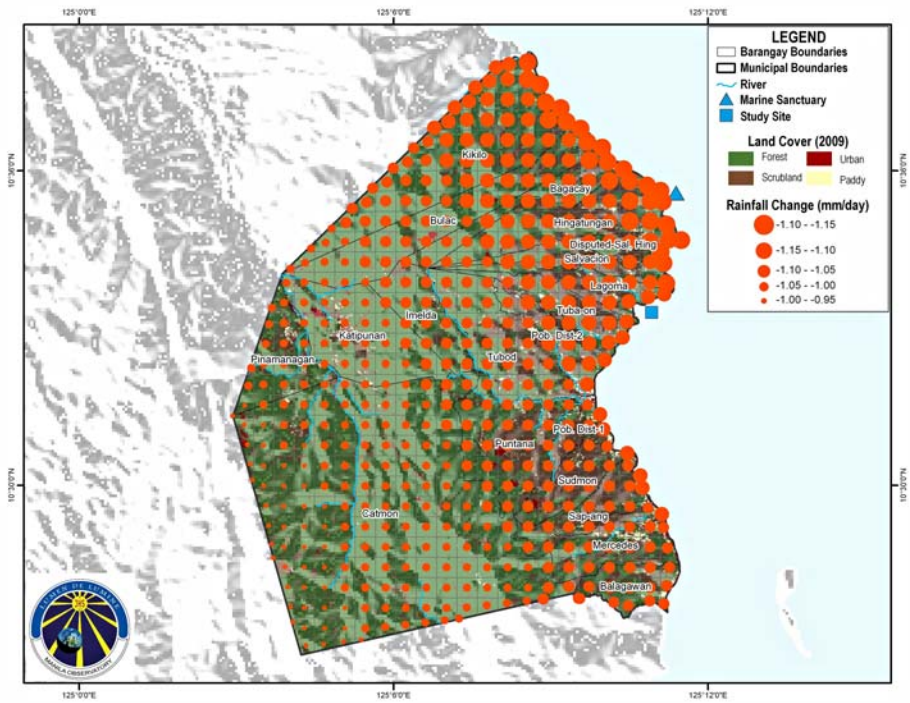


Figure VII.18. *Projected decrease in rainfall by 2050 and the 2009 land cover of Silago. Larger orange dots indicate drier conditions for 2050. . (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Rainfall Anomaly RCS-MO, Landsat 2009).*

The projected changes in minimum temperatures as discussed in Chapter 4 will have serious consequences on rice yield. Figure VII.20 shows an illustration of a potential climate shift due to global warming. In this figure, the future climate will have greater of probabilities of experiencing an increase in the average values (in this case average temperatures), less cold weather, more hot weather, and more extreme hot weather. This behaviour of shifting climate is evident in the projected changes in minimum temperatures in Silago (Figure VII.21). This implies that the future climate regime will have average minimum temperatures that are about 3^{o}C higher than the previous or baseline climate. There will be more warm nights and more extreme warm nights. Figure VII.17 in Chapter 4 showed that there will be more years that will experience more than 270 days of minimum temperatures that are greater than 27.5^{o}C. This means that practically most of the nights throughout the year for these years will have higher night-time temperatures. These changes in minimum temperatures can have significant impacts on crop production. Maximum temperatures are also projected to be higher than normal by 2050. Although the impacts of these may not be as significant as the effects of increasing minimum temperatures, the changes can have potential direct (crop damage) and indirect (temperature related water stress) on agricultural crops. Results in Chapter 4 showed that there will be more years by 2050 that will have more than 180 days of maximum temperatures greater than 32.6^{o}C. There will also be greater variability in hot weather events, with higher probabilities of occurrence for extreme hot weather.

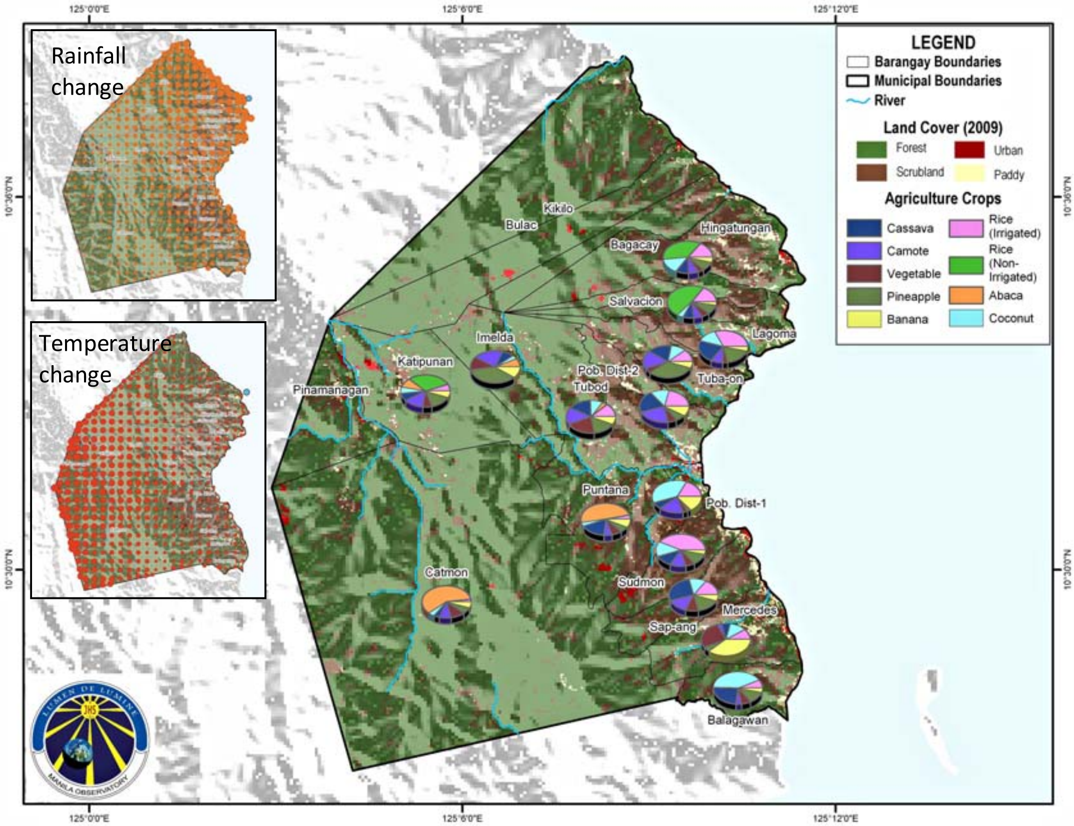


Figure VII.19. *Existing major agricultural crops in Silago per barangay. (Source: Silago CLUP, 2011). . (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Temperature and Rainfall Anomalies RCS-MO, Landsat 2009)*

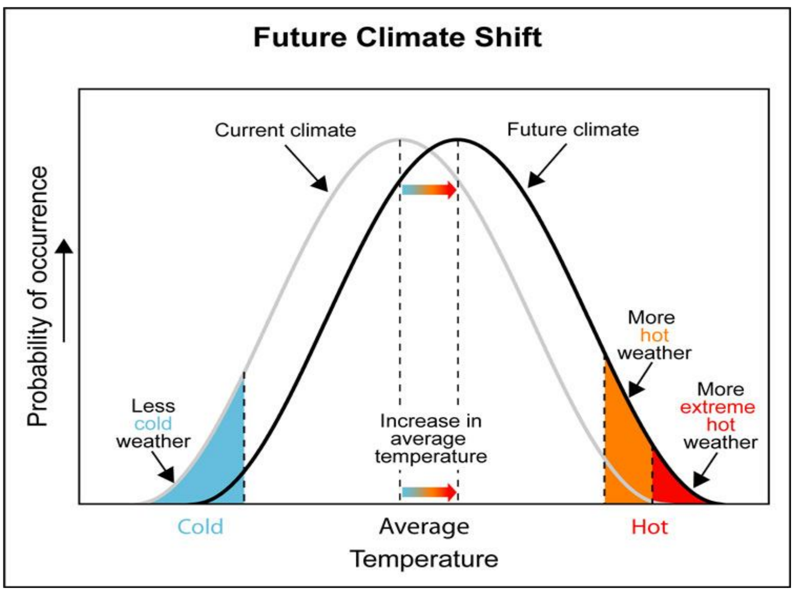


Figure VII.20. *An illustration of the impacts of global warming on future shifts in climate into a new regime. (Figure taken from: http://www.southwestclimatechange.org/figures/temperature-shift)*

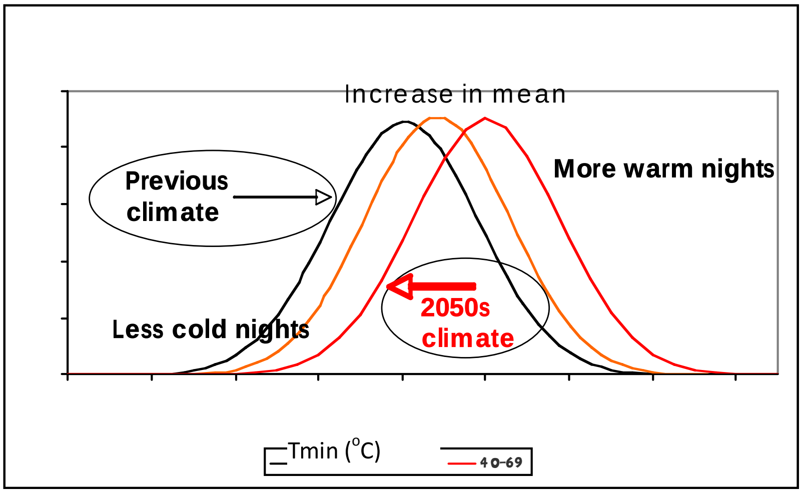


Figure VII.21. *The projected changes in minimum temperatures in Silago showing a potential shift into a new regime by 2020 and 2050.*

Agriculture is also vulnerable to any changes in climate during the planting season. Planting time for non-irrigated rice fields are often done during the rainy season in Silago (Table VII.6). Hence any future change in the wet season may affect rice production. Climate projection results (Figure VII.12) show that there is a slight decrease in rainfall for the month of December in 2050. However, the months of January and February (considered still to be part of the rainy season), will have larger decreases in rainfall. On average, by 2050 Silago will experience a -22% decrease in rainfall during the wet months of October, November, December, January, and February and a -17% decrease in the months of June, July, August, and September. These changes in seasonal climate may also affect the production of sweet potato, taro, and ube (planted in December), and vegetables (planted in February to March).

