USAID
FROM THE AMERICAN PEOPLE

# Climate Change Projections for Local Planning: A Practical Application of Overlay Analysis and Synthetic Impact Assessment in the Cities of Batangas, General Santos, Legazpi, Puerto Princesa and Tagbilaran

Strengthening Urban Resilience for Growth with Equity (SURGE) Project

CONTRACT NO. AID-492-H-15-00001

**AUGUST 8, 2018**

# Climate Change Projections for Local Planning: A Practical Application of Overlay Analysis and Synthetic Impact Assessment in the Cities of Batangas, General Santos, Legazpi, Puerto Princesa and Tagbilaran

## Strengthening Urban Resilience for Growth with Equity (SURGE) Project

## CONTRACT NO. AID-492-H-15-00001


| | |
|---|---|
| Program Title: | USAID/SURGE |
| Sponsoring USAID Office: | USAID/Philippines |
| Contract Number: | AID-492-H-15-00001 |
| Contractor: | International City/County Management Association (ICMA) |
| Date of Publication: | August 8, 2018 |

## Table of Contents

# ACRONYMS

| | |
|---|---|
| BCWD | Batangas City Water District |
| CCA | Climate change adaptation |
| CCAM | Conformal cubic atmospheric model |
| CDI | Cities Development Initiative |
| CLIRAM | Climate information and risk analysis matrix |
| CLUP | Comprehensive Land Use Plan |
| DOST | Department of Science and Technology |
| DREAM | Disaster risk and exposure assessment for mitigation |
| DRRM | Disaster risk reduction and management |
| GCMs | Global climate models |
| GIS | Geographic Information System |
| HLURB | Housing Land Use Regulatory Board |
| IPCC | Intergovernmental Panel on Climate Change |
| LGU | Local government unit |
| LiDAR | Light Detection and Ranging |
| NEDA | National Economic and Development Authority |
| NOAH | Nationwide Operational Assessment of Hazards |
| PAGASA | Philippine Atmospheric, Geophysical and Astronomical Services Administration |
| PHILCCA | Philippines Climate Change Assessment |
| PRECIS | Providing regional climates for impacts studies |
| PSA | Philippine Statistics Authority |
| RCMs | Regional climate models |
| RCP | Representative concentration pathways |
| SURGE | Strengthening Urban Resilience for Growth with Equity |
| USAID | United States Agency for International Development |

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF BATANGAS CITY MAPS

## LIST OF GENERAL SANTOS CITY MAPS

## LIST OF LEGAZPI CITY MAPS



## LIST OF PUERTO PRINCESA CITY MAPS

## LIST OF TAGBILARAN CITY MAPS

# ABSTRACT

While there is a growing number of information on climate change, hazards, and adaptation in the Philippines, what has proven difficult is the application or mainstreaming of this information in local planning within the policy context of the Philippines. This study applies and translates climate change projections available from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and other sources into the local plans of the cities of Batangas, General Santos, Legazpi, Puerto Princesa, and Tagbilaran.

The study was done through a synthetic climate change impact and consequence assessment targeting the specific sectoral characteristics of each of the cities. Synthetic in this study means not a direct development of index or statistical computations but the use of available data such as matching the current characteristics of the area in relation to the PAGASA projections. The sectors assessed are Demography, Social, Economic, Infrastructure, and Environment as prescribed by the Housing Land Use Regulatory Board (HLURB) Guidebook in updating and mainstreaming Climate Change Adaptation (CCA) and Disaster Risk Reduction and Management (DRRM) to the Comprehensive Land Use Plan (CLUP) of the cities.

The assessment was done by firstly profiling the cities, describing their current physical environment, land cover, land use, socio-economic characteristics, and current climate and hazard vulnerabilities by incorporating these in a Geographic Information System (GIS) as layers. These layers will be overlaid with the regional downscaled projections of temperature and precipitation as generated by PAGASA. These data on climate projections were shared by the agency for the conduct of this study.

An overlay analysis was then conducted, identifying the impacts to the different layers as described in literature. The overlay analysis was supplemented by other literature sources such the reports from the Intergovernmental Panel on Climate Change (IPCC) and the Philippine Climate Change Assessment (PHILCCA) reports describing the impacts of climate change in particular sectors of the cities. Adaptation options were drawn from the results of the impact analysis, targeting sectors and *barangays* for each city which will be most affected by the changes in temperature and precipitation.

The study seeks to facilitate in the mainstreaming of climate change adaptation through the proposed methodology. The results of the impact assessment were designed to be easily integrated into the local land use plans and local climate change adaptation plans. The use of readily available data while considering the policy context of the cities provides a framework that can be used by other cities within the same context.

# I. INTRODUCTION

## Background of SURGE

The Strengthening Urban Resilience for Growth with Equity (SURGE) Project is a flagship project of USAID's Cities Development Initiative (CDI), a crucial component of the broader Partnership for Growth with Equity which is initiated by the White House as a "whole of government" partnership between the U.S. Government and the Government of the Philippines. It aims to shift the Philippines to a sustained and more inclusive growth trajectory on par with other high-performing emerging economies.

SURGE currently works on four key areas of development: improvement of urban development and planning, promotion of low-emission local economic development, facilitation of greater connectivity and access between urban and rural areas, and promotion of social inclusion.

The SURGE Project was conceived with the notion that the sustainable development of secondary cities can be supported by well-thought of, responsive, and implementable city development plans, where climate change adaptation and disaster risk reduction (CCA/DRR) are mainstreamed. Mainstreaming CCA/ DRR necessitates accurate ground level data to track boundaries of vulnerable areas and to control development which is to be considered delineated in the Zoning Map.

The CDI cities need to understand the trends and changes in climate variables and design sustainability mechanisms that are envisioned to eventually make cities economically competitive and environmentally resilient to overcome the challenges of having to deliver basic services and infrastructure while shifting to low-emission development strategies. The assistance will focus on modeling various climate change scenarios by identifying long-term changes in climate variables such as temperature and precipitation. The climate information, as well as various climate scenarios should be downscaled at city or *barangay* level to be able to accurately locate boundaries, discover the coverage of hazard- prone vulnerable areas in CDI cities and presenting these using climate hazard and risk maps.

Within these objectives, SURGE conducted a study to provide suggestions for connecting the gap between the climate and weather data and city planners using a framework that employs available data while considering the policy context within which they are subjected to. The study applied an overlay analysis and synthetic impact assessment. The methodology of this study was specifically designed to be easily integrated in local plans. Specifically, the outputs of the study can be used in mainstreaming climate change adaptation into the comprehensive land use plans and local climate change adaptation plans. Moreover, the methodology can easily be replicated in other local government units (LGUs) as it uses available data prescribed by local guidelines and cost-effective resources.

## Translation and Projections

Climate change projections are an important tool in planning for adaptation. They provide a picture of the possible impacts of climatic and weather phenomena to communities and cities. The international scientific community has studied the projections and literature and have developed documents describing these scenarios and their effects, for instance, through the IPCC reports. These documents and projections have provided a robust scientific basis from which researchers, planners, and decision-makers can draw from to aid them in their own studies, policies, and plans.

In spite of the abundance of such information, there has been a disconnect between it and the end user.
The projections and documents like the IPCC reports are scientific documents that contain terms and jargon that may not be commonly understood. Important scientific information should be tailor- fit to the needs of those who will use it (Toda et al. 2014) and must be packaged in a way that can be easily understood and used by the target stakeholders (Boaz & Hayden 2002). The usability of scientific information such as climate change projections is reliant on how these data could easily be understood by those who will eventually use it (Carter et al. 2015 & Lorenz et al. 2015). One study (Carter et al. 2015) was able to collect inputs from planners regarding the usability of climate projections and other climatic and weather data. It was found out that the planners were able to use the information if the consequences of climate change were relayed to them.

In addition, planners and decision makers exist within a given policy context. Past and present climate have their use within the planning and policy environment, but due to their uncertainties they are prevented from being fully utilized (Lorenz et al. 2015). Hence, for climate change projections and other climate and weather related data to be usable it must take note of the institutional and policy contexts and must be package as such (Boaz & Hayden 2002 & Lorenz et al. 2015). One way that this has been done is by modelling the impacts and mapping out their effects to the sectors prioritized by the stakeholders (Puyallup 2016; Beauvais et al. 2015; & Masser et al. 2015).

## Climate Projections in the Philippines

The Philippines' primary climate and weather agency, PAGASA, has generated regional downscaled climate change projections of temperature and precipitation. The projections are also supplemented by multi-hazard maps as provided by the Department of Science and Technology-University of the Philippines Disaster risk and exposure assessment for mitigation - Light Detection and Ranging (DOST-UP DREAM- LiDAR) Project. To utilize such information, it was made imperative for local planners to mainstream climate change adaptation and disaster risk reduction into their plans as mandated by law and provided by the 2013 guidelines of HLURB.

There have also been multiple studies conducted by local and international researchers and institutions that have generated very useful information such as impact assessments which span several sectors such as agriculture (FAO & PAGASA 201; Tongson et al. 2017), nutrition (Duante et al. 2015), land use planning (Santos et al. 2016), and coastal resources (Perez 2002; Tolentino et al. 2015). Modelling techniques have also been the focus of such studies such as the downscaling of regional climate models at the provincial level (Burdeos & Lansigan 2017) and the modelling of impacts of changes in hydrology due to climate change (NIGS, UPD, & GFI 2014).

In spite of the presence of such abundant information and the enabling environment, there have been challenges to mainstreaming and applying such into the plans. One of the primary challenges that were identified was institutional barriers (Cuevas et al. 2015). These barriers were described as the lack of institutional support mechanisms for mainstreaming. The lack of these support mechanisms has left the local planners burdened with the policy requirements (Cuevas et al. 2015). It has been suggested that to overcome such challenges a more comprehensive form of legislation be established that provides a more robust strategy for mainstreaming while providing technical assistance to increase the capacity of the LGUs (Benson 2009).

## Synthesis of Climate Change Impacts

The synthesis of literature to assess and consolidate the impacts of climate change and disaster is an approach that has been done before. The most popular example is the IPCC reports which use such a method, consolidating all literature on both the scientific basis and the impacts and vulnerabilities caused by climate change.

This method has been used as a preliminary step to other methods of assessing impacts, summarizing first order physical impacts of climate change (Roshanka & Ranasinghe 2017). The same method has also been used to build and add to the IPCC reports, summarizing and including literature that has been published since the reports were made (Warren et al. 2014).

One of the key characteristics and benefits of using such a method is the ability to compare and associate impacts across varying scales and industry across time and space (Warren et al. 2017 & Sajise et al 2012). The resultant assessment is holistic and robust providing a clearer picture on the relationship between the causes and impacts of climate change to the actions that help mitigate and/or adapt to such impacts (Sajise et al. 2012). The scale at which this analysis has been conducted ranges from global such as the IPCC reports, country level such as the Philippine Climate Change reports, and even up to the city and local levels (van Oort 2014 & Gil 2004).

In the Philippines, this approach has aided in and augmented such assessments like the one conducted by UN Habitat in Sorsogon City (2010). They were able to gather and synthesize literature to provide a robust background for their assessment. The synthesis augmented the data that they used which was generated by the local agencies.

## Selecting Priority Sectors

Adaptation will be and is currently being done by local government units and communities, hence climate science and its results should be geared towards their application at this level (IPCC WG2 2014). There have been several methods of selecting sectors in assessing the impacts of climate change. Amongst these methods and one that has been emphasized in several studies is the participatory method of selection.

The insight and inputs from stakeholders have been recognized for they provide a picture into to the real world constraints of future resource availabilities and environmental and institutional capabilities (Harrison et al. 2012). The participatory method has also been particularly used for vulnerability assessment methods and adaptation planning. Hence, there have been several studies that seek to unify participatory method in the said realms (Bureima et al. 2013; UN Habitat 2010; SEARCA 2012).

# II. METHODOLOGY

The diagram below *(Figure 2.1)* provides the framework for undertaking the study. With reference to the prevailing policy framework for planning in the Philippines, the study looked at the preparation of a city profile where the projections and scenarios will be overlaid. The results were subjected to impact assessment and for determining the adaptation options in following a process that is easier and palatable for local planners. The options focus on priority sectors identified by guidelines from HLURB and NEDA.

To illustrate the process, a step-wise approach was followed starting with the establishment of baseline data. Subsequently, a profile was prepared, which includes adaptation options based on existing literature. The resulting maps were used in the overlay analysis. The actual steps are presented using Legazpi as an example. The analyzed impacts were then presented for validation to the LGUs for their use in further assessment and impact chains, and for validating their current adaptation options.

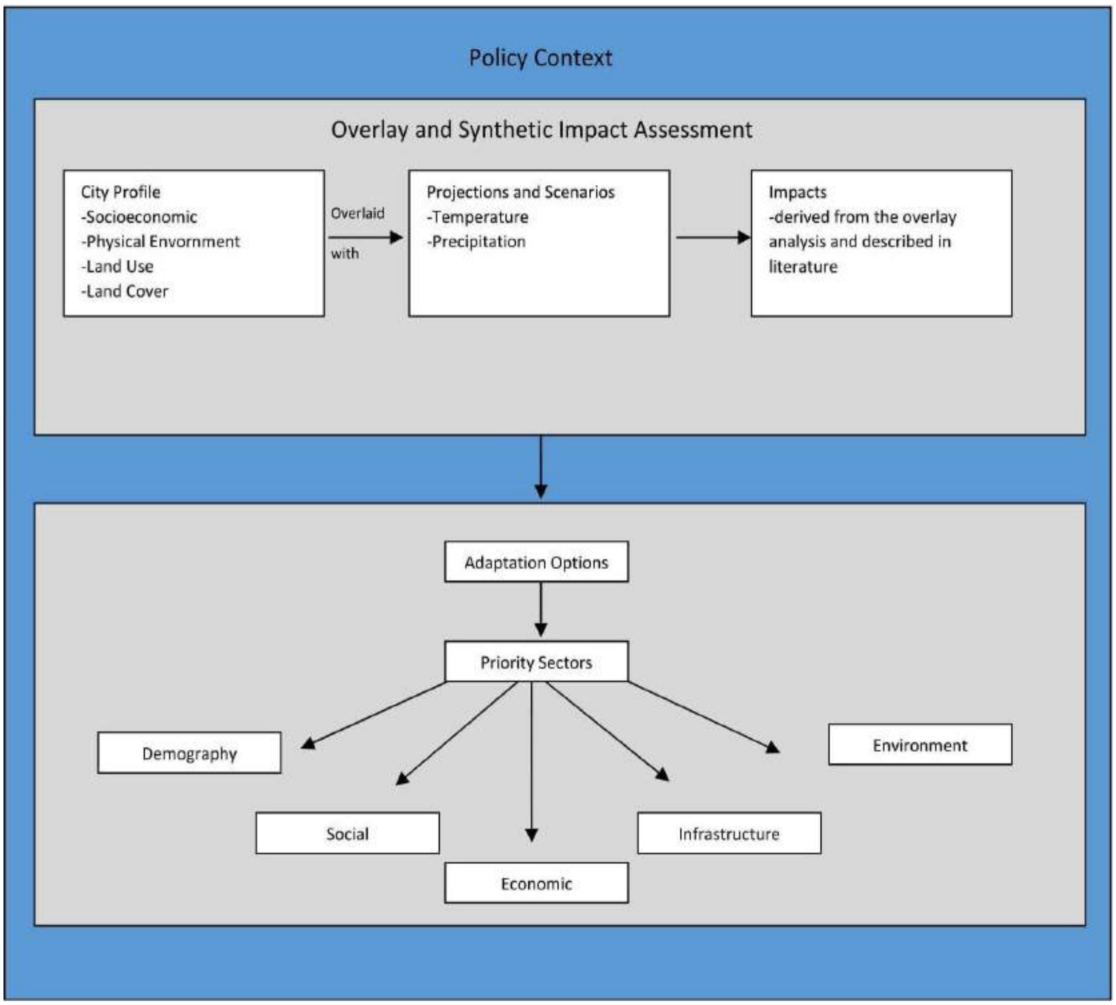



***Figure 2.1****. Methodological Framework 1*

## Inputs and Data Sources

### Baseline Data

For the profile and overlay analysis the following data were used to map out the prevailing characteristics of each of the cities: land use, land cover, socio-economic and demographic factors, flood hazard, storm surge hazard, sea-level rise, drought, barangay-level boundaries, roads and bridges, current climate, topography, and hydrography. They were primarily collected from the local government and national agencies such as the Philippine Statistics Authority (PSA) for the demographic and socio-economic data, DOST-NOAH (Nationwide Operational Assessment of Hazards) for the hazard maps, and PAGASA for the climatic data. Open source data were used for datasets such as roads.

### Climate Change Projections and Scenarios

The study made use of the PAGASA dynamically down-scaled climate projections of precipitation and maximum and minimum temperature. The projections are available in three datasets from PAGASA: historical climate (1971-2000) and two projected future climate (2036-2065; 2070-2099). They were derived from global climate models (GCMs) which project the possible future climate conditions under the representative concentration pathways (RCP) 4.5 and 8.5. The GCM-derived climate projections were then downscaled by the regional climate models (RCMs), namely the Providing Regional Climates for Impacts Studies (PRECIS) model, the Conformal Cubic Atmospheric Model (CCAM), the Regional Climate Model 4 (RegCM4), and the Hadley Environmental Model Version 3 (HadGEM3-RA), to provide more realistic and spatially detailed quantities (e.g., rainfall, temperature, pressure, etc.) at local scales (i.e., downscaled). *Figure 2.2* provides the details of the models used by PAGASA.

| Climate Scenario | Downscaling Model | Driving GCM | Resolution | Available Time Period |
|---|---|---|---|---|
| RCP 4.5 | PRECIS | HadGEM2-ES | 25km | 1971-2099 |
| | CCAM | ACCESS1.0 | 10kms in Vietnam, 25kms around the Philippines | |
| | | CNRM-CM5 | | |
| | | CCSM4 | | |
| | | GFDL-CM3 | | |
| | | MPI-ESM-LR | | |
| | | NorESM1-M | | |
| RCP 8.5 | CCAM(PH) | CNRM-CM5 | 25km | 1971-2099 |
| | PRECIS | HadGEM2-ES | | |
| | RegCM4 | | | |
| | HadGEM3-RA | CNRM-CM5 | 12 km | 1971-2000<br>2036-2065 |
| | | HadGEM2-ES | | 1971-2000<br>2036-2065 |
| | | MRI-CGCM3 | | 1971-2000<br>2036-2065<br>2069-2099 |
| | CCAM | ACCESS1.0 | 10kms in Vietnam, 25kms around the Philippines | 1971-2099 |
| | | CNRM-CM5 | | |
| | | CCSM4 | | |
| | | GFDL-ESM2M | | |
| | | MPI-ESM-LR | | |
| | | NorESM1-M | | |

*Note: CCAM(PH) refers to the CCAM experiment conducted by PAGASA using a domain centered over the Philippines.*

***Figure 2.2*** *List of utilized GCMs and RCMs to generate high resolution climate projections for the Philippines (Source: PAGASA)*

The resulting values generated by the models are presented in the form of a Climate Information and Risk Analysis Matrix (CLIRAM).In an Excel spread sheet, all the projected values for precipitation *(Figure 2.3, Illustration 1)* and temperature (Figure 2.3, *Illustration 2)* are first populated. The values provided are divided into a seasonal temporal scale namely in December, January, and February; March, April, and May; June, July, and August; and September, October, and November. For each season the minimum, median, and maximum values are given for each of the RCPs. Separate tabs are given for the mid and late century projections.

**Projected Changes in Seasonal Rainfall in the Mid-21st Century (2036-2065) for Albay relative to 1971-2000**

| Season | Scenario | Range* | Projected Change: Percent (%) | Projected Change: Rainfall amount (mm) | Projected Seasonal Rainfall Amount (mm) | Potential Impacts | Adaptation Option |
|---|---|---|---|---|---|---|---|
| December-January-February (DJF) | Moderate Emission (RCP4.5) | Lower Bound | -45.4 | -336.2 | 403.6 | Marked decrease in lowest possible precipitatic | |
| | | Median | 1.7 | 12.2 | 752.0 | | |
| | | Upper Bound | 17.5 | 129.6 | 869.4 | Increase in highest possible precipitation | |
| Observed baseline = 739.8 mm | High Emission (RCP8.5) | Lower Bound | -6.6 | -48.7 | 691.1 | | |
| | | Median | 12.1 | 89.3 | 829.1 | Increase in baseline | |
| | | Upper Bound | 27.1 | 200.4 | 940.2 | Marked increase in highest possible precipitati | |
| March-April-May (MAM) | Moderate Emission (RCP4.5) | Lower Bound | -41.2 | -159.5 | 227.4 | Marked decrease in lowest possible precipitatic | |
| | | Median | -0.5 | -1.8 | 385.1 | | |
| | | Upper Bound | 10.8 | 41.7 | 428.6 | Increase in highest possible precipitation | |
| Observed baseline = 386.9 mm | High Emission (RCP8.5) | Lower Bound | -20.6 | -79.7 | 307.2 | Marked decrease in lowest possible precipitatic | |
| | | Median | 5.5 | 21.4 | 408.3 | | |
| | | Upper Bound | 18.1 | 69.9 | 456.8 | Increase in highest possible precipitation | |
| June-July-August (JJA) | Moderate Emission (RCP4.5) | Lower Bound | -59.0 | -416.2 | 289.6 | Marked decrease in lowest possible precipitatic | |
| | | Median | -20.6 | -145.1 | 560.7 | Marked decrease in baseline | |
| | | Upper Bound | -10.6 | -74.7 | 631.1 | Decrease in highest possible precipitation | |
| Observed baseline = 705.8 mm | High Emission (RCP8.5) | Lower Bound | -34.8 | -245.4 | 460.4 | Marked decrease in lowest possible precipitatic | |
| | | Median | -13.3 | -93.8 | 612.0 | Decrease in baseline | |
| | | Upper Bound | 5.5 | 38.9 | 744.7 | | |
| September-October-November (SON) | Moderate Emission (RCP4.5) | Lower Bound | -47.1 | -443.0 | 498.3 | Marked decrease in lowest possible precipitatic | |
| | | Median | -2.6 | -24.7 | 916.6 | | |
| | | Upper Bound | 8.7 | 82.0 | 1023.3 | | |
| Observed baseline = 941.3 mm | High Emission (RCP8.5) | Lower Bound | -14.4 | -135.7 | 805.6 | Decrease in lowest possible precipitation | |
| | | Median | -1.5 | -14.5 | 926.8 | | |
| | | Upper Bound | 8.1 | 76.1 | 1017.4 | | |

Seas projected PRECIP mid _ | Seas projected TAS mid _ | Seas projected PRECIP late _ | Seas projected TAS

***Figure 2.3**, Illustration 1. Projected Changes in Seasonal Rainfall in Mid-21st Century for Albay*

### Impacts and adaptation options

Following the projected changes in precipitation and temperature, the impacts to each of the city sectors and the adaptation options were derived initially from assessment reports, particularly the IPCC reports and PHILCCA as well as reports generated specific to the Philippines such as the reports generated from the FAO-AMICAF project conducted with PAGASA and the National Institute of Geological Sciences-UP Diliman. Furthermore, using the questionnaire, a baseline of current plans and adaptation options were obtained from the local government units to gauge what was currently being done in order to provide plans and adaptation options that would supplement the current programs.

## Preparation of the Profile

The profile establishes the characteristics of each city that were used for the impact assessment. The primary characteristics identified are its physical geography (climate, topography, hydrography, etc.), socio-economic characteristics, infrastructure, land cover and land use, and hazards. The population characteristics, key economic activities, transportation and access, and hazard risks for each of the cities were identified. The characteristics were translated to layers in a geographic information system (GIS). From the GIS, the key spatial features for each of the cities were mapped out and identified.

**Projected Changes in Seasonal Temperature in the Mid-21st Century (2036-2065) for Albay relative to 1971-2000**

| Season | Scenario | Range* | Projected Change | | Potential Impacts | Adaptation Option |
|---|---|---|---|---|---|---|
| | | | Change in °C | Projected Seasonal Mean Temperature (°C) | | |
| December-January-February (DJF) | Moderate Emission (RCP4.5) | Lower Bound | 1.0 | 26.6 | | |
| | | Median | 1.2 | 26.8 | | |
| | | Upper Bound | 1.7 | 27.3 | | |
| Observed baseline = 25.6 °C | High Emission (RCP8.5) | Lower Bound | 1.2 | 26.8 | | |
| | | Median | 1.6 | 27.2 | | |
| | | Upper Bound | 2.1 | 27.7 | | |
| March-April-May (MAM) | Moderate Emission (RCP4.5) | Lower Bound | 1.0 | 28.2 | | |
| | | Median | 1.2 | 28.4 | | |
| | | Upper Bound | 1.8 | 29.0 | | |
| Observed baseline = 27.2 °C | High Emission (RCP8.5) | Lower Bound | 1.4 | 28.6 | | |
| | | Median | 1.7 | 28.9 | | |
| | | Upper Bound | 2.3 | 29.5 | | |
| June-July-August (JJA) | Moderate Emission (RCP4.5) | Lower Bound | 1.0 | 28.8 | | |
| | | Median | 1.2 | 29.0 | | |
| | | Upper Bound | 1.8 | 29.6 | | |
| Observed baseline = 27.8 °C | High Emission (RCP8.5) | Lower Bound | 1.4 | 29.2 | | |
| | | Median | 1.6 | 29.4 | | |
| | | Upper Bound | 2.2 | 30.0 | | |
| September-October-November (SON) | Moderate Emission (RCP4.5) | Lower Bound | 1.0 | 28.1 | | |
| | | Median | 1.1 | 28.2 | | |
| | | Upper Bound | 1.8 | 28.9 | | |
| Observed baseline = 27.1 °C | High Emission (RCP8.5) | Lower Bound | 1.4 | 28.5 | | |
| | | Median | 1.5 | 28.6 | | |
| | | Upper Bound | 2.2 | 29.3 | | |

Seas projected PRECIP mid _ | Seas projected TAS mid _ | Seas projected PRECIP late _ | Seas projected TAS

***Figure 2.4**, Illustration 2. Projected Changes in Seasonal Temperature in Mide-21st Century for Albay*

## Synthetic Impact Assessment and Overlay Analysis

The synthetic impact assessment and the overlay analysis make use of all the outputs from the city profiles and the climate change projections. The baseline climate and the climate change projections were converted into GIS shapefiles in QGIS by inputting the temperature and the precipitation values in the province shapefiles in which the individual local government units belong to *(Figure 2.3, Illustration 3)*. After these were inputted into the respective attribute tables, the values were then color categorized in the style properties of the shapefiles *(Figure 2.3, Illustration 4)*.

