7,000 people make up the local labor force, with a larger percentage of employed males than females. According to a survey conducted in 2006, majority of the labor force is occupied with activities under the agriculture and fisheries sectors (CBMS Survey, 2006). Approximately 61% of the labor force is unemployed.

The 2011 draft of Silago's Comprehensive Land Use Plan (CLUP) identified some priority issues and problems regarding employment in the municipality. Lack of employment opportunities for workers was attributed largely to seasonal nature of employment in agriculture, while the lack of technical trainings on livelihood and specialty skills only added to the abundance of unskilled workers. As a result, members of the local labor force have resorted to out-migration, while those with college degrees have explored employment opportunities abroad.

III. OVERALL METHODOLOGY AND PROCESS

A. PROCESS FLOW

The research flow is shown in Figure III.3. The initial phase consists of the identification and definition of a limited number (2-3) of typical patterns (archetypes) of vulnerability of the identified sectors (forestry, agriculture, coastal and water resources) to climate variability and change and adverse impacts in each sector. These patterns were presented in the form of Pre-Analysis Impact Chains for each sector which identify the relevant climate stimuli, exposure units, direct and indirect impacts, and vulnerable groups in the society, based on current literature.

These generic pre-analysis impact chains were next presented to the local government, non-government organizations, people's organizations, academic institutions and other stakeholders in Silago in a scoping/consultation workshop held in June 2010. The consultation process enabled the research team to get information on the local priorities and climate-related problems and needs of the stakeholders, and ascertain the availability and quality of local data which can be used for climate impact and vulnerability assessments. The pre-analysis impact chains were then revised to reflect the inputs from the stakeholders and the availability of information which could allow the team to proceed with formal analyses.

The climate stimuli selected for the study (temperature and rainfall) were then generated through regional climate modeling to give background and future climate profiles for Silago, Southern Leyte. Additional information for each specific sector was generated to answer the inadequacy of basic data about the municipality. In the case of the forestry and water sectors, land cover change analysis and hydrological analysis were conducted, respectively, to augment the information provided by Silago's local government office (Draft CLUP, 2011).

With these additional information, influence diagrams were constructed, to show the interactions among different biophysical and socioeconomic variables relevant to the study area which affect the archetypes of vulnerability of the sectors to climate change and climate variability. Indicator data which could serve as proxies to the variables to quantify the defined archetypes and their internal dynamics were also identified.

The next steps involved validation of the identified patterns of vulnerability by the stakeholders of Silago and discussion on additional data needs and field studies to empirically validate the patterns identified in the diagrams. The influence diagrams will be further adjusted through a feedback process, and serve as basis for the formulation of appropriate adaptation options for each sector.

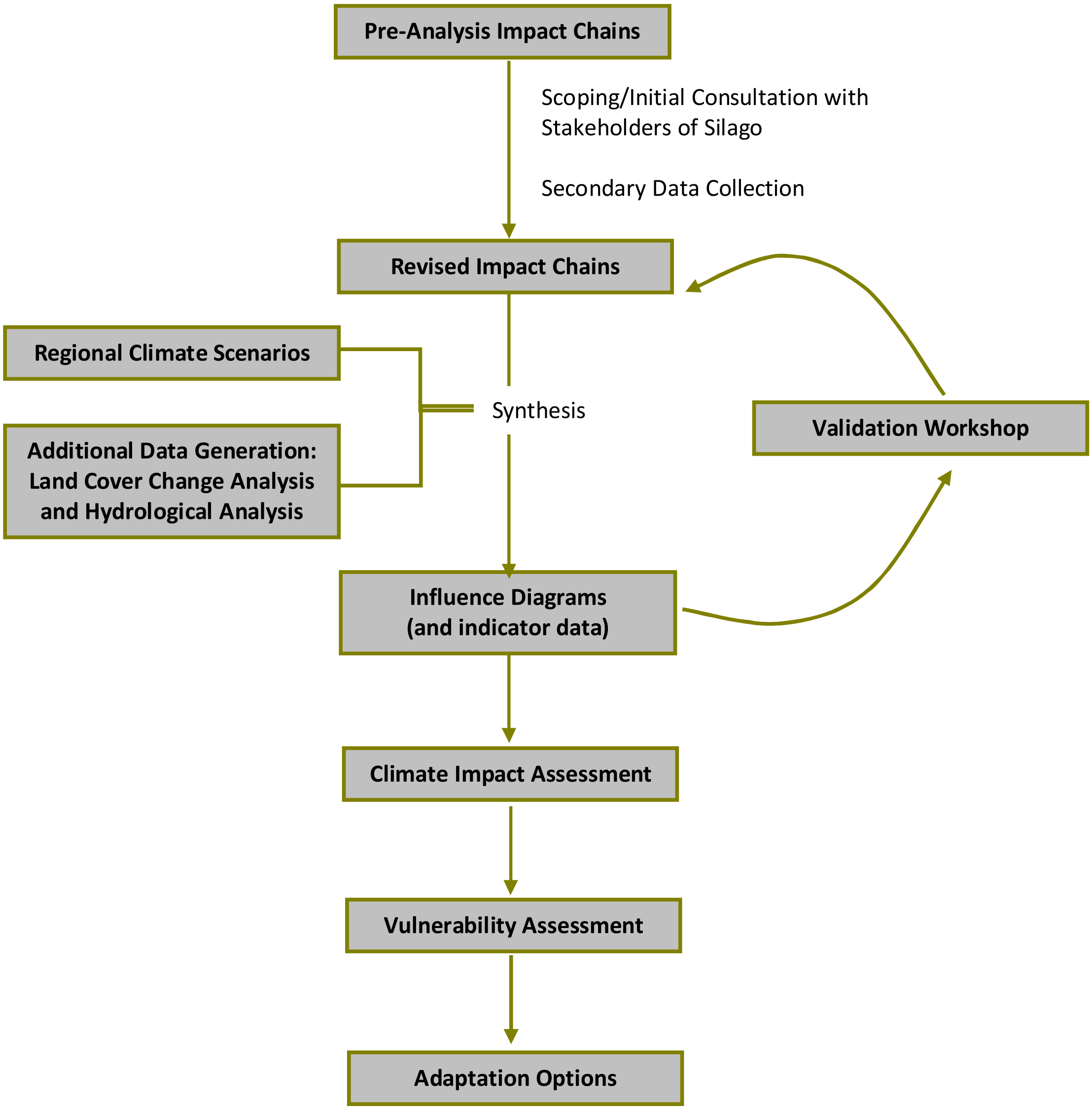


Figure III.1. *Process Flow of the ci:grasp Project for Silago, Southern Leyte, Philippines.*

B. DEVELOPMENT OF IMPACT CHAINS AND INFLUENCE DIAGRAMS

The scope and context for analyzing the impacts of climate change and variability on the forestry and water sectors of Silago were defined through the following processes:

- Meetings and consultation between members of the research team Manila Observatory (MO) and the World Agroforestry Centre (ICRAF) Philippines and GIZ were held between May and November 2010 to develop a common understanding of the ci:grasp approach, construct the pre-analysis impact chains, clarify methodologies and assess data gaps.

- A consultation workshop was held with the local stakeholders of Silago in June 2010 to present and validate the Pre-Analysis Impact Chains and assess the availability of local data for analysis.

- Literature review was conducted to provide context to the analysis of the forestry and water sectors of the study area. Baseline conditions of the forest and water sectors were described with data coming mainly from the draft Comprehensive Land Use Plan (2011) of the municipality of Silago. In the absence of specific information at the municipal level, the team made use of historical and geographical analogues (Feenstra et al., 1998) from findings from related studies conducted in the study area (Silago), its larger bounding provincial (Southern Leyte) and regional (Eastern Visayas) administrative units, and nearby areas under similar biophysical and socio-economic conditions to fill in data gaps and infer likely future change trajectories for each sector. Most of this information is qualitative in nature.

- A workshop was again held in March 2011 with the stakeholders of the municipality to present and validate the initial findings from the study. Based on this validation and updated information on the forest and water sectors of Silago, the influence diagrams and impact chains were revised accordingly.

IV. Climate Analysis and Projected Change

A. Climate Profile of Silago, Southern Leyte

The climate of Silago, a municipality of Southern Leyte (Figure IV.1) is classified as Type II as shown by the modified Coronas Classification (Figure IV.2; Kintanar 1984). Under this classification, rainfall over this area is most pronounced during the months of November to January without a distinct dry season.

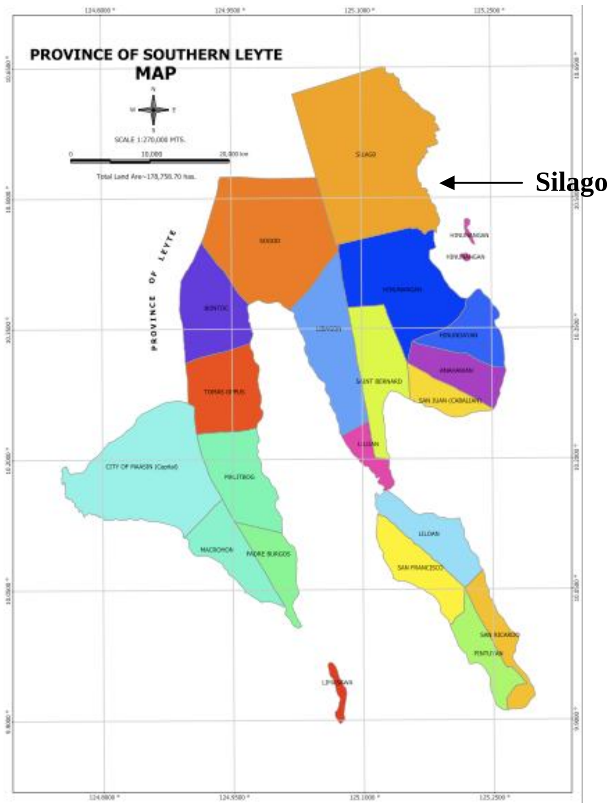


Figure IV.1. *Area of study – Silago, Southern Leyte (Source: Silago CLUP, 2011).*

In this study, we aim to characterize the historical climate profile of Silago, using observed and modeled data. This profile will be used as a climate baseline. We then use a climate model for future climate projections and analyze the changes with respect to the climate baseline.

B. Regional Climate Modeling Simulations

RegCM3 Model

Regional climate models are used to dynamically downscale large-scale meteorological fields generated from global circulation models (GCM) to study the climate and seasonal predictability for a particular region. This is necessary since some features of a regional climate are lost or weakly represented in the relative coarseness in spatial resolution of a GCM. In this project, we use version 3 of the Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climate Model (RegCM3), a three-dimensional hydrostatic model developed in ICTP in Trieste, Italy (Pal et al., 2007). This model consists of mathematical equations dealing with climate dynamics and includes parameterization schemes to represent radiative transfer, planetary boundary layer, cloud and precipitation processes.

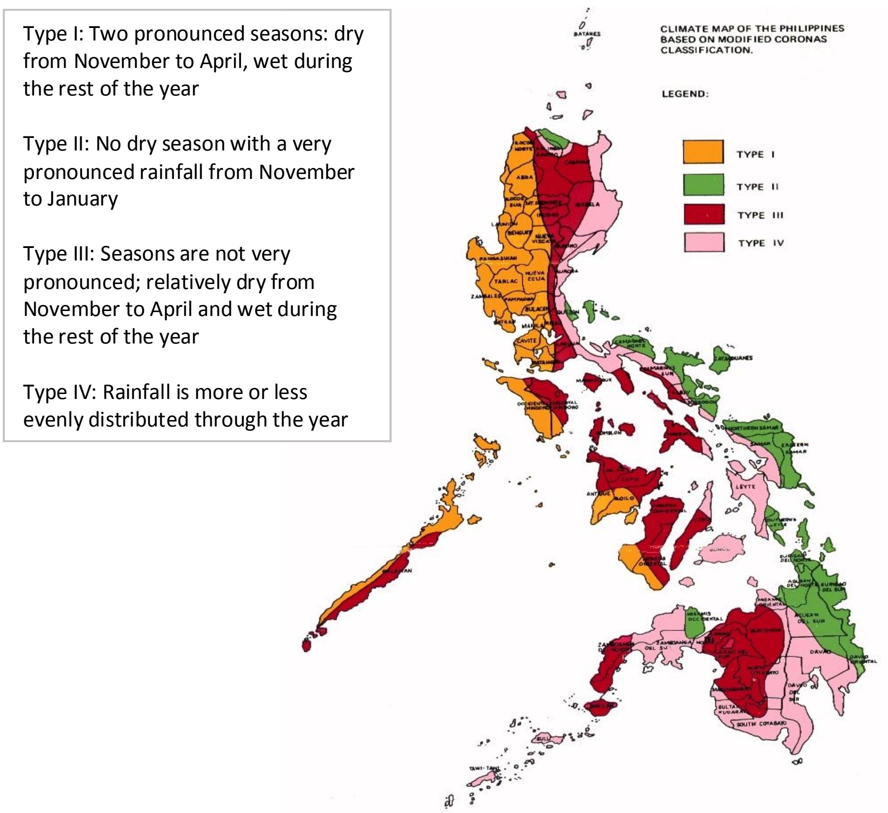


Figure IV.2. *Climate Classification of the Philippines based on modified Coronas (from Kintanar, 1984).*

Description of experiments

We run RegCM3 at a 40 km spatial resolution over the Philippine domain (Figure IV.3) for the years 1961 to 1990. Initial and boundary conditions for the model are derived from the ~200 km resolution output of ECHAM5/MPI-OM, which is a coupled atmosphere-ocean general circulation model of the Max Planck Institute for Meteorology (Roeckner et al., 2003; Marsland et al., 2003). However, to characterize the climate profile of Silago in finer detail, there is a need to further downscale this 40 km-resolution model output. Hence, RegCM3 is run again at a 20 km spatial resolution over a smaller area centered at Panay island (Figure IV.3) for the same 30-year period. The result of this simulation over Silago is used to establish its historical climate profile that will be used as a baseline climate.