Table VII.6. *Crops and the corresponding labor peaks and acitvites in Silago.*

Crops	Activities
Abaca	Processing is done during dry season
Cassava	Planting time is April to May
Coconut	Processing is done every quarter of the year
Corn	Planting season is in March and harvesting is done after five months.
Irrigated rice field	Planting can be done three times per year.
Non irrigated field	Planting time during rainy season (June and December)
Pineapple	Harvesting is done during May after two years from planting
Sweet potato, taro, ube	August - October: Preparation of land (clearing, burning) December: planting
Vegetables	Planting time during February to March

(Source: NRMS, Leyte Island, 2001)

Given the projected severe impacts of climate change on rice yield in Silago, a production-consumption analysis for rice is useful to assess the current status of food supply in the municipality. Such an anlaysis was done in the CLUP of Silago (MPDO, 2010). Table VII.7 shows that, currently there is more than enough rice produced for consumption and that there was a projected net surplus of 200,588 kilograms of rice for 2010 given an estimated population of 13,463. Rice surplus, however, is estimated to have steeply decreased since 2000 as the population in Silago continues to increase. This inverse relationship is evident in Figure VII.22.

Hence, even without climate change, population increase alone may put pressures on the rice supply of Silago. Given the potential negative impacts of the projected changes in climate and climate variability on rice yield, it will be important for Silago to incorporate climate scenarios when analysing the future relationships between production and consumption.

Table VII.7. *Production-Consumption Analysis for Rice, 2000-2010.*

Year	Estimated Population
2000	10,963
2001	11,212
2005	12,199
2010	13,463
Rice Production Area Classification	Area (in Hectare)
Irrigated Rice Non-Irrigated Rice	500 40
Production	
Irrigated Rice	70,000 cavans of Palay/Annum
Non-Irrigated Rice	4,800 cavans of Palay/Annum
TOTAL	74,800 cavans of Palay
Total Rice Yield at 50% recovery	37,400 cavans of Rice
Total Rice in kgs. At 50 kgs./cavans of Rice	1,870,000 kgs. Of Rice
Population that can be supported by rice production from standard of 124 kgs. Per capita consumption	15,080
Rice Surplus in kgs.	Kilograms
2000	* 510,588 kgs.of Rice
2001	* 479,712 kgs.of Rice
2005	* 357,324 kgs.of Rice
2010	* 200,588 kgs.of rice

(Source: Silago CLUP, 2006; MPDO, 2010)

Assumptions as mentioned in the municipal CLUP:
a) Yield/hectare/harvest for irrigated rice = 70 cavans of palay
b) Yield/hectare/harvest for non irrigated rice = 60 cavans of palay
* Derived from multiplying the population by the standard of 124 kg per capita consumption, less rice production of 1,870,000 kg of rice.

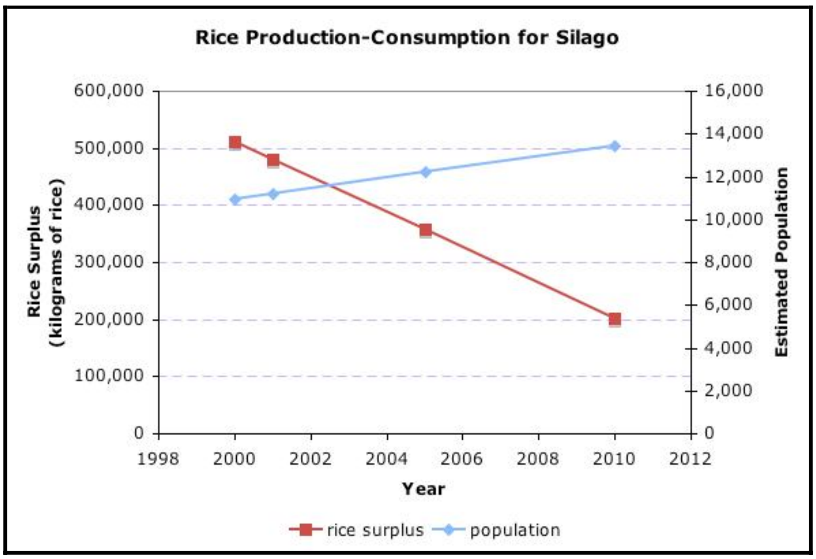


Figure VII.22. *Rice Production-Consumption analysis for Silago based on the data from the municipal CLUP. (Source: Silago CLUP, 2006)*

F. ADAPTATION OPTIONS FOR THE AGRICULTURAL SECTOR

There are numerous proposed adaptation options for the agricultural sector given the extreme vulnerability of this sector to the impacts of climate change. These measures range from technology advances (such as developing rice varieties), government interventions (such improving and building new irrigation infrastructures), farm productions (such as changes in planting date), and financial management systems. Table VII.8 outlines a series of adaptation options taken as is from different literature sources.

Table VII.8. *Adaptation options for the agricultural sector.*

Adaptation Options	References
TECHNOLOGICAL DEVELOPMENTS *Crop development* • Develop new crop varieties, including hybrids, to increase tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions. *Weather and climate information systems* • Develop early warning systems that provide daily weather predictions and seasonal forecasts. *Resource management innovations* • Develop water management innovations, including irrigation, to address the risk of moisture deficiencies and increasing frequency of droughts. • Develop farm-level resource management innovations to address the risk associated with changing temperature, moisture and other relevant climatic conditions.	Smit, Barry and Skinner, Mark W. 2004. Adaptation Options in Agriculture to Climate Change: A Typology. (http://www.springerlink.com/content/w5j4ug89760tdbjd/fulltext.pdf). Journal: Mitigation and Adaptation Strategies for Global Change Volume 7, Number 1 / March, 2002 Publisher: Springer Netherlands
GOVERNMENT PROGRAMS AND INSURANCE *Agricultural subsidy and support programs* • Modify crop insurance programs to influence farm-level risk management strategies with respect to climate-related loss of crop yields. • Change investment in established income stabilization programs to influence farm-level risk management strategies with respect to climate-related income loss. • Modify subsidy, support and incentive programs to influence farm-level production practices and financial management. • Change ad hoc compensation and assistance programs to share publicly the risk of farmlevel income loss associated with disasters and extreme events. *Private insurance* • Develop private insurance to reduce climate-related risks to farm-level production, infrastructure and income. *Resource management programs* • Develop and implement policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions.	
FARM PRODUCTION PRACTICES *Farm production* • Diversify crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change. • Diversify livestock types and varieties to address the environmental variations and economic risks associated with climate change. • Change the intensification of production to address the environmental variations and economic risks associated with climate change. *Land Use* • Change the location of crop and livestock production to address the environmental variations and economic risks associated with climate change. • Use alternative fallow and tillage practices to address climate change-related moisture and nutrient deficiencies.	

<table>
<tr>
<td>Land topography
• Change land topography to address the moisture deficiencies associated with climate change and reduce the risk of farm land degradation.

Irrigation
• Implement irrigation practices to address the moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought.

Timing of operations
• Change timing of farm operations to address the changing duration of growing seasons and associated changes in temperature and moisture.</td>
<td rowspan="2"></td>
</tr>
<tr>
<td>FARM FINANCIAL MANAGEMENT

Crop insurance
• Purchase crop insurance to reduce the risks of climate-related income loss.

Crop shares and futures
• Invest in crop shares and futures to reduce the risks of climate-related income loss.

Income stabilization programs
• Participate in income stabilization programs to reduce the risk of income loss due to changing climate conditions and variability.

Household income
• Diversify source of household income in order to address the risk of climate-related income loss.</td>
</tr>
<tr>
<td>Risk: Crop area changes due to decrease in optimal farming conditions

Main climatic causes of risk:

Changes in monthly precipitation distribution
Increased temperatures in critical periods
Increased erosion
Loss of soil water retention capacity

A. Farming optimal conditions altered resulting in creased risk to rural income
• Livelihood diversification
• Strengthen local capacity to reduce sensitivity
• Conversion of ambient storage to refrigerated stores
• Irrigation
• Changing cultivation practices
• Increased irrigation
• Change of cropping mix
• Switching to alternative crops

B. Loss of Indigenous species
• Climate change resilient crops
• Insurance

C. Soils deterioration due to land-use changes
• Extensification: enhance carbon management and zero tillage
• Precision agriculture: improve soil and crop management

D. Land abandonment due to very large changes in optimal conditions
• Intensify research efforts and an enhanced training
• Livelihood diversification</td>
<td rowspan="2">Table 27 Potential consequences for agricultural production of the identified risks and opportunities, adaptation options, option category and level of implementation.
* T: Technical / M: Management / I: Infrastructural / E: Equipment
** F: Farm level / S: Sector level

Authors: Ana Iglesias, Keesje Avis, Magnus Benzie, Paul Fisher, Mike Harley, Nikki Hodgson, Lisa Horrocks, Marta Moneo, Jim Webb
Report Title: Adaptation to Climate Change in the Agricultural Sector AGRI-2006-G4-05

AEA Energy & Environment and Universidad de Politécnica de Madrid

Report to European Commission Directorate -</td>
</tr>
<tr>
<td>Risk: Decreased Crop Productivity

Main climatic causes of risk:
Changes in monthly precipitation distribution
Increased temperatures in critical periods (heat stress)</td>
</tr>
</table>