AlbayProj :: Features total: 52, filtered: 52, selected: 0

| | Months | RCP | Period | Precip | Temp | Percentile |
|---|---|---|---|---|---|---|
| 1 | DJF | Historic | Historic | 739.800 | 25.600 | Base |
| 2 | MAM | Historic | Historic | 386.900 | 27.200 | Base |
| 3 | JJA | 4.5 | Mid | 289.600 | 28.800 | Min |
| 4 | JJA | 4.5 | Mid | 560.700 | 29.000 | Med |
| 5 | JJA | 4.5 | Mid | 631.100 | 29.600 | Max |
| 6 | SON | 4.5 | Mid | 498.300 | 28.100 | Min |
| 7 | SON | 4.5 | Mid | 916.600 | 28.200 | Med |
| 8 | SON | 4.5 | Mid | 1023.300 | 28.900 | Max |
| 9 | DJF | 8.5 | Mid | 691.100 | 26.800 | Min |
| 10 | DJF | 8.5 | Mid | 829.100 | 27.200 | Med |
| 11 | DJF | 8.5 | Mid | 940.200 | 27.700 | Max |
| 12 | MAM | 8.5 | Mod | 307.200 | 28.600 | Min |
| 13 | JJA | Historic | Historic | 705.800 | 27.800 | Base |
| 14 | MAM | 8.5 | Mid | 408.300 | 28.900 | Med |
| 15 | MAM | 8.5 | Mid | 456.800 | 29.500 | Max |
| 16 | JJA | 8.5 | Mid | 460.400 | 29.200 | Min |
| 17 | JJA | 8.5 | Mid | 612.000 | 29.400 | Med |
| 18 | JJA | 8.5 | Mid | 744.700 | 30.000 | Max |
| 19 | SON | 8.5 | Mid | 805.600 | 28.500 | Min |
| 20 | SON | 8.5 | Mid | 926.800 | 28.600 | Med |
| 21 | SON | 8.5 | Mid | 1017.400 | 29.300 | Max |
| 22 | DJF | 4.5 | Late | 392.000 | 26.800 | Min |
| 23 | DJF | 4.5 | Late | 799.400 | 27.100 | Med |
| 24 | SON | Historic | Historic | 941.300 | 27.100 | Base |
| 25 | DJF | 4.5 | Late | 957.900 | 28.000 | Max |
| 26 | MAM | 4.5 | Late | 221.100 | 28.500 | Min |
| 27 | MAM | 4.5 | Late | 389.300 | 28.800 | Med |

Show All Features

***Figure 2.5**, Illustration 3. Temperature and the precipitation values for preparing province shapefiles*

A color categorization was used to represent the values of precipitation and temperature in comparison to the other values in color scale. The projection layers were then overlaid with the land cover of the city to provide a visual representation of the physical characteristics of the city. Individual maps were generated that represented the minimum, median, and maximum values for each seasonal, for each scenario, and for each time period were generated. These individual maps were then grouped together in a single map to show the values in comparison to each other *(Figure 2,.3, Illustration 5)*. The maps were used to visualize the degree of change in the temperature and precipitation values compared to the baseline for each scenario and for each time period.

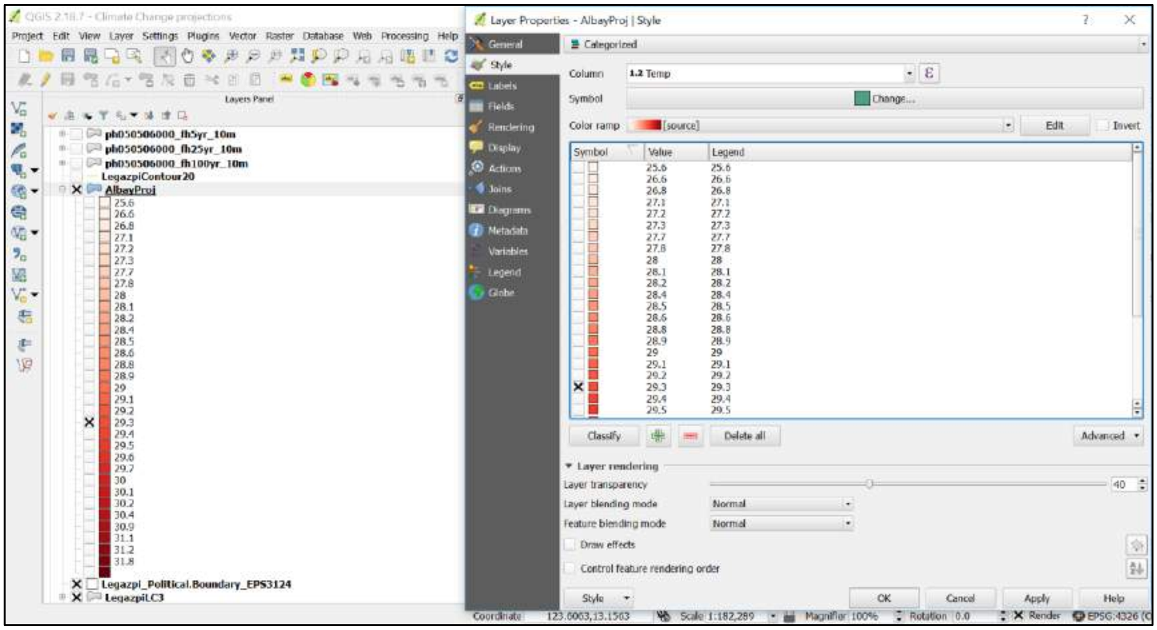


***Figure 2.6****, Illustration 4****.*** *Color categorization of values according to the style properties of the shapefiles.*

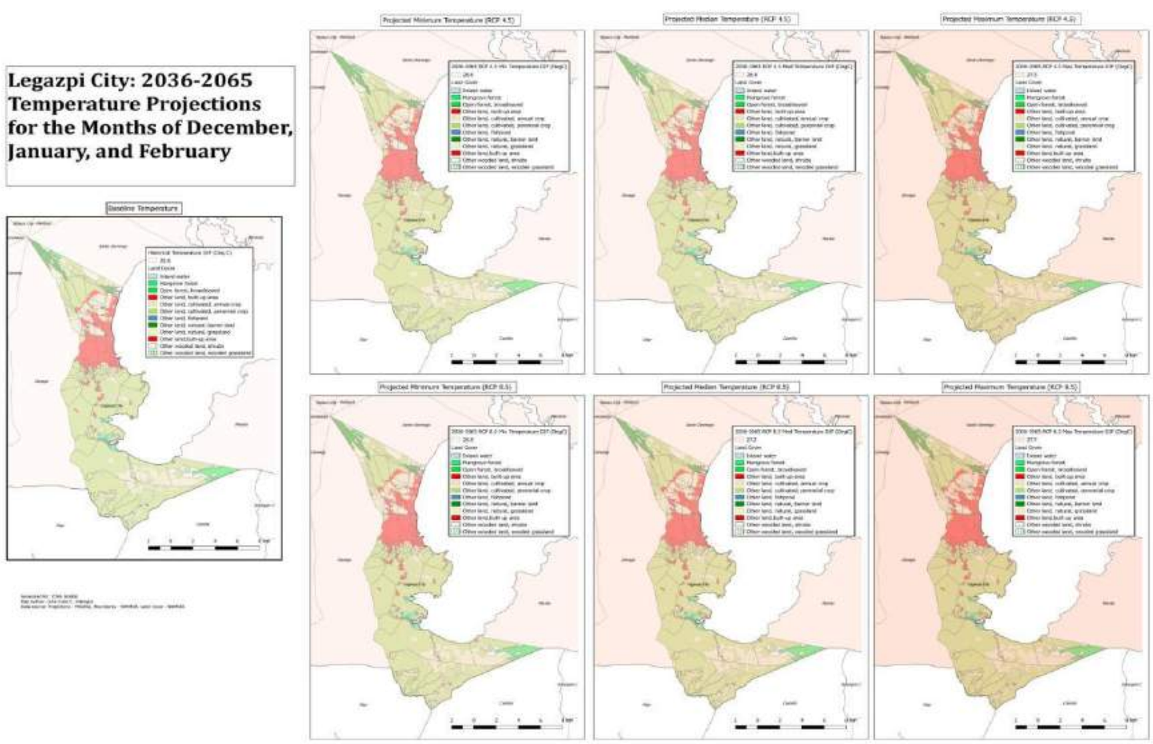



***Figure 2.7****, Illustration 5****.*** *Individual maps that represent the minimum, median, and maximum values for each season, for each scenario, and for each time period were prepared for comparison (Sample output map of Legazpi City).*

Using the primary characteristics found in the profile, the impacts of the projections were then cross-referenced to the available assessment reports and other relevant literature and then tabulated (modification of UN-HABITAT 2010 and SEARCA methodologies 2012).

## Identifying Priority Sectors

Identification of the priority sectors were used for the translation of the impacts to outputs that can easily be mainstreamed into the plans of the local government units. These sectors were initially determined from the HLURB Guidelines for updating the CLUPs of the LGUs. The priority sectors as described in the guidelines are: demography, social, economic, and infrastructure. Environment is added as a priority sector as derived from the provincial development and physical framework plan guidelines prescribed by the National Economic Development Authority (NEDA). A questionnaire *(Annex 1)* was constructed that was answered by the local government units, identifying other priority sectors and aspects of the sectors prescribed by HLURB and NEDA.

### Adaptation Options

Using the results of the impact assessment in conjunction with the priority sectors identified by the LGUs, the adaptation options were generated based on existing literature. The adaptation options also took account of the current plans and programs that the city is implementing. The options and impacts were then tabulated to provide a quick reference and summary of the results of the assessment. The format of the tables uses the same inputs that are prescribed by HLURB in the creation of the local climate change adaptation plans for the city. Hence, these summary tables can be used as an input for their own plans.

### Validation

A validation workshop was conducted through a workshop which involved the members of the subject cities. The results *(Annex 2)* were presented to the cities and these were validated through the construction of an impact chain by the participants. The participants involved were the heads of the planning, environment, and disaster risk management departments of the individual cities and hence had appropriate knowledge and experience regarding the possible impacts and solutions for the projections. The impact chains were constructed by first identifying a particular sector and then selecting an impact from a climate variable such as rise in temperature. The results of the impact chains were then compared to the results of the synthetic assessment.

## Limitations of the Study

The study relies on the use of available data that can be collected and gathered from PAGASA. Considering this limitation, the methodology that was developed for this study focused mainly on a pragmatic framework that can make use of data that can be accessed openly from government documents and agencies. For this particular study, climate change projections from PAGASA are only available at a particular resolution (25 sq. km). This has implications on the display of the climate variations, not to mention the topographic characteristics such as having mountainous areas. The availability of baseline data for preparing the profiles is likewise a limitation. The profiles of each of the LGUs were derived from data that were easily accessed through available documents such as the Philippine Statistics Authority (PSA) for the demographic and socio-economic data, DOST-NOAH (Nationwide Operational Assessment of Hazards) for the hazard maps, and PAGASA for the climatic data. Open source data were used for datasets such as roads and waterways. The data being open sourced, may not always reflect the current conditions of the LGUs. This is because local data, though frequently updated, are not always uploaded and accessible to the public. As such, open source data is not always validated with the local data. The impacts and adaptation options were derived from available literature from journals and reports available online, such as the IPCC reports for Climate Change projections. The results and conclusions of these studies can be changed or challenged by subsequent studies such as when the IPCC release their updated assessments. Furthermore, the reliance on literature could be a limitation to areas which have characteristics that have not yet been extensively researched such as deep marine ecosystems.

This study will be useful for cities that are undertaking climate-resilient planning as it provides a method for easy integration of climate change projections into the local plans of the cities. The emphasis on available data and open access techniques are expected to facilitate updating following the proposed framework. As new data comes, cities can do the adjustments by just replacing the primary data used in the generation of the results hence; update the impacts and adaptation options following the same framework.

# III. CDI CITIES

## 3.1. BATANGAS CITY

### Executive Summary

Batangas City is an urban and rural landscape within the province of Batangas. Its terrain is mountainous and highly elevated to the south with low lying and highly built up areas to the north. The city has large swaths of agricultural land interspersed with woodland further south.

Moreover, the city is where the famed Verde Island passage can be found which has rich marine and coastal resources within its area. The projections for Batangas City are varied between RCP 4.5 and RCP 8.5 and between the mid and late century. The only constant between all scenarios and between the mid and late century is the increase in temperatures, RCP 8.5 is hotter than RCP 4.5 and the late century is hotter than the mid-century.

Furthermore, RCP 8.5 is wetter than RCP 4.5 and has a wider range of values than RCP 4.5. The impacts and adaptation options generated for the city are summarized below.

| **Summary of Impacts and adaptation options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation options** |
| Increase in Temperature (Year-round and for all scenarios) and decrease in precipitation (JJA and SON) Decrease in precipitation for months of SON, JJA, and MAM (Mid Century RCP 4.5 and Late Century RCP 8.5) | Demography | Increased heat related health risk to population, loss of livelihood | capacity building activities, policies that adapt the behaviour and customs of the citizens such as changes in uniform and class and work hours |
| | Social | Increased heat related health risk to population, loss of livelihood, increased health risk to urban poor, | Stock piling of food and non-food resources, education campaigns, policies that adapt customs and behaviour to the projections, construction of public buildings and facilities adopting more resilient materials and designs such as better ventilation to reduce consumption of electricity while increasing air circulation, climate financing schemes |
| | Economic | Reduction of water supply, increased demand for water, | Climate, tolerant crop varieties, alternating crops, development of water storage systems and water usage management practices, shifting of cropping calendars for rice crops to coincide with the generally higher precipitation projected for the months from December to January. |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate |

| | | | |
|---|---|---|---|
| | | maintenance, Lowering of groundwater table, | appropriate infrastructure materials, development of water storage systems |
| | Environment | Deforestation, increased forest stress | Environmental code, plans to protect protected areas and critical ecosystems, and multiple capacity building programs |
| | Hazards | Increased possibility of drought and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |
| General increase in precipitation in the months of (DJF) | Demography | Increased risk of water borne diseases | capacity building activities, emergency drills, policies that adapt the behaviour and customs of the citizens such as changes in uniform and class and work hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, |
| | Hazards | Increased risk of floods | capacity building activities, emergency drills, flood protection infrastructure |

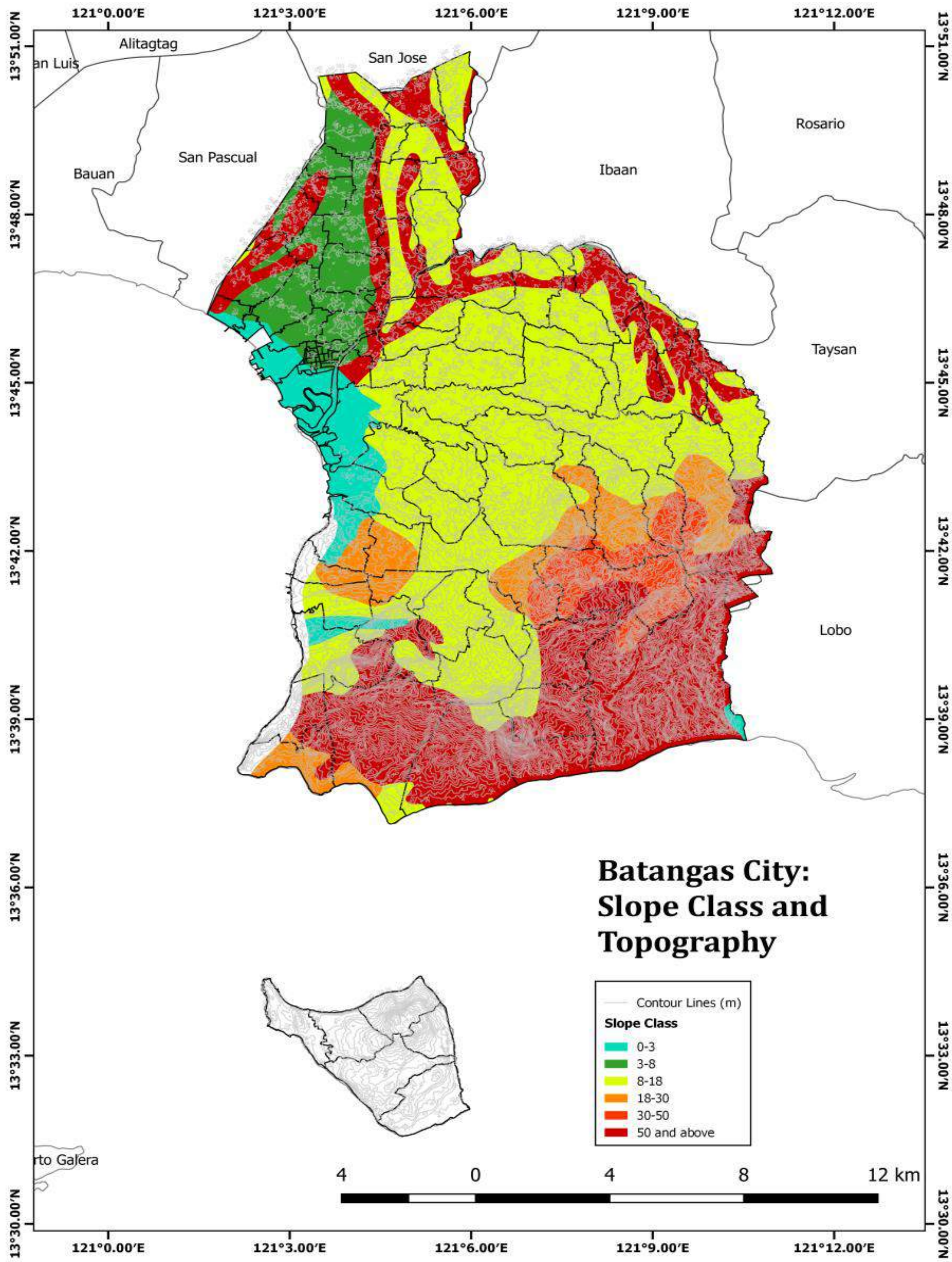
## Physical Geography

### *Location*

Batangas City is found on the southern end of the Province of Batangas. It is the capital of the province and is situated along the coast of Batangas Bay. The city is bound on the northwest by the municipality of San Pascual; on the north by the municipality of San Jose; on the east by the municipalities of Ibaan, Taysan, and Lobo; and on the south by the Batangas Bay ***(Map 3.1.1)***.

### *Physical Characteristics*

The city has an area of approximately 28,541.44 hectares (Batangas SEPP 2017). Its terrain is characterized by rolling slopeswith its highest elevation at 968 meters. Its highest peak is Mount Banoy in *Barangay* Talumpok Silangan which is 968 meters above sea level ***(Map 3.1.1)***.

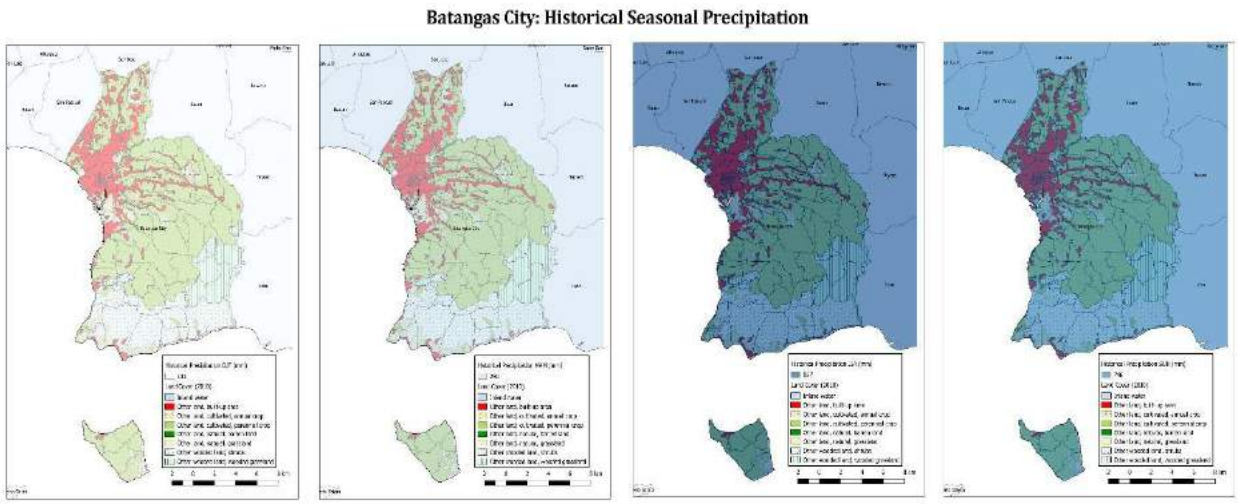



***Map 3.1.1*** *Batangas City Slope Class and Topography Map (Source: 30m GDEM)*

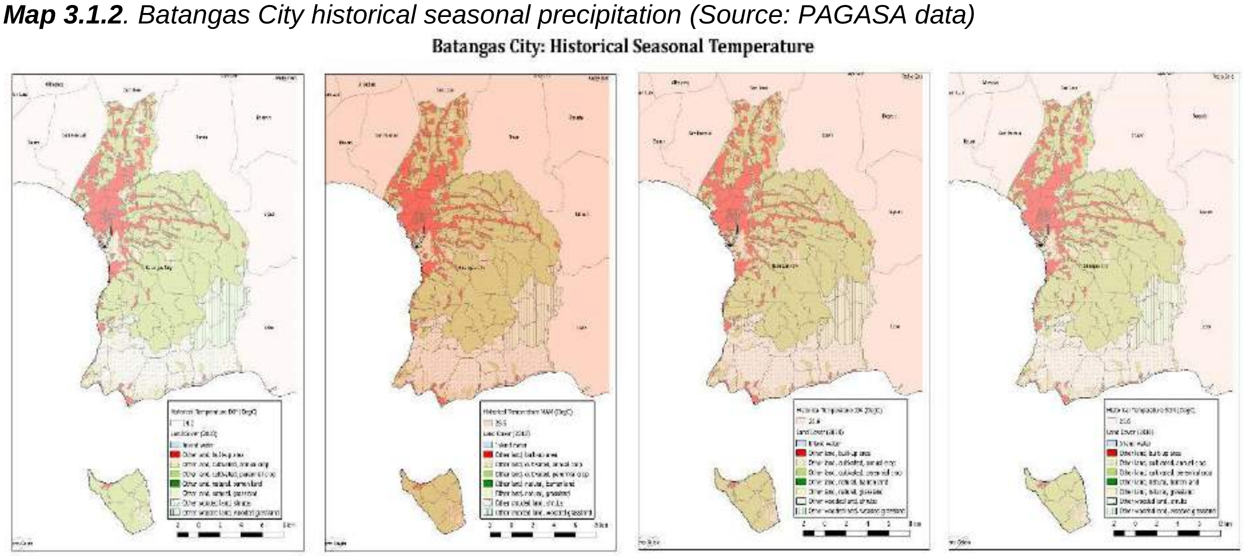
### *Climate*

The climate of Batangas is characterized by four seasonal variations in precipitation and temperature ***(Maps 3.1.2 & 3.1.3)*** as modelled and recorded by the PAGASA.

The months of December, February, and January are the coolest of the year with an average temperature of 24.2 degrees Celsius and the driest with an average cumulative amount of rainfall of 231mm. The months of March, April, and May on the other hand are the hottest months of the year with an average temperature of 26.5 degrees Celsius and the second driest with an average cumulative amount of rainfall of 280mm.The months of June, July, and August are cooler than the months of March, April, and May but are still relatively hot with an average of 25.9 degrees Celsius. Furthermore, the months of June, July, and August are the wettest with an average cumulative amount of rainfall of 857 mm. Finally, the months of September, October, and November are where the temperature begins to cool down averaging 25.6 degrees Celsius and still relatively wet with an average cumulative amount of rainfall of 746 mm.