The baseline climate is validated with observed datasets, including surface temperature and rainfall measurements. This is done to determine the model's skill in capturing the observed climate. It is important to establish the accuracy and reliability of the model since this will be used as a guide in analyzing the model results for projections of the future climate.

Additional experiments following the same procedure above are conducted to determine the projected climate of Silago. In this case, RegCM3 is run for two 30-year periods: 2010 to 2039 and 2040 to 2069. Simulations from the ECHAM5/MPI-OM using the A1B scenario of the IPCC are used as initial and boundary conditions for the model because the scenario represents a non-extreme case. The A1 family of the IPCC emission scenarios describes a future world with rapid economic growth where the growing population reaches its peak by 2050 and declines afterwards. In particular, the A1B scenario assumes a balanced use of fossil intensive and non-fossil energy sources. These assumptions are expressed in terms of anthropogenic emissions of these greenhouse gases: CO_2, CH_4, N_2O and SO_2 (IPCC, 2007). Model output is again downscaled to obtain a 20 km resolution output over Silago. Changes in the simulated projected climate are analyzed relative to the baseline climate.

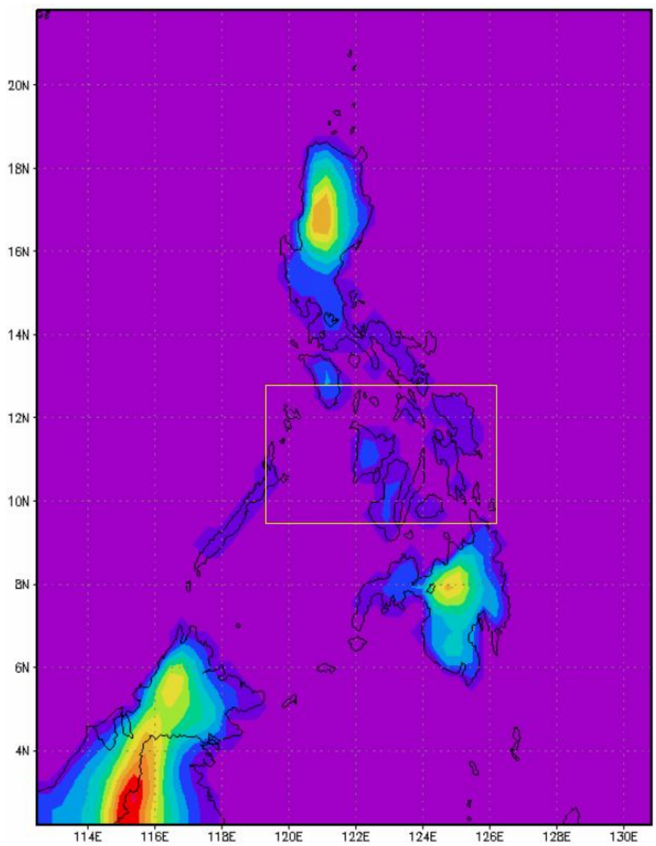


Figure IV.3. *RegCM3 model domains. Domain covering the Philippines at 40 km spatial resolution and domain centered at Panay at 20 km spatial resolution (inside the box).*

Observed Dataset

Surface observations in the area of study are needed to help establish its climate profile. Currently, there is no meteorological station from Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) in Silago. Thus, we intend to use temperature and rainfall data from two gridded reanalysis datasets. Temperature data will be obtained from the Climatic Research Unit (CRU), which provides monthly temperature data from 1901-2000 at 0.5 degree grid-point horizontal spacing (see Mitchell et al., 2003). On the other hand, rainfall data will be taken from Asian Precipitation – Highly Resolved Observational Data Integration Towards Evaluation (APHRODITE), a daily precipitation data from 1951-2004 obtained from rain-gauge observations interpolated on a 0.25 degree grid resolution (Yatagai et al., 2009).

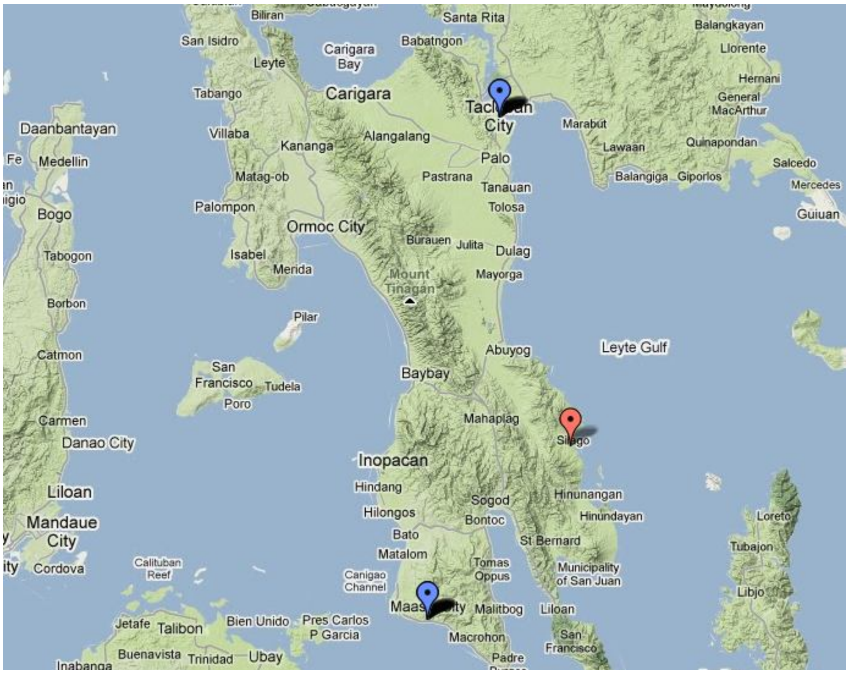


Figure IV.4. *Topography map of Leyte island. Red marker indicates location of Silago. Blue marker indicates location of PAGASA meteorological observing stations. (Mapped with Google Earth).*

Data from CRU and APHRODITE need to be evaluated over areas where surface observations from PAGASA are available. This is essential in establishing the validity in using these gridded datasets in the absence of an observation station in Silago. The nearest PAGASA stations are found in Maasin City, Southern Leyte (Maasin) and Tacloban City, Leyte (Tacloban) (Figure IV.4). The grid point from the CRU and APHRODITE datasets closest to the location of these stations is selected for comparison. Differences are anticipated since data at a point source will be compared with data averaged over an area. However, apart from actual values, there should be an agreement in the seasonal trends in both datasets.

C. GRIDDED DATA AND MODEL RESULTS VALIDATION

Validation of CRU Temperature Data

The monthly mean temperature from 1961 to 1990 is derived over Maasin and Tacloban stations to validate the CRU data with observed data from PAGASA (Figure IV.5 and Figure IV.6). In both locations, CRU follows the seasonal trend in temperature of PAGASA. While the CRU data underestimates the temperature in Maasin uniformly throughout the year, CRU is closer to PAGASA values in Tacloban.

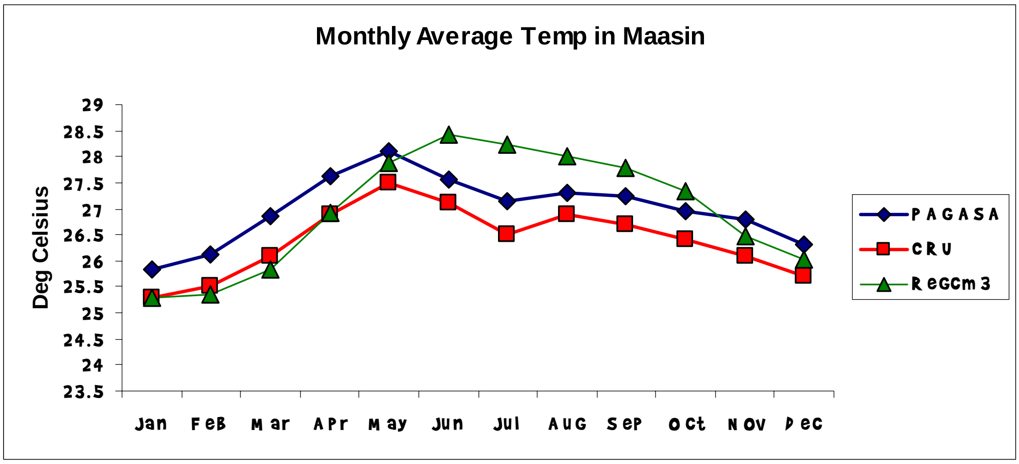


Figure IV.5. *Monthly mean temperature in Maasin from PAGASA, CRU and RegCM3.*

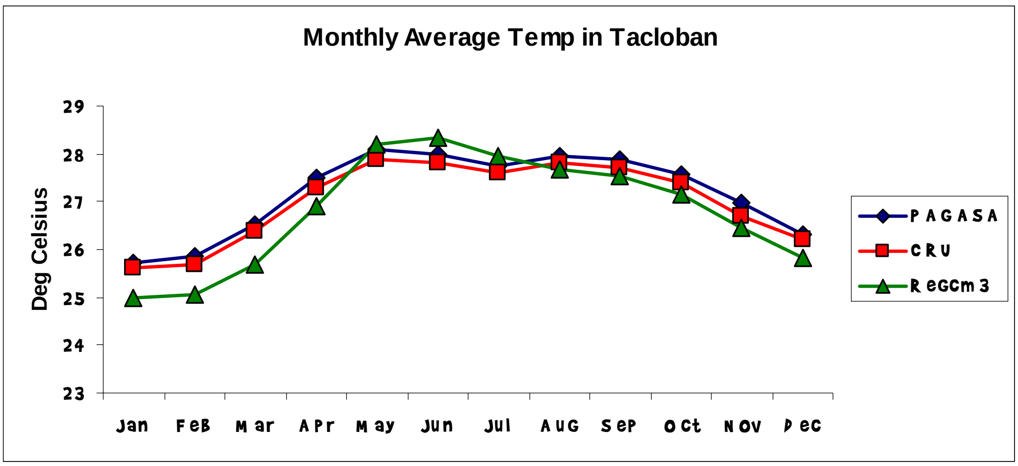


Figure IV.6. *As in Figure IV.5, but in Tacloban.*

Validation of APHRODITE Rainfall Data

A comparison of the monthly mean rainfall from 1961 to 1990 from PAGASA and APHRODITE indicates that both exhibit a similar seasonality in rainfall in Maasin (Figure IV.7) and in Tacloban (Figure IV.8).

While there is less rainfall in APHRODITE particularly in the wet months from July to January in Maasin, APHRODITE underestimates rainfall in Tacloban throughout the year.

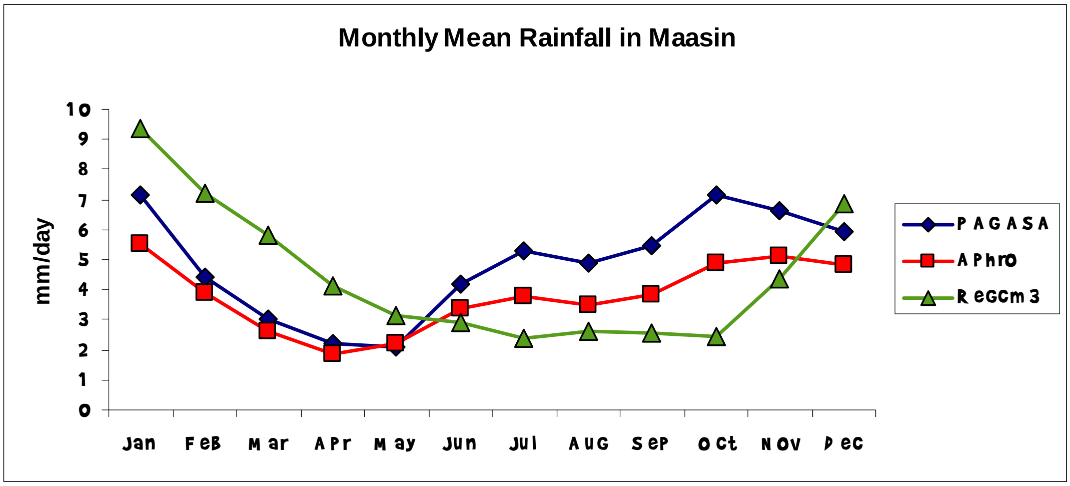


Figure IV.7. *Monthly mean rainfall in Maasin from PAGASA, APHRODITE and RegCM3.*

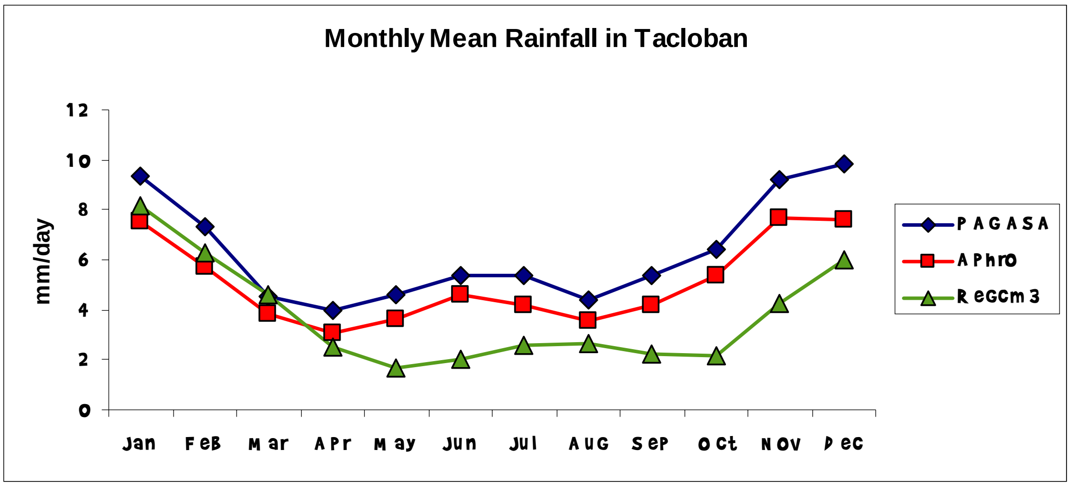


Figure IV.8. *As in Figure IV.7, but in Tacloban.*

Modeling Results Validation for Maasin and Tacloban

In this section, the model output from RegCM3 will be validated with data from PAGASA, CRU and APHRODITE. The monthly mean temperature in Maasin indicates that the model is able to generally follow the seasonal trend observed from both PAGASA and CRU but tends to overestimate the temperature from June to October (Figure IV.5). However, the model performs better in Tacloban (Figure IV.6).