Loss of soil water retention capacity A. Crop productivity decrease • Change in crops and cropping patterns • Irrigation • Advisory services for farmers on adapted farming practices, new crops B. Crop productivity variability risk Increased • Agricultural insurance • Crop planting diversification C. Land abandonment • Design of regional adaptation plans • Livelihood diversification D. Agricultural trade intensification • Strengthen local capacity to reduce sensitivity	General for Agriculture and Rural Development Issue Number 1 December 2007
Risk: Increased risk of agricultural pests, diseases, weeds Main climatic causes of risk: Increased water logging Increased average temperatures A. Pest populations increase and distribution with increased temp • Use new pest resistant varieties • Develop sustainable integrated pesticides strategy • Use of natural predators • Vaccinate livestock • Monitoring of pests/diseases patterns to prevent damages B. Pollution by increased use of pesticides • Develop sustainable integrated pesticides strategy • Advisory support for farmers	
Risk: Crop quality decrease Main climatic causes of risk: Heat stress Changes in annual and seasonal precipitation distribution A. Crop quality reduction in fruits and vegetables • Thermal screens • Temperature control B. Damage to grain formation due to heat stress • Thermal screens • Temperature control	
Risk: Increased risk of floods Main climatic causes of risk Increase of extreme events frequency Loss of soil water retention capacity A. Increased expenditure in emergency and remediation actions • Develop contingency plans • Create/restore wetlands • Enhance flood plain management • Hard defences B. Flash flood frequency and intensity increase • Increase rainfall interception capacity	

• Move towards farmers as ‘custodians’ of floodplain lands with appropriate compensation • Reduce grazing pressures to protect against soil erosion from flash flooding C. Flooding and storm damage increase • Increase rainfall interception capacity/soil management • Contour ploughing • Increase drainage • Addition of organic material into clay soils (difficult to work in wetter conditions) • Insurance for farm infrastructure	
Risk: Increased risk of drought and water scarcity Main climatic causes of risk: Decreased annual and/ or seasonal precipitation Increase in the frequency of extreme conditions (droughts and heat waves) A. Conflicts among water users due to drought and water scarcity • Shift crops from areas that are vulnerable to drought • Set clear water use priorities • Increase water use efficiency B. Water supply reduced • Increase rainfall interception capacity (techniques for conserving soil moisture) • Improve field drainage and soil absorption capacity • Reduced run-off via contoured hedgerows and buffers • Altering crop rotations to introduce crops more tolerant to heat/drought • Woodland planting • Use of precision farming: tillage and timing of operations • Small-scale reservoirs and methods to collect water • Water management • Water audits • Water charging/tradable permit schemes to promote efficient use of prescribed (reduced) sources • Insurance (or other risk protection tools) C. Damage to Wetlands • Installation of small-scale water reservoirs on farmland • Recreate wetlands	
Risk: Increased irrigation requirements Main climatic causes of risk: Increased average and extreme temperature Increase of drought and heat stress conditions frequency Decreased precipitation A. Water availability decrease, Water shortage in irrigated areas • Invest in irrigation equipment that helps reduce the severity and collects rain water • Technical improvements in advanced irrigation equipment • Trickle irrigation • Irrigation during the night • Separation of clean and dirty water • Installation of small-scale water reservoirs on farmland	
Risk: Water quality deterioration Main climatic causes of risk: Increased precipitations extremes, flood and drought frequency A. Water quality loss due to the higher leaching and run-off • Aerating ploughing equipment	

• Develop less polluting inputs • Timed input of N inputs • Reduce N outputs from soil through enhanced efficiency of fertiliser use	
Risk: Soil erosion, salinisation, desertification Main climatic causes of risk: Increased temperature Sea level rise Decreased precipitation Extreme conditions (heavy precipitations, drought) A. Desertification due to water resources deficit, loss of soil structure, land abandonment • Livelihood diversification • Strengthen local capacity to reduce sensitivity • Intensify research efforts and an enhanced training B. Soil salinisation increases • Change in cropping • Allocate fields prone to flooding from sea level rise as set aside C. Erosion and accretion increase • Change fallow and mulching practices to retain moisture and organic matter • Use intercropping to maximise use of moisture D. Soil drainage changes leading to increased salinity • Change fallow and mulching practices to retain moisture and organic matter E. Water logging increases • Invest in machinery or development and disseminate good practices that minimise the adverse effects of water logging F. Loss of rural income • Change fallow and mulching practices to retain moisture and organic matter • Livelihood diversification • Strengthen local capacity to reduce sensitivity	
Risk: Sea-level rise Main climatic causes of risk: Increased sea temperature and accompanying thermal expansion of sea water A. Sea level intrusion in coastal agricultural areas and salination of water supply • Hard defences • Alternative drainage systems • Set aside of land for buffer zones • Alternative crops • Livelihood diversification • Research into other options for management of salt water intrusion	
Opportunity: Crop distribution changes leading to increase in optimal farming conditions Main climatic causes of opportunity: Increased availability of CO_2 Increased temperatures A. Crop suitability increase • Introduce more productive varieties • Increase range of crops (annual and permanent) • Grow quicker maturing varieties to maximize yields • Investment in energy crops, short-rotation coppice and miscanthus	
Opportunity: Crop productivity increase	

(Main climatic causes of opportunity Increased availability of CO_2 Increased temperatures A. Crop yield and biomass increase leading to increased potential efficiency of physiological water use due to CO_2 increase • Introduce more productive varieties • Grow quicker maturing varieties to maximize yields B. Reduced drought impacts and damage • Drought resistant varieties obtained by improved breeding or by importing them from drier locations	

VIII. VULNERABILITY AND IMPACTS OF CLIMATE CHANGE ON THE COASTAL SECTOR

A. GENERAL INTRODUCTION: COASTAL SECTOR

The Municipality of Silago is coastal in nature, with approximately 27.82 kms of coastline, covering 14 barangays namely: Kikilo, Bulac, Bagacay, Hingatungan, Salvacion, Lagoma, Tuba-on, Poblacion District 2, Poblacion District 1, Sudmon, Sap-ang, Mercedes, and Balagawan (Figure VIII.1).

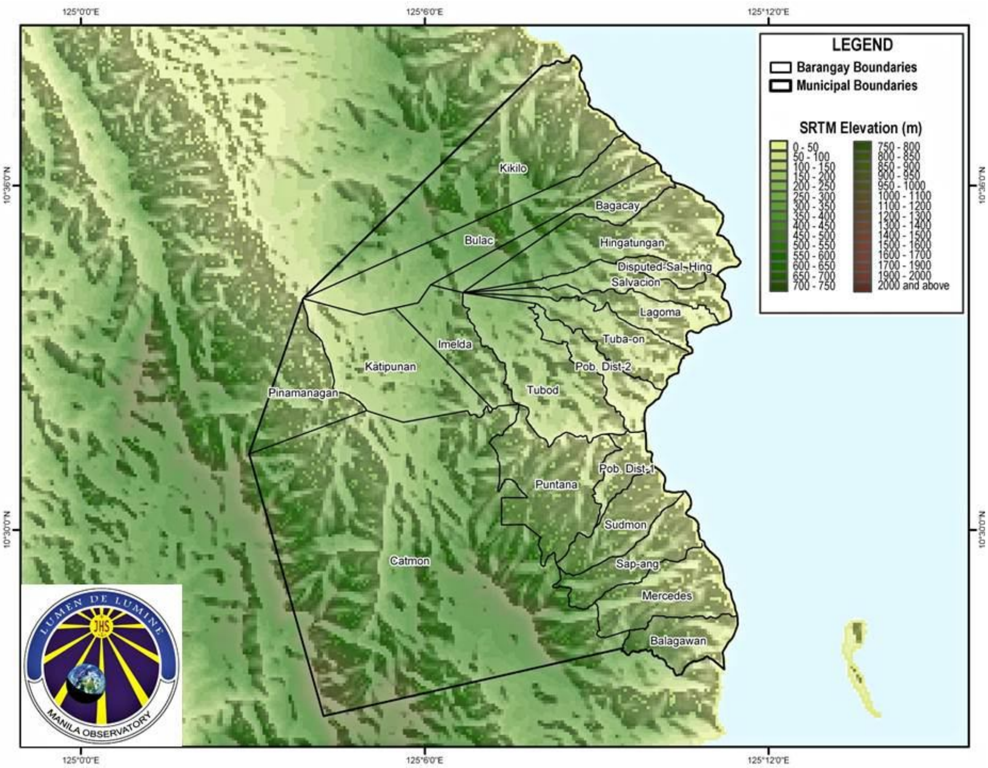


Figure VIII.1. *Map of Municipality of Silago, Southern Leyte. . (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000))*

Various ecosystems can be found in the coastal area. These include coral reefs, seagrass and seaweed beds, mangroves, estuaries, and beaches. At present, there is no mapped information of the spatial location of these ecosystems. However, it has been mentioned in the municipality's CLUP (2000) that protected mangrove areas cover 40 hectares while beach areas cover 7 hectares. The mangrove areas contribute to 0.18% of the total general land-use in Silago, while the beach areas contribute 0.03%.

There is a marine sanctuary located in Brgy. Hingatungan with detailed resource and ecological assessment conducted (Cesar et al., 2003). The physico-chemical parameters for 2002 and 2003 were examined and compared. However, the gathered data were not complete for comparison and certain conditions (e.g. date of sampling and exact time) were not explicitly described in the report (see Table VIII.1).

Table VIII.1. *Physico-chemical parameters and GPS readings of Hingatungan Sanctuary, Silago, Southern Leyte.*

Parameters		2002	2003
	Surface	*	30
Water Temperature (°C)	Bottom	28.5	**
	Surface	*	35
Salinity (o/°°)	Bottom	31	**
	Surface	*	8.4
pH	Bottom	8.24	**
Depth (m)		6	12.5
Conductivity (µS/cm)	Surface	-	50,000
Water transparency (m)		*	17
GPS Readings	N 10° 35' 34.7" E 125° 11' 17.1"		
*No data gathered due to strong wave and current			
**Bottom water sample was not taken due nonfunctional water sampler.			