***Map 3.1.2**. Batangas City historical seasonal precipitation (Source: PAGASA data)*

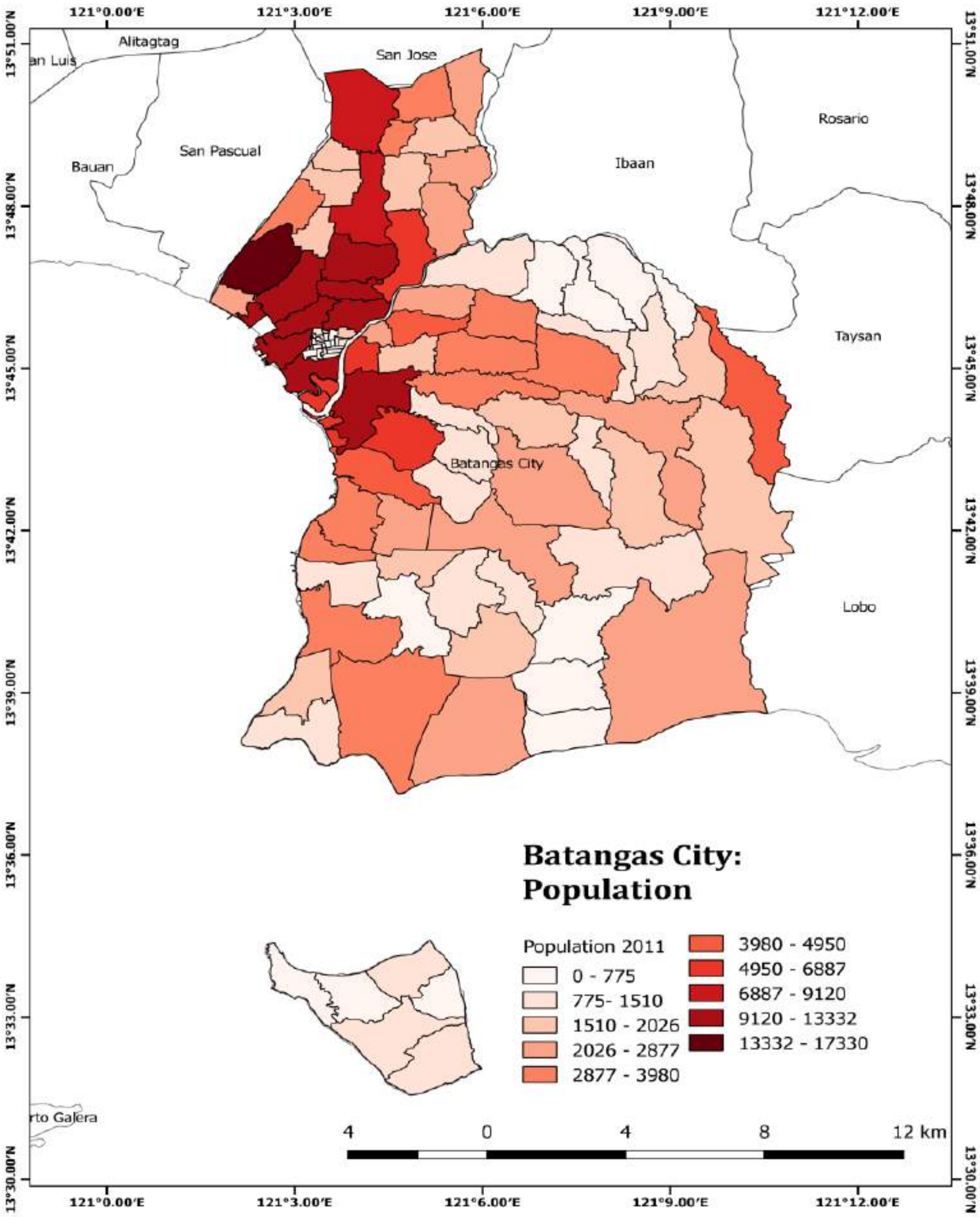



***Map 3.1.3**. Batangas City historical seasonal temperature (Source: PAGASA data)*

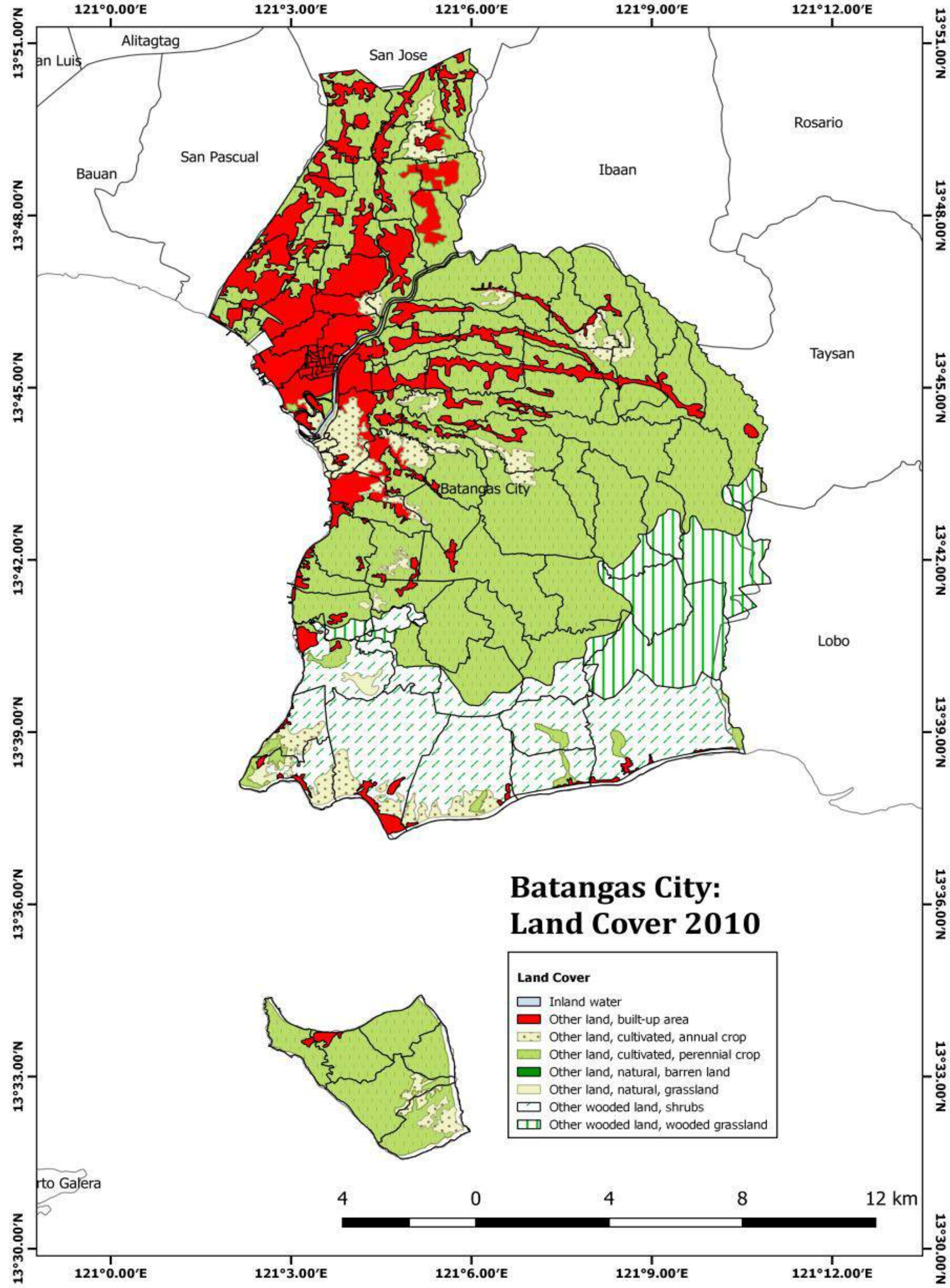
## Socio-Economic Characteristics (derived from Batangas City's SEPP 2016)

### *Population*

As of 2011, the total population of Batangas City is 312,109 with the female population slightly higher than the male population (1.00:0.99 ratio). The population is concentrated on the north eastern portions of the city ***(Map 3.1.4)*** where the terrain is mostly level and low lying *(Map 1)*. In turn, it is where built up areas are concentrated ***(Map 3.1.5)***. *Barangay* Sta. Rita Karsada is the most populous *barangay* of the city with an estimated population of 17,699.




***Map 3.1.4.*** *Barangay population map (Source: Batangas SEPP 2016)*




***Map 3.1.5.*** *Land Cover Class (Source: Batangas SEPP 2016)*

The projected population of the area for 2016 is 346,756 with a projected household number of 76,312 and an average household size of five. Given this projected population and the land area of the city, the population density is 12.18 persons per hectare or 1,165 persons per square kilometer. Mostly are living in the urban area (about 56%) while others are in the rural area (about 44%).

### *Education*

Batangas City offers all levels of education and is considered as the center of learning in Region IV-A (Cavite, Laguna, Batangas, Rizal and Quezon or CALABARZON). In SY 2016-2017, the total enrolment is 130,631 with majority (about 66%) enrolled in public schools. The table below shows the number of schools per level of education.

***Table 3.1.1.*** *Number of Schools per Level of Education in Batangas (Source: Batangas SEPP 2017)*

| **Level of Education** | **Public** | **Private** |
|---|---|---|
| Pre-school (day care centers) | 108 | 25 |
| Elementary level | 84 | 38 |
| Secondary level | 33 | 40 |
| Tertiary level | 2 | 7 |
| Post Graduate, Pre-Baccalaureate and Vocational | 3 | 10 |
| Computer Courses | 2 | 10 |

### *Economic Activities*

- *Agriculture*

Batangas City has limited production of rice. Other crops such as vegetables, rootcrops (cassava and sweet potato), corn and fruits like mangoes, *atis* (custard apple), tamarind, and bananas are highly produced in the area. These are planted in almost 6,000 hectares of farm land and produced by more than 10,000 farmers in the area. The total production is around 36,500 metric tons with highest yield from mango (10,350 metric tons), sugarcane (6,300 metric tons), and *atis* (6,000 metric tons). The marketing of these farm products is done through cooperatives, direct linkages to buyer/wholesaler, and middlemen.

- *Fishery*

Shallow Fishing is prominent in the area, with a total of 728 registered fishermen using a total of 722 registered motorized *banca* (boat). The total volume of production is more than 340,000 metric tons. The documented Fishermen Associations in the area are: (1) *Bantay Dagat* Federation, (2) *Lakas Bigkis ng Mangingisda sa Baybayin ng Tabangao* (LAMBAT), (3) Vibrant Economy Through Responsive Development of Ecosystem (VERDE I), and (4) *Samahan ng mga Mag-Aaquarium sa* San Andres (SAMASA).

### *Livestock*

Chickens, geese, pigs, cattle, goat, carabao, and horses are available in the area. The number of heads per livestock is listed in the table below. There are several piggery and poultry farms in the area. For the piggery farms, most are backyard farms (780 farms) and a few commercial farms (15 farms). For the poultry farms, there are 18 egg type farms and 26 meat type farms.

***Table 3.1.2.*** *Livestock Raisers by Type in Batangas (Source: Batangas SEPP 2017)*

| | | **Individual Raisers** | **Private Commercials** | **Contract Growers** | **Total** |
|---|---|---|---|---|---|
| **A.** | **Poultry** | | | | |
| a. | Broilers | 31,302 | 7,800 | 209,000 | 248,102 |
| b. | Layers | 1,295 | 1,550 | 35,500 | 38,345 |

| | | | | |
|---|---|---|---|---|
| c. Native | 30,054 | 1,108 | - | 31,662 |
| d. Fighting Cocks | 7,509 | 1,450 | - | 8,959 |
| **B. Goose** | 1,123 | - | - | 1,123 |
| **C. Piggery** | | | | |
| a. Fattening | 25,232 | 20,903 | - | 46,135 |
| b. Breeding | 5,620 | 1,836 | - | 7,456 |
| **D. Cattle** | | | | |
| a. Fattening | 2,493 | - | - | 7,184 |
| b. Breeding | 1,218 | 150 | - | 117 |
| **E. Goat** | 7,134 | 50 | - | 7,184 |
| **F. Carabaos** | 117 | - | - | 117 |
| G. **Others** (specify) | | | | |
| a. Dogs | 7,561 | - | - | 7,561 |
| b. Cat | 2,684 | - | - | 2,684 |
| c. Horse | 277 | - | - | 277 |

There is only one documented livestock association: *Barangay* Livestock Agricultural Technicians (BLATs). Several animal production programs have been implemented in the area such as (1) F1 Dispersal Program, (2) Upgraded Female Goat Dispersal Program, (3) Native Chicken Dispersal, (4) Carabao Dispersal Program, and (5) Cattle Fattening Project.

## Infrastructure

### *Water Supply*

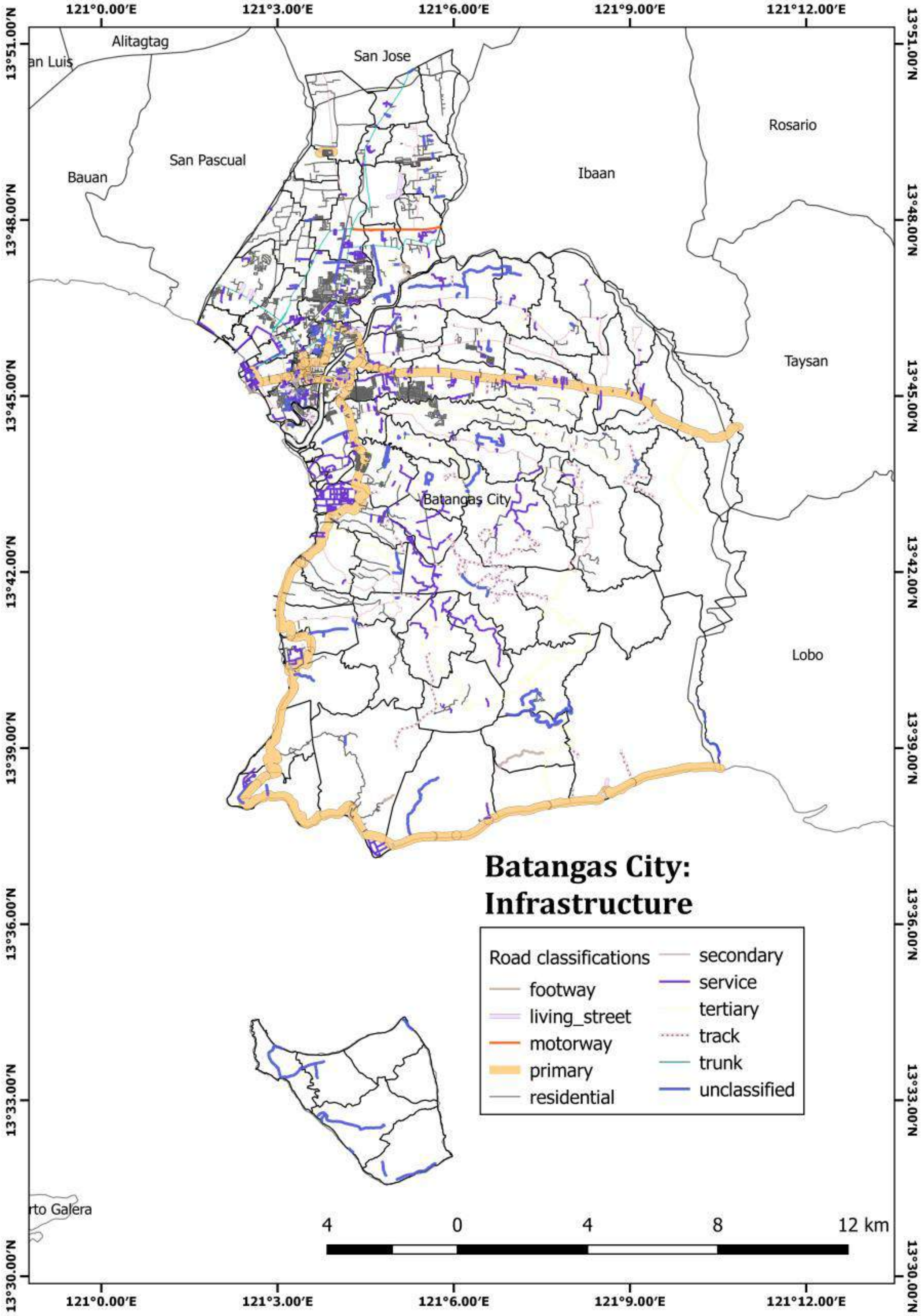
The main water supply for the city is groundwater. The water supply pipes are operated and managed by the Batangas City Water District (BCWD). However, seven (7) of the rural *barangays* of the city are serviced by the waterworks system created under the Batangas Water Program.

### *Power Supply*

Most of the energy of the city comes from the Manila Electric Company while several of the rural areas are sourced from the Batangas Electric Cooperative. The occupants of Verde Island, on the other hand, depend on the diesel engine generators.

### *Roads and Bridges (from Batangas City SEPP 2016)*

The total length of all roads in Batangas City is around 485.185 kilometers. It is classified into 77.305 kilometers of national roads, 23.01 kilometers of city roads, and 383.87 kilometers of *barangay* roads. Forty-seven (47) bridges and one (1) flyover can also be found in the area ***(Map 3.1.6)*** which are classified further as twenty-nine (29) local bridges and eighteen (18) national bridges.




***Map 3.1.6.*** *Road Infrastructure Map (Source: Batangas SEPP 2016)*

## Land Cover and Land Use

***Table 3.1.3.*** *Batangas City Land Cover (Source: GDEM 2010)*

| Batangas City Land Cover (2010) | | |
|---|---|---|
| **Land Cover Class** | **Area (ha) Derived from GIS calculations** | **Percent** |
| Inland Water | 79.37907364 | 0.29% |
| Built-up Area | 3873.851318 | 14.08% |
| Cultivated, Annual Crop | 1530.767131 | 5.56% |
| Cultivated, Perennial Crop | 15280.38596 | 55.55% |
| Barren Land | 0.62451279 | 0.0023% |
| Grassland | 99.2337091 | 0.36% |
| Shrubs | 4459.834072 | 16.21% |
| Wooded Grassland | 2184.698696 | 7.94% |
| Total | 275087.7448 | 100.00 % |

Batangas City is largely crop land with approximately 61.11 per cent of its area composed of cultivated land covering most of the eastern side of the city ***(Map 3.1.5)***. Shrub land, grass land, and wooded grassland mostly occupy the southern portion of the city with several areas interspersed with the agricultural land aggregately occupying 24.51 per cent of the area of the city. There are 65 *barangays* that are found in these agricultural, shrub, wooded, and grass lands. Hence, are classified as rural *(barangay table)*.

The built up areas of the city are concentrated on its north western portion near the coasts and following the roads of the city. Approximately 14.08 per cent of the city is built-up as of 2010. There are 41 out of 106 *barangays* that are found in the highly built up areas and are such classified as urban *(barangay table)*.

## Climatic Hazards

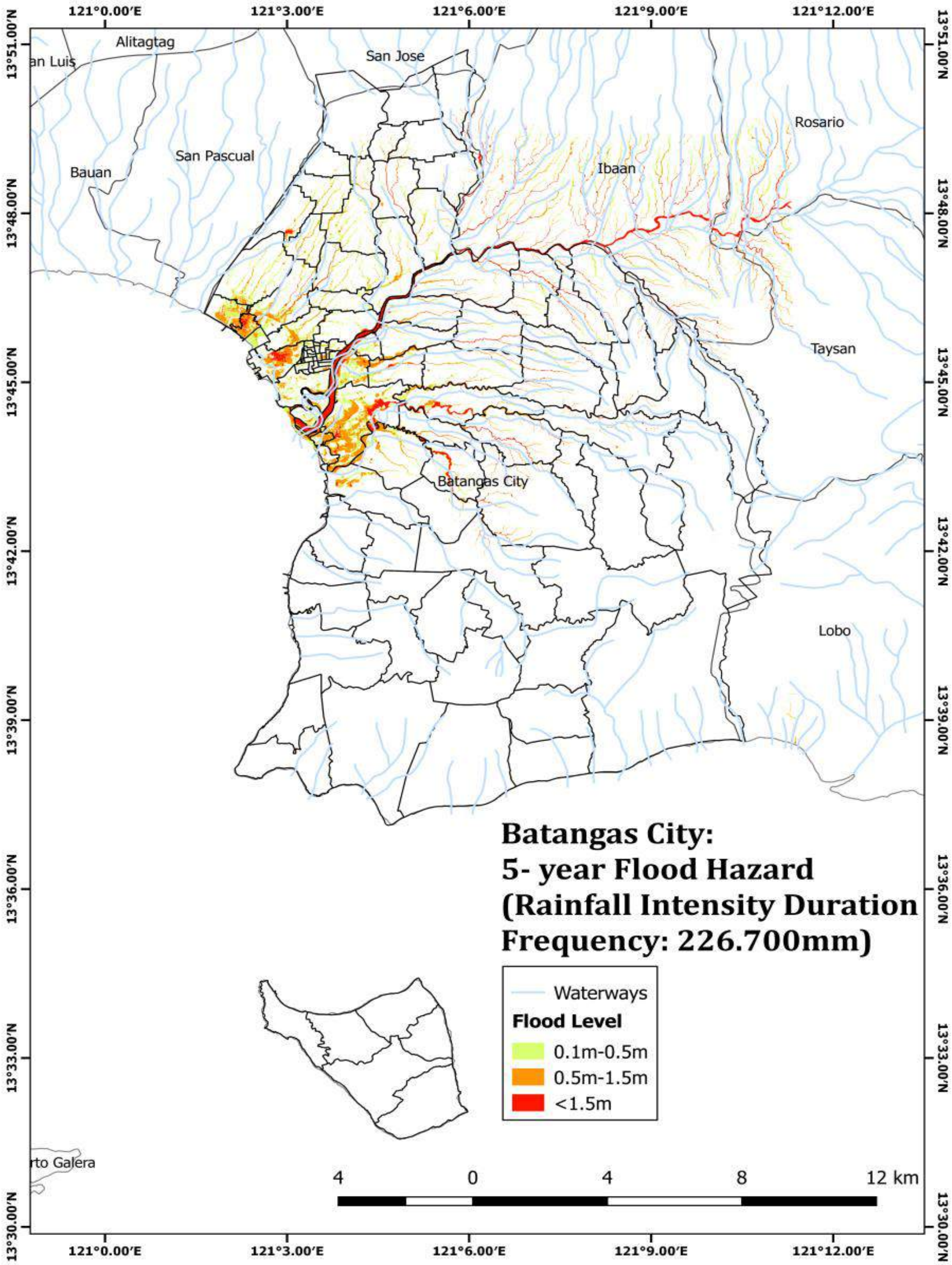
### *Flood Hazard*

The city of Batangas is characterized by multiple streams and rivers that traverse it, as such it is no stranger to flooding caused by riverine and run off sources ***(Maps 3.1.7-3.1.9)***. The flood hazard maps were generated by the Disaster, Risk, and Exposure Assessment (DREAM) Project – UP Diliman. These were generated using the 2D modelling software that calculated the velocity of the riverine flow and the rise and behaviour of water over differing surfaces.

Flooding is concentrated in the low lying areas where much of the built up land and subsequently the populous *barangays* are found ***(Maps 3.1.4 and 3.1.5)***.

### *Five (5) Year Return Period*

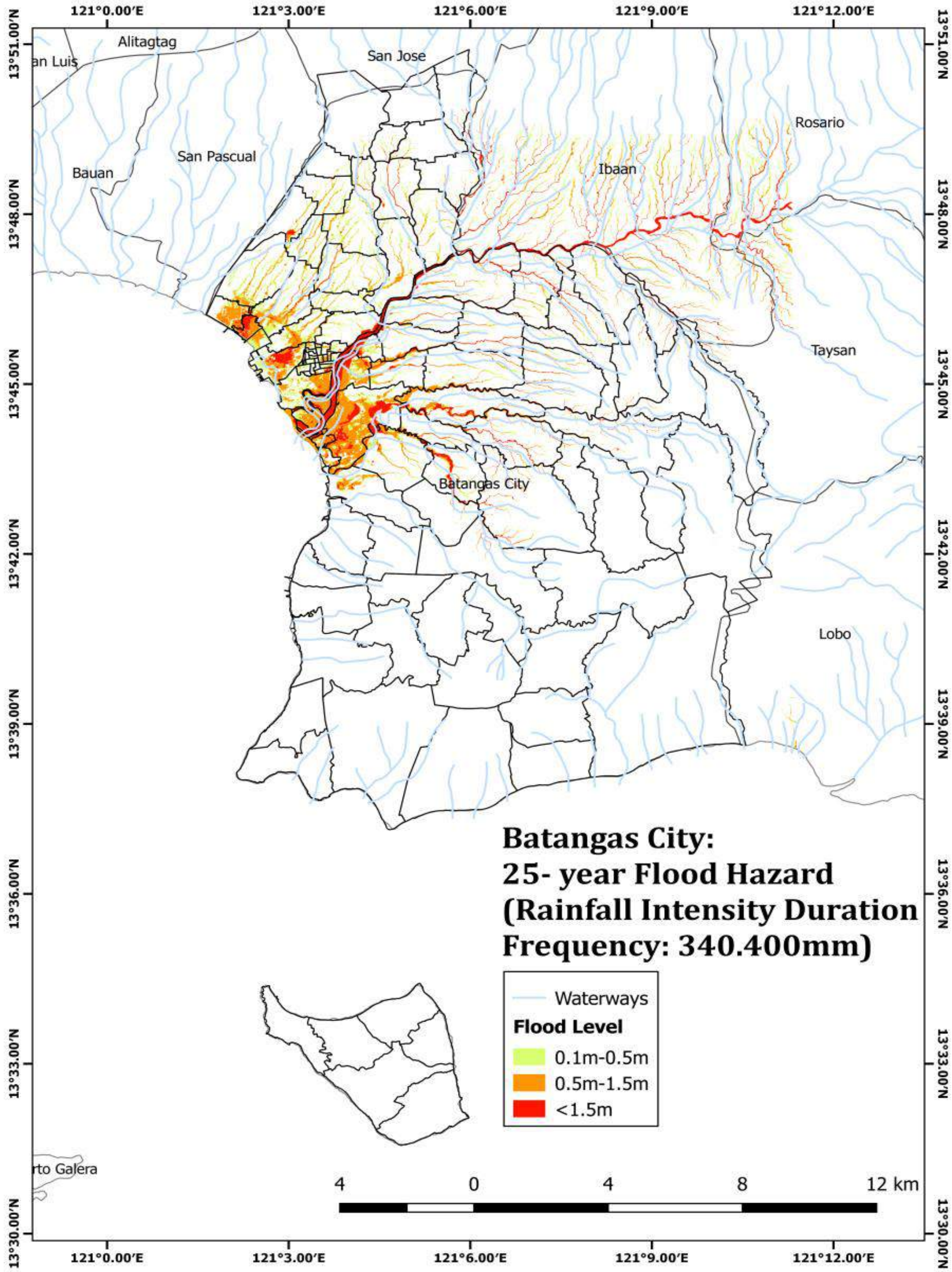
There is a 1/5 (20%) probability of a flood with 5 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 226.700mm.




***Map 3.1.7.*** *Five (5) Year Flood Hazard Map (Source: DREAM Project)*

### *25-Year Return Period*

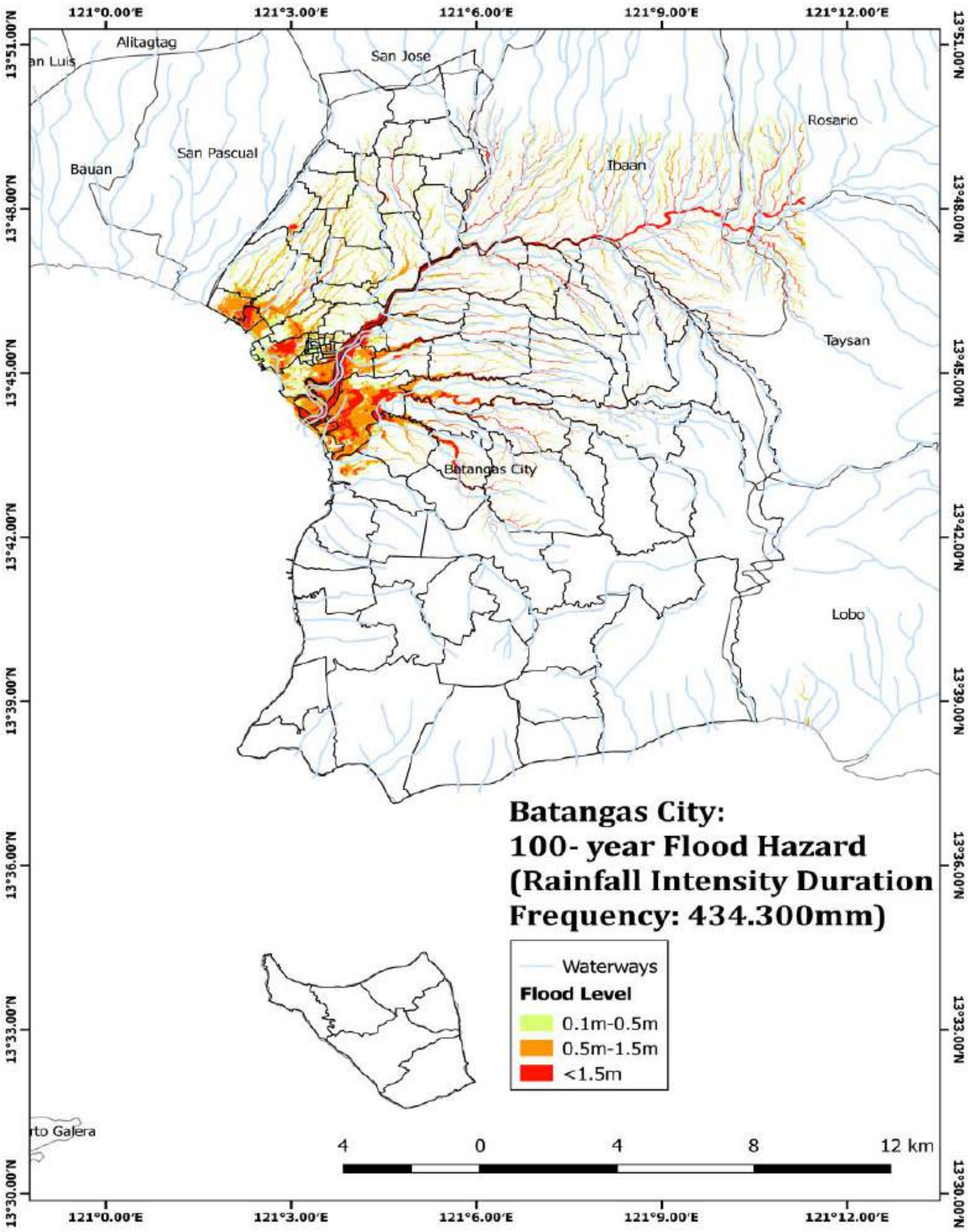
There is a 1/25 (about 4%) probability of a flood with 25 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 340.400 mm.