In the case of rainfall, RegCM3 tends to simulate more rainfall in Maasin at the start of the year compared with observations (Figure IV.7). On the other hand, the model underestimates rainfall in the latter half of the year in both Maasin and Tacloban (Figure IV.7 and Figure IV.8).

Modeling Results Validation for Silago

In the previous section, we were able to show that the temperature from CRU and the rainfall from APHRODITE closely follow the values from PAGASA in Maasin and Tacloban. Thus, this provides additional confidence in the reliability of using data obtained from these gridded datasets over Silago, in the absence of an observation station at this location.

Figure IV.9 shows that RegCM3 is able to follow the seasonal variation in temperature over Silago, although the months of May to August tend to be warmer. In both observation and model output, pronounced wet months are seen from November to January with slightly wet months for the other months except March to May (Figure IV.10). However, the model tends to underestimate rainfall during the wet months.

While the model tends to have a warm and dry bias during the latter months of the year, it is able to capture the observed temperature and rainfall in Silago at other months. This relative skill of the model should be noted in the analysis of the simulated future projections in Silago.

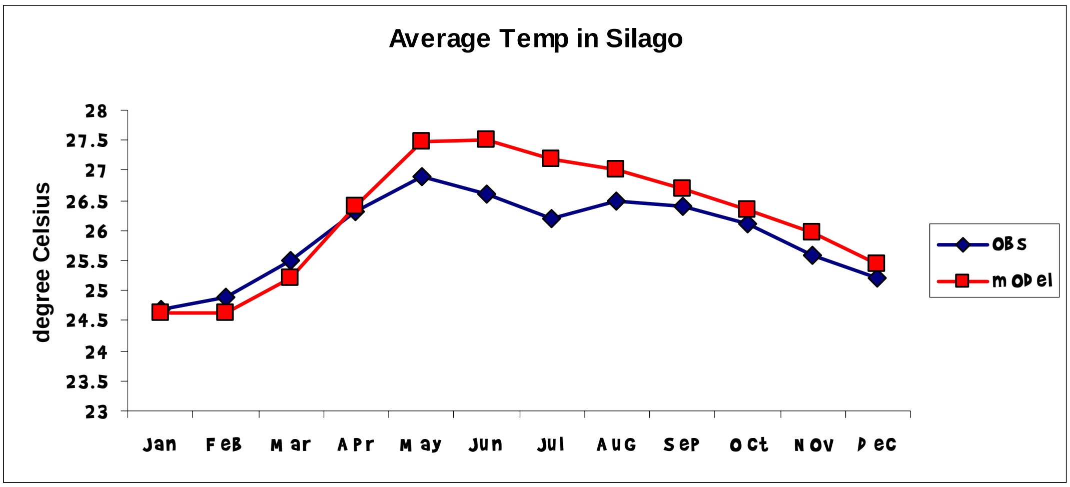


Figure IV.9. *Monthly average temperature in Silago from CRU (obs) and RegCM3 (model).*

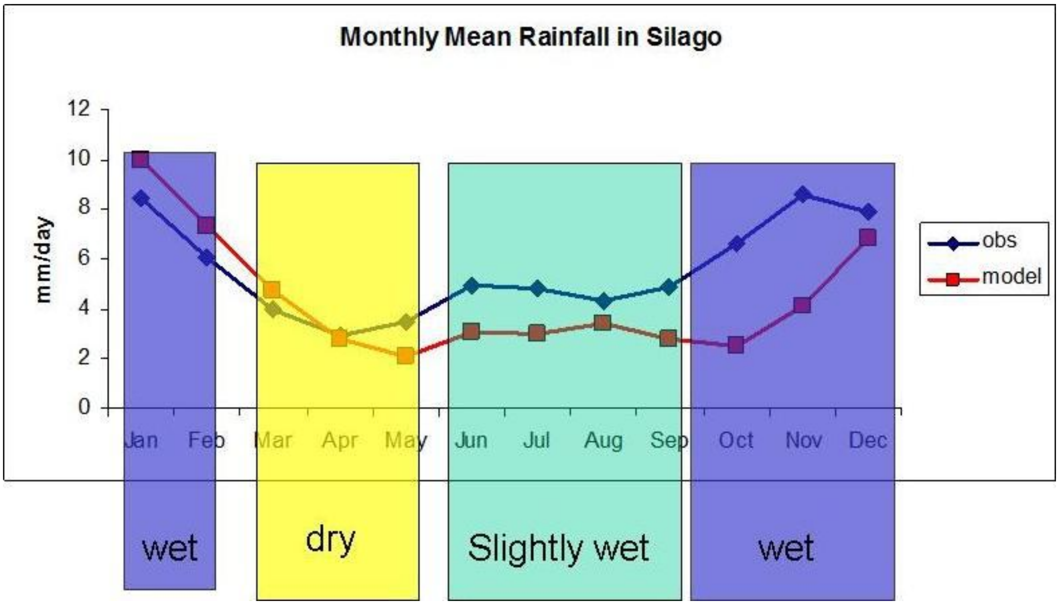


Figure IV.10. *Monthly mean rainfall in Silago from APHRODITE (obs) and RegCM3 (model).*

D. Climate Change Projections for Silago

In this section, we characterize the changes in the projected future climate in Silago, relative to its baseline climate as simulated from RegCM3. Mean changes in the variations in temperature and rainfall will be examined in both time and space. In addition, the changes in selected indices of climate extremes will also be presented since these tend to have a more significant impact compared with the differences in the means.

Seasonal variation

Figure IV.11 shows a comparison of the simulated monthly mean temperatures in Silago for the three 30-year periods. The monthly variation is consistent across the periods, which indicates no change in the onset of the warm and cool seasons in Silago. However, throughout the year, there is a distinct uniform increase of about 1°C in the projected temperature in the 2020s and 2050s, relative to the baseline.

There seems to be no change in the timing of the rainfall season in Silago since there is no change in the monthly trend of the projected rainfall (Figure IV.12). In general, the projected rainfall is slightly lower than the baseline, particularly at the start of the year.

Spatial changes

One of the advantages of using a regional climate model is that it allows us to examine the spatial variation of the projected changes in regional climate, which is difficult to accomplish with few observation stations existing in the area of interest. Spatial variability in the climate response is anticipated because of local influences such as orography, land use, geographical location, such as distance from the coastline, in addition to the changes in the climate forcing, including the enhanced greenhouse effect.

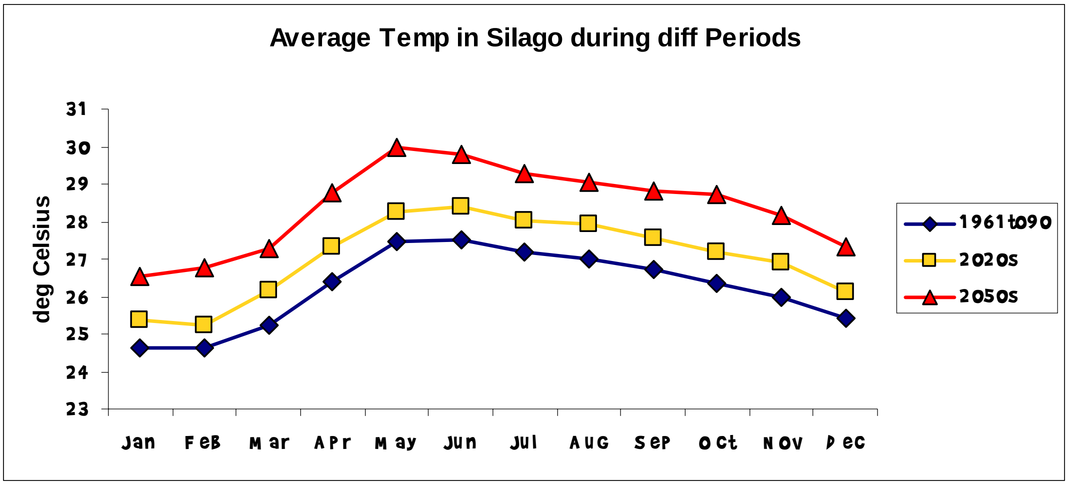


Figure IV.11. *Simulated monthly mean temperature in Silago for the years 1961 to 1990 (baseline), 2010 to 2039 (2020s) and 2040 to 2069 (2050s).*

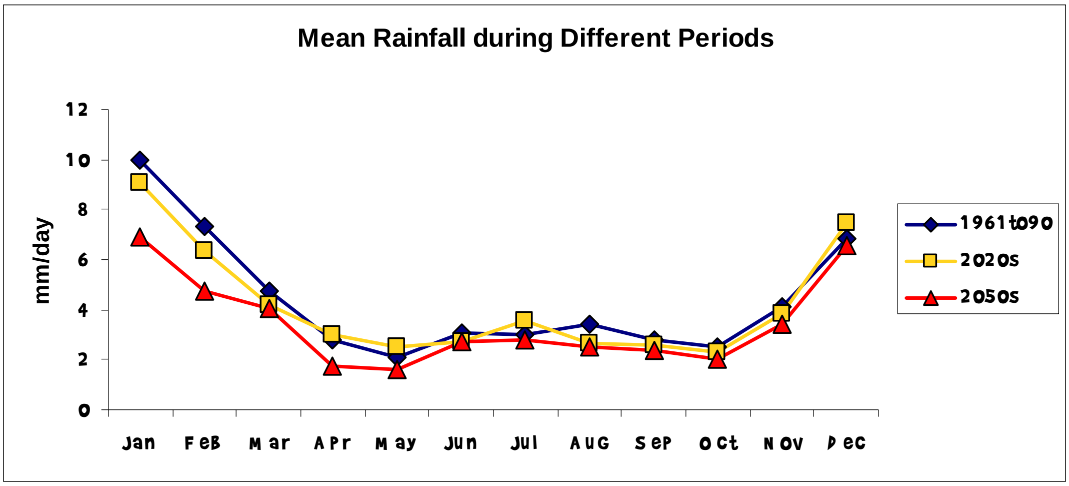


Figure IV.12. *As in Figure IV.11, but for rainfall.*

In the 2020s, there is an overall warming of up to 0.8°C in Leyte island during the cold, wet months from November to February (Figure IV.13a). The warming inland intensifies from April to May, making the temperature difference between the island and the surrounding ocean distinct (Figure IV.13b). A significant increase in temperature reaching 2°C can be found in the 2050s, particularly inland (Figure IV.13c). The warming inland becomes stronger and widespread over the island during the warm, dry months (Figure IV.13d). The sea surface temperature east of Silago warms by up to 1.8°C, whereas the sea surface west of Leyte island can reach the high temperatures shown over the island.

Changes in the area of Silago are highlighted in Figure IV.14. In the 2020s, there is a mean warming of 0.7°C in the area during the cold, wet season. However, a look at the spatial distribution of the warming indicates that the western section of Silago can be up to 0.1°C warmer, compared to the eastern section (Figure IV.14a). This may be attributed to its location near the coastline since the sea breeze can modulate temperature changes. In the warm, dry season, the mean temperature increase is 0.8°C, where the spatial gradient in the temperature change is still evident but smaller in magnitude (Figure IV.14b). The projected warming in Silago intensifies in the 2050s where the temperature increases by 1.9°C in the cold, wet season and by 2.2°C in the warm, dry season, relative to the baseline climate (Figure IV.14c and Figure IV.14d). The spatial temperature gradient between the inland and coastal areas of Silago also becomes more distinct.

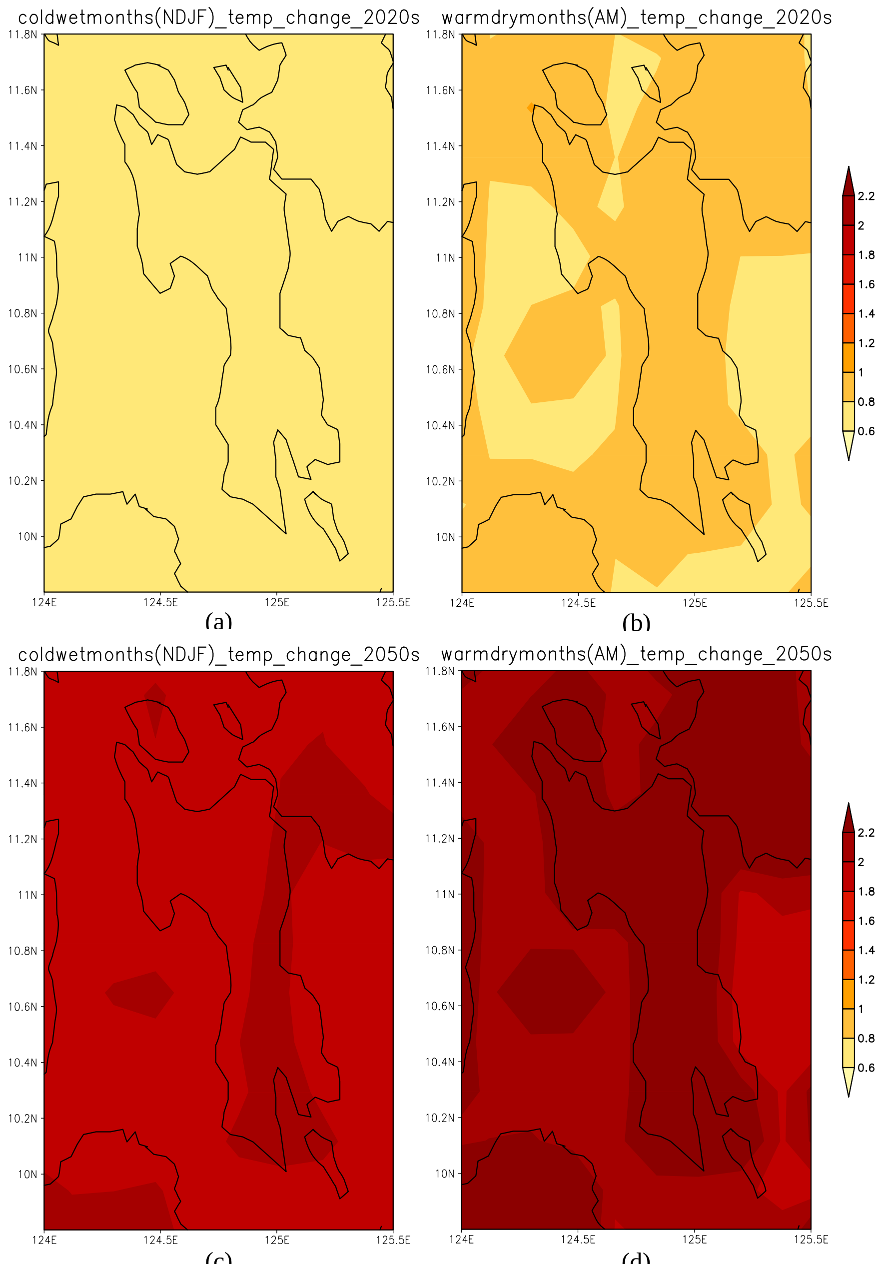


Figure IV.13. *Mean temperature difference (°C) over Leyte island from the baseline climate (1960 to 1990) averaged (a) over November to February and (b) April to May in the 2020s, and (c) over November to February and (d) April to May in the 2050s.*