Source: Cesar et al., 2003

Mangroves species are present in Barangay Hingatungan (11 species) and Barangay Lagoma (4 species). Comparisons of the 2002 and 2003 data showed no significant changes in Barangay Lagoma while changes in composition for Barangay Hingatungan were attributed to transect locations surveyed during the different years.

There are three seaweed, four seagrass, and one associated species recorded inside the marine sanctuary of Hingatungan (see Table VIII.2). Changes in the seaweed/seagrass frequency and cover were noted for 2002 and 2003 and attributed to the location of the transect lines.

Table VIII.2. *Species composition, frequency of occurrence, cover of seaweeds and seagrasses and density associated invertebrates at the marine sanctuary of Hingatungan, Silago, Southern Leyte.*

Species	F	C	Remarks
Phaeophytes:	**10.4**	**4.5**	
Padina minor	2.8	0.3	(Transect was inside
Sargassum polycystum	7.6	4.1	marine sanctuary; 150m
Rhodophytes:	**6**	**0.2**	reef flat; intertidal area
Gracilaria eucheumoides	6	0.2	
Mean F/Total C	8.2	4.6	mainly sandy substrate;
Seagrasses:	22.3	25.1	lower intertidal rocky
Cymodocea serrulata	40.4	14.4	exposed to big waves)
Halodule uninervis	20	3.5	
H. pinifolia	24	5.3	
Thalassia hemprichii	4.8	2	
Associated Invertebrates:	0.2	0.2	
Univalve (no./0.25m²)	0.2	0.2	

Source: Cesar et al., 2003

The assessment for coral reefs was done only for 2003 due to constraints in weather condition during the 2002 sampling. The total live coral cover for the study area is 15.13% and is under the poor category. During the survey, there were minimal observations of destructive fishing that may contribute to the poor reef status. However, it was noted that the natural topography of the area makes it susceptible to strong currents and wave actions thereby lessens massive reef development.

The survey for fish resources showed a low fish counts for Hinatungan marine sanctuary, being attributed to the differences in the physical features of the reef (Figure VIII.2). The sanctuary's reef has many large smooth bare rocks and do not provide food for corallivores (fishes eating corals) nor shelter for other fishes. The area is also exposed to swells from the Pacific ocean resulting to stronger and heavier wave motion sending fishes to deeper waters or refuge into coral heads.

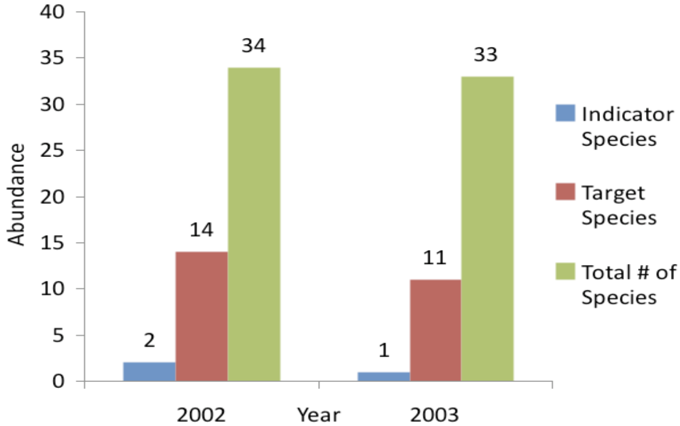


Figure VIII.2. *Results of fish visual census carried out at Hingatungan, Silago, Southern Leyte. (Source: Cesar et. al., 2003).*

The residents in the coastal communities are involved in fishing, farming, aquaculture, vending, and dealing goods. There were 100 registered fisherfolks in 12 coastal barangays as of September, 2009. Most of them are into part-time fishing and farming, aquaculture, vending, and dealing (see Figure VIII.3, Cesar et. al. 2003). Several fish dealers were noted in the municipality. However, they operate on a seasonal basis depending on the available supply (CLUP, 2000). Since most of the barangays in Silago are located along the coast, it implies a high dependence on the coastal resources by the populace for food consumption, trade, and income.

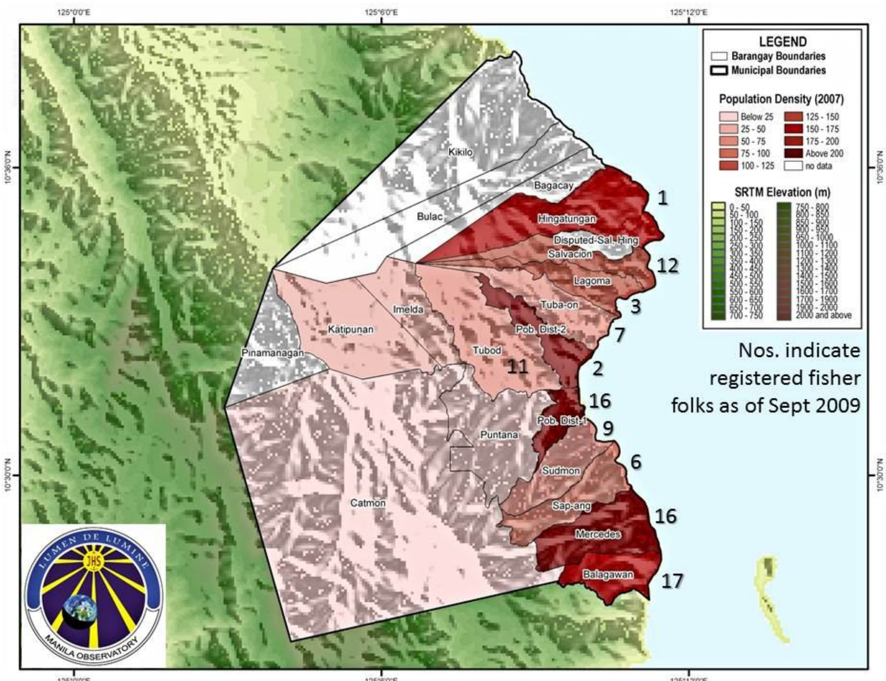


Figure VIII.3. *Population Density (2007) of Silago, Southern Leyte. The numbers indicate the registered fisherfolks as of September 2009. (Source: DA-LGU Silago). . (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Population Density National Statistics Office).*

The municipality has identified a Fishery Development Zone of 40 hectares, comprising the 0.1% of the total development zone in the area. To help in protecting and conserving the coastal resources, efforts on coastal resource management were supported by GIZ (Silago-Anahawan) together with the implementing agencies namely: the Municipality of Silago LGU and people's organizations. The protected mangrove areas are located at Barangays Hingatungan, Lagoma, and Sudmon covering 40 hectares (CLUP, 2000).

B. Impact Chain, Influence Diagram, and Projections for the Coastal Sector of Silago

Impact Chain and Influence diagram

The changes in climate system affect ocean life and processes. Among the climate stimulus affecting the oceans include: increasing sea surface temperatures (SSTs), increasing number of tropical cyclones, increase in rainfall variation, and increasing concentrations of dust due to iron (Fe) fertilization.

The different climate stimulus influence ocean dynamics and processes, primarily the physic-chemical and biological properties of the oceans. The changes in the climate stimulus will definitely alter plankton dynamics and algal production. The changes will eventually cascade to the different coastal ecosystems such as estuaries, seagrass and seaweed beds, mangrove areas, beaches and shorelines, and coral reefs. The over-all impact of these changes will be felt by the coastal communities that depend on these areas for livelihood and sustainability (see Figure VIII.4).

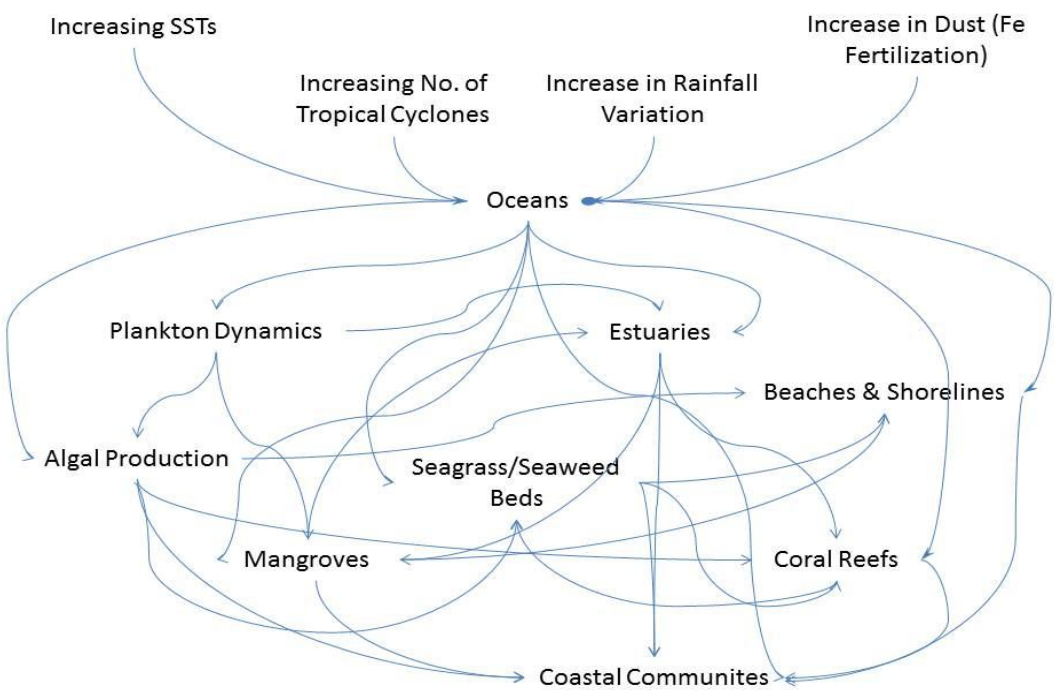


Figure VIII.4. *Influence Diagram for the Coastal Sector of the Municipality of Silago, Southern Leyte.*

The flow of impacts on various parameters is shown in the impact chain below (Figure VIII.5 and Figure VIII.6). The direct and indirect impacts for each ecosystem were identified by the research team and validated by the stakeholders in the municipality. The figures also indicate impacts to the society and implications for risk assessment. The different ecosystems exposed to climate changes include coral reefs, seagrass and seaweed beds, mangroves, estuaries, and beaches/shorelines. In Silago, all these ecosystems are present in the coastal zone.