***Map 3.1.8.*** *25-Year Flood Hazard Map (Source: DREAM Project)*

### *100-Year Return Period*

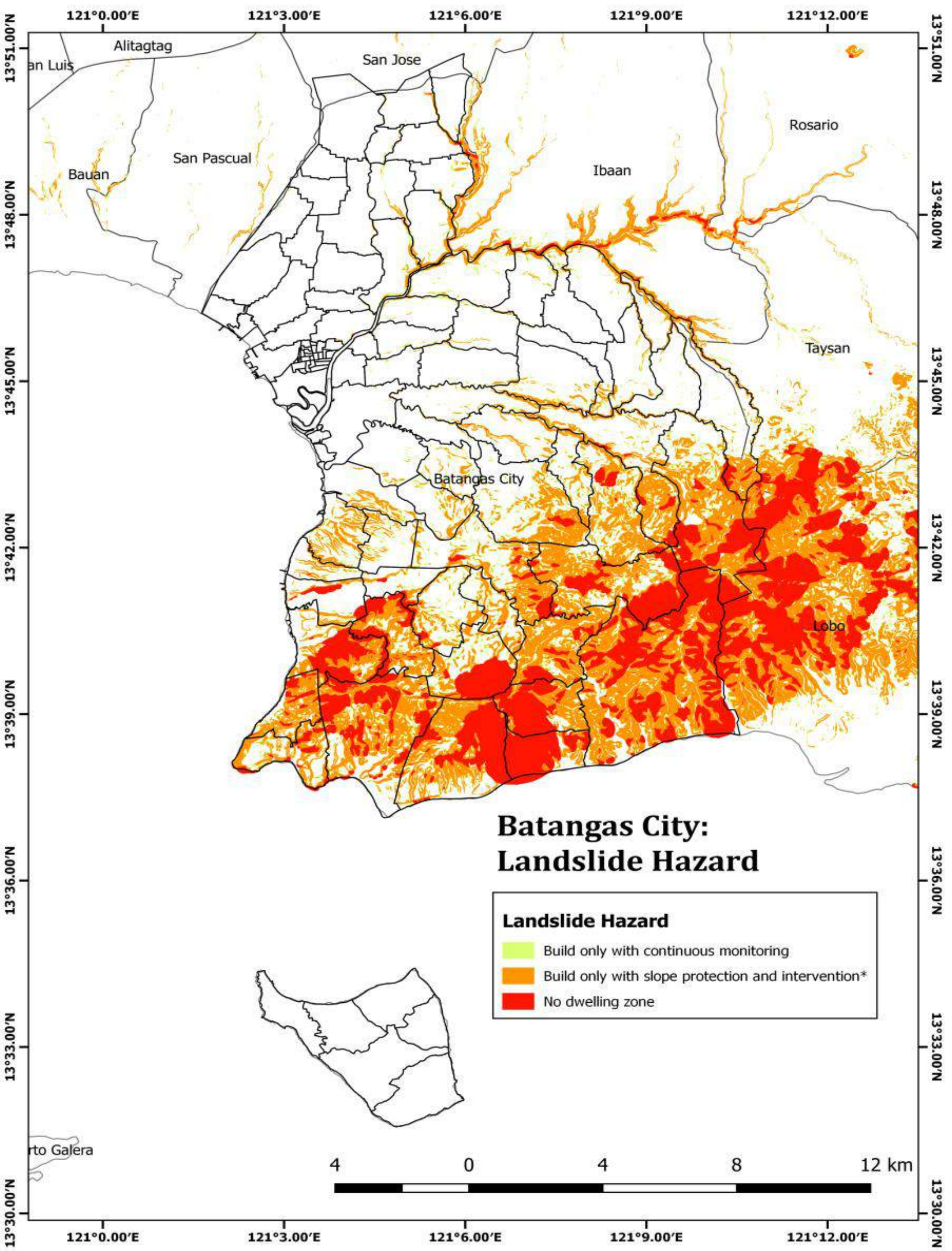
There is a 1/100 (about 1%) probability of a flood with 100 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 434.300mm.




***Map 3.1.9.*** *100-Year Flood Hazard Map (Source: DREAM Project)*

### Landslide Hazard

The landslide hazards ***(Map 3.1.10)*** for Batangas City are concentrated in the South to South western portions of the city. These portions are where the slopes and elevation are higher ***(Map 3.1.1)***. The landslide classification in these areas are no dwelling zones which signifies that no residences should be present due to the risk of landslide hazards ***(Map 3.1.4)***.



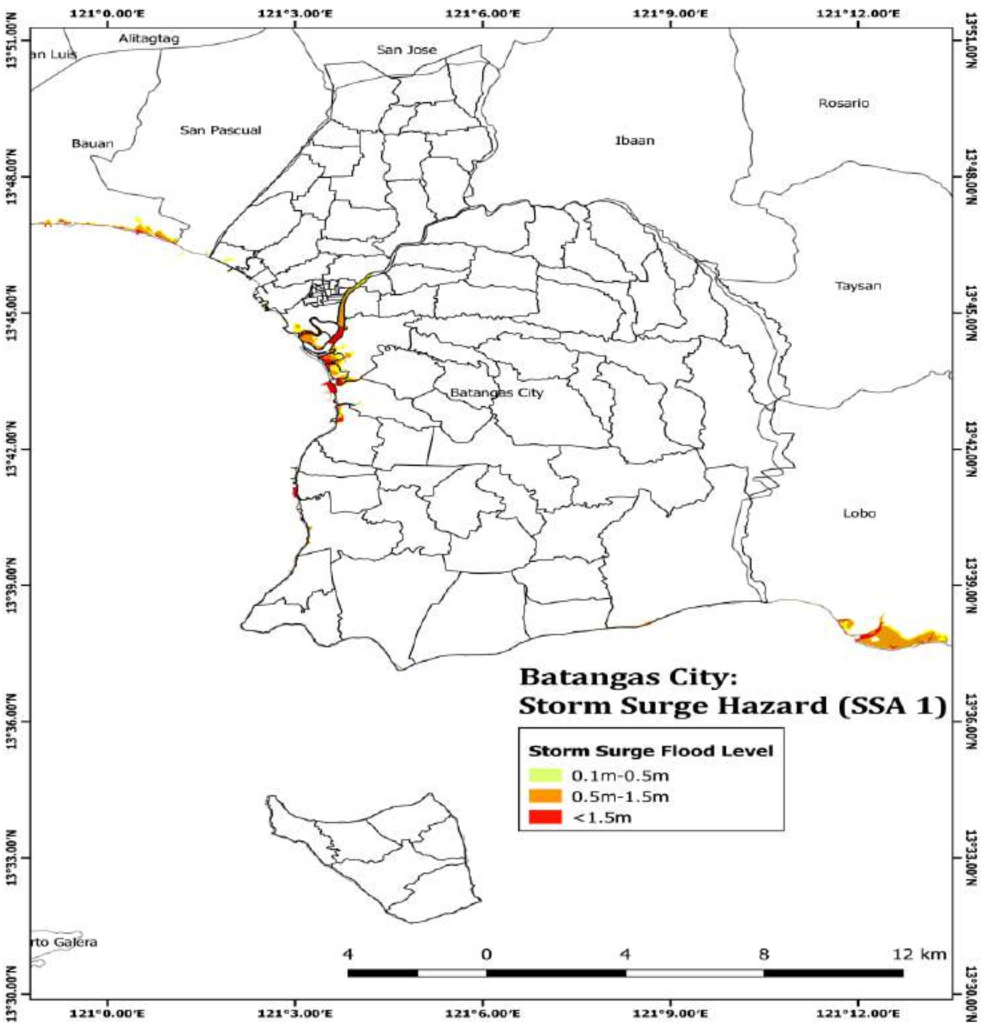

***Map 3.1.10.*** *Landslide Hazard Map (Source: DREAM Project)*

### Storm Surge Hazard (Maps 11-13), (Data from Project NOAH)

The low lying areas located at the south of the city ***(Map 3.1.1)***. The main *barangays* that will be affected by a SSA 1 Storm Surge ***(Map 3.1.11)*** are Malitan, Tabangao Ambulong, Tabangao Aplaya, Wawa and Cuta. In a SSA 2 Storm Surge (***Map 3.1.12***) the affected *barangays* remain the same, but is spread to *barangay* Libjo. The same can be said in a SSA 3 Storm Surge ***(Map 3.1.13)***. It is worth noting that in the event of any of the three storm surges flooding will occur along the river and water ways that empty out into the seas so the *barangays* of Pallocan Kanluran, Poblacion, Kumintang Ibaba, Gulod Labac, Gulod Itaas, and Libjo are vulnerable to riverine overflow in the event of a storm surge.

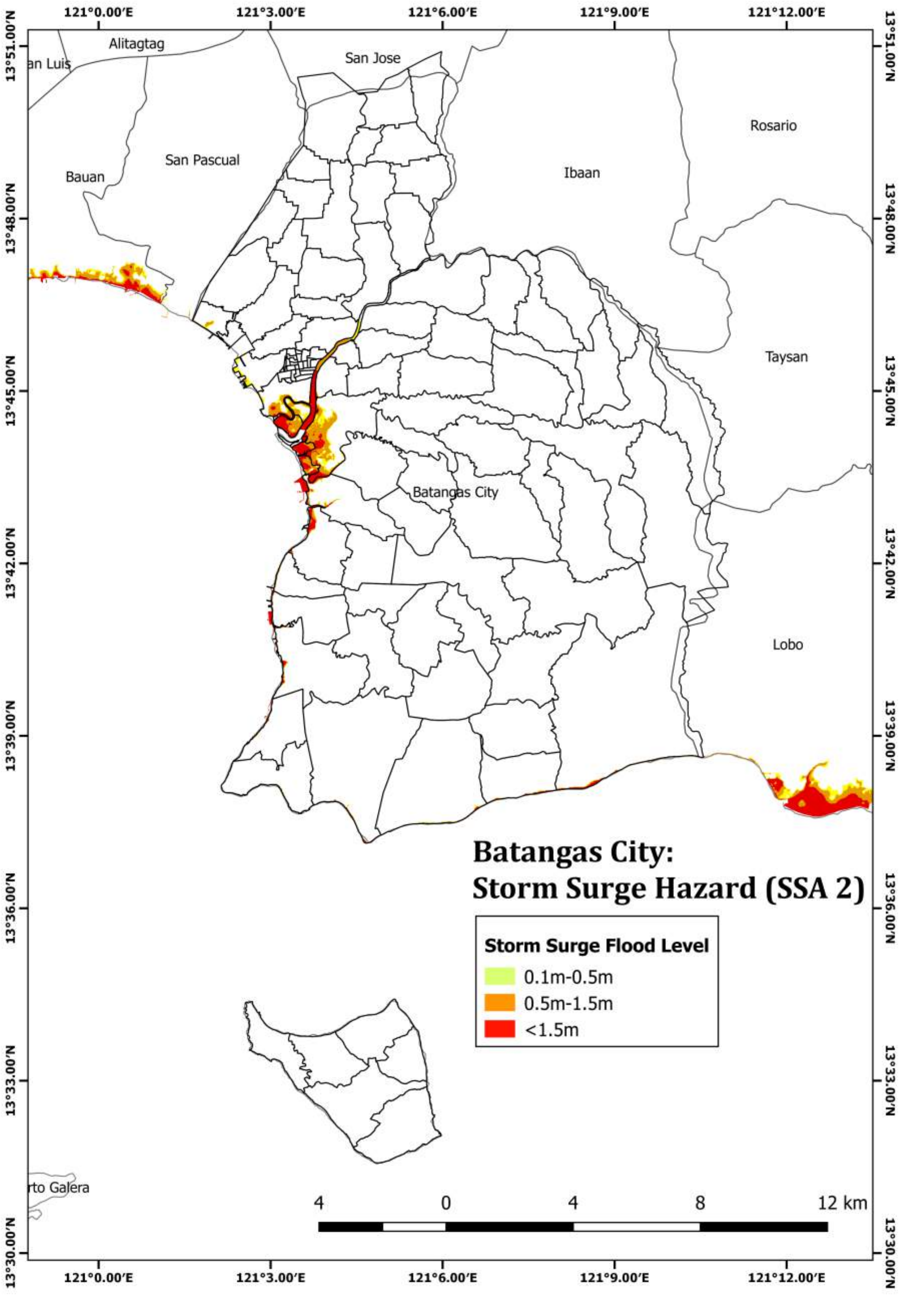
In 2007, storm surge affected the coastal *barangays* of Dela Paz Proper, Dela Paz Pulot Aplaya and Talahib Pandayan causing damages to sea walls and national road.

*SSA 1 Storm Tide Level of 2.01 m to 3.0 m*



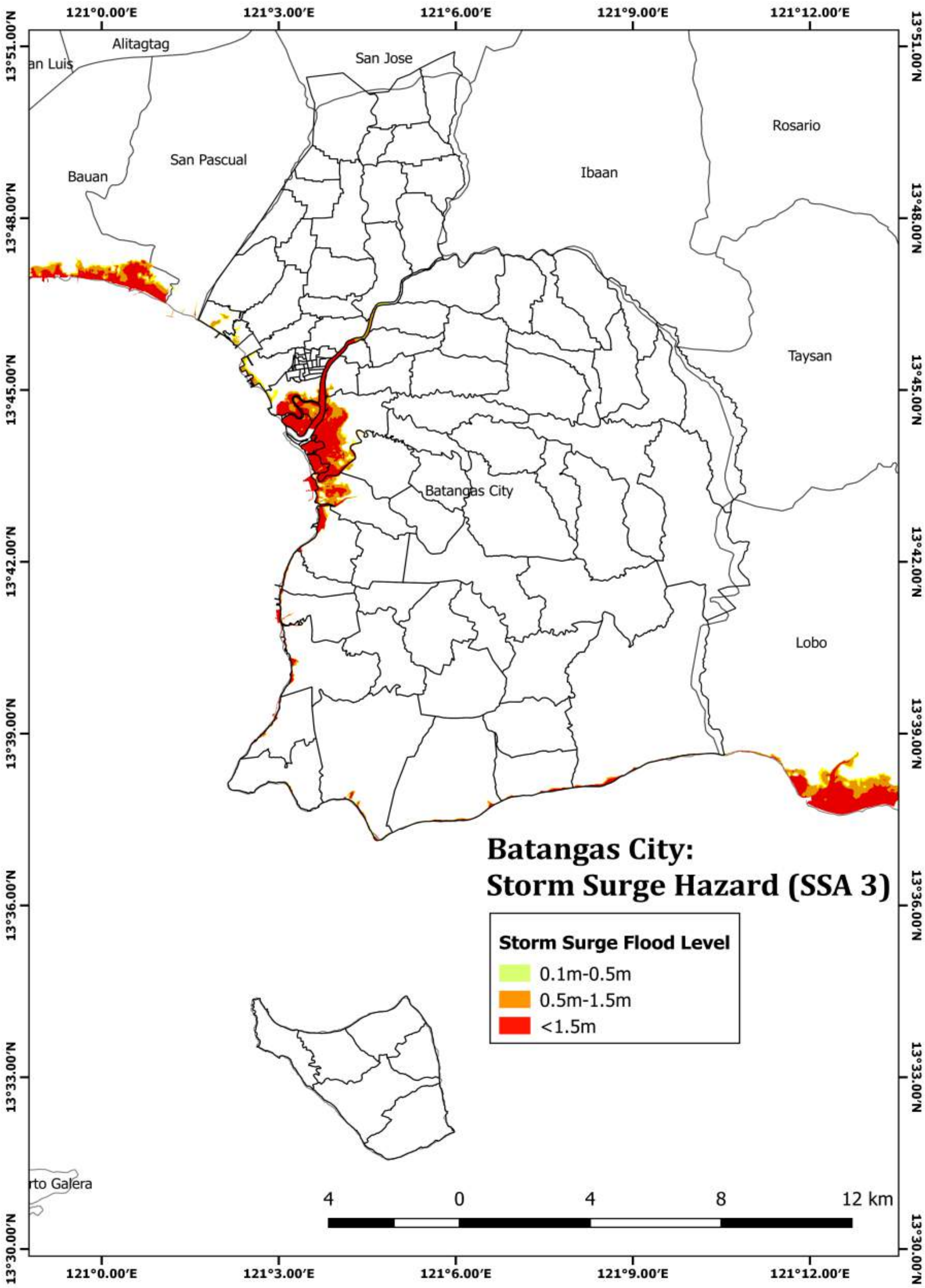

***Map 3.1.11.*** *Storm Surge (SSA 1) hazard map (Source: Project NOAH data)*

## SSA 2 Storm Tide Level of 3.01 m to 4.0 m




***Map 3.1.12.*** *Storm Surge (SSA 2) Hazard Map (Source: Project NOAH data)*

*SSA 3 Storm Tide Level of Greater Than 4.0 m*



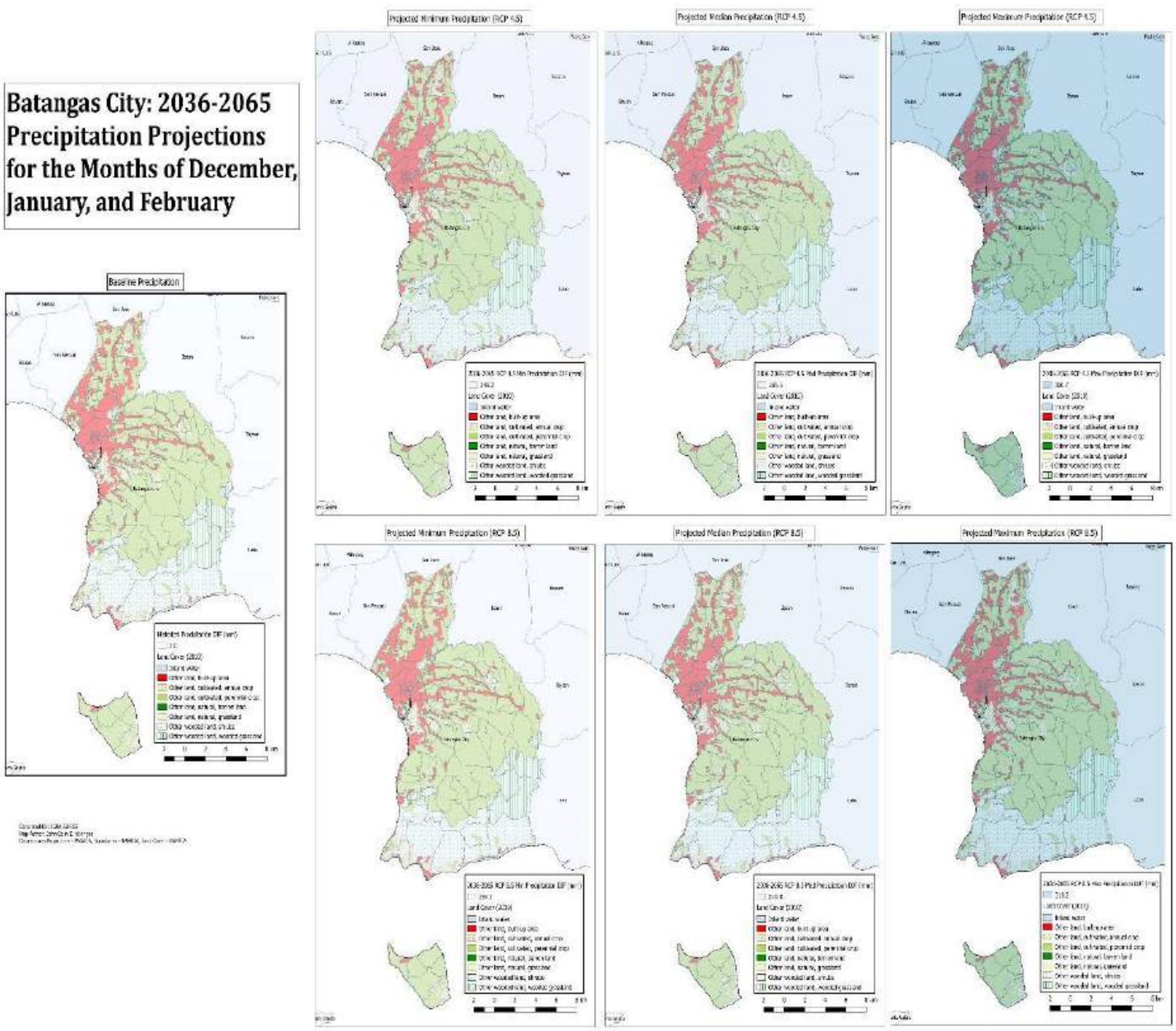

***Map 3.1.13.*** *Storm Surge (SSA 3) Hazard Map (Source: Project NOAH data)*

## Projections and Grid Extent (data on Projections come from PAGASA)

### *A. Change in Precipitation*

### Mid-21st Century Projections (2036-2065), Maps 14-17

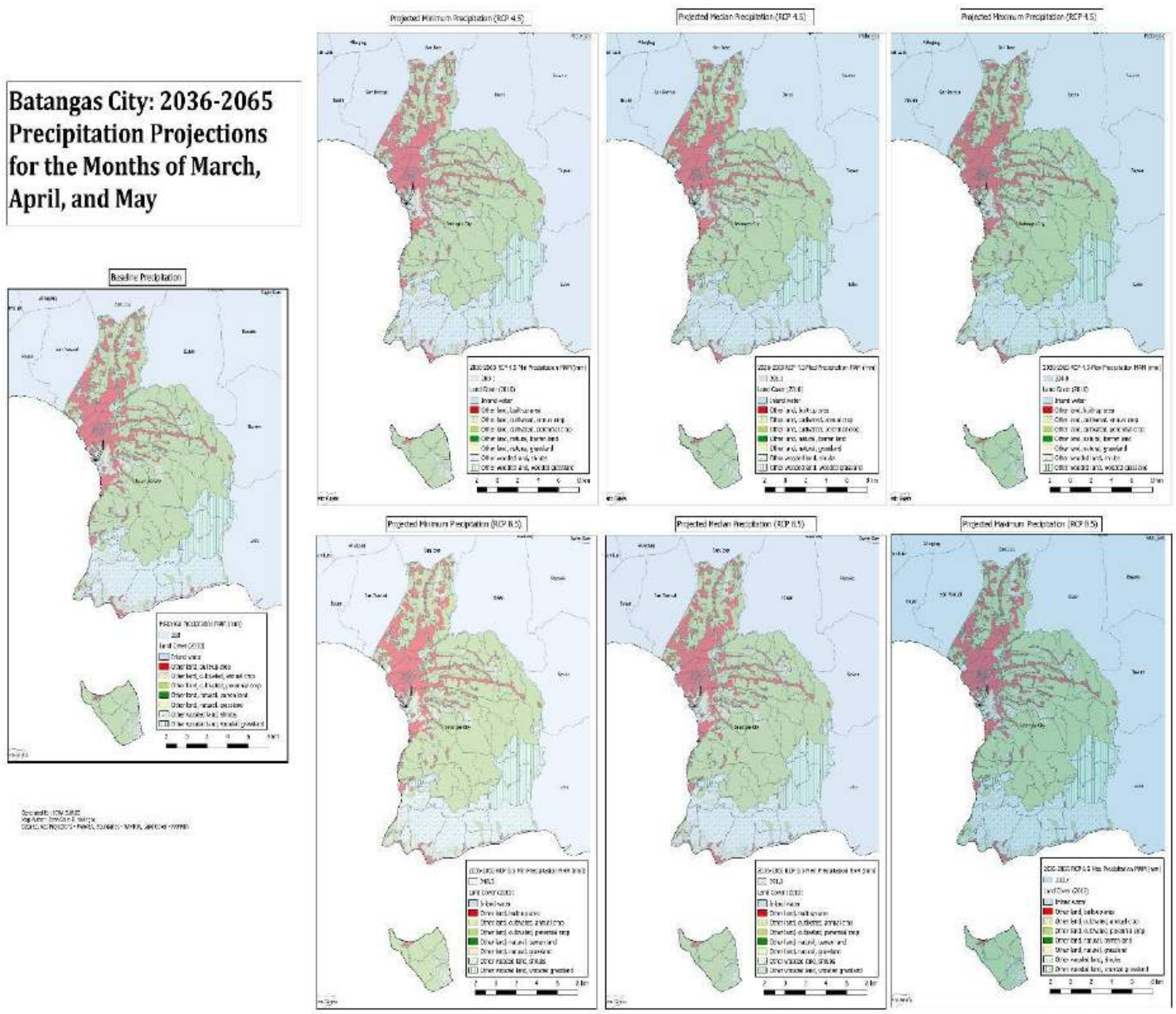
The maps show that for the months of December, January and February ***(Map 3.1.14)*** there is a general increase in precipitation for either scenario with a more increased possible amount for RCP 4.5 with its median being an increase of 14.9% from the baseline. Worth taking note is that the minimum projected amount of rain in either RCP 4.5 or 8.5 is higher than the historical baseline with an increase of 7.5% for RCP 4.5 and 1.4 % in RCP 8.5. Thus, it is projected that the months of December, January, and February are to be wetter than what is usually experienced.




***Map 3.1.14.*** *2036-2065 Precipitation Projections for December, January and February (Source: PAGASA data)*

For the months of March, April, and May, a similar trend is projected as that in the previous quarter ***(Map 3.1.15)***.