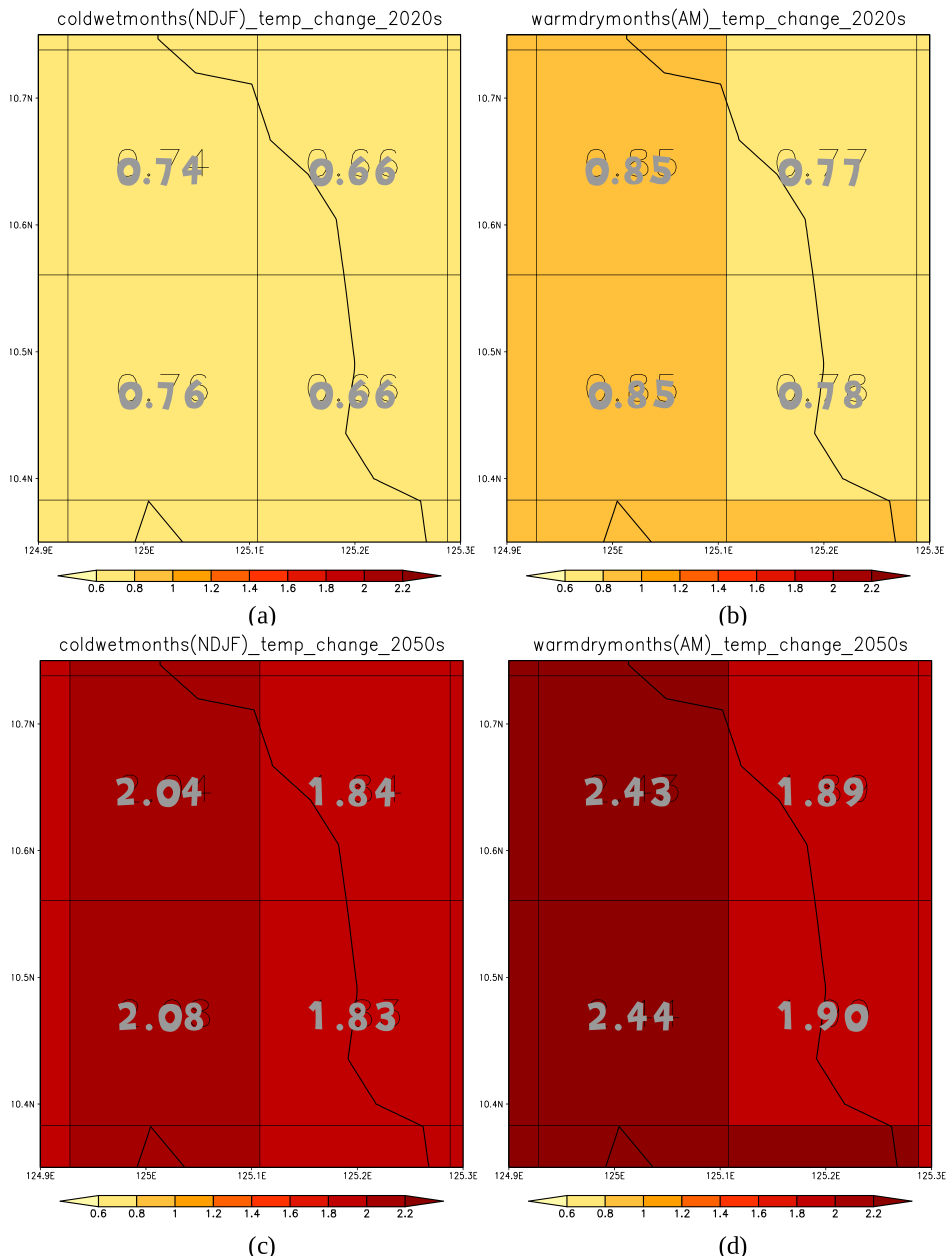


Figure IV.14. *As in Figure IV.13, but over Silago. Temperature difference values over each grid point are also displayed.*

Changes in the rainfall are expressed as the percentage difference between the projected values and the baseline. A distinct gradient in the rainfall change is observed over Leyte island during the dry season in the 2020s (a). There is roughly a 10% increase in rainfall northeast of the island but a 5% decrease in the southwest. These drier areas extend to the northeast in the wet seasons (Figure IV.15b and Figure IV.15c). In the 2050s, there is a shift in the rainfall change towards drier conditions in the dry season (Figure IV.15d). While rainfall has further decreased during the wet seasons, there is minimal change in the spatial profile of the rainfall difference compared with the 2020s (Figure IV.15e and Figure IV.15f).

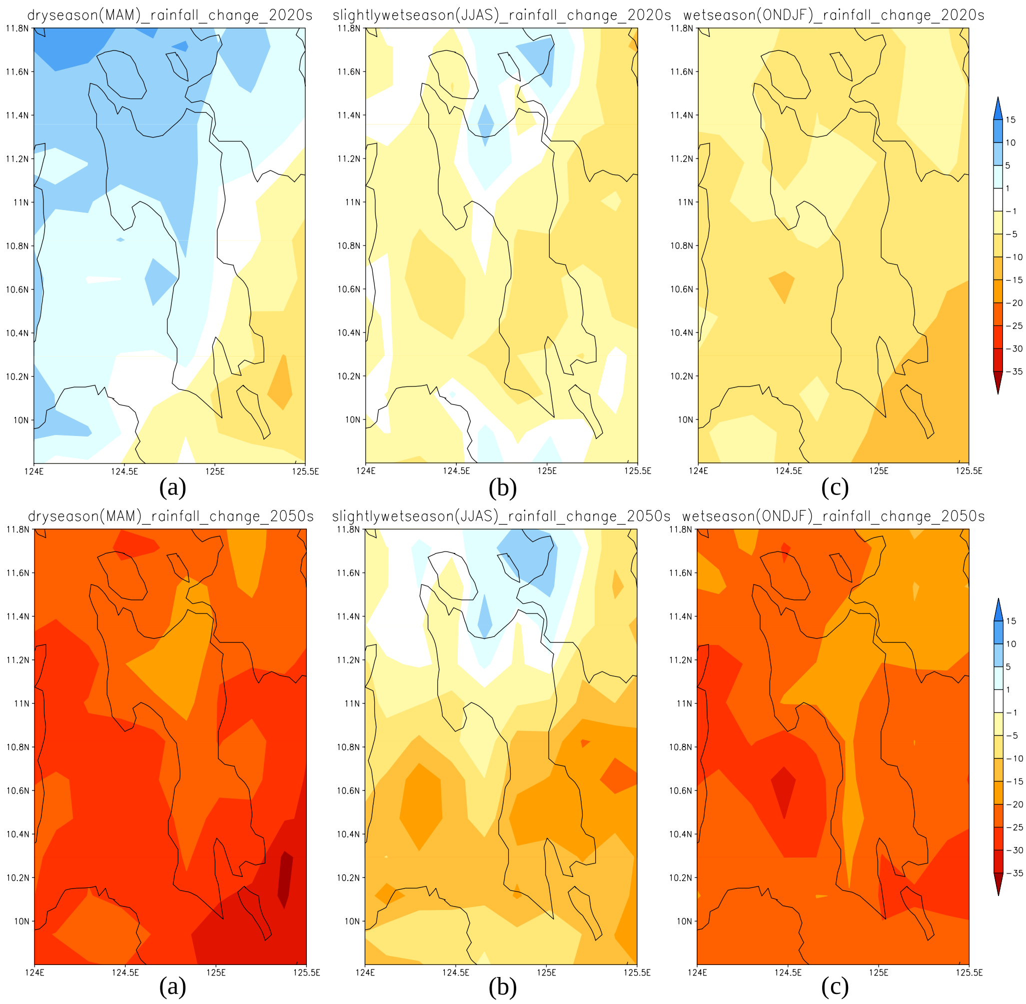


Figure IV.15. *Mean rainfall percentage difference (%) over Leyte island from the baseline climate (1960 to 1990) averaged (a) over the dry season, (b) slightly wet season, and (c) wet season in the 2020s, and (d) over the dry season, (e) slightly wet season, and (f) wet season in the 2050s. Seasons are defined in Figure IV.10.*

The rainfall change over Silago differs over the eastern and western sections during the dry season of the 2020s, where there is a slight increase in rainfall inland but a decrease simulated along the coastline (Figure IV.16a). Interestingly, the inland area becomes drier than the coastal area in the months of June to September (Figure IV.16b). In the wet season, the dry condition is more uniformly distributed over Silago (Figure IV.16c). In the 2050s, the mean decrease in rainfall over Silago is highest during the dry season (25%), compared to the slightly wet season (17.1%) and the wet season (22.2%) (Figure IV.16d, Figure IV.16e and Figure IV.16f).

In summary, a warmer and drier climate is projected generally over Leyte island, particularly Silago. However, the intensity of this change can vary according to season and geographical location.

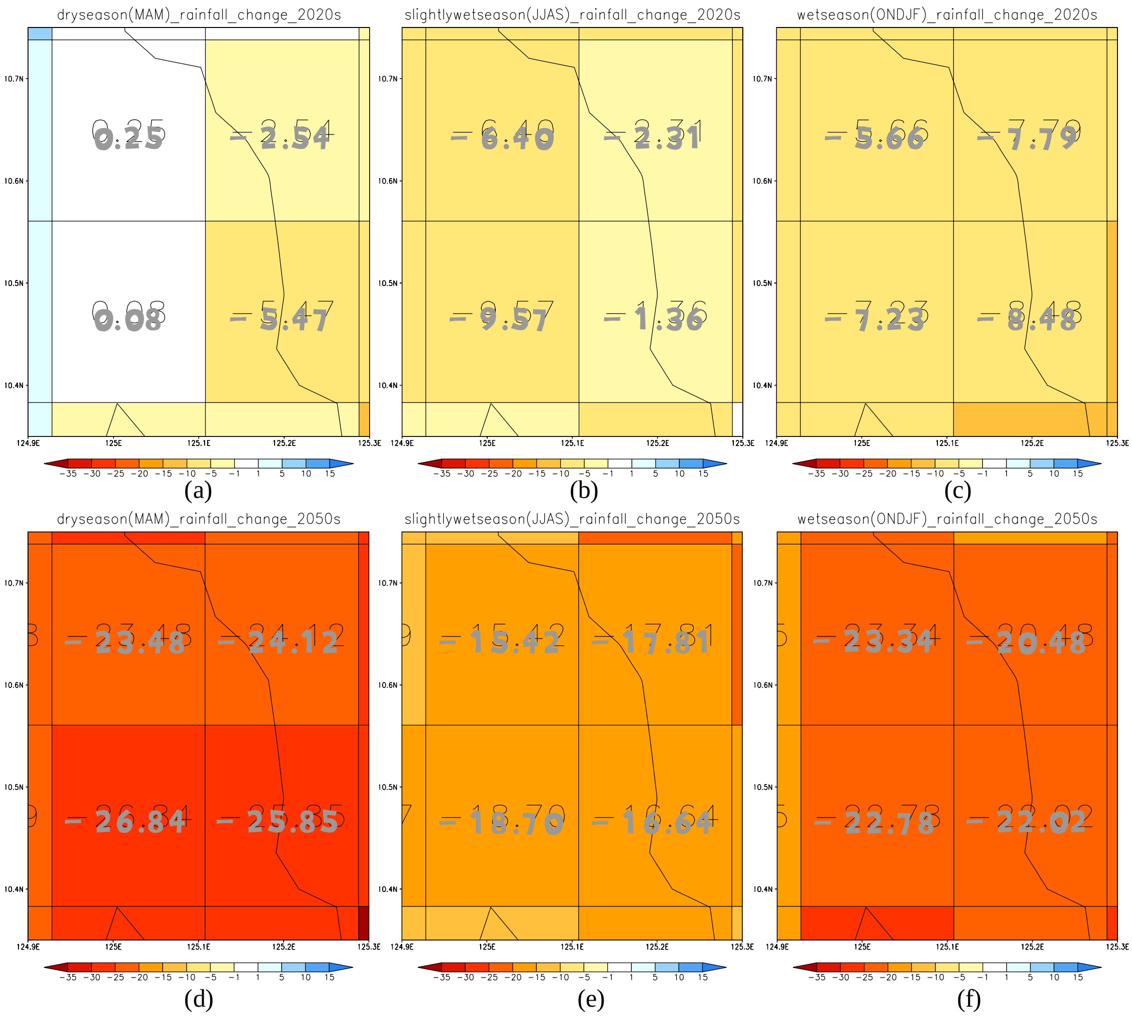


Figure IV.16. *As in Figure IV.15, but over Silago. Rainfall percentage difference values over each grid point are also displayed.*

Changes in extremes

So far, we have only examined the projected changes in the mean values of temperature and rainfall. As mentioned, changes in the climate extremes will also be analyzed since these tend to have a more significant impact on the community and ecosystem. For example, increases in the frequency of extreme rainfall events can lead to higher incidences of flooding.