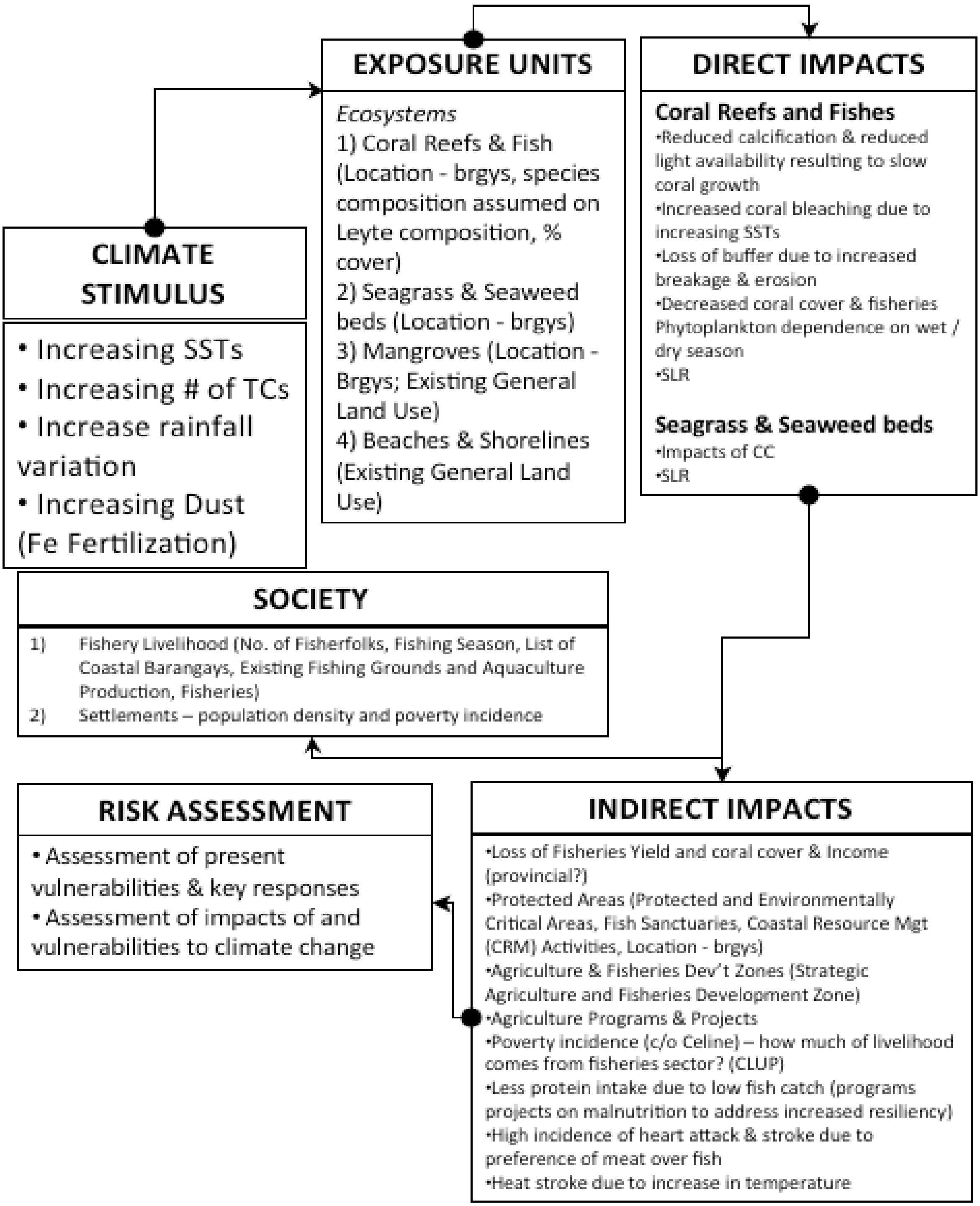


Figure VIII.5. *Impact Chain for the Coastal Sector (1 of 2).*

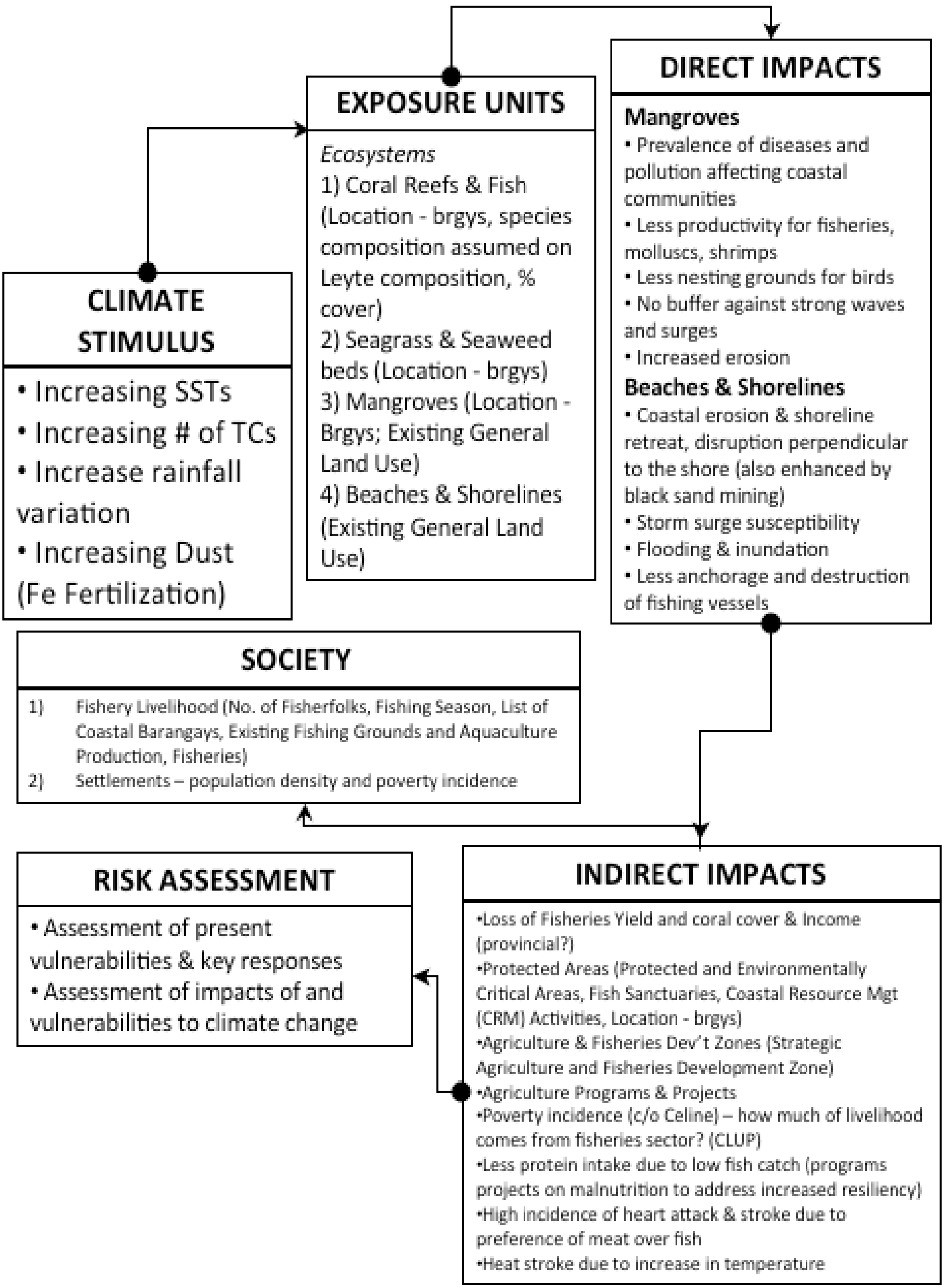


Figure VIII.6. *Impact Chain for the Coastal Sector (2 of 2).*

The changes in climate will definitely affect ocean dynamics and processes. These impacts include: a) differential increase in sea surface temperature (SST), b) variations in SST due to the changing frequency of the El Nino Southern Oscillation or ENSO, c) changes in the South China Sea (SCS) wind system during ENSO periods resulting in warming of surface waters, d) strengthening of alongshore winds that eventually enhance upwelling, e) lowering of thermocline (depth in the ocean zone where abrupt change in temperature is observed) resulting to disrupted upwelling areas, f) decrease capacity to dissolve carbon dioxide resulting in a decrease in biological carbonate formation, and g) sea-level rise resulting in increased water depths, tidal variations, and water movement alterations (Capili et al., 2005).

Moreover, Capili et al. (2005) also discussed that:

- Shifts in the physico-chemical properties of ocean waters may result in enhanced upwelling, where nutrients from deeper waters are transported to the shallower areas of the oceans. These shifts will impact plankton dynamics. Any change in plankton productivity, especially in shallow waters, will affect primary production. The increase concentrations of atmospheric carbon dioxide will result to an increase in primary production for carbon limited areas. This implies shifts in plankton abundance that will affect fishery production in the municipality of Silago. Such changes need to be considered in the efforts of the municipality's Fishery Development Zone as well as other associated livelihood activities. The same shifts may also increase the occurrence of toxic algal blooms that may result in mortality of various marine organisms, especially reef fishes.

- The changes in temperature and rainfall will affect the salinity and pH of the ocean, thereby disrupting the balance of fresh and salt waters in estuaries. This will eventually lead to reduced water mixing and oxygen depletion, affecting the nursery grounds of juvenile fishes and shell fishes. This will also block the normal migration routes outside the estuaries, resulting in mismatches between plankton blooms and juvenile fishes affecting food chain.