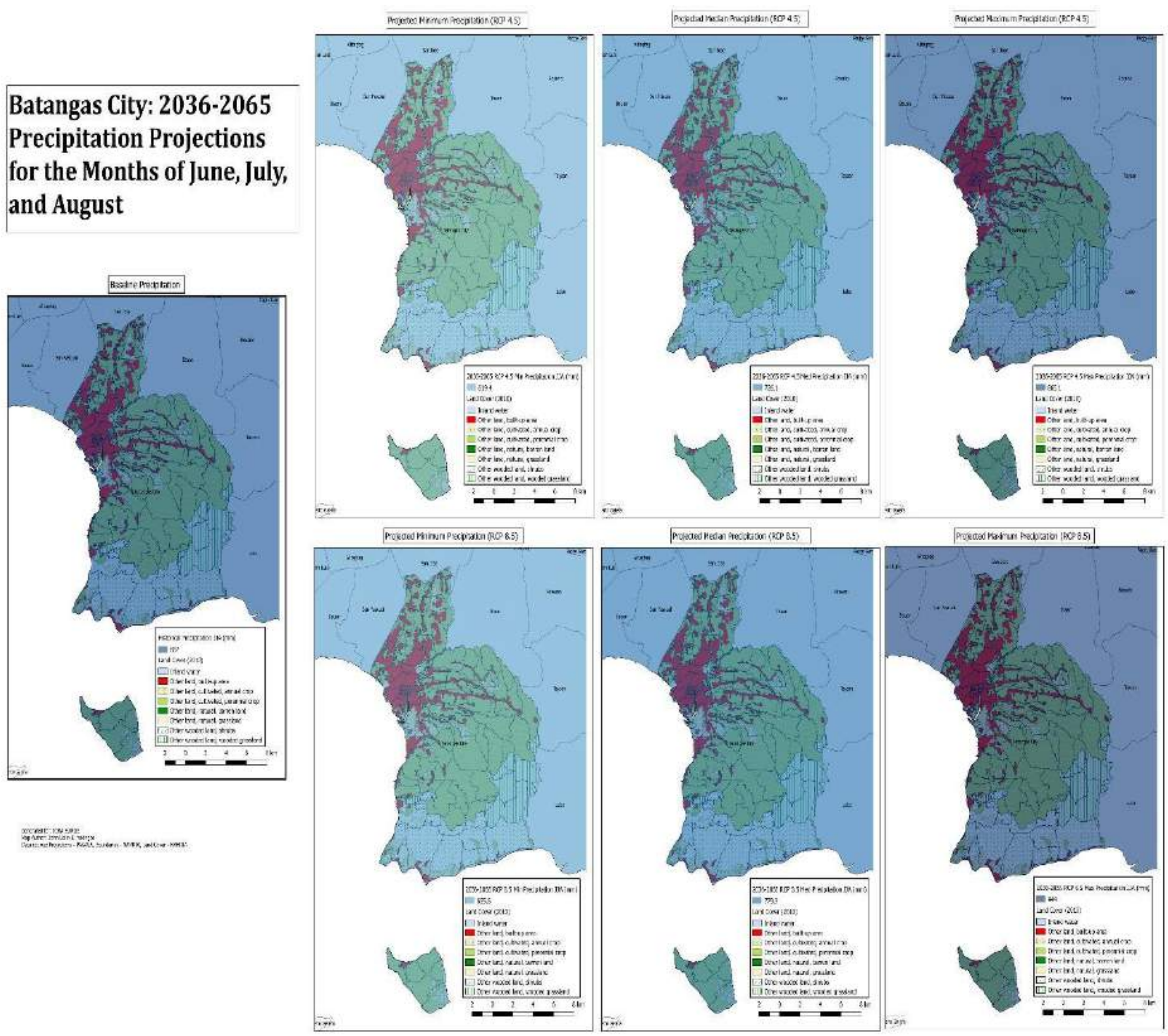
It is projected to be wetter than the baseline, but it is worth taking note that for RCP 8.5 the minimum possible amount is approximately 11.4 % lower than the median possible amount. This translates to possibilities of dryer months and events that what is normally experienced.




***Map 3.1.15.*** *2036-2065 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are historically the wettest, but they are projected to have a lower median amount decreasing by 15.2 % in RCP 4.5 and 8.9 % in RCP 8.5 ***(Map 3.1.16).***

The maximum projected rainfall for each scenario being closer to the baseline differing by 1 % in RCP 4.5 and 10.2 % in RCP 8.5 The minimum projected possible rainfall is markedly decreased at a 27.7 % decrease in RCP 4.5 and 23.5 % in RCP 8.5. These projections would signify that the months of June, July, and August would be projected to experience drier months with the minimum possible rainfall amount markedly lower than the usual and the maximum amount only reaching the baseline. Furthermore, for RCP 8.5 there is wider range of possible rainfall amounts which signify a higher possibility of extreme wet and dry events.

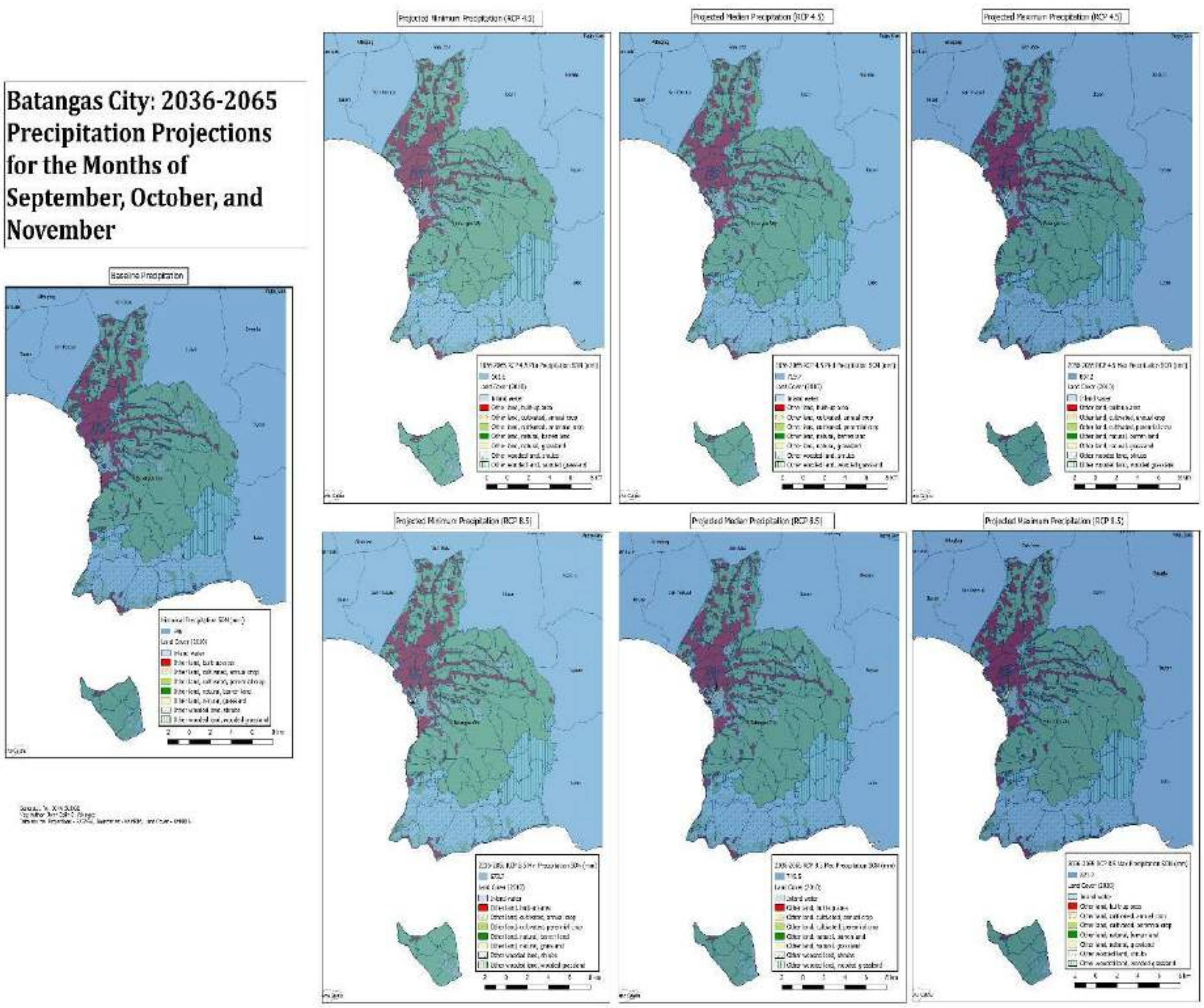



***Map 3.1.16.*** *2036-2065 Precipitation Projections for June, July and August (Source: PAGASA data)*

The last quarter will be experiencing two different trends for the two scenarios ***(Map 3.1.17)***. For RCP 4.5, the months of September, October, and November will be projected to have a drier median precipitation than the baseline projected to have a decrease of 3.6 %. The projected minimum precipitation would have a decrease of 11.4 % from the baseline. The maximum precipitation on the other hand will be projected to be an increase of 8.2 % from the baseline.

For RCP 8.5 on the other hand it is projected to be slightly wetter from the baseline with a negligible 0.4 % increase from the baseline. An approximate of 10 % increase and decrease from the baseline will be projected respectively for the maximum and minimum projected precipitation.

In sum, the months of September, October, and November will be slightly drier in RCP 4.5 while it will be slightly wetter in RCP 8.5.

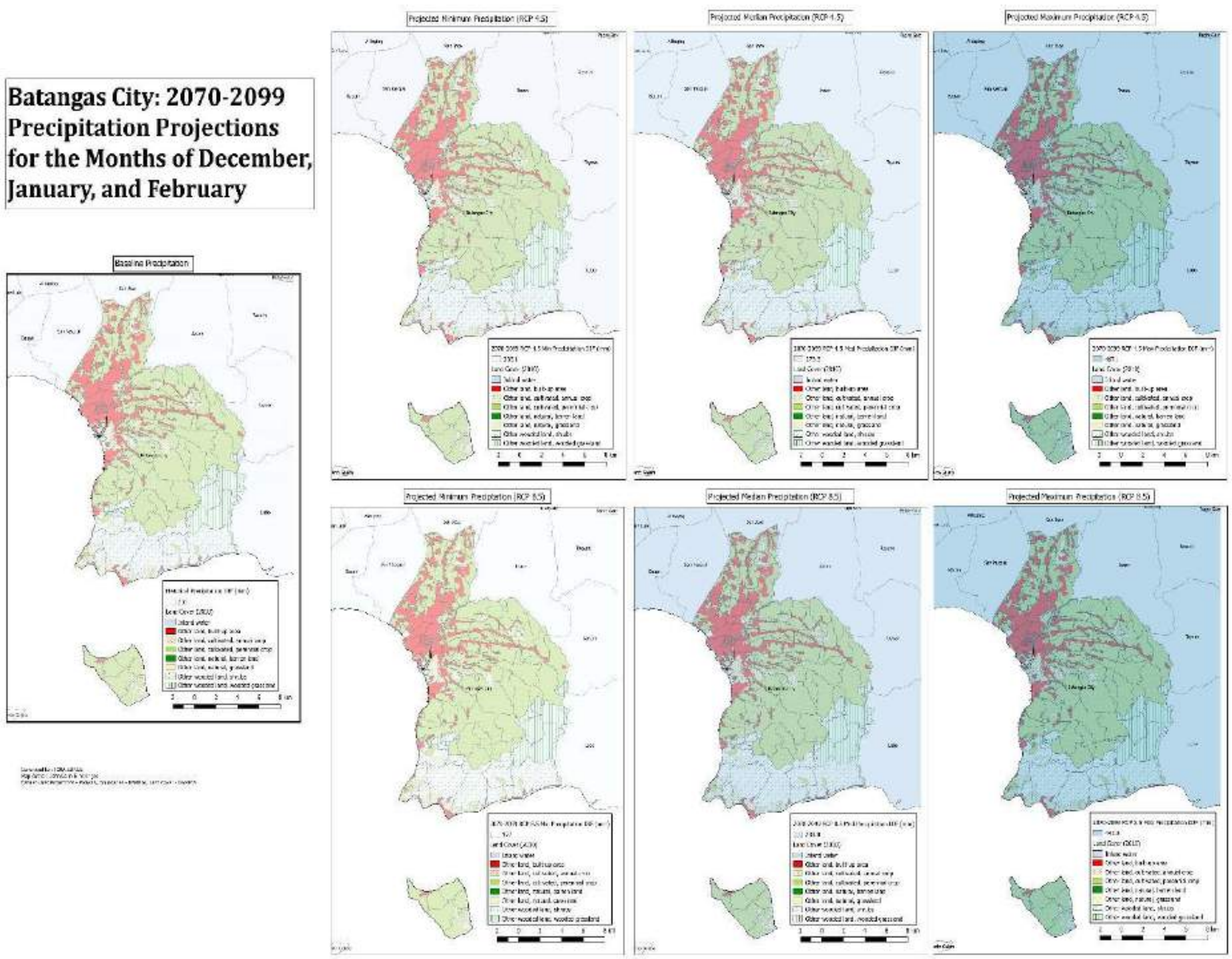



***Map 3.1.17.*** *2036-2065 Precipitation Projections for September, October and November (Source: PAGASA data)*

### Late 21st Century Projection (2070-2099), Maps 18-20

The projected trend continues from the mid-century to the late century for the months of December, January, and February. ***(Map 3.1.18)*** The projected median precipitations for the scenarios are wetter than the baseline with an increase of 18.3 % for RCP 4.5 and 22.8 % for RCP 8.5. The projected minimum precipitation is where the two scenarios differ. For RCP 4.5 there is a projected increase of 1.8 % from the baseline while for RCP 8.5 there is a decrease of 23.4 %. This would signify a possibility of extreme dry events for the months of December, January, and February in the latter scenario.

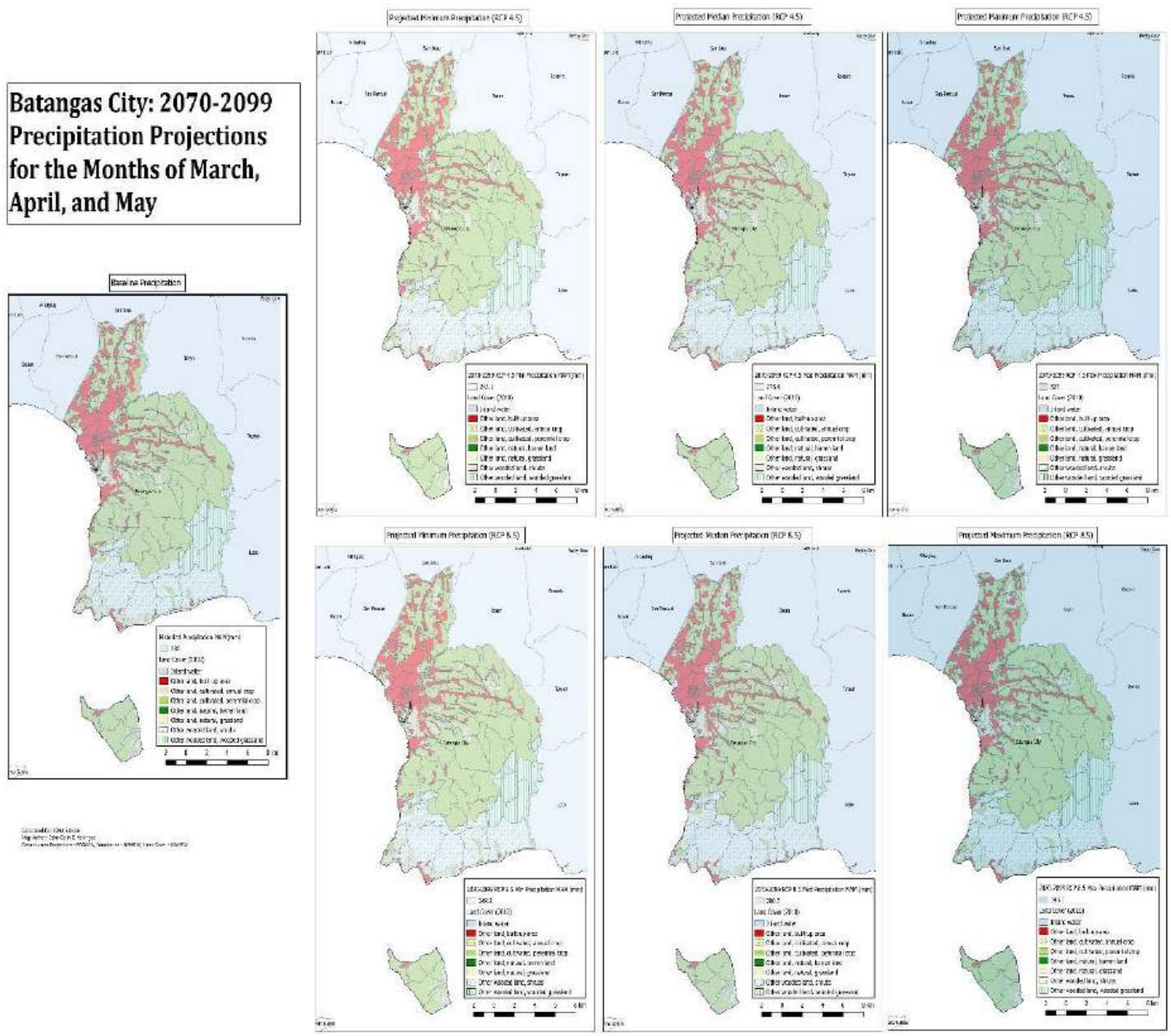
There is a marked increase in the projected maximum precipitation for both scenarios with an increase of 102.2 % for RCP 4.5 and 91.5 % for RCP 8.5. The trends signify a general increase in precipitation for both scenarios, but a higher level of variability for RCP 8.5 having marked a decrease in the projected minimum precipitation and marked increase in the projected maximum precipitation.




***Map 3.1.18.*** *2070-2099 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April, and May on the other hand are projected not to vary too far from the historical baseline ***(Map 3.1.19)***. The median precipitation is projected to decrease by 0.7 % from the baseline for RCP 4.5 while for RCP 8.5 it is projected to increase by 0.1 %. The maximum and minimum projected precipitation for the scenarios differ in that for RCP 4.5 the range of values are projected to be drier while in RCP 8.5 it is wetter. It is projected to have a decrease of 13.3 % from the baseline in the projected minimum value for RCP 4.5.

In comparison, for RCP 8.5 the projected minimum precipitation is a decrease of 11.4 % from the baseline. The maximum projected precipitation for RCP 4.5 is an increase of 9.5 % from the baseline while in RCP 8.5 the increase of 22.4 % from the baseline. In sum, for the months of March, April, and May will not vary from the baseline, but the projected possible range of values will differ in that for RCP 4.5 it will be drier while for RCP 8.5 it will be wetter.

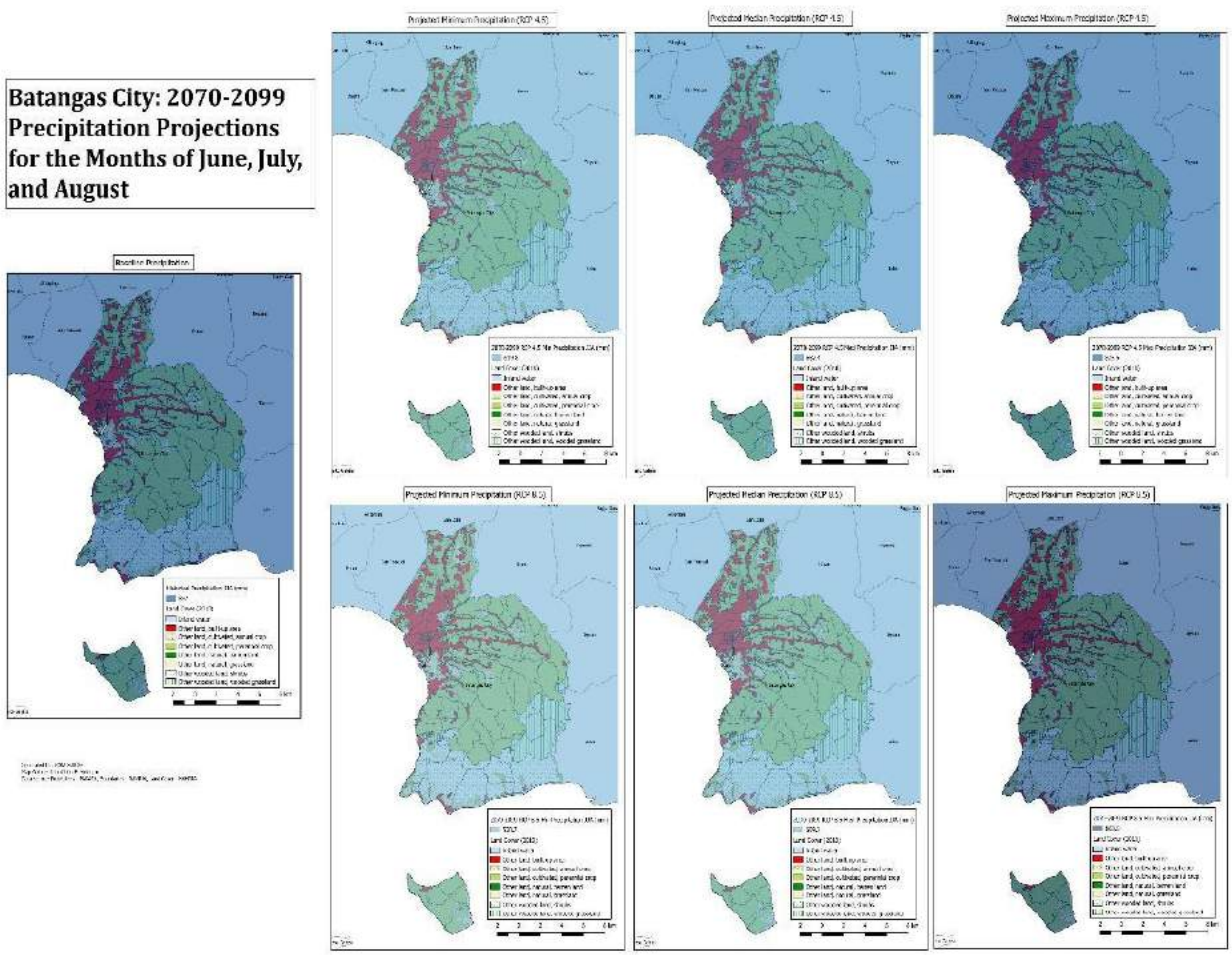



***Map 3.1.19.*** *2070-2099 Precipitation Projections for March, April and May (Source: PAGASA data)*

For both scenarios, the months of June, July, and August are projected to be drier than the baseline precipitation for those months in both scenarios ***(Map 3.1.20)***. This is indicative in the projected maximum precipitations for either scenario. There is a projected decrease of 3.6% for RCP 4.5 and an increase of 3.2% for RCP 8.5 from the baseline for the maximum projected precipitation. This signifies that even in the event of wetter events than the projected median, the amount of rain will only be at the range of what was historically experienced.

The median projected precipitation is a marked decrease from the baseline in both scenarios. For RCP 4.5, the median is a projected 20.3% decrease in precipitation from the baseline while in RCP 8.5 the median is projected to be 28.9% decrease from the baseline. The minimum projected precipitation for RCP 4.5 is a decrease of 27.6% from the baseline while for RCP 8.5 there is a projected 34.8% decrease from the baseline.

In sum, the months of June, July, and August will be drier than the historical baseline even in wetter events in either scenario. RCP 8.5 will have a wider range of values even drier than RCP 4.5 at its minimum and wetter at its maximum.

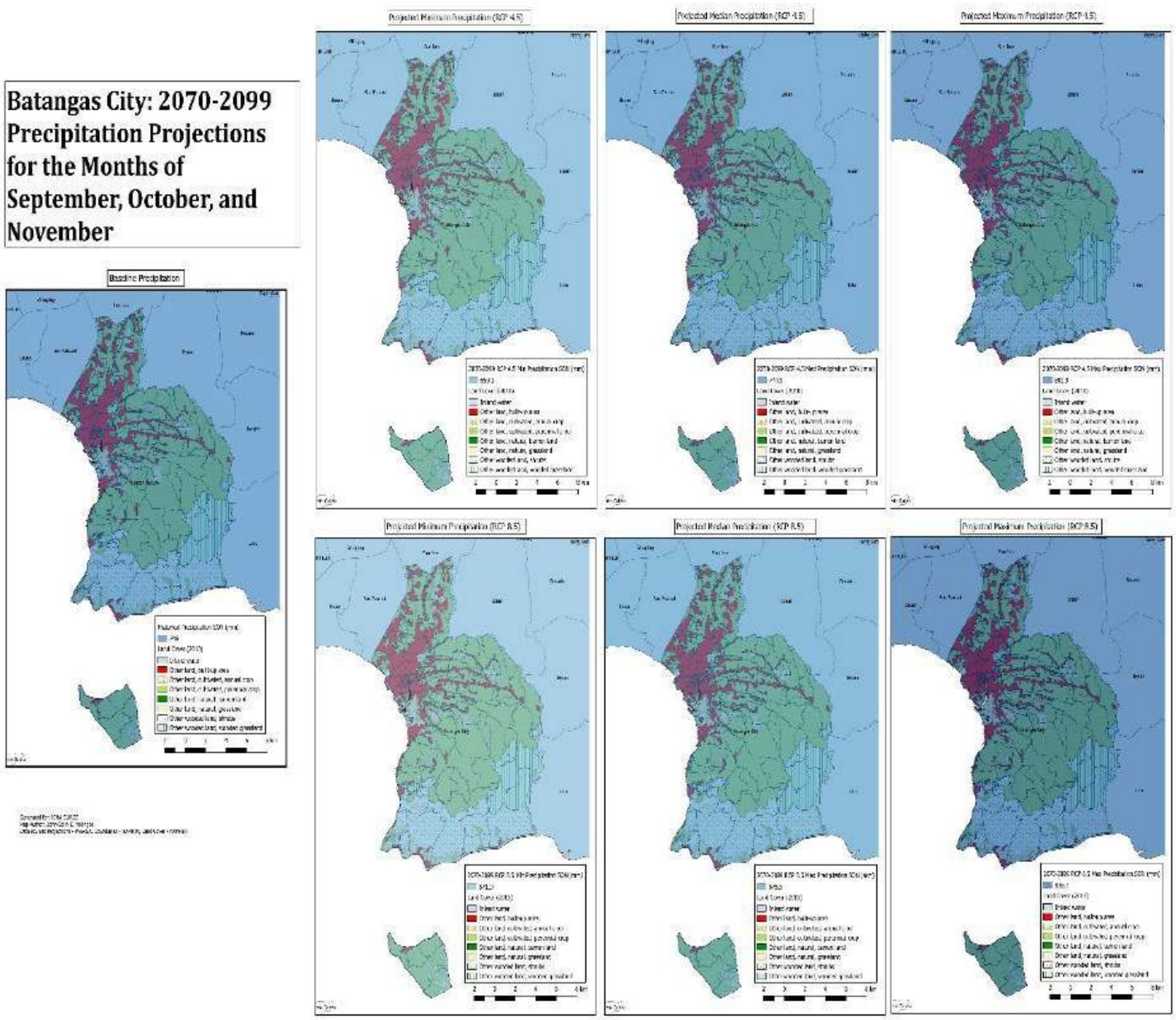



***Map 3.1.20.*** *2070-2099 Precipitation Projections for June, July and August (Source: PAGASA data)*

The last quarter is projected to have a drier median while having a wider range of values for the maximum and minimum in either scenario ***(Map 3.1.21)***.

The months of September, October, and November will be generally drier than the baseline having a decrease of 0.2% in the median projected precipitation for RCP 4.5 and a decrease of 9.5% for RCP 8.5.

The maximum projected precipitation for RCP 4.5 is projected to have an increase of 7.4% from the base lines. For RCP 8.5 on the other hand there is a projected 12.1 increase from the baseline for the maximum projected precipitation. The minimum projected precipitation for RCP 4.5 is projected to be a 12.9% decrease from the baseline while for RCP 8.5 there is a projected decrease of 23.4%. In sum the median for both scenarios are drier with a wide range of possible wet or dry events, but RCP 8.5 is projected to be drier with a wider range of possible events for the months of September, October and November.