The probability density functions (PDF) of the monthly means of the daily maximum temperature and daily minimum temperature from the four grid points covering Silago (shown in Figure IV.14 and Figure IV.16) are derived for the three 30-year periods as simulated from RegCM3. A clear shift towards higher maximum temperatures is evident in the projected climate of the 2020s and 2050s relative to the baseline (Figure

IV.17a). Apart from Silago experiencing more days with warmer daytime temperatures as indicated by the change in the mean value or the peak of the PDF, there is also an increase in the minimum and maximum values of daytime temperature indicated by the tails of the PDF. A similar trend can be observed in the PDF of the minimum temperature which suggests the increase in the occurrence of warmer nights in the area (Figure IV.17b).

Selected climate extreme indices are derived based on the temperature and rainfall-based indices recommended by the CCl/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI) with user-defined thresholds (Peterson, 2005). A FORTRAN-based program called FClimDex, was downloaded from http://cccma.seos.uvic.ca/ETCCDI/software.shtml, and used to perform data quality control and to calculate the indices. A comparison of the changes in the indices will be conducted for Silago across the three 30-year periods. Figure IV.18 shows the frequency distribution of the number of days in a year within each of the 30-year period over the four points in Silago, where the maximum and minimum temperatures exceeded thresholds we have defined. The thresholds have been selected from the 10th and 90th percentiles of the maximum and minimum temperatures from the baseline climate in Silago.

In the 2020s, there are more years that have more than 120 days where the maximum temperature is greater than 32.6 °C compared with the baseline (Figure IV.18a). This number increases in the 2050s where there are years in this period with high daytime temperatures lasting almost throughout the year. This is consistent with the trend in Figure IV.17a, where there are more hot days anticipated in Silago. On the other hand, all years in the 2050s are simulated to have only up to 30 days where the daily maximum temperature is less than 26.0 °C (Figure IV.18b).

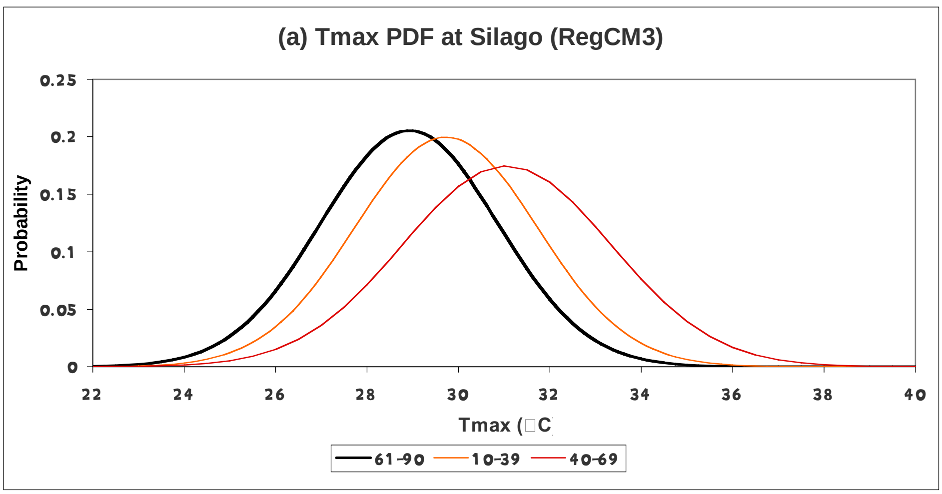


Figure IV.17. *Probability density functions of the monthly mean (a) daily maximum temperature, and (b) daily minimum temperature in Silago from the years 1961 to 1990, 2010 to 2039 and 2040 to 2069 from RegCM3.*

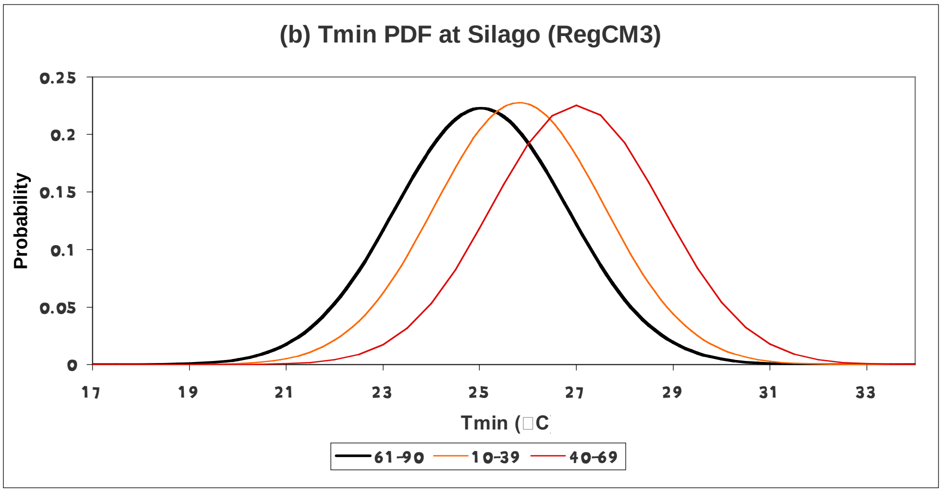
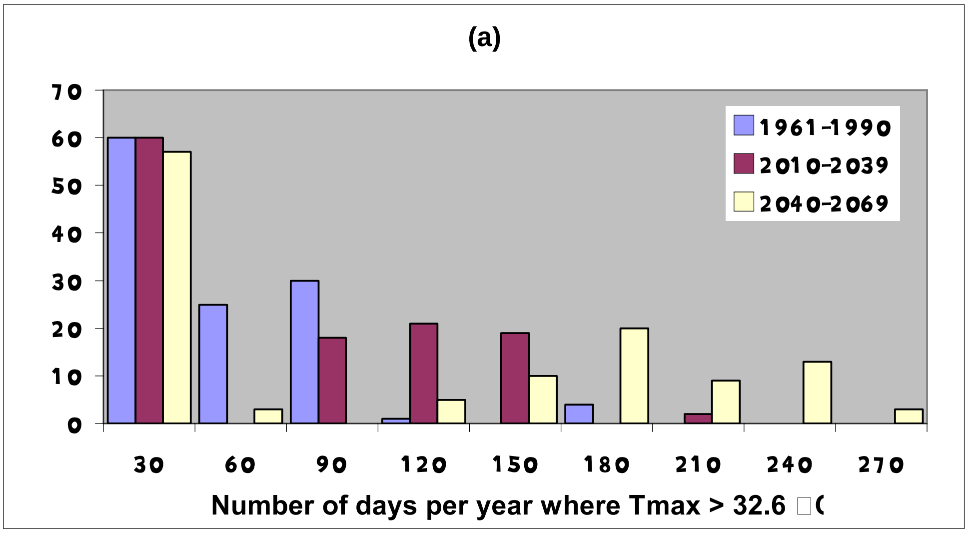


Figure IV.17. *Continued.*



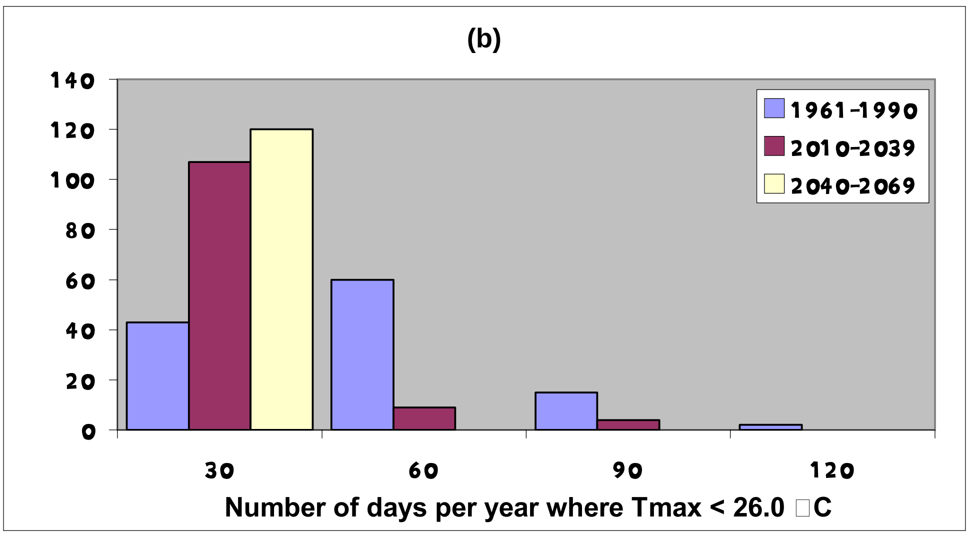


Figure IV.18*.* *Frequency distribution of days where the (a, b) daily maximum temperature and (c, d) daily minimum temperature exceeded defined thresholds in Silago from the years 1961 to 1990, 2010 to 2039 and 2040 to 2069 from RegCM3.*

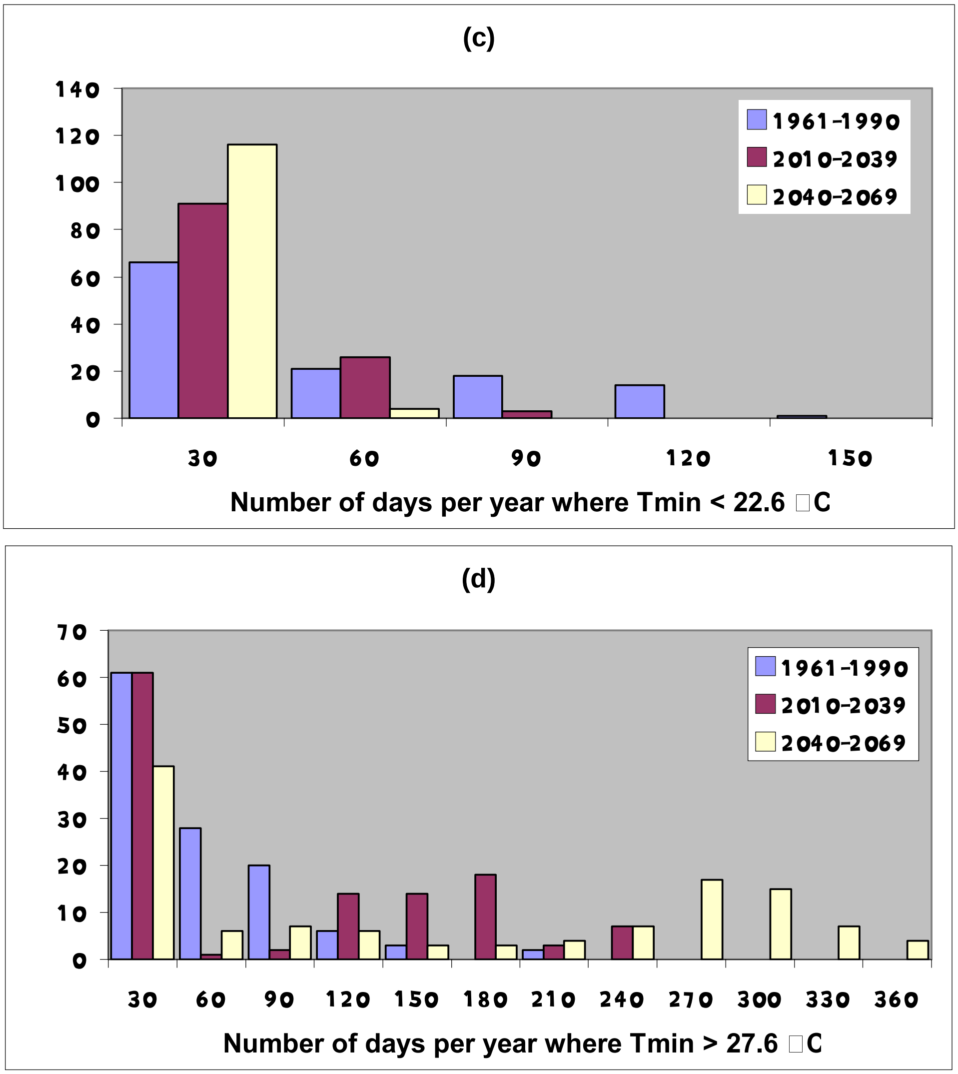


Figure IV.18. *Continued.*

Whereas in the baseline there are years with up to 150 days which have minimum temperatures lower than 22.6 °C, the projection for 2050s indicates most years to have a maximum of 60 days with cool night time temperatures (Figure IV.18c). Interestingly, most of the 2050s is characterized by warmer nights (i.e. daily minimum temperature greater than 25 °C) during half or the entire year (Figure IV.18d).

Changes in indices based on rainfall are also examined. Unlike the change in the temperature indices, there is minimal difference in the distribution of years with periods where rainfall exceeds 10 mm across the three 30-year periods (Figure IV.19). However, the trend is to have fewer years with long periods of wet days in the future. The frequency distribution of the highest number of consecutive dry and wet days is shown in Figure IV.20 and Figure IV.21. A notable difference among the three periods is that the occurrence of consecutive dry days lasting more than 2 months is possible in the 2050s (Figure IV.20). On the other hand, there are fewer instances of consecutive wet days that last for more than 1 month in the 2020s and 2050s (Figure IV.21).