- Impacts in the seagrass and seaweed beds will also be evident at the onset of climatic changes. Expect altered growth rates, physiological functions, distribution, and reproduction patterns in these organisms. Also, the changes in the climate stimulus will disrupt competition and interaction among species and between seagrass and algal populations. In addition, there will be reduced productivity due to decrease light availability caused by water depths by sea-level rise. The changes in salinity will alter photosynthesis, growth, and biomass while frequent erosion alter nearshore areas where most seagrasses and seaweeds thrive.

- In mangrove areas, a decrease in run-off and increase in salinity will result to lesser mangrove production. These areas will also be affected by the disrupted balance of fresh and salt waters.

The changes in climate will alter the mangroves' reproductive patterns and seasonality, and may cause mortality during extreme conditions. These will have significant implications in terms of the viability of nursery grounds for fisheries and other associated livelihood in Silago.

- The beaches and shorelines of Silago are important locations for tourism and livelihood. The onset of erosion, however, may increase susceptibility of storm surges in these areas. They will also be exposed to salt-water intrusion and flooding that will affect coastal infrastructure and other activities.

- For coral reefs, changes in the SSTs will result in stress and coral bleaching that may lead to decrease in productivity and mortality. This will also increase the chances of disease incidence. Elevated sea-levels and lowering of pH will affect light availability thereby disrupting coral reef formation and productivity. These will all cascade to a decrease in the abundance of herbivores and result in an exponential decrease in fisheries yield. A redistribution of fish populations may also be observed as well as disrupted migration patterns of pelagic fishes. Coral species diversity and assemblage structure of recruits will also change.

All the changes in the coastal ecosystems will hit the coastal communities in one way or another. These communities will experience decline in fisheries yield, shifting livelihood sources, dietary constraints and poisoning due to toxic blooms, relocation of homes and may increase in migration of people (Capili et al., 2005).

The projections for temperature increase in Silago (see Figure VIII.7 and Figure VIII.8) showed increases in temperature in the coastal areas for both 2020 and 2050. These may also translate to changes in the SSTs as land and sea temperatures interact. A small increase in SSTs will have big impacts in marine life and processes. It will definitely impact coral reef productivity and will alter the impact thresholds of coastal organisms. All the above-mentioned impacts in the coastal zone are probable to happen.

The projected changes in rainfall for Silago (see Figure VIII.9 and Figure VIII.10) showed increased incidences of rainfall in coastal areas for both 2020 and 2050. These imply changes in the fresh and salt water balance thereby affecting salinity and pH of ocean waters, a critical part of primary productivity. The compounding effects of temperature and rainfall increase will definitely impact the state of the coastal resources and the sustainability of the coastal communities in the municipality.

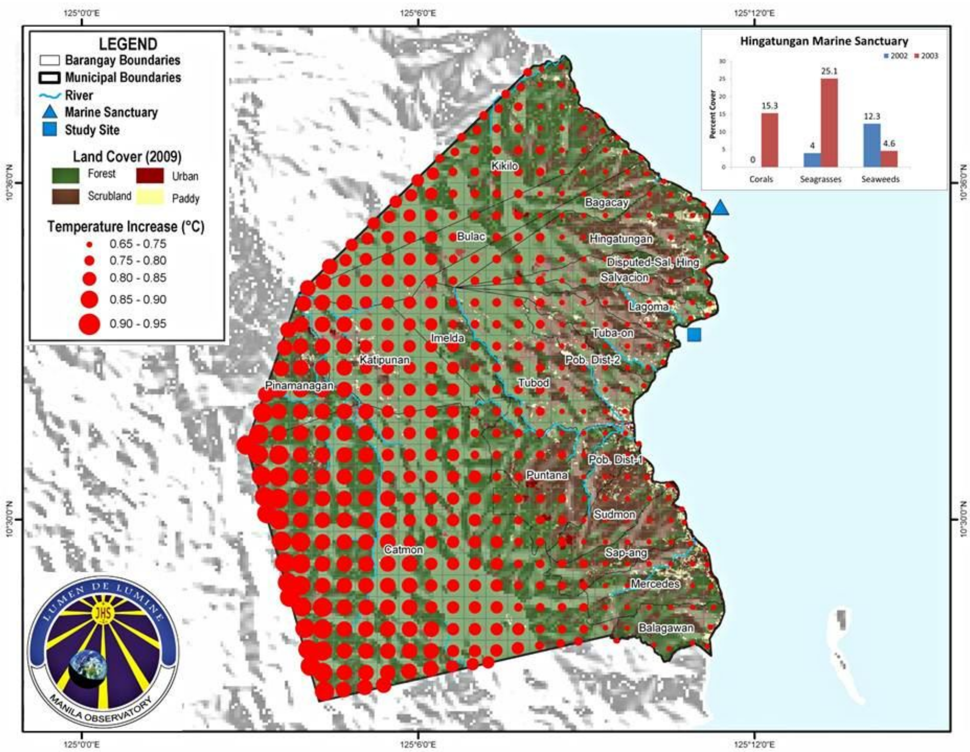


Figure VIII.7. *Land Cover (2009) and Projected Temperature Increase (2020) of Silago, Southern Leyte. Inset: Percent Cover of Corals, Seagrasses, and Seaweeds during 2002 and 2003 in Hingatungan Marine Sanctuary. Changes in temperature will affect productivity of coastal ecosystems. (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Temperature Anomaly RCS-MO, Landsat 2009).*

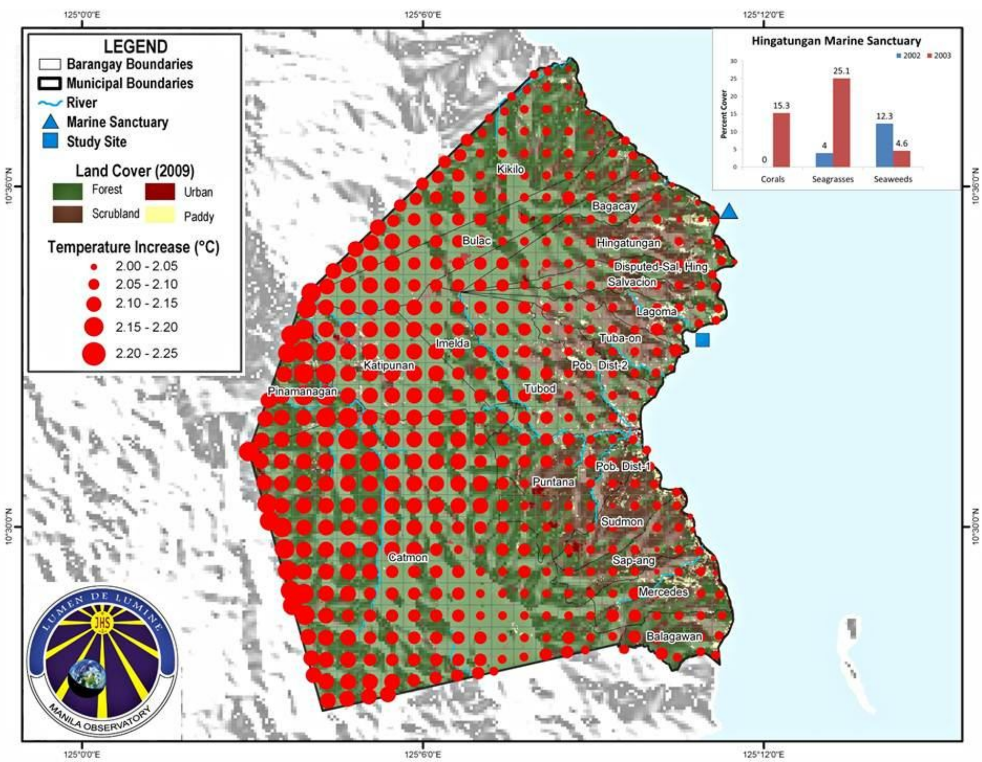


Figure VIII.8. *As in Figure VIII.7 but for 2050.*

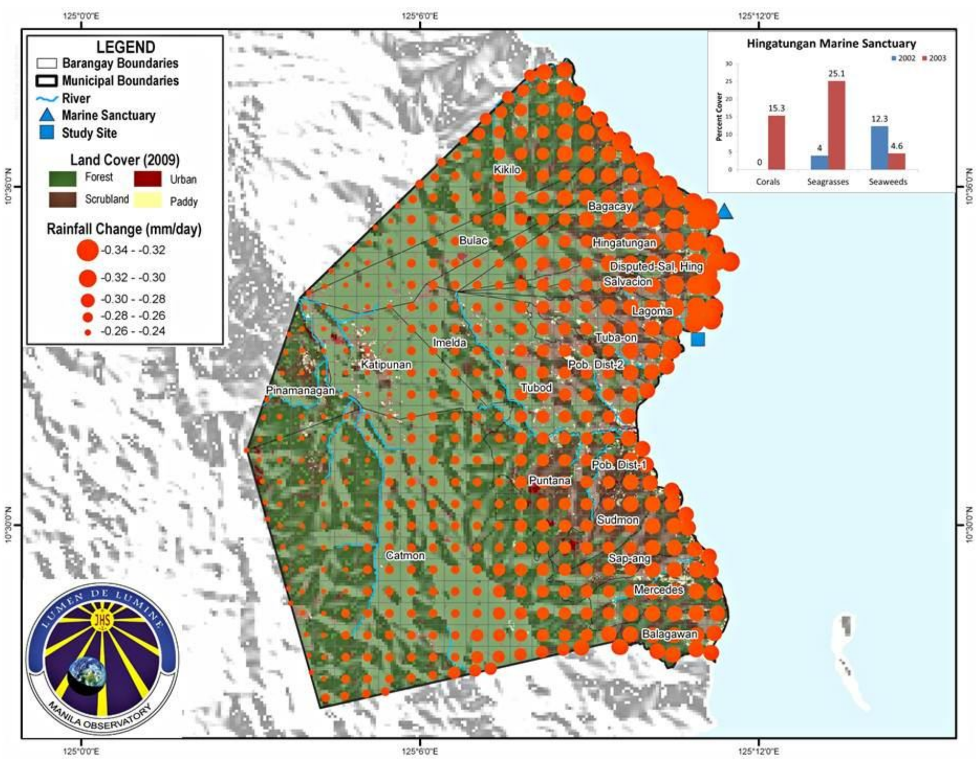


Figure VIII.9. *Land Cover (2009) and Projected Rainfall Change (2020) of Silago, Southern Leyte. Inset: Percent Cover of Corals, Seagrasses, and Seaweeds during 2002 and 2003 in Hingatungan Marine Sanctuary. Changes in rainfall will affect pH and salinity of ocean waters thereby affecting coastal ecosystems. (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Rainfall Anomaly RCS-MO, Landsat 2009).*