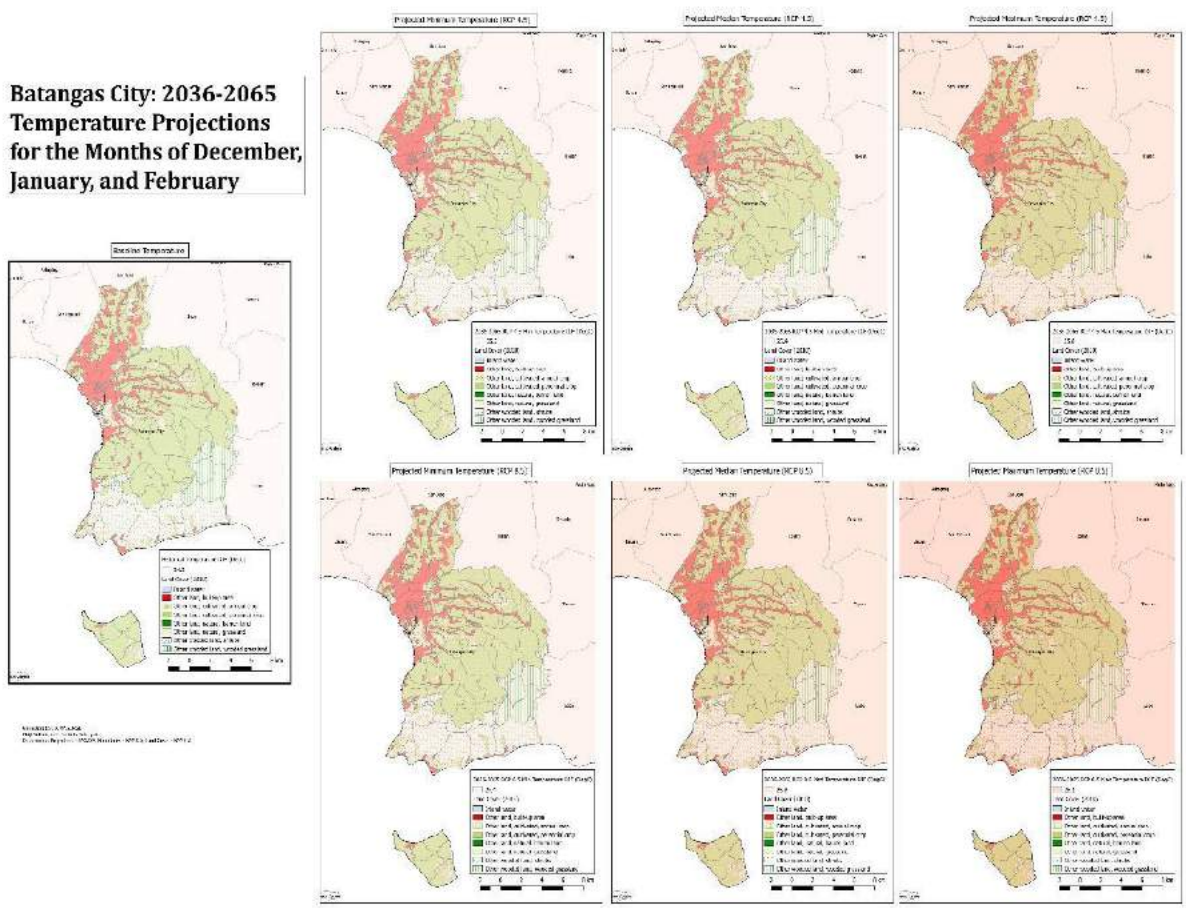

***Map 3.1.21.*** *2070-2099 Precipitation Projections for September, October and November (Source: PAGASA data)*

## *B. Change in Temperature*

### Mid-21st Century Projections (2036-2065), (Maps 22-24)

In general temperatures will increase for all scenarios varying in certain degrees for each quarter. The months of December, January, and February are historically the coolest and will continue to be so, but will experience temperatures that are closer to the historical temperature of the quarters of June, July, and August and September, October, and November ***(Map 3.1.22)***.

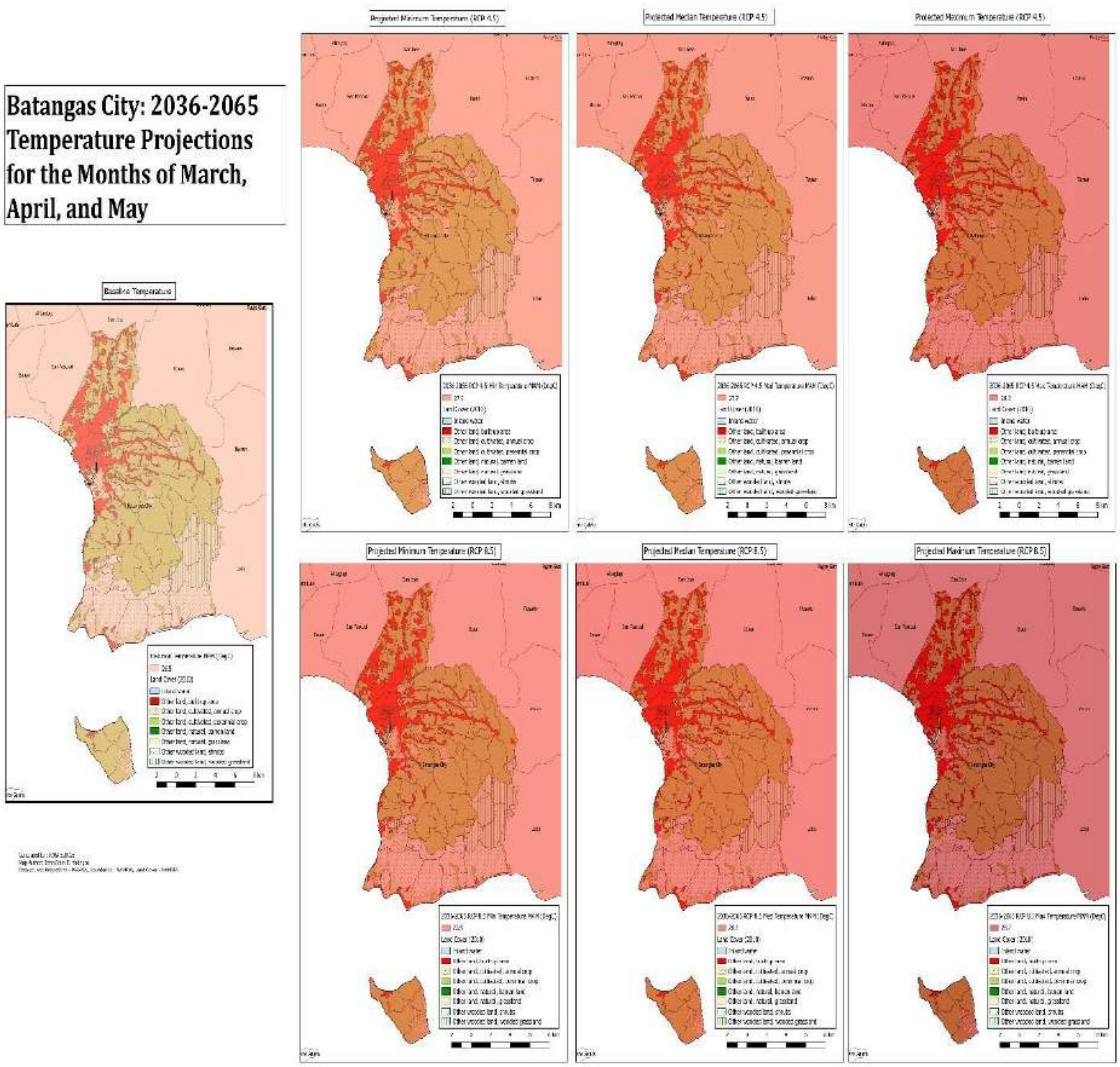
The temperature increase will be projected to be higher in RCP 8.5 then RCP 4.5 with a 1.6 degree projected increase in the median temperature for the former and a 1.2 increase in the latter. The maximum projected temperature for RCP 8.5 is an increase of 1.9 degrees from the baseline. To further compare the difference in the temperature increase for the scenarios, the maximum projected temperature for RCP 4.5 is an increase of 1.6 degrees from the baseline which is the same value as the median for RCP 8.5. Furthermore, the projected minimum temperature for RCP 8.5 is an increase of 1.2 degrees from the baseline which is the same value as the median of RCP 4.5. The minimum projected temperature for RCP 4.5, on the other hand, is an increase of 1.0 degrees from the minimum.




***Map 3.1.22.*** *2036-2065 Temperature Projections for December, January and February (Source: PAGASA data)*

A similar trend continues from the last quarter to the months of March, April, and May ***(Map 3.1.23)***. Temperatures will be higher for RCP 8.5 with a range of 1.3-2.2 degrees increase from the base line for the quarter with a median of 1.6, the maximum and minimum temperature increase being higher than the previous quarter.

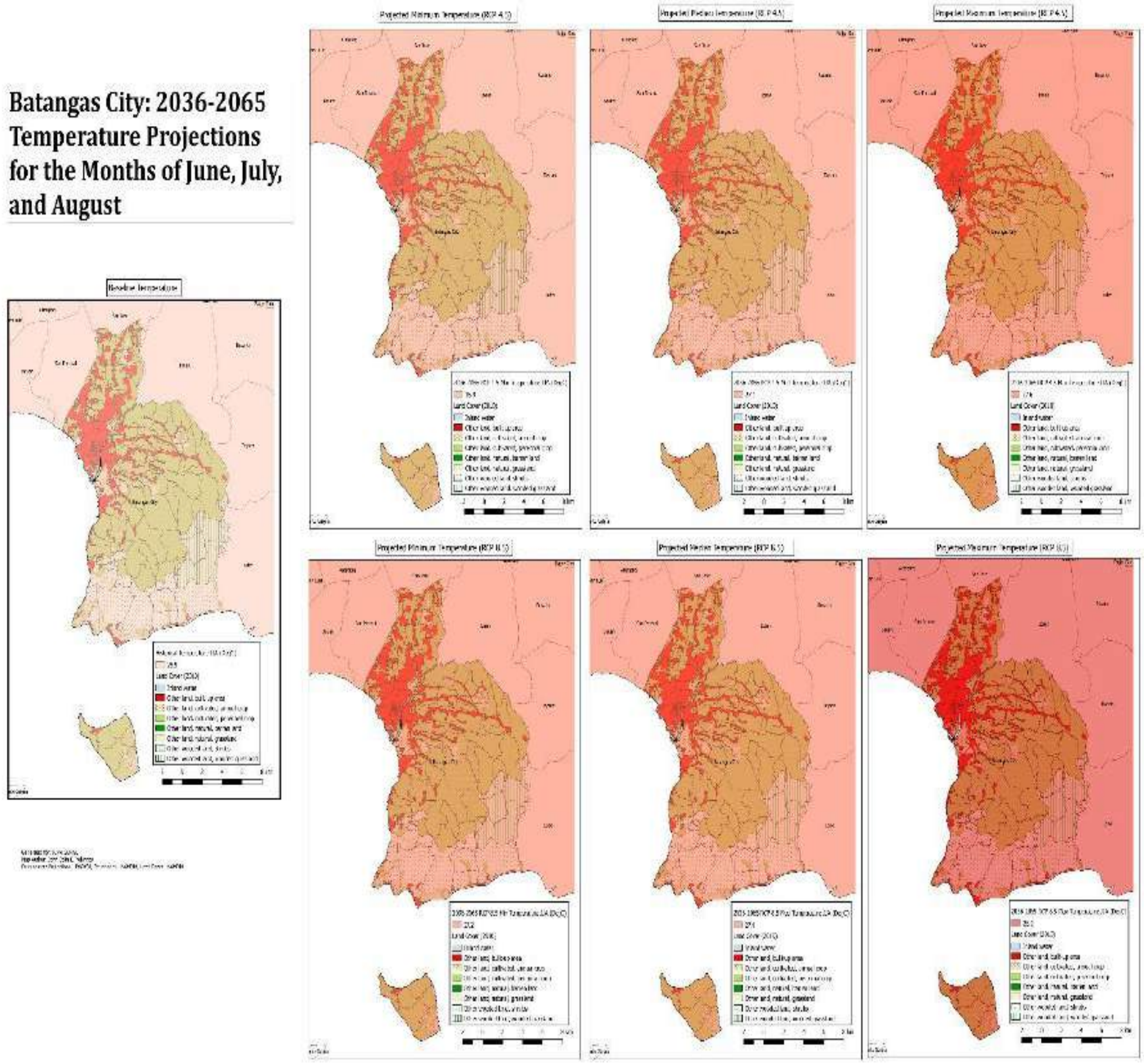
For RCP 4.5, the minimum and median projected temperature increases are the same as the previous quarter, but the maximum projected temperature increase has been increased to 1.7 degrees from the base line. March, April, and May are still projected to be the hottest months for the year, but with higher baseline and possible temperatures.




***Map 3.1.23.*** *2036-2065 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to be hotter than the historical baseline for the hottest temperatures of the year ***(Map 3.1.24)***.

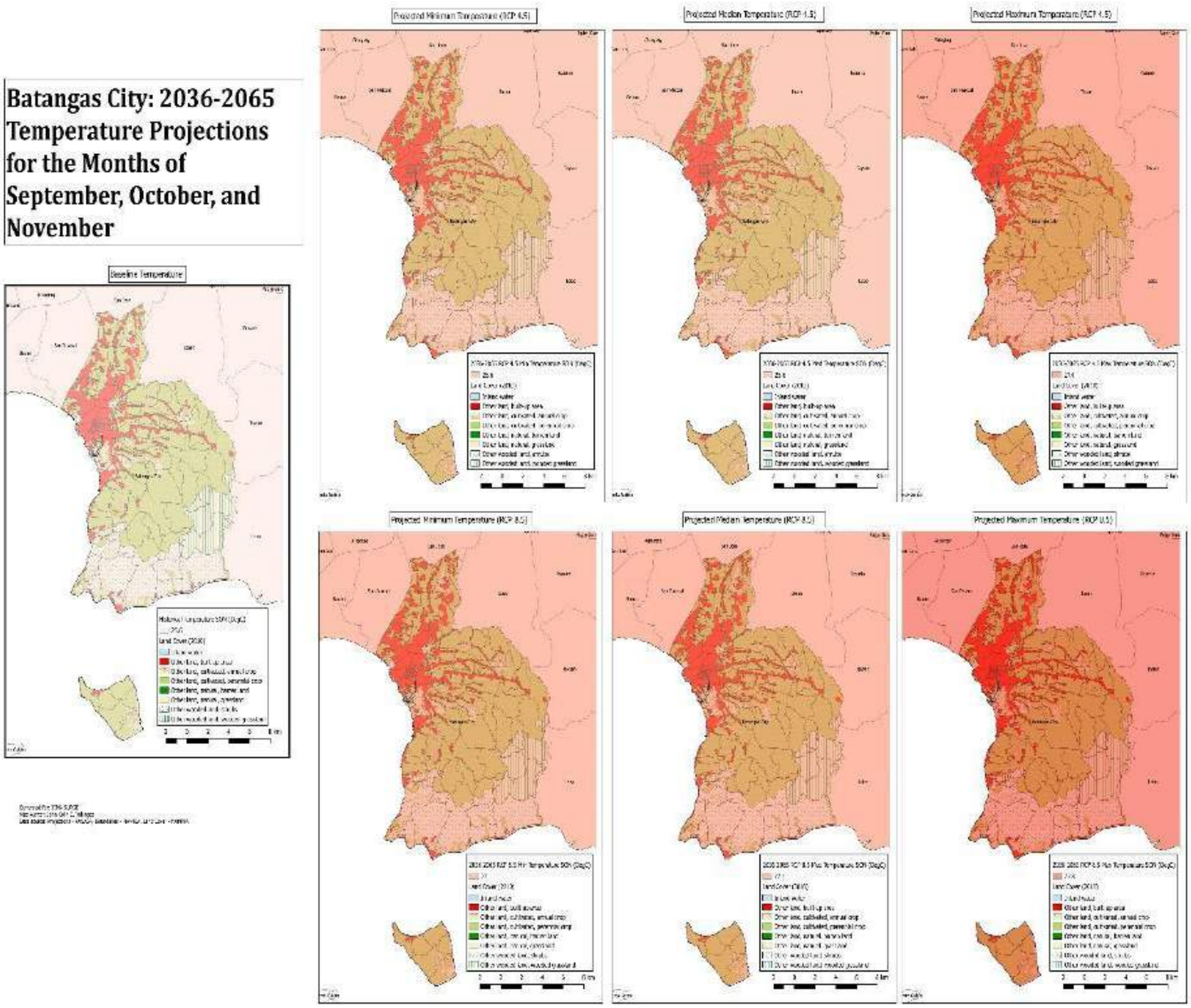
The temperatures ranging from 26.9 to 27.6 degrees Celsius with a median of 27.1 degrees for RCP 4.5 and 27.2 to 28.2 degrees Celsius with a median of 27.4 degrees for RCP 8.5 in comparison to the historically hottest temperature of 26.5 degrees Celsius.




***Map 3.1.24.*** *2036-2065 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October, and November have a similar trend to the previous quarter in that the projected temperatures are hotter than the historical hottest temperature of 26.5 degrees Celsius ***(Map 3.1.25)***.

Worth noting is that in RCP 4.5 the median and the minimum projected temperatures are the same at 26.6 degrees and its maximum at 27.4 degrees. For RCP 8.5 the projected range of temperatures are 27-27.8 degrees Celsius with a median of 27.1. This signifies that the temperatures during these months remain relatively at the median point having a narrower range of temperatures.



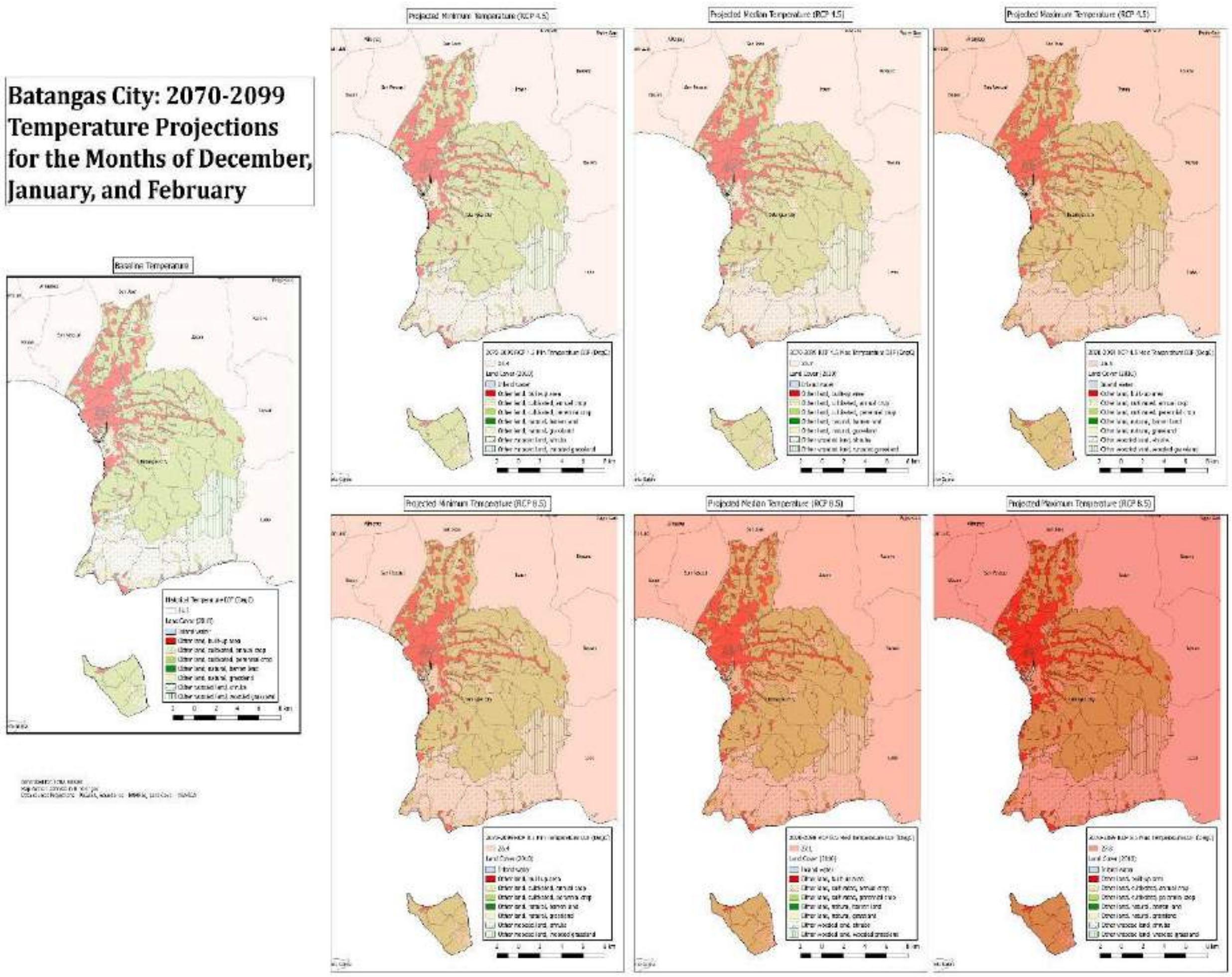

***Map 3.1.25.*** *2036-2065 Temperature Projections for September, October, and November (Source: PAGASA data)*

## Late 21st Century Projections (2070-2099), Maps 26-29

Although the trend of increasing temperatures remains the same, the amount of increase greatly differs between the scenarios for the late century projections. The temperatures in RCP 8.5 increasing from between 2.2 to 4 degrees compared to RCP 4.5 which increased from 1.2 to 2.5 degrees. Comparatively, the increase of temperature from RCP 8.5 is almost twice that from RCP 4.5.

For the months of December, January, and February, the projections for RCP 4.5 range from 25.4-26.5 degrees Celsius with a median of 25.7 degrees ***(Map 3.1.26)***. While for RCP 8.5, the projected temperatures range from 26.4 degrees to 27.8 degrees with a median of 27.1 degrees.

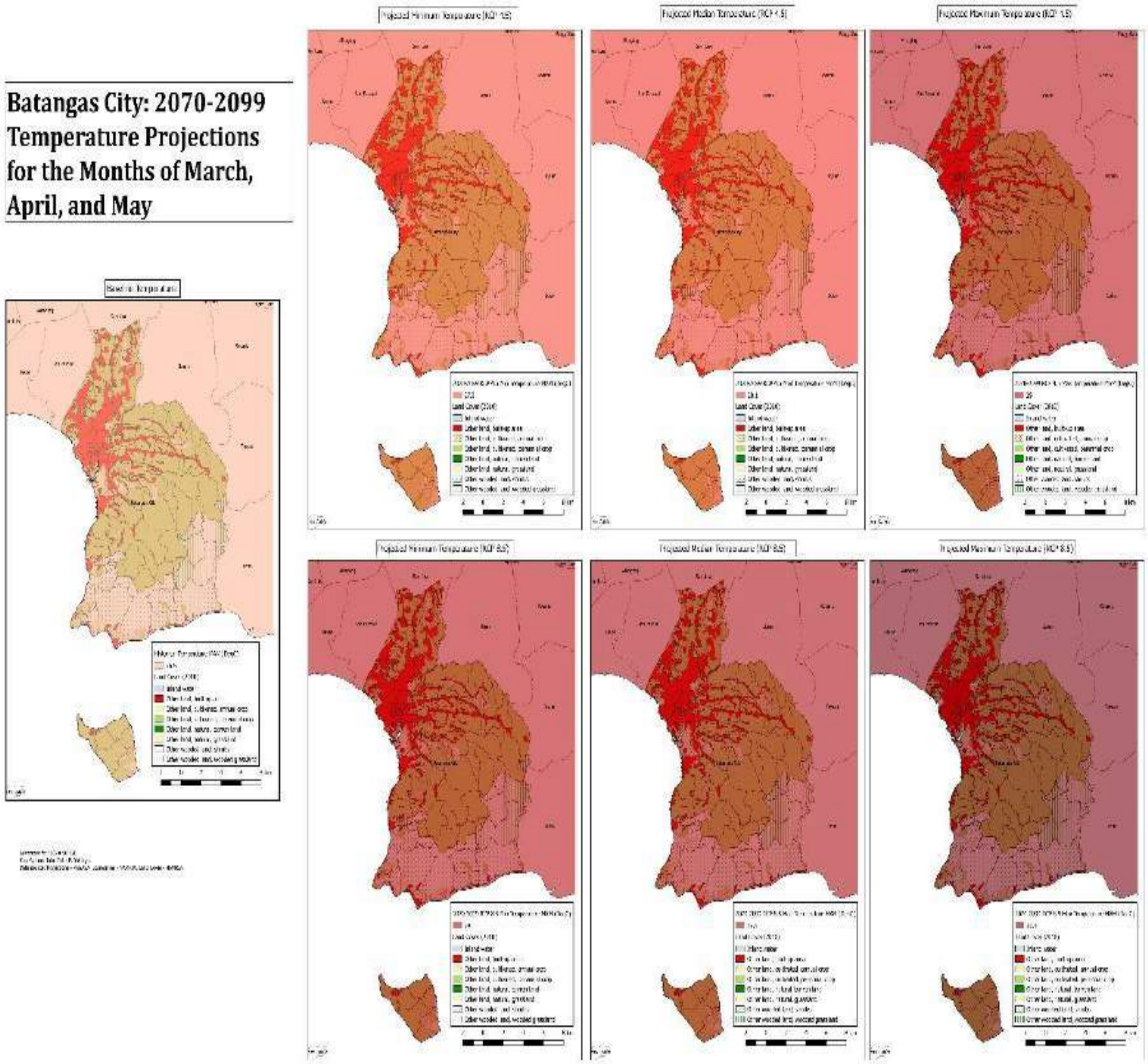
The projected temperatures for RCP 8.5 for these months are hotter than the historical hottest temperature of 26.5 degrees Celsius. This signifies that under the scenario, these months which are historically the coolest will be experiencing a median temperature higher than the historical summer temperatures.




***Map 3.1.26.*** *2070-2099 Temperature Projections for December, January, and February (Source: PAGASA data)*

The months of March, April, and May are projected to have higher temperatures in either scenario, ranging from 27.8 to 29 degrees Celsius with a median of 28.1 degrees for RCP 4.5 and ranging from 29 to 30.4 degrees Celsius with a median of 29.5 degrees for RCP 8.5 ***(Map 3.1.27)***.