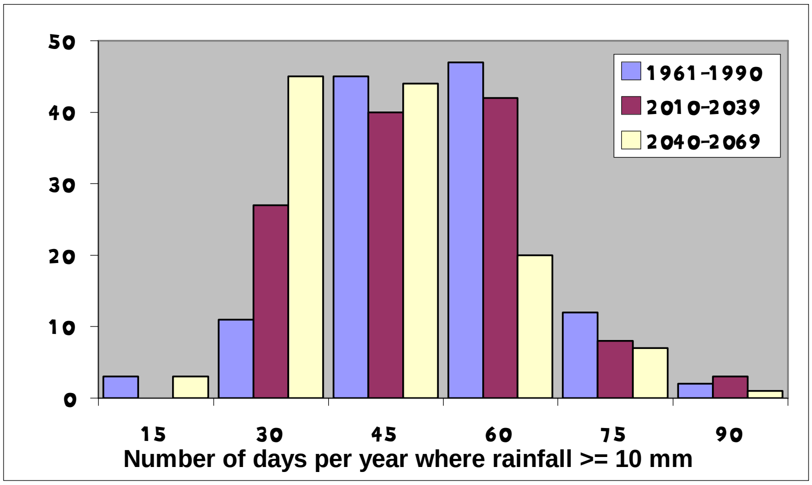


Figure IV.19. *Frequency distribution of days where the daily rainfall is greater than or equal to 10 mm in Silago from the years 1961 to 1990, 2010 to 2039 and 2040 to 2069 from RegCM3.*

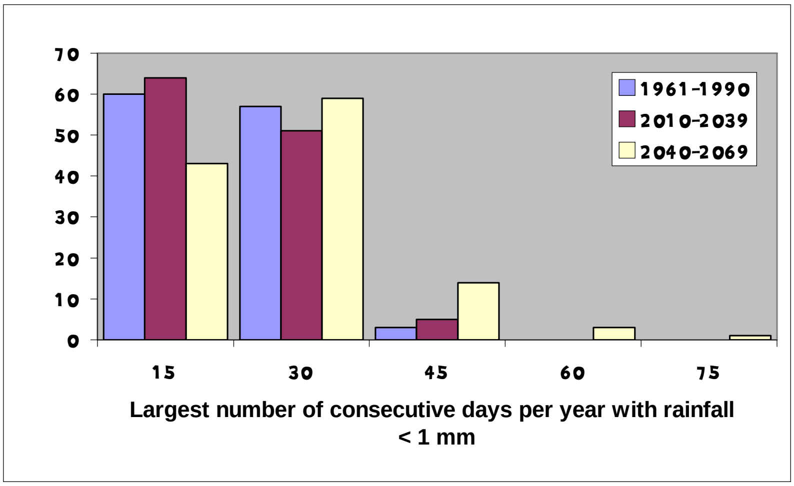


Figure IV.20. *Frequency distribution of the largest number of consecutive days where the daily rainfall is less than 1 mm (consecutive dry days) in Silago from the years 1961 to 1990, 2010 to 2039 and 2040 to 2069 from RegCM3.*

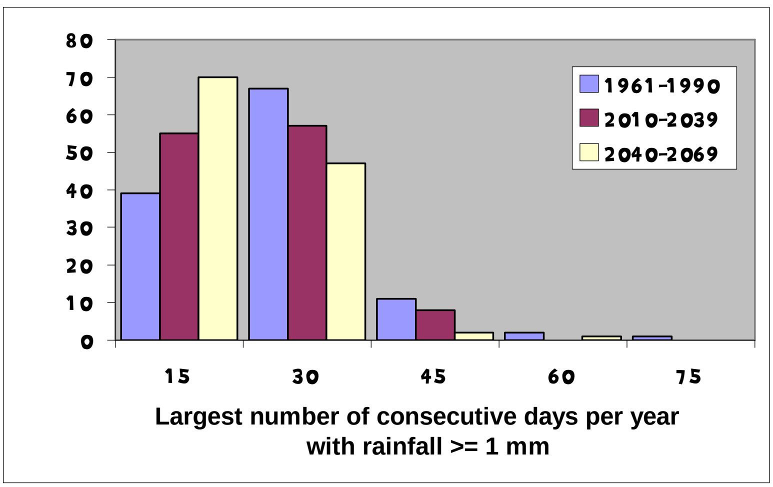


Figure IV.21. *Frequency distribution of the largest number of consecutive days where the daily rainfall is greater than or equal to 1 mm (consecutive wet days) in Silago from the years 1961 to 1990, 2010 to 2039 and 2040 to 2069 from RegCM3.*

V. VULNERABILITY AND IMPACTS OF CLIMATE CHANGE ON THE FORESTRY SECTOR

A. THE FORESTRY SECTOR OF SILAGO

Leyte Island is part of the Eastern Visayas and was formed through geologic uplifting during the tertiary and by a central, largely volcanic mountain ridge called the Leyte Cordillera, with its peak at Mt. Pangasugan (1150 m asl) (Margraf and Milan, 1996; Scinicz, 2005). Leyte island and the neighboring islands of Samar, Mindanao, and Bohol were most likely connected during the Pleistocene to form a single island called Greater Mindanao. The faunal affinities of these islands to each other persist to this day (Heaney and Regalado, 1998).

There is little published literature on the biodiversity of forests in Leyte island. Margraf and Milan (1996) in their reconstruction of the potential natural vegetation of the island, proposed the occurrence of 14 major vegetation types, mainly forest formations, which include lowland dipterocarp forests, as well as swamp forests that had been largely felled for timber and agricultural production. Deforestation in Leyte island in recent years can be attributed to the clearing of forests for commercial and marginal upland agriculture, and non-timber plantation establishment (mainly coconut)[6]. Settlement projects, agriculture and forestry development projects and road construction were said to have also contributed to forest loss (Dargantes and Koch, 1994). Forest clearing and repeated cultivation of root crops, abaca, banana, corn, coconut and use for livestock production result in the formation of degraded lands dominated by grasses such as *Chrysopogon acicularis*, *Imperata cylindrica*, *Axonopus compressus* or *Saccharum spontaneum*, (Quimio, 1996). Dipterocarp forest remnants are now generally found in localities where large-scale logging was not profitable and where access was hampered by the difficult terrain (Langerberger, 2006).

Agroforestry systems adopted by farmers in Leyte were broadly classified by Harrison et al. (2005b) as coconuts and timber trees, coconuts and other products (e.g. fruit trees, livestock), timber trees and fruit trees, and coconuts or timber trees and rice. Rice is widely grown on relatively flat coastal areas, while coconuts and bananas are commonly planted in sloping land. Analysis done at the farm and parcel level by the same authors showed the almost exclusive reliance on gmelina and mahogany for timber, and a resurgence in coconut production, following the recovery of the copra price, with little recent planting of timber trees. Fruit trees are typically a secondary crop on farms growing coconuts and timber trees and few farmers were involved in abaca growing. On a farm and land parcel basis, there were indications that growing multiple species provides income stability, increased self-sufficiency and some species complementarities, but the

[6] There is information (www.forestry.denr.gov.ph) that a logging company once operated in Region 8, its Timber License Agreement (TLA) issued in 1972, with an annual allowable cut (AAC) of 80,000 m^3, and an area of 26,000 has encompassing the towns of Hinunungan, St. Bernard, Silago and Sogod in Southern Leyte, and Baybay, Javier and Abuyog in Leyte; the TLA was cancelled in 1993 by the DENR due to the declaration of a logging moratorium.

economic and ecological benefits associated with agroforestry interactions is not taken full advantage of (Harrison et al., 2005b).

At present, both natural forests and plantations are not able to fully provide local needs for wood in the region. In the Eastern Visayas, log production for lumber had reached an annual average of 212,589.86 m3 per year, but after the imposition of a logging moratorium in 1989, dropped to 4,391 m3 a year, causing a severe supply shortage for all wood requirements (DENR, 1990). In Leyte province, timber from native species including molave and narra has been decreasing, while the demand for high quality furniture and house construction is increasing. Even the supply of exotic timbers from plantation forests would not be able to meet the shortage, with wood-based industries procuring most of their timber from Cebu and Mindanao (Mangaoang et al., 2005). The supply problem is further complicated by the strict implementation of the DENR policies against illegal cutting of timber for forest preservation (Mangaoang et al., 2005).

Contemporary kaingin farming has a range of interpretations for upland communities in Leyte island, some of them akin to 'shifting cultivation', (involving rotation of fields and a forest fallow period), but now usually consistent with 'slash and burn' as a means to open new land, with most migrants actually practicing sedentary agriculture, the end point being either perennial plantations or *Imperata* wastelands, the latter "shifted" only in the sense of crop rotations and short-term fallow (Lawrence, 1997).

Forests are an important source of both subsistence and commercial goods. Lacuna-Richman (2003) reported the heavy extraction of rattan (*Calamus sp.*) by households living in the forest margins of the town of Cienda in Leyte province. Family members also take the opportunity to collect various non-wood forest products (NWFP) for food, medicine and building materials for houses, while growing and harvesting abaca (*Musa textilis L.*), in their kaingin plots in the forest margins. The same author reported the heavier use by poorer families of various NWFP for food.

Within the production forests of Silago (estimated at 6,233.15 has based on latest perimeter survey) are two Community-Based Forest Management (CBFM) projects, one managed by the Puntana Livelihood Project and Environmental Development Association, Inc (PLPEDA) in Barangay Puntana, and the other by the Katipunan Imelda Catmon Community Forestry Association (KICCFA) in Barangays Katipunan, Imelda and Catmon. Based on 2003 records of the Department of Environment and Natural Resources, the KICCFA CBFM area was measured at roughly 1,617 hectares with 110 households under its provisions. The KICCFA currently manages 1,698 hectares of the common forest area of the three barangays (FLUP, March 2011). The latest available data from the LGU shows that majority of the area is composed of growing forest trees, while there are equal areas covered with matured and young forest trees (Table V.1). Meanwhile, the PLPEDA CBFM area was 250 hectares, with 94 households under its jurisdiction (http://forestry.denr.gov.ph/CBFMP.xls). These projects are monitored by the Municipal Environment and Natural Resources Office (MENRO) and the Department of Environment and Natural Resources (DENR), with funding sourced from non-government organizations (NGOs), particularly the German Technical Cooperation (GTZ).

Table V.1. *Types of forest trees in the KICCFA CBFM project site by estimated area and percent of total area.*

Classification	Percent of total area (%)	Estimated area (ha)
Young forest trees	20	339.60
Growing forest trees	60	1,018.80
Matured forest trees	20	339.60
TOTAL	100	1,698.00

The local government also launched an agroforestry program by distributing 3,000 assorted fruit bearing tree seedlings, 10,000 coffee seedlings, 5,000 mangrove seedlings and 500 jackfruit seedlings. Forest-based production activities include planting of indigenous and fruit bearing trees, weeding, cleaning, monitoring and supervision of designated forest areas.

Langerberger (2006) reported that about 40% of the total land area of Leyte island was occupied by grasslands and barren lands; 40% by coconut plantations and only 2% by primary forests. A land cover analysis done by REIS (2009), on the other hand shows that, of the total surface area of 725, 810 ha, 31% of Leyte island is covered with closed forest; 31% with perennial crop, 16% with annual crops, and the rest with pastures, shrubland, and barren land (Table V.2).

Table V.2. *Percent land cover distribution of Leyte Island.*

Land Cover Class	Area (Ha)	Percent Cover
Closed Forest	228,665.33	31.50
Mangrove Forest	6,567.31	0.90
Shrubs	53,957.19	7.43
Barren Land	5,133.39	0.71
Annual Crop	117,022.72	16.12
Perennial Crop	229,610.37	31.64
Pastures	71,979.91	9.92
Road, Settlement, Rivers	12,873.98	1.77
TOTAL	725,810.19	100.00

Source: REIS, 2009

Latest estimates for the area of classified forest land in Silago vary, from 12,939.98 hectares (according to the mucipality’s draft Forest Land Use Plan (FLUP, March 2011)) to 14,653.22 hectares according to the perimeter survey conducted by the Municipal Investigating Team (MIT) and used in the Draft CLUP (March 2011). While discrepancies are still yet to be reconciled, these values indicate that forestlands make up more than half of the municipality`s total land area, showing the dominance of this ecosystem in the landscape. However, as stated earlier in this report, declared forest lands may not be under actual forest cover.

An analysis of remotely sensed data by the GTZ (2009) shows that Silago has 9,677 has of closed forests, which comprised almost half of the estimated total area of 19,610 has of the municipality, and 69% of the total forest cover of the province of Southern Leyte (Table V.3).

Table V.3. *Percent land cover distribution of Silago, Southern Leyte, GTZ (2009) data.*

Land cover type*	Area (ha)	Percent Share of Silago (%)
Grassland 70-coconut 30	1,004.16	5.12
Grassland 70-shrub 30	1,245.89	6.35
Shrubs	769.08	3.92
Shrubs 70-forest 30	1,710.00	8.72
Shrubs 70-coconut 30	370.73	1.89
Coconut	4,721.00	24.07
Settlements	111.91	0.57
Forest	9,677.59	49.35
TOTAL	19,610.36	100.00

** Based on percent canopy cover distribution of selected vegetation type*
Source: GTZ, 2009

The results of the land cover change analysis done for this study is shown in Table V.4. While our analysis shows higher estimates of the area under forest compared with the GTZ study described earlier, what is consistent is the predominance of this land cover in Silago, succeeded in decreasing order by scrubland (which in this analysis, includes coconut plantations), paddy and urban. Forest cover loss based on this analysis is estimated at a total of 1,340 ha, or a rate of about 148 ha per year over the last decade. In contrast, the other land cover classes increased in area over time, with scrubland gaining the highest at about 123 ha/year, followed by the other classes, at relative much lower rates of increase. The area for paddy fields may not be reliable since the images were taken in different months. Paddies during the fallow season of wetland rice could have been underreported in some images. Urban areas have expanded almost four-fold yet remain trifle compared with the total area of Silago. If the classification holds true then it is evident that the forest area is also becoming patchier, giving way to islands of scrubland and urban areas surrounded by forest (Figure V.1). The impact of the newly-constructed Abuyog-Silago Road on land cover change may not yet be evident since it has only been completed recently. But newer patches of non-forest has been observed in the 2009 image that correspond to areas near farm to market roads (FMR) which became operational in the last 5 years (e.g. Imelda FMR and Catmon FMR) (Figure V.2).