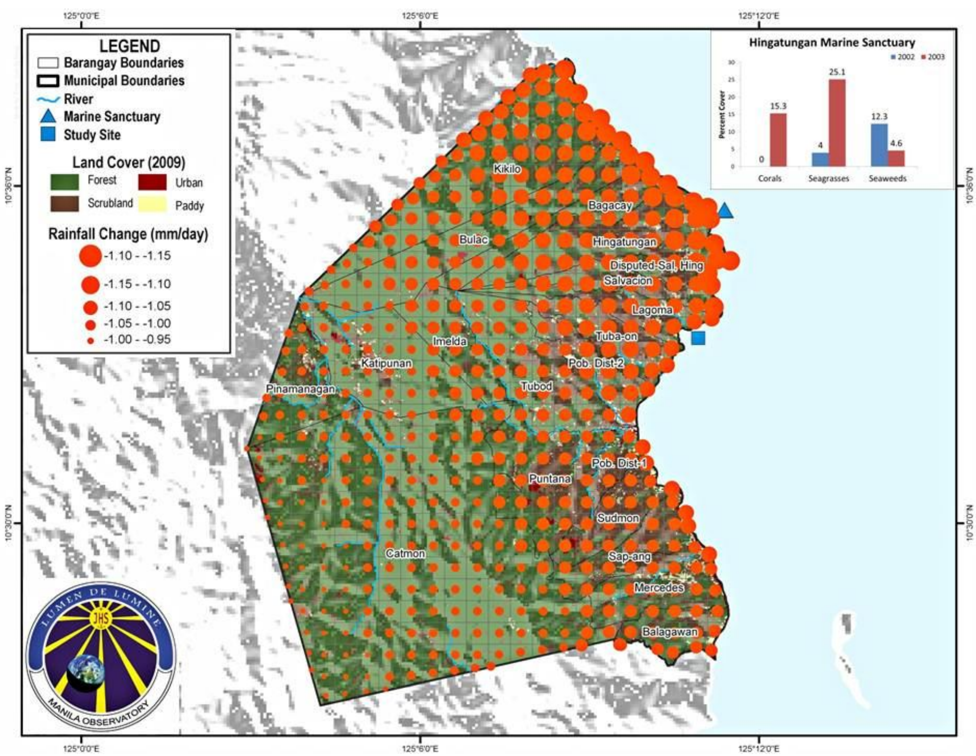


Figure VIII.10. *As in Figure VIII.9 but for 2050.*

IX. DISCUSSION AND CONCLUSION

This study aims to describe the patterns of vulnerability of the forestry, water, agriculture, and coastal sectors of Silago, Southern Leyte, using the archetype approach prescribed within the CI:GRASP Framework.

A. 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 coconut as the major product. Among the identified development needs include the improvement of 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.

B. CLIMATE PROJECTIONS

Climate projections for Silago indicate: a) a slight increase in mean rainfall for the dry season of 2020s while a decrease for the other seasons. 2050s might reach a decrease on its mean rainfall by as much as 20-25% during the dry season; b) as much as 1.9 to 2 ^{o}C increase in average temperature which might be expected during the warm dry months (April & May) during the 2050's, and c) extremely hot maximum temperature (95th Percentile of the baseline period, 1961 to 1990) which will be more common by at least 50 percent during the 2050's.

C. CLIMATE IMPACTS AND KEY VULNERABILITIES

Forest Sector

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.

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

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.

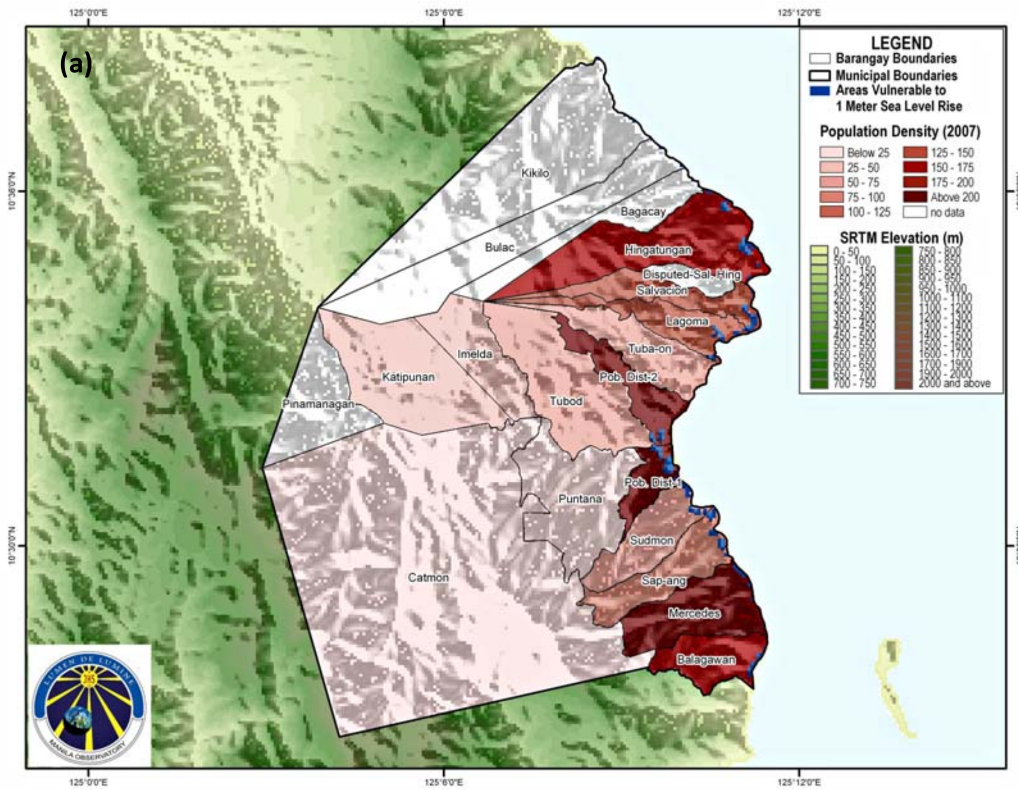
Agriculture Sector

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.

D. RISK IMPLICATIONS OF FUTURE CLIMATE CHANGES IN SILAGO

Patterns of vulnerabilities and the potential adverse effects of future climate changes on the four sectors of forestry, water, agriculture and coastal have been discussed. The analyses have mainly centered on the climate stimulus, i.e. the projected impacts of climate change on temperature, rainfall, and sea level rise. But 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. Here, indicators based on available data on these two important factors are discussed and shown to provide a qualitative assessment of the overall risks to climate change that Silago may face in the future.

Population density can be one indicator of social exposure and consequently vulnerability. Figure IX.1 shows the 2007 population density for Silago and the potential impacts of various levels of increase in sea level on these population. Barangays Hingatungan, Poblacion District 2, Poblacion District 1, Mercedes are the most vulnerable given the high population density and larger flooded areas in these barangays. Note that decreases in rainfall will also affect rice production in Hingatungan where most of the municipal's non-irrigated riceland are located. Changes in temperature will affect the population inland, which is relatively small compared with the population density along the coastal areas (Figure IX.2). Rainfall decrease, however, will affect the most the highly populated areas in Bgys Hingatungan, Salvaction, and Lagoma. Barangays Kikilo, Bulac, Bagacay, Tuba-on, and Poblacion District 2 will also be affected by the drier conditions.



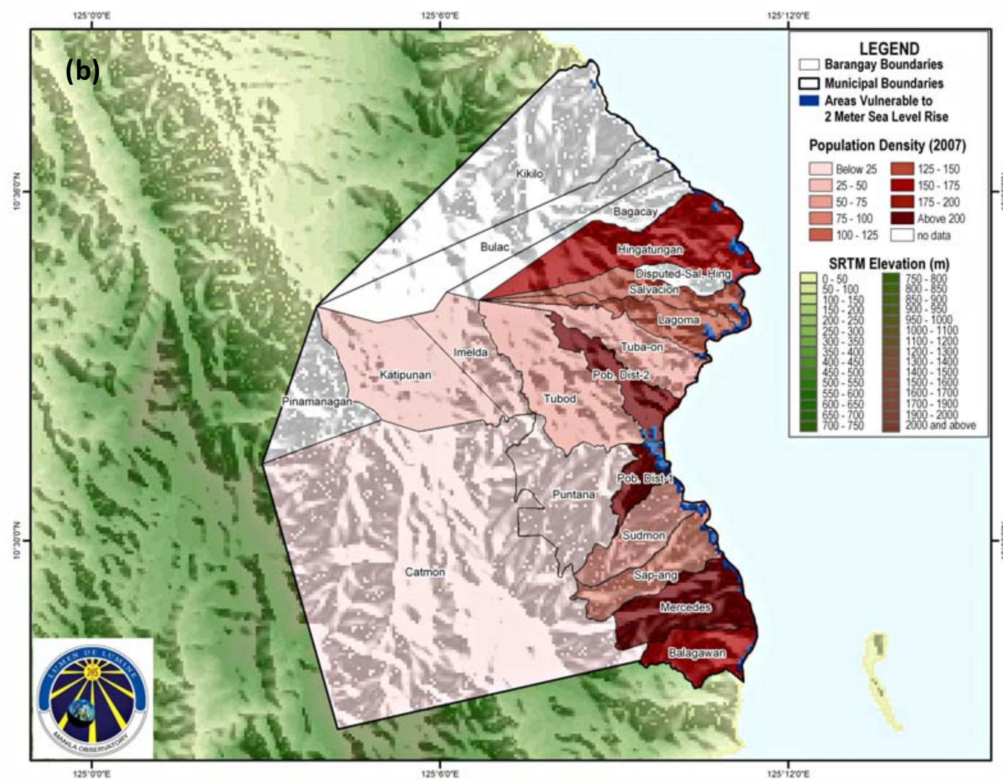


Figure IX.1. *Areas and population densities vulnerable to a a) 1 meter-, b) 2 meter-, and c) 4-meter rise in sea level. (Population data source: National Statistics Office) (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Population Density National Statistics Office).*