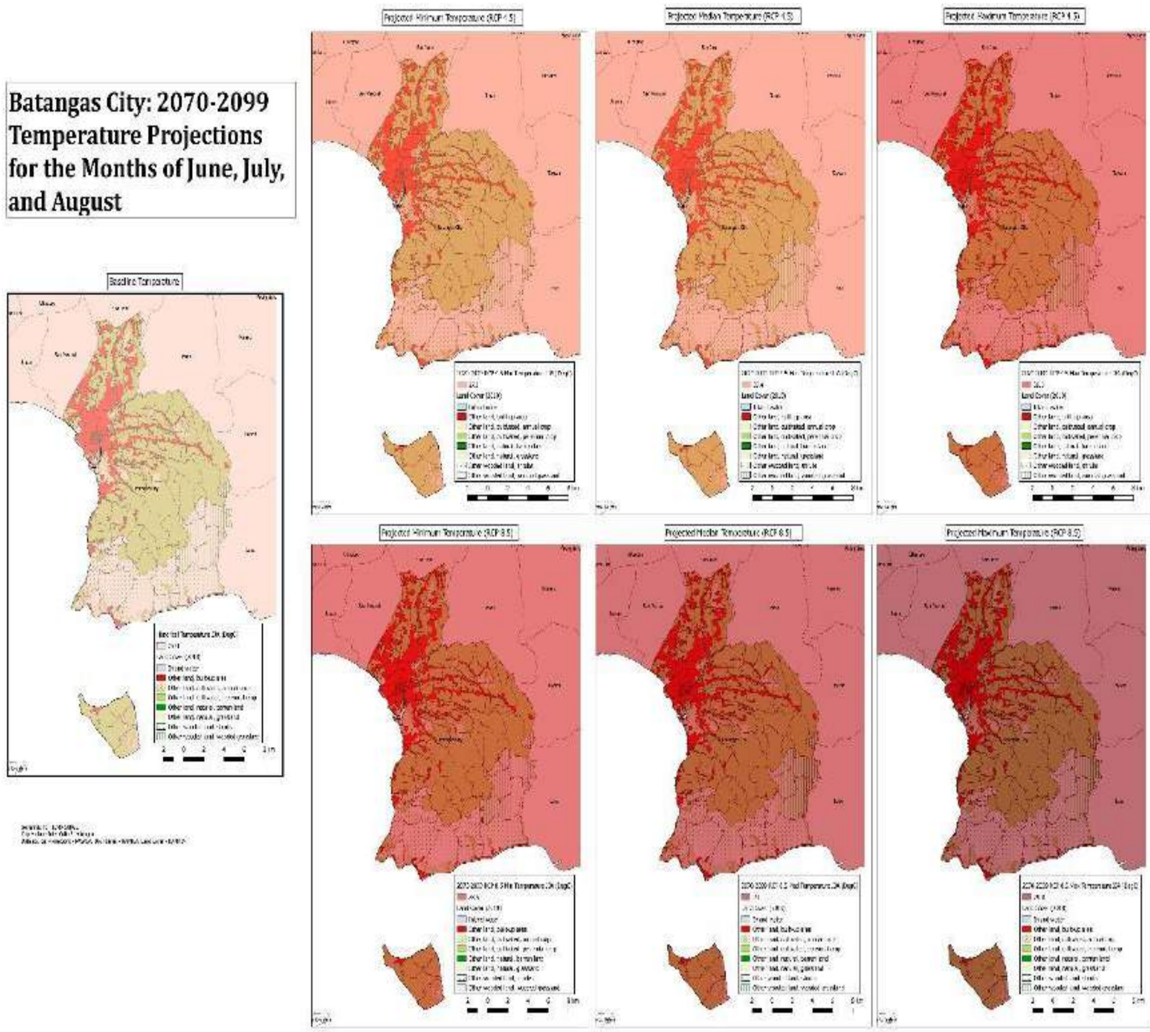
The difference in the two scenarios is significant as the minimum projected temperature for RCP 8.5 is the maximum possible temperature for RCP 4.5.




***Map 3.1.27.*** *2070-2099 Temperature Projections for March, April, and May (Source: PAGASA data)*

For June, July, and August the projected range of temperatures for RCP 4.5 are 27.2-28.3 degrees Celsius with a median of 27.4 degrees while for RCP 8.5 the range is from 28.5-29.8 degrees Celsius with a median of 29 degrees ***(Map 3.1.28)***.

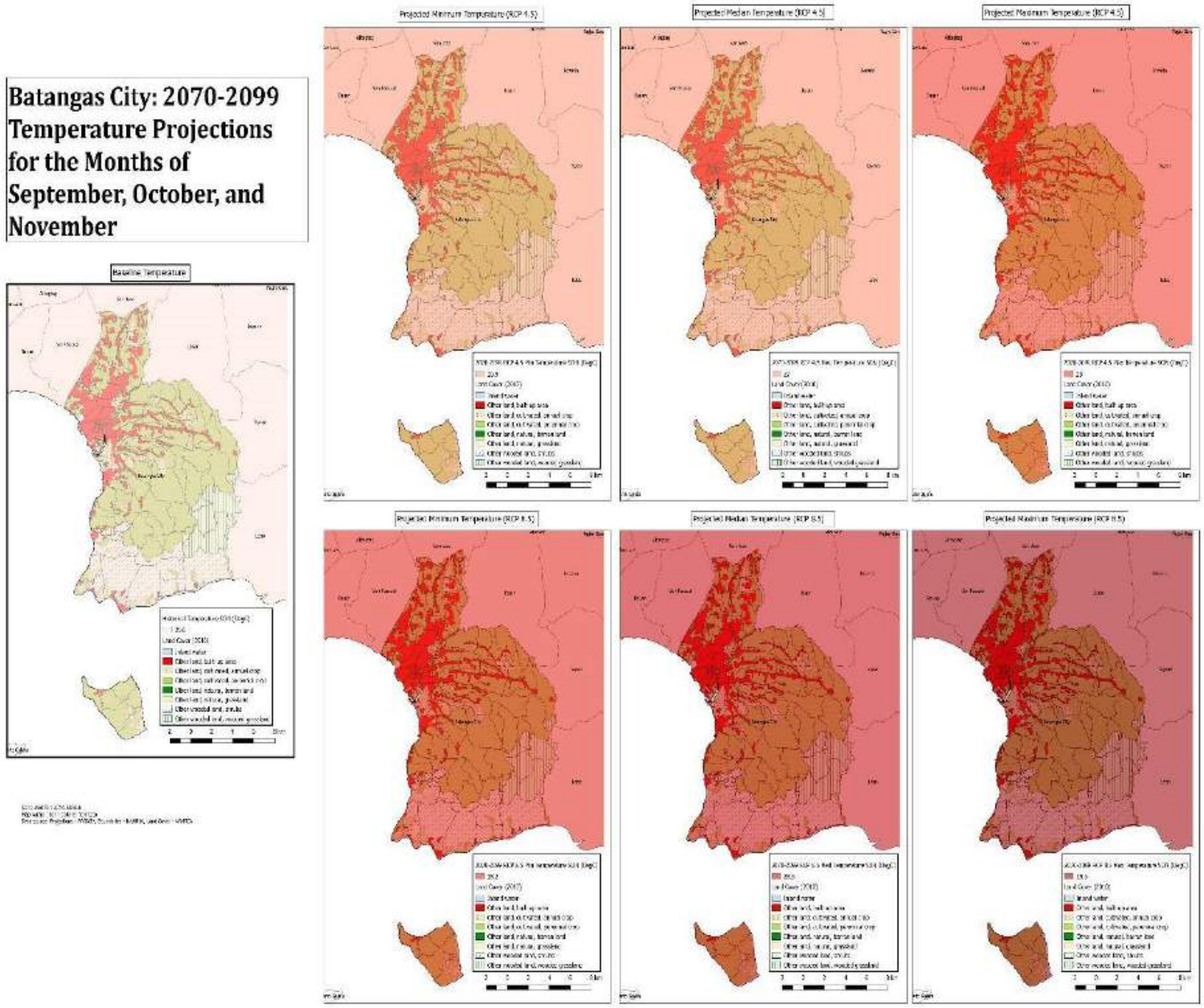
The difference between the two scenarios is also significant in these months as the maximum temperature for RCP 4.5 is not even within the range of temperatures for RCP 8.5.




***Map 3.1.28.*** *2070-2099 Temperature Projections for June, July, and, August (Source: PAGASA data)*

Lastly, the months of September, November, and December the projected range of temperatures for RCP 4.5 are 26.9-28.0 degrees Celsius with a median of 27.0 degrees while for RCP 8.5 the range is from 28.2-29.6 degrees Celsius with a median of 28.6 degrees ***(Map 3.1.29)***.

This quarter continues to maintain a similar range in the RCP 8.5 scenario as that of the previous quarter dropping only between 0.3 to 0.2 degrees indicating that even if the temperatures are cooling the range of temperatures are still within the hottest ranges.




***Map 3.1.29.*** *2070-2099 Temperature Projections for September, October, and November (Source: PAGASA data)*

### Impacts and Adaptation Options

Batangas City is an urban and rural landscape within the Province of Batangas. Its terrain is mountainous and highly elevated to the south with low lying and highly built up areas to the north. The city has large swaths of agricultural land interspersed with woodland further south.

Moreover, the city is where the famed Verde Island passage can be found and as such has rich marine and coastal resources found within its area. The projections for Batangas City are varied between RCP 4.5 and RCP 8.5 and between the mid and late century. The only constant between all scenarios and between the mid and late century is the increase in temperatures, RCP 8.5 is hotter than RCP 4.5 and the late century is hotter than the mid-century. RCP 8.5 is also wetter than RCP 4.5 and has a wider range of values than RCP 4.5.

### A. Demography

The impacts to the demographic sector include health risks to the vulnerable members of the population brought about by the projected increase in temperatures throughout the year and for all scenarios. These health risks include dehydration and heat stroke especially in the highly urbanized areas due to the urban heat island effect (IPCC 2014). Furthermore, the projected increases in precipitation during the months of December, January, and February for all scenarios may also increase the spread of waterborne diseases and cases of colds and the flu (IPCC 2014).

The projected impacts to livelihoods and resources may also bring about migration from rural areas to urban areas where livelihoods opportunities are abundant (Black et al. 2008). To address the impacts to the population of the city, the local government has mostly employed capacity building activities such as training for first responders, emergency drills and the like.

Other strategies that the city may employ to address the said impacts are policies that adapt the behaviour and customs of the citizens such as changes in uniform and class and work hours. This would mostly be beneficial to adapt to increasing temperatures so that class and work hours can be adjusted to cooler hours of the day (Sabbag 2013).

### B. Social

The social impacts to the city are connected with the health risks discussed in the previous section and include possible impacts to health resources due to the possible increase in temperatures. Furthermore, livelihoods such as farming and fishing will likely be affected which can create vulnerabilities and lower coping capacities in households that are dependent on the said livelihoods and the urban poor (IPCC 2014).

The projected increase in precipitation in the months of December, January and February can increase the possibility of class cancellations which can affect the education sector of the city. The health risks, possibility of migration to urban areas, impacts to health facilities, and impacts to livelihoods could strain the social services of the city. The local government has prepared the social sector for possible impacts through stockpiling of food and non-food resources and through information education campaigns. Similar to what was suggested in the previous sector, the city can adopt policies that adapt customs and behaviour to the projections (Sabbag 2013).

Furthermore, the construction of public buildings and facilities can adopt more resilient materials and designs such as better ventilation to reduce consumption of electricity while increasing air circulation (Sabbag 2013). The city can also invest in climate financing schemes to aid the urban poor and the households whose livelihood will be affected (IPCC 2014).

### C. Economic

The notable impacts that can possibly happen due to the projections are a decrease in yield for crops due to the increase in temperature and the projected decrease in precipitation in the months of June, July and August which are historically the wettest. Furthermore, the projected wide range of rainfall values in the rest of the year could possibly mean differing levels of water supply from year to year (IPCC 2014). The projected increase in precipitation for December, January and February can mean better water supply in those months, but when it is coupled with the projected wider range of rainfall values extreme rainfall events can occur which can also damage crops through floods and excess rainfall (IPCC 2014).

Specifically, rice and corn crops are projected to be negatively affected by the said projections (Eitzinger et al. 2017). The projected increase in temperature may also cause heat stroke in livestock. The projected wide range of rainfall values can also cause respiratory problems livestock (Howden et al. 2007). The impacts to the fisheries industry on the other hand are possible changes in migration patterns. This may be caused by the increase in temperatures which can change the nutrient cycles in the ocean (IPCC 2014 & Howden et al. 2007).

Increases in temperature could also possibly trigger coral bleaching as well as increase the population of crown of thorn in the area (IPCC 2014 and Batangas City Responses 2017). The city has adopted organic and natural farming practices, sustainable fishing practices, as well as fish habitat protection and conservation strategies to help mitigate the projected impacts. The city can augment their current plans by adopting climate tolerant varieties of rice and other crops as well as improve water management practices and facilities to address the impacts to agriculture (Howden et al. 2007 & Toda et al. 2017).

The city can also adjust the cropping calendars to accommodate the said projectionsdue to the projected increase in precipitation in the months of December, January and February The farmers can also rotate and plant cassava crops during dry and hot seasons due to the fact that the said root crops are ideal in that climate (Eitzinger et al. 2017). The city can also promote the establishment of climate appropriate shelters and improved feeds as well as climate tolerant livestock varieties to aid the livestock industry (Howden et al. 2007).

In terms of possible strategies for the fisheries industry it is suggested that migration patterns are monitored and fishing seasons be monitored to allow the replenishment of the ecosystem (Howden et al. 2007).

### *D. Infrastructure*

The projected increase in temperature as well as the wider range of rainfall values for the city showcases a possible strain on its infrastructure system. In terms of its roads and bridges the projected increase in temperature can cause cracking and deformation on concrete and asphalt roads. Furthermore, the wide range of rainfall values can possibly project extreme wet events which can also damage the said roads and bridges through the increased possibility of floods (Sabbag 2013 & Schweikert et al. 2014).

The projected increase in temperatures and the decrease in precipitation in some of the months can also cause the lowering of the water table and reduction of groundwater discharge. This can decrease water supply as well as cause water salination especially in the *barangays* located in the coast of the city (IPCC 2014).

Furthermore, increases in temperature also increase the consumption of electricity (IPCC 2014). The city has currently their drainage and canal infrastructure, as well as conduct annual inspections on all of their infrastructures. The city can further augment their programs by employing resilient and more climate appropriate infrastructure materials and design (Sabbag 2013).

The city can adopt infrastructure monitoring methods to improve their maintenance of their roads through computer programs such as 2100 (Schweikert et al. 2014). They can adopt water management practices to mitigate the effects of the possible decrease in water supply (Puyallup 2016 & Howden et al. 2007). The city can also adopt more sustainable sources of energy to bolster their own energy supply (IPCC 2014).

### *E. Environment*

The effects to the environment include the increased possibility of wildfires, the increased concentration of pollutant concentration, and the possible effects to the wooded grassland areas. These are the possible effects that may be caused by the projected increase in temperature (IPCC 2014). In particular forest survival rates may lower and deforestation can occur in the wooded areas of the city (Andregg, Kane, &Andregg 2012).

Moreover, the forest ecosystems can drastically change due to the increase in temperatures changing vegetation composition and species distribution (FAO 2008). The city has implemented biodiversity and habitat conservation efforts as well as enacting their very own environmental code and waste management system.

The city can further augment their policies to adapt the environment to the impacts particularly for the forests by planning to reduce disease losses through monitoring and sanitation harvests, managing stand structure to reduce impacts on water availability and implementing silvicultural techniques to promote stand vigour (Keenan and Nitschke 2016).

### *F. Hazards*

The impacts of the hazards are illustrated in the previous sectors. The projections show that the possibility of drought, flooding, and wildfire may occur in the city. The city has addressed mostly flood based hazards such as flooding through their trainings and construction of flood protection and drainage infrastructure.

Although the city has fire suppression teams, the city can further augment this hazard prevention strategy by identifying hot zones and monitoring these (Four Twenty-seven Climate Solutions 2017). Moreover, the city can address the effects of drought by investing in the development of water storage and management strategies (Howden et al. 2007).

## Adaptation Options

***Table 3.1.4.*** *Summary of Impacts and Adaptation Options for Batangas City*

| **Summary of Impacts and Adaptation Options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature (Year-round and for all scenarios) and decrease in | Demography | Increased heat related health risk to population, loss of livelihood | capacity building activities, policies that adapt the behaviour and customs of the citizens such as changes in uniform and class and work hours |

| | | | |
|---|---|---|---|
| precipitation (JJA and SON) Decrease in precipitation for months of SON, JJA, and MAM (Mid Century RCP 4.5 and Late Century RCP 8.5) | Social | Increased heat related health risk to population, loss of livelihood, increased health risk to urban poor, | Stock piling of food and non-food resources, education campaigns, policies that adapt customs and behaviour to the projections, construction of public buildings and facilities adopting more resilient materials and designs such as better ventilation to reduce consumption of electricity while increasing air circulation, climate financing schemes |
| | Economic | Reduction of water supply, increased demand for water, | Climate, tolerant crop varieties, alternating crops, development of water storage systems and water usage management practices, shifting of cropping calendars for rice crops to coincide with the generally higher precipitation projected for the months from December to January. |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Deforestation, increased forest stress | Environmental Code, plans to protect protected areas and critical ecosystems, and multiple capacity building programs |
| | Hazards | Increased possibility of drought and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |
| General increase in precipitation in the months of (DJF) | Demography | Increased risk of water borne diseases | capacity building activities, emergency drills, policies that adapt the behaviour and customs of the citizens such as changes in uniform and class and work hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, |
| | Hazards | Increased risk of floods | capacity building activities, emergency drills, flood protection infrastructure |

## References

Anderegg, W; Kane, J; and Anderegg, L. (2012).Consequences of widespread tree mortality triggered by drought and temperature stress. Nature Climate Change 9 september 2012 doi: 10.1038/nclimate1635

Black, R.; Kniveton, D.; Skeldon, R.; Coppard, D.; Murata, A.; & Schmidt-Verkerk, K. (2008). Demographics and Climate Change: Future Trends and their Policy Implications for Migration. Working Paper, Development Research Center on Migration, Globalisation, and Poverty.

Forest and Agriculture Organization of the United Nations (2008) Climate change impacts on forest health. Forest Health and Biosecurity Working Papers

Four Twenty-seven Climate Solutions (2017). Fremont Climate Hazard Assessment and Adaptation Options.

Eitzinger, A.; Laderach, P.; Giang Tuan, L.; Ramaraj, A.; Ng'ang'a, K.; Parker, L.; Learning and Coping with Change: Case Stories of Climate Change Adaptation in Southeast Asia. Case Story Book Vol. 1. Pp 83-97

Howden, S.M.; Soussana, J.; Tubiello, F.; Chhetri, N.; Dunlop, M.; & Meinke, H. (2007) Adaptingagriculture to climate change. Proceedings of the National Acadamy of Sciences of the United States of America. Vol 104 no. 50

IPCC, 2014: Climate Change 2014: Synthesis Report. Working Groups II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.IPCC, Geneva, Switzerland, 151 pp.

Rodney, K; & Nitschke, C. (2016). Forest management options for adaptation to climate change: a case study of tall, wet eucalypt forests in Victoria’s Central Highlands region. Australian Forestry.Vol 79.No. 2. pp 96-107

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Sabbag, L. (2013). Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation.From Sheltering from a Gathering Storm working paper No. 4. Institute for Social and Environmental Transition-International.

Schweikert, A.; Chinowsky, P.; Espinet, X.; & Tarbert, M. (2014). Climate Change and infrastructure impacts: comparing the impact on roads in ten countries through 2100. Procedia Engineering 78. pp 306-316.

Toda.L.L., Yokingco, J.C.E., Paringit, E.C., Lasco, R.D.L. (2017) A LiDARbased flood modelling approach for mapping rice cultivation areas in Apalit, Pampanga.Journal of Applied Geography.Vol. 80. Pp 34-47.

## Barangay Population

| BARANGAY | POPULATION 2011 | FEMALE | MALE |
|---|---|---|---|
| ALANGILAN | 13332 | 6982 | 6634 |
| BALAGTAS | 9120 | 4590 | 4724 |
| BALETE | 9098 | 4590 | 4702 |
| BANABA CENTER | 1984 | 989 | 1037 |
| BANABA EAST | 1931 | 1854 | 1632 |
| BANABA SOUTH | 2023 | 1034 | 938 |
| BANABA WEST | 3413 | 996 | 1070 |
| BARANGAY 1 | 706 | 387 | 334 |
| BARANGAY 10 | 353 | 183 | 178 |
| BARANGAY 11 | 768 | 414 | 370 |
| BARANGAY 12 | 1377 | 739 | 667 |
| BARANGAY 13 | 509 | 266 | 254 |
| BARANGAY 14 | 294 | 164 | 136 |
| BARANGAY 15 | 170 | 100 | 74 |
| BARANGAY 16 | 197 | 98 | 103 |
| BARANGAY 17 | 104 | 58 | 48 |
| BARANGAY 18 | 382 | 214 | 176 |
| BARANGAY 19 | 955 | 509 | 466 |
| BARANGAY 2 | 606 | 346 | 273 |
| BARANGAY 20 | 344 | 188 | 163 |
| BARANGAY 21 | 664 | 338 | 340 |
| BARANGAY 22 | 234 | 130 | 109 |
| BARANGAY 23 | 635 | 325 | 324 |
| BARANGAY 24 | 2877 | 1449 | 1489 |
| BARANGAY 3 | 367 | 197 | 178 |
| BARANGAY 4 | 1499 | 837 | 694 |
| BARANGAY 5 | 634 | 326 | 321 |
| BARANGAY 6 | 2009 | 1093 | 959 |
| BARANGAY 7 | 715 | 378 | 352 |
| BARANGAY 8 | 577 | 286 | 303 |
| BARANGAY 9 | 283 | 149 | 140 |
| BILOGO | 1829 | 898 | 970 |
| BOLBOK | 11806 | 6094 | 5963 |
| BUCAL | 2460 | 1245 | 1267 |
| CALICANTO | 10315 | 5287 | 5246 |
| CATANDALA | 644 | 325 | 333 |
| CONCEPCION | 3412 | 1711 | 1774 |
| CONDE ITAAS | 1305 | 639 | 694 |
| CONDE LABAC | 1763 | 891 | 910 |
| CUMBA | 914 | 432 | 501 |
| CUTA | 11460 | 5927 | 5777 |
| DALIG | 2248 | 1133 | 1163 |
| DELA PAZ PROPER | 2377 | 1188 | 1240 |
| DELA PAZ PULOT APLAYA | 583 | 293 | 302 |
| DELA PAZ PULOT ITAAS | 419 | 217 | 211 |
| DUMANTAY | 3685 | 1906 | 1857 |
| DUMUCLAY | 3246 | 1615 | 1700 |
| GULOD ITAAS | 4950 | 2549 | 2506 |

| | | | |
|---|---|---|---|
| GULOD LABAC | 2433 | 1211 | 1274 |
| HALIGUE KANLURAN | 1112 | 573 | 563 |
| HALIGUE SILANGAN | 1699 | 858 | 877 |
| ILIJAN | 3920 | 1948 | 2055 |
| KUMINTANG IBABA | 10134 | 5309 | 5041 |
| KUMINTANG ILAYA | 10320 | 5341 | 5199 |
| LIBJO | 10964 | 6265 | 4932 |
| LIPONPON, ISLA VERDE | 746 | 373 | 389 |
| MAAPAZ | 208 | 102 | 110 |
| MABACONG | 1873 | 914 | 999 |
| MAHABANG DAHILIG | 1430 | 718 | 742 |
| MAHABANG PARANG | 3267 | 1679 | 1657 |
| MAHACOT KANLURAN | 600 | 325 | 288 |
| MAHACOT SILANGAN | 680 | 347 | 347 |
| MALALIM | 1190 | 616 | 599 |
| MALIBAYO | 461 | 240 | 231 |
| MALITAM | 6686 | 3414 | 3414 |
| MARUCLAP | 957 | 476 | 501 |
| PAGKILATAN | 1321 | 680 | 669 |
| PAHARANG KANLURAN | 1314 | 656 | 686 |
| PAHARANG SILANGAN | 1222 | 666 | 582 |
| PALLOCAN KANLURAN | 6259 | 3171 | 3221 |
| PALLOCAN SILANGAN | 2026 | 1021 | 1048 |
| PINAMUCAN IBABA | 1410 | 707 | 733 |
| PINAMUCAN PROPER | 3607 | 1850 | 1834 |
| PINAMUCAN SILANGAN | 2026 | 551 | 598 |
| SAMPAGA | 3980 | 2024 | 2041 |
| SAN AGAPITO, ISLA VERDE | 1191 | 603 | 613 |
| SAN AGUSTIN KANLURAN, ISLA VERDE | 715 | 352 | 378 |
| SAN AGUSTIN SILANGAN, ISLA VERDE | 775 | 409 | 383 |
| SAN ANDRES, ISLA VERDE | 972 | 491 | 502 |
| SAN ANTONIO, ISLA VERDE | 1098 | 562 | 559 |
| SAN ISIDRO | 6887 | 3461 | 3573 |
| SAN JOSE SICO | 4627 | 2295 | 2430 |
| SAN MIGUEL | 2247 | 1102 | 1193 |
| SAN PEDRO | 1510 | 709 | 833 |
| SIMLONG | 3800 | 1950 | 1931 |
| SIRANG LUPA | 1369 | 712 | 686 |
| SORO-SORO IBABA | 2713 | 1354 | 1417 |
| SORO-SORO ILAYA | 1801 | 899 | 940 |
| SORO-SORO KARSADA | 1764 | 909 | 893 |
| STA. CLARA | 10584 | 5402 | 5407 |
| STA. RITA APLAYA | 2281 | 1146 | 1184 |
| STA. RITA KARSADA | 17330 | 8940 | 8759 |
| STO. DOMINGO | 1789 | 871 | 956 |
| STO. NIÑO | 2520 | 1320 | 1254 |
| TABANGAO AMBULONG | 4862 | 2438 | 2527 |
| TABANGAO APLAYA | 3216 | 1605 | 1679 |
| TABANGAO DAO | 2625 | 1349 | 1332 |
| TALAHIB PANDAYAN | 2301 | 1167 | 1183 |

| | | | |
|---|---|---|---|
| TALAHIB PAYAPA | 575 | 296 | 291 |
| TALUMPOK KANLURAN | 2867 | 1435 | 1493 |
| TALUMPOK SILANGAN | 1845 | 899 | 985 |
| TINGA ITAAS | 2801 | 1454 | 1407 |
| TINGA LABAC | 5883 | 2906 | 3102 |
| TULO | 3684 | 1882 | 1880 |
| WAWA | 6455 | 3217 | 3375 |

## 3.2. GENERAL SANTOS CITY

### Executive Summary

General Santos City is a highly populated urban and rural landscape in South Cotabato. Found at its center is a highly built up area that coincides with the extensive network of roads and transportation. The agricultural and woodland areas of the city can be found in its northern and southern regions. Furthermore, the south of the city is bound by the Moro Gulf and has an extensive relationship with marine fishing industries. The city can be seen as an industrial, transportation, and ecological center in the region. With this in mind, the impacts of the projected changes in precipitation and temperature will vary for each sector.