Table V.4. *Relative areas of cover classes resulting from supervised classification of LandSat 7 images and REIS (2009) data.*

Cover class	Hectares							
	2000	**%**	**2003**	**%**	**2006**	**%**	**2009**	**%**
Forest	17,437.278	79.00	17,698.193	80.00	15,200.725	69.00	16,097.128	73.00
Scrubland	4,087.722	18.00	5,219.246	24.00	5,828.931	26.00	5,197.281	24.00
Paddy	358.196	1.60	282.152	1.30	862.576	3.90	530.637	2.4
Urban	56.107	0.25	150.135	0.68	48.861	0.22	210.950	0.94
Others	177.538	0.81	130.841	0.59	-	-	-	-

Recognizing the importance of conserving its forest resources, the town has been the site of reforestation projects which were implemented through community-based forest management (CBFM). Such projects are monitored by the Municipal Environment and Natural Resources Office (MENRO) and the Department of Environment and Natural Resources (DENR), with funding sourced from non-government organizations (NGOs), particularly the German Technical Cooperation (GTZ).

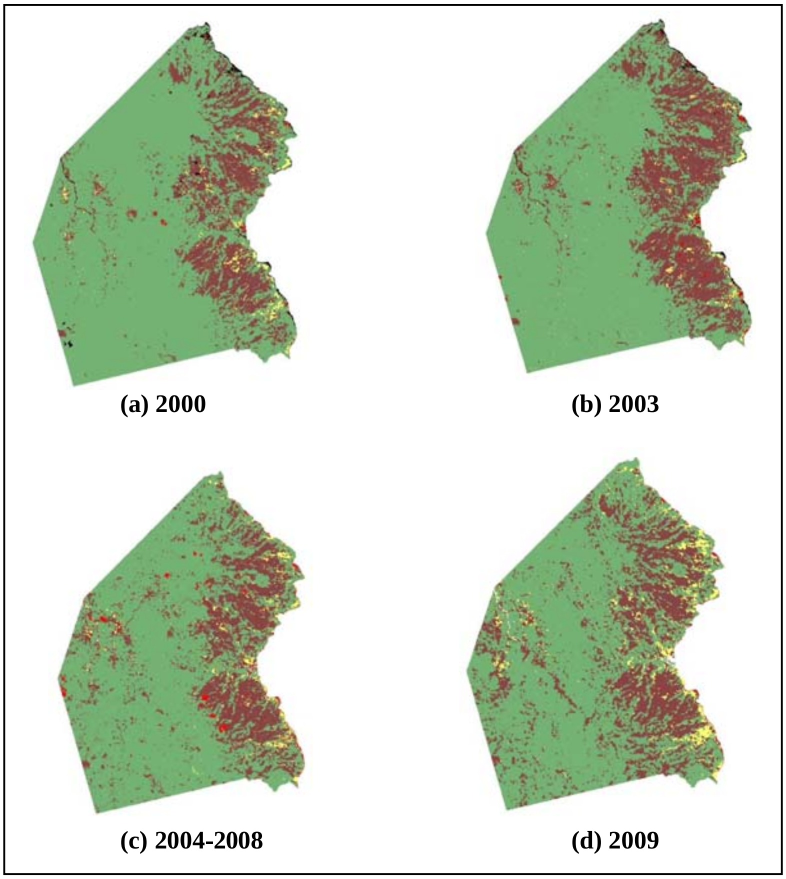
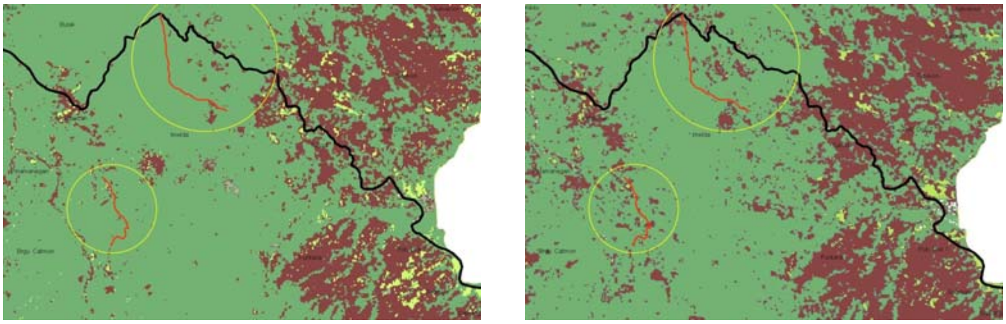


Figure V.1. *Land cover map of Silago, Southern Leyte.*
Legend: green: forest, brown: scrubland, yellow: paddy, red: urban, black: others.

In the absence of historical data, the analysis done serves as a preliminary investigation into the general patterns of change among the chosen land cover types over the last decade. The accuracy of the estimates is constrained by the availability of images with higher spatial resolution and low cloud cover, and validation (ground-truthing) data which would greatly improve classification and change detection. The data from the perimeter survey recently conducted by the MIT (Table V.5) indicate a lower forest cover (further classified into types: primary forest, secondary forest and plantation forest) at around 58% of the total land area of the municipality; still, this can be considered a good condition compared with background deforestation rates in the Philippines. However, it is important to note that there are many insidious activities in forest lands such as *kaingin*-making, timber poaching and fuelwood collection that occur in such a small scale that they escape detection by remote-sensing techniques, and thus for Silago a better understanding of how these threats operate at the local scale is needed.



(A) 2000 **(B) 2009**

Figure V.2.. *Forest area in areas surrounding Abuyog-Silago Road in (A) 2000 and (B) 2009; forests became patchier near farm to market roads in Imelda and Catmon.*

Table V.5. *General Land Use and Forest Cover Type by Land Classification, Silago, Southern Leyte, 2010.*

	Land Classification		Total Area	Percent
	FFL (Ha)	A & D (Ha)	Ha	%
Natural Forest Closed (NFC) Primary Forest	5,929.41	33.12	5,962.53	27.10
Natural Forest Fragmented (NFF) Secondary Forest	6,196.82	365.86	6,565.54	29.84
Plantation /Production Forest	149.61	66.92	217.55	0.98
Grassland/ Brush land (GL/BL)	1,394.87	3,833.67	5,228.54	23.77
Cultivated Area (AC,CC)	380.03	5,338.28	5,718.31	25.99
Urban Use area	0.30	53.77	54.07	0.24
Road Network	3.45	85.45	88.90	0.40
Foot trail	0.44	7.80	8.24	0.03
Agro-Industrial		4.85	4.85	0.02
Water Use Area:	9.53	39.76	49.27	0.22
Rivers	14.88	53.36	68.24	0.31
Creeks				
TOTAL	8,512.03	13,483.10	21,995.13	100.0

Source: Draft CLUP, 2011

Land Cover Change Analysis

Recognizing the importance of land use as a dominant driver of change that encompasses the different sectors, land cover change analysis using remote sensing and GIS was done to assess the extent of deforestation and forest cover fragmentation in the landscape. Analysis was done for the period 2000-2009 using downloaded satellite images (www.usgs.gov).

The succeeding section details the methods used to explore land cover change in the Municipality of Silago in Southern Leyte Province from 2000 to 2009 using LandSat 7 images. For the period between 2003 and 2008, the resulting land cover map from REIS' Production of Enhanced Land Cover Map of Leyte Island Project was used as proxy. Supervised Image classification was done using Envi 4.x. Gap-filling via vector editing processes were done using ArcGIS 9.2. Results of unvalidated image classification and corresponding areas are then presented.

Data acquisition

The best LandSat 7 images in WRS-2 Path/Row 113,53 with least cloud cover over the area of Silago where selected and downloaded free from www.landsat.usgs.gov for the years 2000, 2003 and 2009. Specifically scene ID # L71113053_05320001204 dated 4 December 2000, L71113053_05320030807 dated 7 August 2003 and L71113053_0532009072 dated 22 July 2009 (Figure V.3, Figure V.4 and Figure V.5). The boundary delineation of the municipality used for this analysis was based on the area described in the Cadastral Survey of the Municipality of Silago (Bureau of Lands), and was also compared (clipped) with the shapefile data used in the municipality's Land Use\ Barangay Development Plan (LU-BDP) to determine the municipality`s official, undisputed boundary.

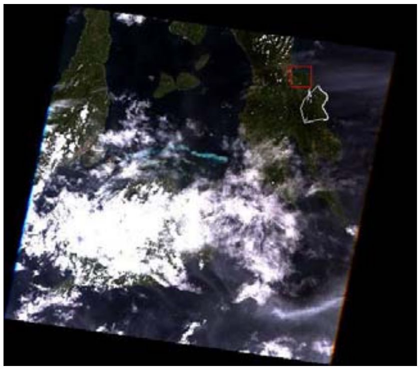


Figure V.3. *L71113053_05320001204, 4 Dec. 2000, Bands 3, 2, 1.*

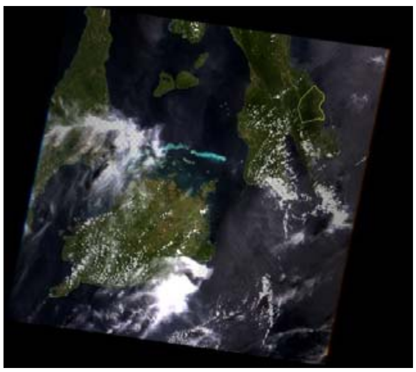


Figure V.4. *L71113053_05320030807, 7 Aug. 2003, Bands 3, 2, 1.*

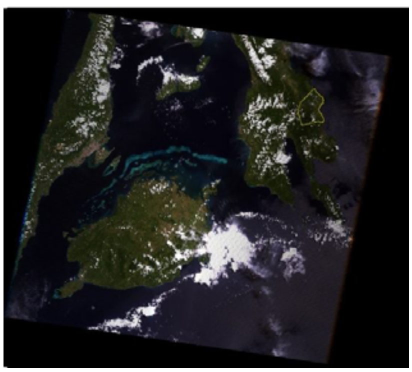


Figure V.5. *L71113053_0532009072, 7 July 2009, Bands 3, 2, 1.*

Pre-processing

Radiometric correction for Bands 1-5 and 7 of each image was done in ENVI by converting DN values to radiance values. Spatial subsetting of each band to cover only the area of Silago (Figure V.6) was done for more efficient processing. Stacks of RGB composites B145, B123, B753 and B321 were then prepared for image classification.

Figure V.6. *Subset of Landsat 7 image, RGB composite B753.*

Image classification

Training classes for classification were set for forests, scrubland, paddy fields and urban using the spectral profiles (Figure V.7) of each class at specific band composites where these classes have highest contrast. B145 was used for classifying forest and scrubland. B123 was used for classifying paddy while B753 was used for classifying urban surfaces.

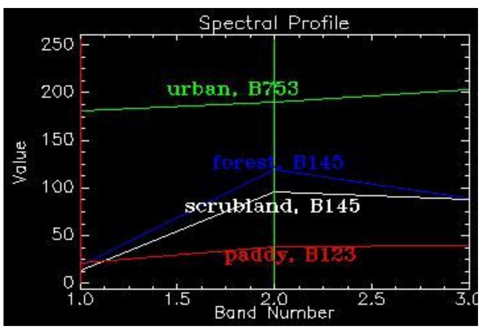


Figure V.7. *Spectral plots of training classes with corresponding band composites.*

Supervised classification was done using spectral angle mapper. Default values in Envi were used. Areas eclipsed by cloud and shadow were assumed to be forest areas. Classes were then converted to vectors for editing.

Post-classification

Vector editing was done in ArcGIS resulting to a harmonized land cover theme per satellite image acquired. A gap-filled land cover theme for 2003 (b) was produced by intersecting its LandSat 7 gap masks with the final land cover theme of year 2000 (a). As for the years between 2003 and 2008, the classification done by REIS which used SPOT 5 image for Silago taken in 2004, 2006 and 2008 (REIS, 2009) was used as proxy. The classes used by REIS where however simplified: 'forest' and 'perennial crops' were reclassified as forest, 'pastures' and 'shrubs' were reclassified to scrubland, 'annual crops' were reclassified to paddy and 'barren land' was reclassified to urban (c). Gaps in the 2009 classified LandSat 7 image were gap-filled using the reclassified REIS land cover map (d).

B. IMPACT CHAIN, INFLUENCE DIAGRAM, AND INDICATOR DATA FOR THE FORESTRY SECTOR OF SILAGO

Impact Chain

Figure V.8 shows the refinement of the Pre-Analysis Impact Chains for the Forestry sector. The scoping process with the LGU and other stakeholder of Silago led to the identification of the exposure units and direct and indirect climate impacts that are deemed most relevant for the municipality. Further data collection efforts however showed that there was little substantive information on hand to support quantitative assessments at the level of the municipality, especially with regards to measures of direct and indirect impacts.

Influence diagram

Climate variables (rainfall and temperature; the effects of increased atmospheric CO_2 concentrations was not considered here) affect ecophysiologal processes and ecosystem functions and properties which eventually would influence the way forests deliver the different services derived by both local communities in Silago and downstream users (Figure V.9). For Silago these important ecosystem services include the provision of goods (food, fuelwood and non-timber forest products), regulation of the flow and quality of water (considering the high dependence of the municipality on surface flows for its water and the absence of efficient storage and distribution infrastructure), and influences on soil formation and nutrient recovery (agriculture being the major source of livelihood), all of which have direct and indirect impacts on human well-being. However, the vulnerability of forests and forest ecosystem services to future climate impacts would be largely affected by current threats of deforestation and forest degradation. Silago's forests remained intact probably due to the area's inaccessibility for (commercial) logging operations in the past. Based on the information gathered, among the current important drivers of deforestation and degradation are the expansion of farming activities in forest lands; the current scarcity of timber in the region in the face of increasing demands for wood for construction and other uses, and road construction, particularly the Junction Abuyog-Silago junction road.

The potential direct and indirect damage of the construction of the new road to forests have been described earlier; socioeconomic impacts, such as the greater integration of the municipality with the regional economy would also likely further enhance the effects of land use change and links with demand for food and other agricultural products, creating pressures to clear more forest land. The resulting changes in land use would have consequences for the other priority sectors of the municipality.