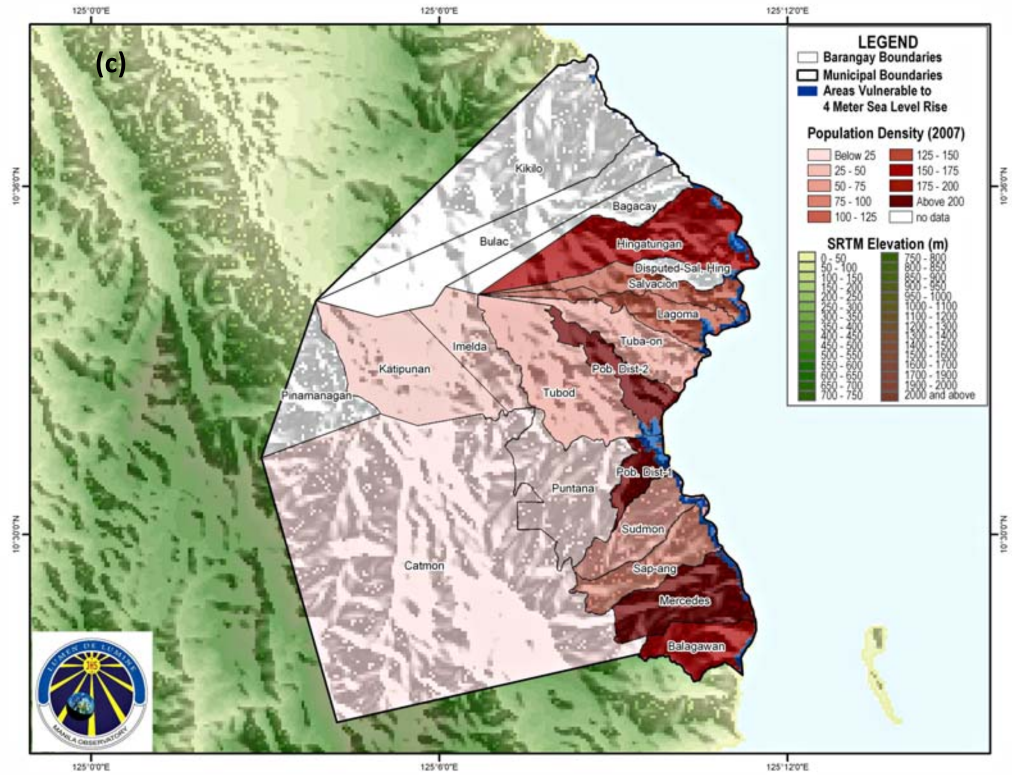


Figure IX.1. *Continued.*

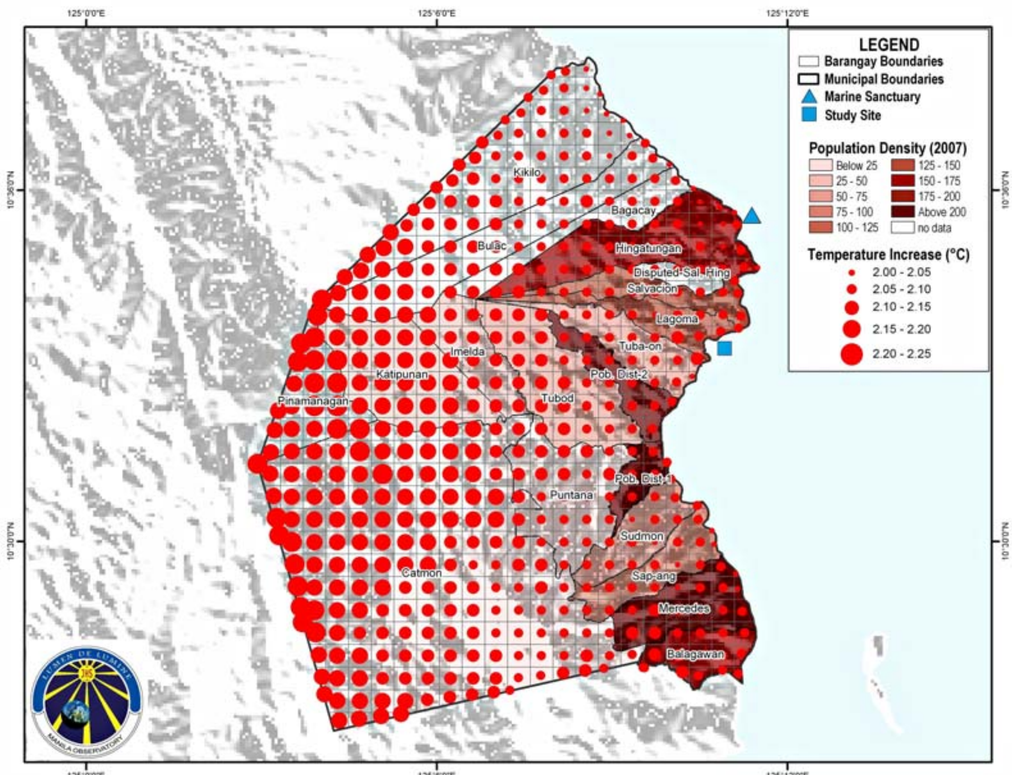


Figure IX.2. *Projected increase in temperature by 2050 in Silago and the 2007 population density. (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Population Density National Statistics Office, Temperature Anomaly RCS-MO).*

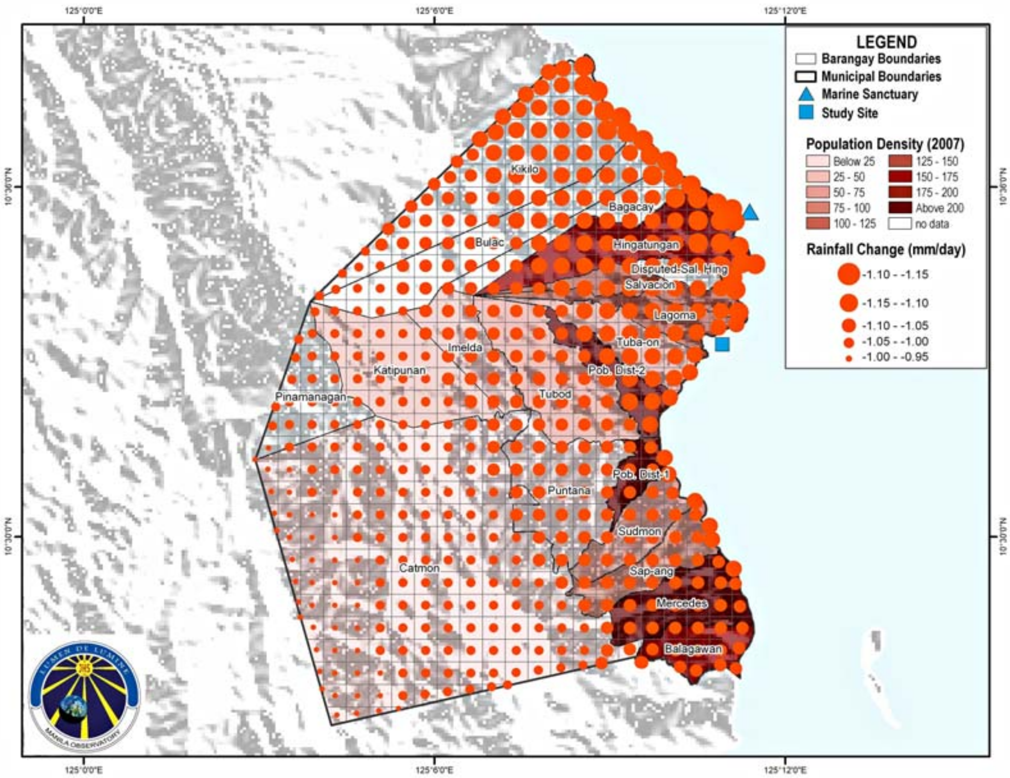


Figure IX.3. *Projected decrease in rainfall by 2050 in Silago and the 2007 population density. (Map Data Sources: Shuttle Radar Topographic Mission version 4 (Feb. 2000), Population Density National Statistics Office, Rainfall Anomaly RCS-MO).*

The number of malnourished children is a useful indicator of vulnerability to climate change effects. In a policy report by the International Food Policy Research Institute on "climate change impact on agriculture and costs of adaptation" (Nelson et al., 2009), the study used per capita calorie consumption and child malnutrition as the two indicators for assessing the impacts of climate change on food security and human well-being. The report assessed how much it would cost in investments to return the values of the two indicators into a no climate change scenario in 2050. Their analysis shows that using the projections of two global climate models, it will cost developing countries around US$7.1 to US$7.3 billion of investments on agricultural research, irrigation, and rural roads to counteract the impacts of climate change on child malnutrition. Hence, pre-existing high occurrences of child malnutrition indicate greater vulnerabilities to climate change effects on the health and well-being of children. Figure IX.4 shows the number of malnourished children in Silago in 1999 per barangay expressed as a percentage of the population 14 years old and below. Barangays Tubod, Imelda, and Poblacion District 2 have the highest percentage, 50% and above, of malnourished children. Cases child malnutrition in Puntana, Mercedes, Tuba-on and Lagoma are also relatively high, with values ranging from 35% to 47%.