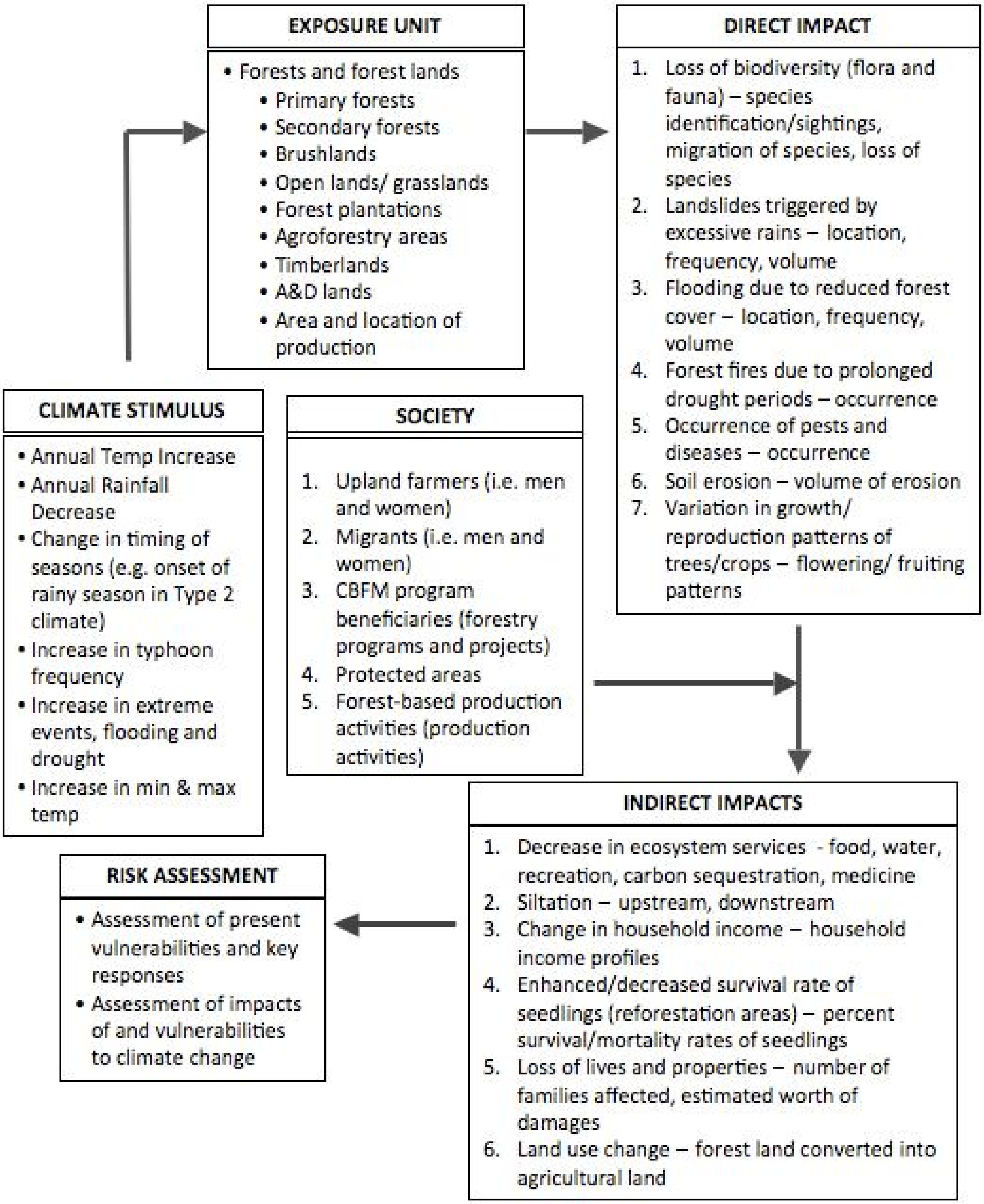


Figure V.8. *Impact chain for forestry sector of Silago, Southern Leyte.*

Figure V.9. *Influence diagram for the forestry sector of Silago.*

C. CLIMATE IMPACTS AND PATTERNS OF VULNERABILITY

One key vulnerability of Silago to climate change lies in its fresh water sector, the anthropogenic link between these two being land cover change. More forest cover means more freshwater sources. However it should also be noted that the significant threshold relating forest cover and springflow/streamflow production is still poorly understood. Although the volume of rainfall infiltrating into Silago's forest soils can be easily modelled, how these infiltrated water is partitioned underground is still a subject of a baseline study which, at least, requires measuring springflow rates, and ideally, mapping the aquifer structure. Only then can one fully understand the relationship between forest and the fresh water sector in the municipality.

In the context of Silago which is a municipality highly dependent on springs for both domestic use and irrigation needs, a continuing decrease in forest cover may result in the long-term to decreased aquifer recharge, spring flow and base flow and instead lead to increased runoff production, erosion and siltation. Conversion to urban, impermeable surfaces completely translates rainfall to runoff.

The absence of meters in the existing distribution system makes it difficult to ascertain the current demand for water in the Municipality, as well as project the future demand. At present, rough estimates indicate that there is a potentially large supply of water in Silago. However, climate-sensitive variables are also present, particularly 1) the incidence of enteric waterborne diseases, and 2) water siltation. Incidence of enteric waterborne diseases can be exacerbated by the presence of favorable climatic (i.e. temperature, moisture) and other environmental conditions. Meanwhile, siltation – although also greatly affected by land use change – is aggravated by climate stimuli such as increase in rainfall, strong winds and occurrence of extreme climate events.

Although we cannot categorically state how much forest cover is actually needed to sustain ample water supply for the needs of the Municipality's current and future population, it is evident that the urgent need of the hydro-forest sector is the establishment of an improved distribution network to maximize the use of the currently underutilized water resources.

A note regarding forest cover and hazards. Although Silago lies along a major faultline traversing Southern Leyte, there are no significant settlements near the faultzone. While landslides have been linked to deforestation and land degradation processes, important information on geology and soil properties specific to the municipality need to be obtained to clarify interactions between forest land use, climate and the occurrence of these hazards.

Indicator Data

Considering current inadequacies of basic data, local priorities for assessment, and resource limitations for data collection, the following set of indicator data for analyzing climate impacts and vulnerability and possible sources are identified (Table V.6).

Table V.6. *Possible indicators of vulnerability to climate variability and climate change of the forestry sector.*

Component of Vulnerability	Parameter	Proxy/Auxiliary Parameter	Possible Data Source
Exposure	Rainfall time series		Measured rainfall or proxy from the nearest PAGASA station
	Land use change (High resolution)		National mapping authority (NAMRIA)
	Land cover fragmentation		National mapping authority (NAMRIA),
	Timber and NFTP utilization	Production/ Harvest Data	Municipal Environment and Natural Resources Office (MENRO) (based on local monitoring records)
Sensitivity			
	Biodiversity	Floristic Inventory	Expert assessment/ Biodiversity assessment
	Productivity	Stand (Volume) Inventory	MENRO/ Local forest inventory
		Stand Biomass Assessment	MENRO/ Local forest inventory
	Soil properties	In-situ saturated hydraulic conductivity	Field measurements, laboratory procedures
	Geologic profile		MENRO and Bureau of Mines

D. Adaptation and Mitigation Options for the Forest Sector of Silago

Adaptation Options for the Forestry Sector of Silago: Some Considerations

In implementing forest adaptation, it is important to account for local variations, i.e. differences in geographical and population characteristics among barangays or sub-watersheds, when establishing adaptation plans and policies. While it may be considered difficult, impractical and costly, peculiarities in different localities need to be considered to allow successful implementation of adaptation measures. In order to do this, local institutions and stakeholders need to become more involved in the adoption of adaptation strategies, from planning and implementation to monitoring and evaluation; the involvement of local people especially for the latter two activities (M & E) becoming all the more important given the scarcity of available information and the limited resources that the local government may have for data collection efforts.

Strengthening local institutions and establishing a greater sense of ownership and access among stakeholders are instrumental in adaptation implementation; in this aspect the municipality may have already some gains with the implementation of CBFM projects; the critical part would be in involving those lasting networks/institutions within this sector that would play a role in sustaining programs after external agencies withdraw support, and in the face of changing policies on forest lands and forest resource utilization.

Adaptation options for the forestry sector are hinged on the priority development needs of Silago; poverty in the municipality must be addressed to lend greater adaptive capacity to present- and future climate stresses. The importance of forest ecosystems to the local economy and the environment should therefore be realistically viewed within the context of the specific development goals of the different sectors of the municipality; this means that certain trade-offs may occur between development priorities vs. adaptation strategies for forests. An example given here are the results of the evaluation of the effects of selected adaptation strategies for the forest and agriculture sector on other sectors of the Pantabangan- Carranglan watershed (Table V.6) (Cruz et al., 2005).

It is also possible to come up with complementary strategies that would contribute to reducing the vulnerability of forests and forest- dependent communities at the same time create new opportunities for improved livelihoods. Agroforestry technologies, for instance could be tapped for their potential to address multiple problems in forest lands such as soil erosion, land degradation, food security and provision of additional/ alternative sources of incomes while contributing to the resilience of the system (see Box V.1 below).

Table V.7. *Adaptation options for forests and agriculture in the Pantabangan-Caranglan Watershed and their potential impacts on water resources, institutions and local communities.*

Adaptation Strategy for Forests and Agriculture	Effect on Water Resources	Effect on Institutions	Effects on Local Communities
Use of early maturing crops	+Low water demand	0	+Higher income
Use of drought-resistant crops	+Low water demand	0	+Higher income
Supplemental watering	-Higher demand for water	-Increase cost of developing alternative sources of water	-Greater labor demand +Higher income
Proper scheduling of planting	0	-Increase cost for training, technical assistance, R&D	-Cash expenses
Soil and water conservation	+ Conservation of water	- Increase cost for training, techinical assistance, R&D	- Cash expenses
Establishment of fire lines	+ More vegetative cover promotes good hydrology	+ Less expense for fire fighting	- More labor demand + Less damage to crops from fire; more income
Construction of drainage structures	+ Better water quality	- Increase cost of implementation	+ Less soil erosion in the farm; greater yield
Controlled burning	+ Less damage to watershed cover	0	0
Enhance community-based organizations	0	+ Better participation in the political process	+ Better participation
Total logging ban	+ More forest cover	- Increase cost of enforcement and protection	- Less income - Fewer sources of income
Use of appropriate silvicultural practices	+/- Could promote or impair hydrology depending on the practice	- Increase cost of implementation	- Increase cost of implementation
Better coordination between LGUs	+ Promotes better watershed management	+ Greater collaboration among LGUs	+ Better delivery of services to farmers
Informati0on campaign		+ Increase awareness and competence	+ Increase awareness and competence
Better implementation of forest laws	+ Promotes better watershed management	- Increase cost of implementation	+/- Could adversely affect current livelihood of farmers that are deemed "illegal"

Source: Cruz et al. 2005

The following are some considerations for climate change–related opportunities for the forest sector (Robledo and Forner, 2005):

- Recognition of local knowledge in coping with climate variability
- Promotion of native species that adapt better to climate variability
- Diversification of forest use so that the impact of each activity is reduced and, therefore, also the overall vulnerability
- Promotion of sustainable forest management as a means for reducing vulnerability
- Development of new market opportunities for traditional forest products that are highly resilient to climate change

- Sustainable forest management as a means for reducing GHG emissions and for enhancing carbon sinks.

Box V.1. Agroforestry options for Silago

Agroforestry is the practice of incorporating trees on farms. Trees on farms enhance the coping capacity of small farmers to climate risks through crop and income diversification, soil and water conservation and efficient nutrient cycling and conservation (Lasco and Pulhin, 2009). Agroforestry offers a means for diversifying production systems and increasing smallholder farms` agility in respond to climate changes because tree-based systems have the following characteristics and properties (Verchot et al., 2007):

- deep root systems that are able to explore larger soil volume for water and nutrients (helpful during droughts)
- increased soil porosity, reduced runoff and increased soil cover lead to increased water infiltration and retention in the soil profile that reduces moisture stress during low rainfall years
- higher evapotanspiration rates than row crops or pastures can maintain aerated soil conditions by pumping excess water out of the soil profile more rapidly than other production systems
- often produce crops of higher value than (annual) row crops

Diversifying the production system to include a significant tree component may buffer against income risks associated with climate variability. In addition to all these advantages, agroforestry management systems offer opportunities for synergies between adaptation and mitigation strategies.

Silago has an abundance of coconut plantations, also producing a small yield of bananas. A study by Magat (2007) discusses the suitable pairing of coconut and banana under an agroforestry system, since the two do not compete for soil resources (except in dry areas). With over 5,000 hectares of land dedicated to coconut production, there is potential to increase incomes through interplanting in areas previously mono-cropped. The additional income from the sale of banana and its processed forms could help augment household income. In doing so, the farming family becomes better equipped to avail of necessary goods and services in the face of climate –related stresses. Similarly, rubber-based agroforestry systems (RAS) like those in Mindanao can also provide alternative income prospects for smallholder farmers.

Correspondence with the LGU of Silago revealed intent to develop rubber plantations in the municipality. The rubber tree (*Heava brasiliensis*) grows in all soil types with year-round rainfall. Although these plans have not yet materialized, there is good demand for rubber latex both in local and export markets. In 2005, cup lump (naturally coagulated) rubber latex sold for PhP 14.26 per kilogram (BAS, 2010). According to the Department of Agriculture, typical yield is 1 to 1.8 tons of dry rubber per hectare per year (Young undated). The suitability of these suggested technologies/production systems to anticipated changes in climate in the municipality should of course need to be assessed.

Reducing Emissions from Deforestation and Forest Degradation (REDD)

Reducing Emissions from Deforestation and Forest Degradation (REDD) was conceptualized at the 11th Conference of Parties (COP) in Montreal in December 2005. The aim of the agenda was to reduce carbon dioxide emissions from land use and land use change by assigning financial value to carbon stored in forests. Aside from encouraging mitigation of carbon emissions, the corresponding income from carbon storage also doubles as an adaptation for the communities that stand to benefit from the monetary returns. With Silago's more than 12,000 hectares of forest land, including almost two thousand hectares under CBFM, implementation of REDD initiatives in the municipality – once materialized – could present viable alternative sources of income for locals involved in forest conservation and protection. REDD activities could be beneficial for adaptation, but badly designed projects could deprive people of their main sources of livelihoods (Guarigata et al., 2008) and leave out food security issues (DeFries and Rosenzweig, 2010).