The notable projections are the marked increases in temperature under both RCP 4.5 and RCP 8.5. The projected decrease in precipitation under RCP 4.5 and projected wide range of possible precipitation values under both scenarios also show the possibility of a generally dry climate with the possibility of extreme wet and extreme dry events. The impacts and adaptation options for each sector are summarized below.

| **Summary of Impacts and Adaptation Options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature (Year-round and for all scenarios) and decrease in precipitation (Year round in RCP 4.5 and some months in RCP 8.5 in the mid-century and year round in both scenarios in the late century) | Demography | Increased heat related health risk to population, loss of livelihood | incorporating climate change adaptation into plans, programs, policies, increasing green areas within the city, policies that can adjust or change behaviour to adopt to the climate, adopt education campaigns regarding climate change effects and adaptation options, |
| | Social | Increased heat related health risk to population, increased health risk to urban poor, | Smart design and technologies to adopt to climatic needs and reduce energy consumption, policies that adapt attire to higher temperatures and adjustment of working and class hours, relocation of informal settlers in flood and landslide risk areas |
| | Economic | Reduction of water supply, increased demand for water, crop damage and yield reduction, higher risk of disease in coconut plants, loss of livelihood | integrate plans, programs, and activities in the economic sector with climate change adaptation measures, and trainings on livelihood, distribution of climate tolerant varieties of crops, improvement of water infrastructure, cloud seeding, rainwater harvesting, information education campaigns on of El Niño & La Niña events, distribution of corn and rice seeds to farmers affected by extreme events, shift cropping calendars to take into account the projected marginal increase in precipitation during the months of June, July, and August. Lastly, adopt crops that are favourable to dry and hot environments such as cassava, adopt climate appropriate shelters, water |

| | | | |
|---|---|---|---|
| | | | storage systems, and improved feeds for livestock, adopt ways to monitor fishing patterns and alternate fishing seasons |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, rain water harvesting, |
| | Environment | Deforestation, increased forest stress, | spring water development, hydro mapping, effective water storage systems |
| | Hazards | Increased possibility of drought and wildfires | firefighting measures, planting of *Sansevieria* species to delineate fire zones, |
| Wide range of possible precipitation values in the months of March to August under RCP 4.5 in the mid-century and in the same months under both scenarios in the late century; Possibility of extreme wet events | Demography | Increased risk of water borne diseases | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Increased rate of erosion | Sloping agricultural land technology, riverbank reforestation |
| | Hazards | Increased risk of floods | relocation of at risk urban poor sector, improvement of drainage systems, dredging and desilting of rivers, flood protection infrastructure |

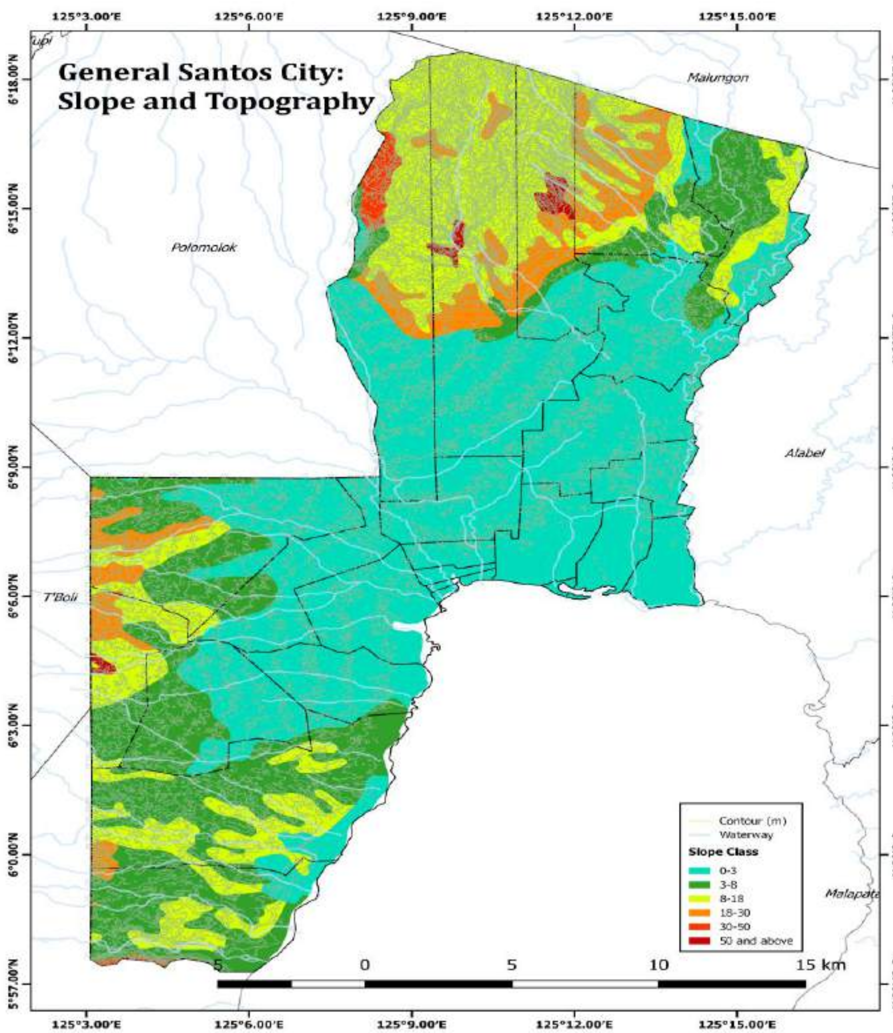
## Physical Geography

### *Location*

General Santos City is found in the southern portion of South Cotabato. It is bound to the north by the municipality of Malungon, the east by the municipality of Alabel, to the south and west by Saranggani Bay and the Moro Gulf, and the west by the municipalities of Polomolok, T'boli, and Maasim. It has a total area of 536,060 hectares and is composed of 26 *barangays*.

### *Physical Characteristics*

The city is bound by two peaks to its north and south with a majority of the land lying in between those peaks being flat terrain ***(Map 3.2.1)***. The northern peak is Mt. Matutum and it lies 2,293 meters above sea level. The southern peak on the other hand is Mt. Parker and lies 2,040 meters above sea level. The northeastern plain has slopes ranging from 0-3 percent while the peaks at the northern and southern end have slopes ranging from 3 to 50 percent. Four major rivers traverse the city. These rivers are namely, Buayan, Silway, Makar, and Siguel.



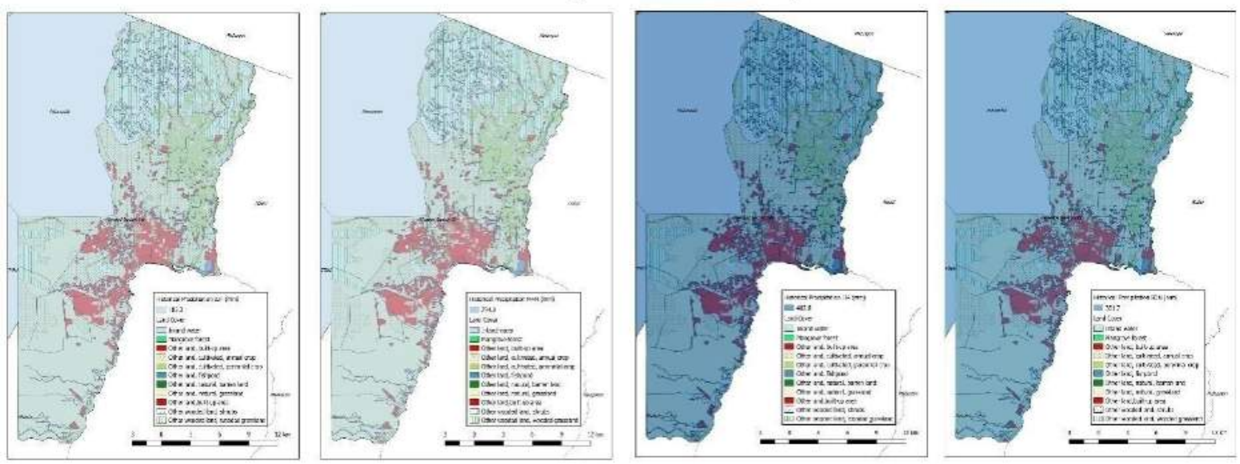

***Map 3.2.1****. General Santos City Slope Class and Topography Map (Source: 30m GDEM)*

## *Climate*

The climate of General Santos City is characterized by seasonal variations in precipitation and temperature ***(Maps 3.2.2 & 3.2.3)*** as modelled and recorded by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

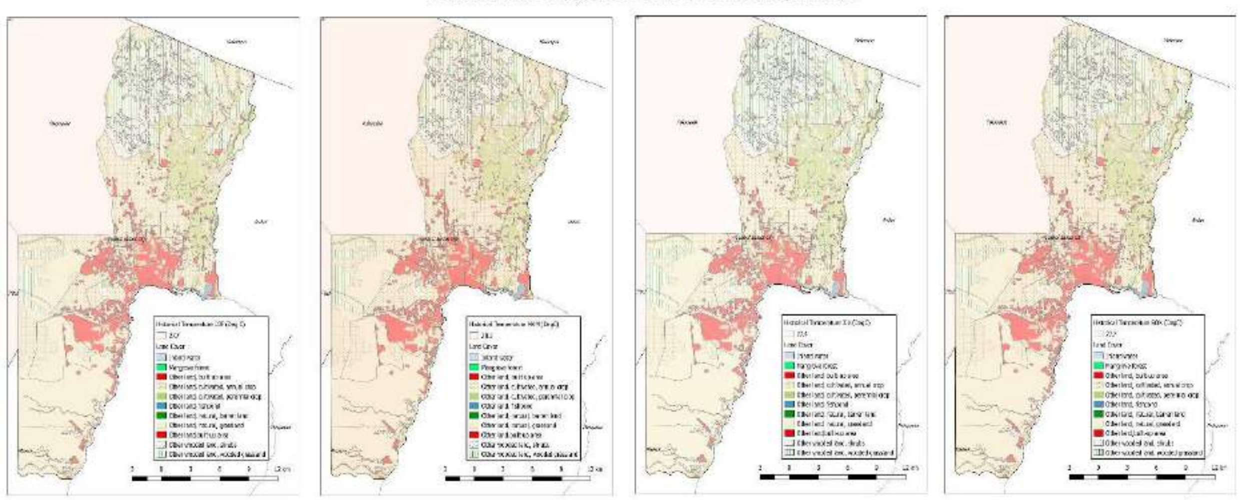
The months of December, January, and February are the driest of the year with an average cumulative rainfall amount of 183.3 mm and has the second average coolest temperature for the year at 27.7 degrees Celsius. The months of March, April, and May are the second driest with an average cumulative rainfall amount of 234.1 mm and are the hottest months with an average temperature 28.5 degrees Celsius. The months of June, July, and August are the wettest of the year with an average cumulative rainfall amount of 402.8 mm and the said months are the coolest of the year with an average temperature of 27.4 degrees Celsius. The months of September, October, and November are the second wettest with an average cumulative rainfall amount of 351.7 mm and are the second with an average temperature of 27.7 degrees Celsius.

**General Santos City: Historical Seasonal Precipitation**



***Map 3.2.2****. General Santos City Historical Seasonal Precipitation (Source: PAGASA data)*

**General Santos City: Historical Seasonal Temperature**

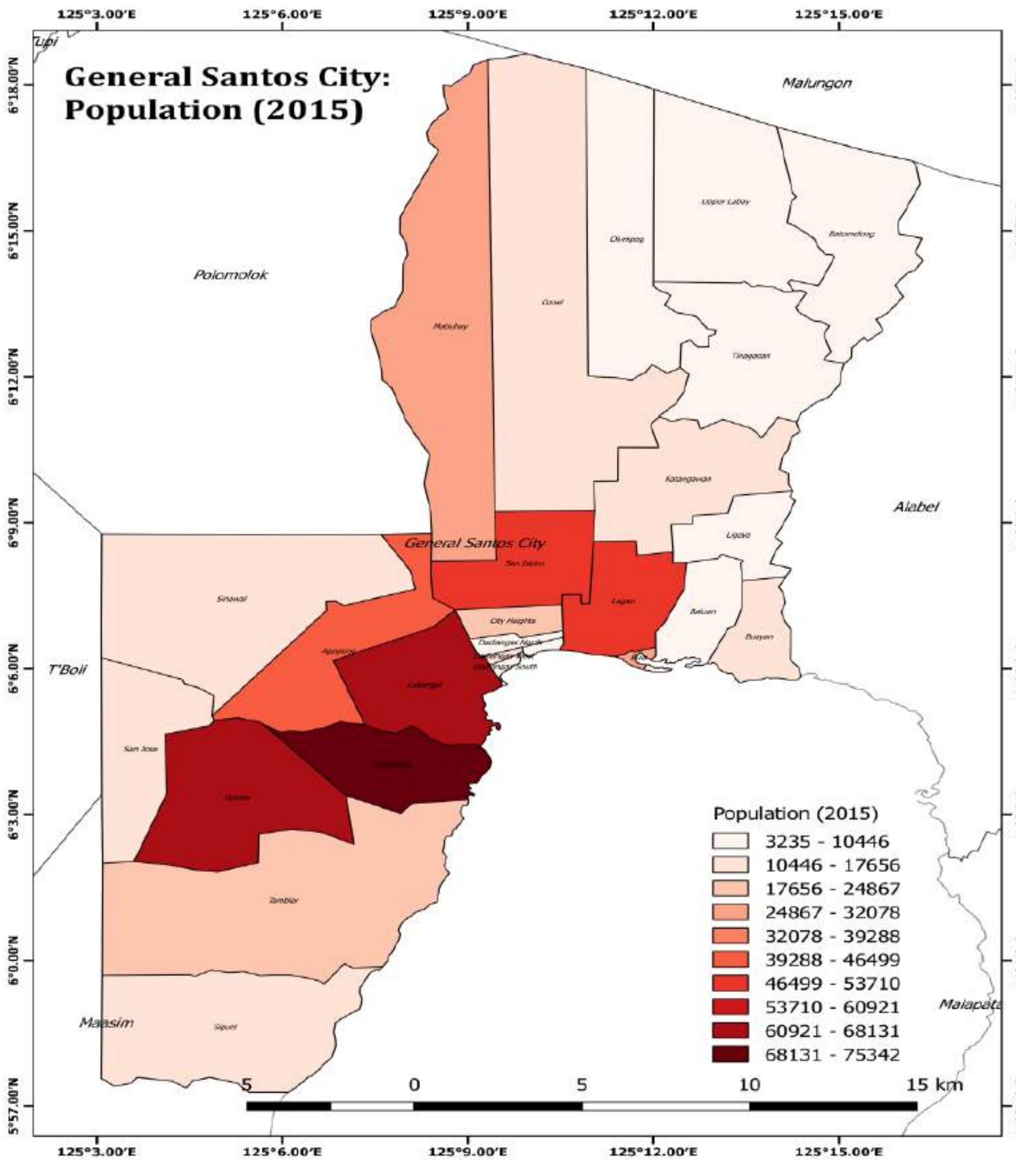


***Map 3.2.3****. General Santos City Historical Seasonal Temperature (Source: PAGASA data)*

## Socio-Economic Characteristics

### *Population*

The population of General Santos City as of 2015 (PSA) is 594,446. The population is concentrated on the south eastern portion of the city (Map 5) and lessens outwards. The most populous barangay is Calumpang with a population of 75,342. In terms of population Calumpang is followed by the *barangays* of Fatima with a population of 66,460; Labangal with a population of 61,713; San Isidro with a population of 52,832; and Lagao with a population of 50,789 *(Population Table Annex),* ***(Map 3.2.4)***. The city has a population density of 1,108 persons per square kilometer as of 2015.




***Map 3.2.4.*** *Barangay population map (Source: PSA data)*

### *Education*

The city is also a central provider of education with a total of 150 schools found within it; 50 are private institutions and 100 are public institutions. Three universities are also found within the city, and the University of Sto.Tomas campus is set to be established within it as well.

### *Economic Activities*

- ***Agriculture***

Rice, coconut, mango, corn, and banana are the major crops that are cultivated in General Santos City. Other crops that are cultivated are asparagus, cassava, pineapple,coffee, sugarcane and other assorted vegetables. These crops occupy large portion of the city ***(Map 3.2.6)*** and also provide the livelihood of approximately 5,837 households (City Agricultural office 2015). The agricultural land covers approximately fifteen *barangays*: Batomelong, Conel, Katangawan, Lagao, Ligaya, Mabuhay, Olympog, San Isidro, San Jose, Sinawal, Tinagacan and Upper Labay. The city is also known as the hub for fresh and processed agricultural products in the SOCSKARGEN region (South Cotabato, Sultan Kudarat, Sarangani Province and General Santos).

- ***Livestock***

Livestock production in the city is composed mostly of poultry and piggery houses. Poultry houses are found in the *barangays* of Katangawan, Ligaya, Olympog, and Sinawal. The poultry that is produced includes chicken, ducks, turkeys, and geese. There are also chicken egg producers in the *barangays* of Conel and Katangawan. Other than poultry, the city also produces pigs in piggery houses in *barangays* Katangawan and Ligaya.

- ***Fisheries***

The fishing industry in the city includes both marine and inland fishing. There are nine coastal *barangays* in the city: Baluan, Buayan, Bula, Dadiangas South, Dadiangas West, Calumpang, Labangal, Siguel and Tambler. These *barangays* face Sarangani Bay which is the main fishing ground for the city. The main fishport of the city is located in *barangay* Tambler. The Moro Gulf and Mindanao Sea are also frequent fishing grounds for the local fishermen due to them being tuna rich. As such, General Santos City is considered the “Tuna Capital” of the Philippines. There are also fishponds in the city particularly in *Barangay* Buayan ***(Map 3.2.6)***. The city has a total of 4,468 households who are dependent on fishing as a livelihood (General Santos City Agricultural office). There are also eight registered canning factories in the city as of 2015 which employs 9,148 employees.

- ***Exports***

General Santos City has two top exports: canned pineapple and canned tuna. These two products made up for approximately 37.02% of the total exported products of the city during 2015.

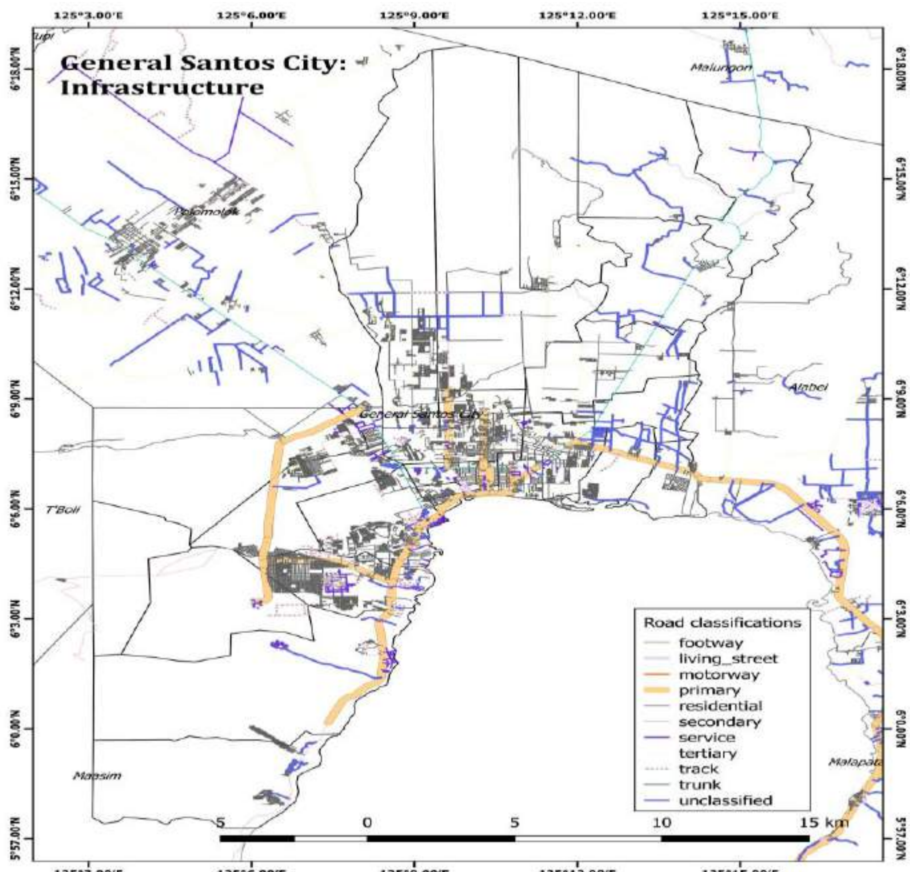
## Infrastructure

### *Transportation*

General Santos City is a transportation hub within the Mindanao area. It provides for air, sea, and land transportation. Found within its borders is General Santos City International Airport. It is the largest airport in Mindanao with a 3,221-meter concrete runway (Civil Aviation Authority Philippines). For sea transportation the city has the Makar Wharf which has ports for ferries for both inter island travel within the Philippines and international travel between the city and Indonesia. Lastly, the city has road transportation provided by buses, tricycles, jeepneys, and taxicabs that operate on the extensive road network of the city.

### *Roads*

General Santos City has approximately 700.279 kilometers of extensive road network ***(Map 3.2.5)***. There are 117.64 kilometers of those roads made of National roads which connect the city to the other provinces within its vicinity, 67% of the national roads are paved with concrete while 33% are paved with asphalt. On the other hand, 314.932 kilometers of the road network is composed of city roads. Of the city roads, 39.3% is paved in concrete. 0.97% is paved in asphalt, 0.51% is paved covered in gravel, and 59.24% are earth roads. The remaining 267.707 kilometers are barangay roads 71.74% are earth roads, 18.63% are paved in concrete, and 9.63% are covered in gravel.




***Map 3.2.5.*** *Road Infrastructure Map*

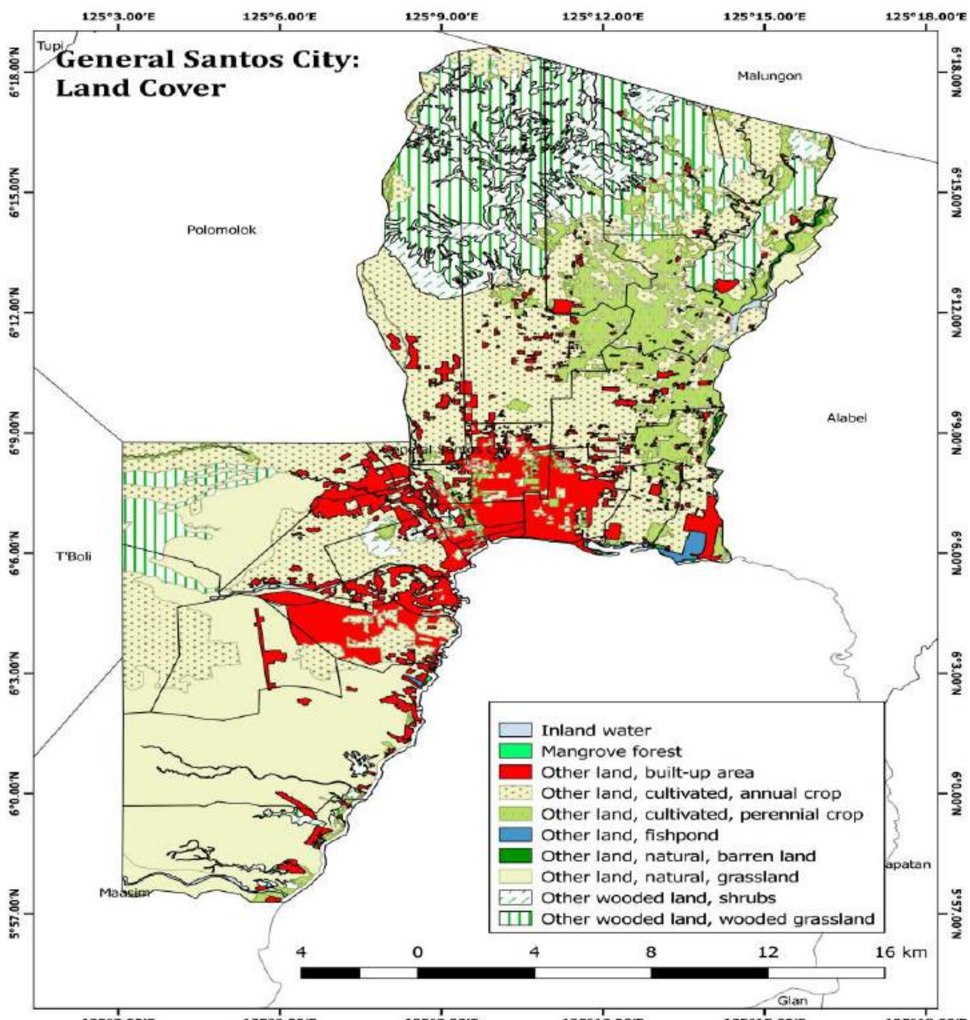
*Water*

The primary source of water in the city is ground water. Water is provided through the Rural Water and Sanitation Association (RWSA) and the General Santos City Water District (GSCWD). There are 167 RWSAs as of 2016 and they serve 17 barangays. The water services consist of seven shallow wells, ninety deep wells, six improved spring serving and 57 free flowing (CPDO 2016).

*Electricity*

The electricity in the city is provided by the South Cotabato Electric Cooperative II (SOCOTECO II). The cooperative distributes the electricity in the city through the East, Central, and West Districts. The transmission and distribution lines in the city are owned by the National Grid Corporation if the Philippines and have been constructed since 1977 with continuous expansions. The city experiences rotational brownouts due to the insufficient supply of electricity within the Mindanao area.

## Land Cover and Land Use



***Map 3.2.6.*** *Land Cover Class (Source GDEM 2010)*

***Table 3.2.1.*** *General Santos City Land Cover (Source: GDEM 2010)*

| General Santos City Land Cover (2010) | | |
|---|---|---|
| **Land Cover Class** | **Area (ha) Derived from GIS calculations** | **Percent** |
| Other land, cultivated, annual crop | 154319.2 | 32.76% |
| Other land, built-up area | 52648.39 | 11.18% |
| Other land, fishpond | 1400.012 | 0.30% |
| Other land, natural, grassland | 106141.8 | 22.53% |
| Inland water | 4210.543 | 0.89% |
| Mangrove forest | 172.9558 | 0.04% |
| Other land, natural, barren land | 780.7177 | 0.17% |
| Other land, cultivated, perennial crop | 44100.67 | 9.36% |
| Other wooded land, shrubs | 29276.32 | 6.21% |
| Other wooded land, wooded grassland | 78030.24 | 16.56% |
| **Total** | **471080.9** | **100.00%** |

The land cover of General Santos City is largely rural in character. The majority of its land is covered in grassland, forest land, and agricultural land. The crop land in the city covers approximately 42.136 % of its land area and can be found in the northern and southern ends of the city.

The natural grassland on the other hand covers approximately 22.53% of its land area and can be found in large expanses in the southern end of the city. Wooded grassland covers approximately 16.56% of the land area of the city and can be found on the northern and southern ends of the city. Interspersed with the wooded grass land are shrub lands that make up 6.21% of the land area of the city.

The built up area in the city is concentrated near its center and spreads outward towards the northern and southern ends and make up for approximately 11.18% of its area.

## Climatic Hazards

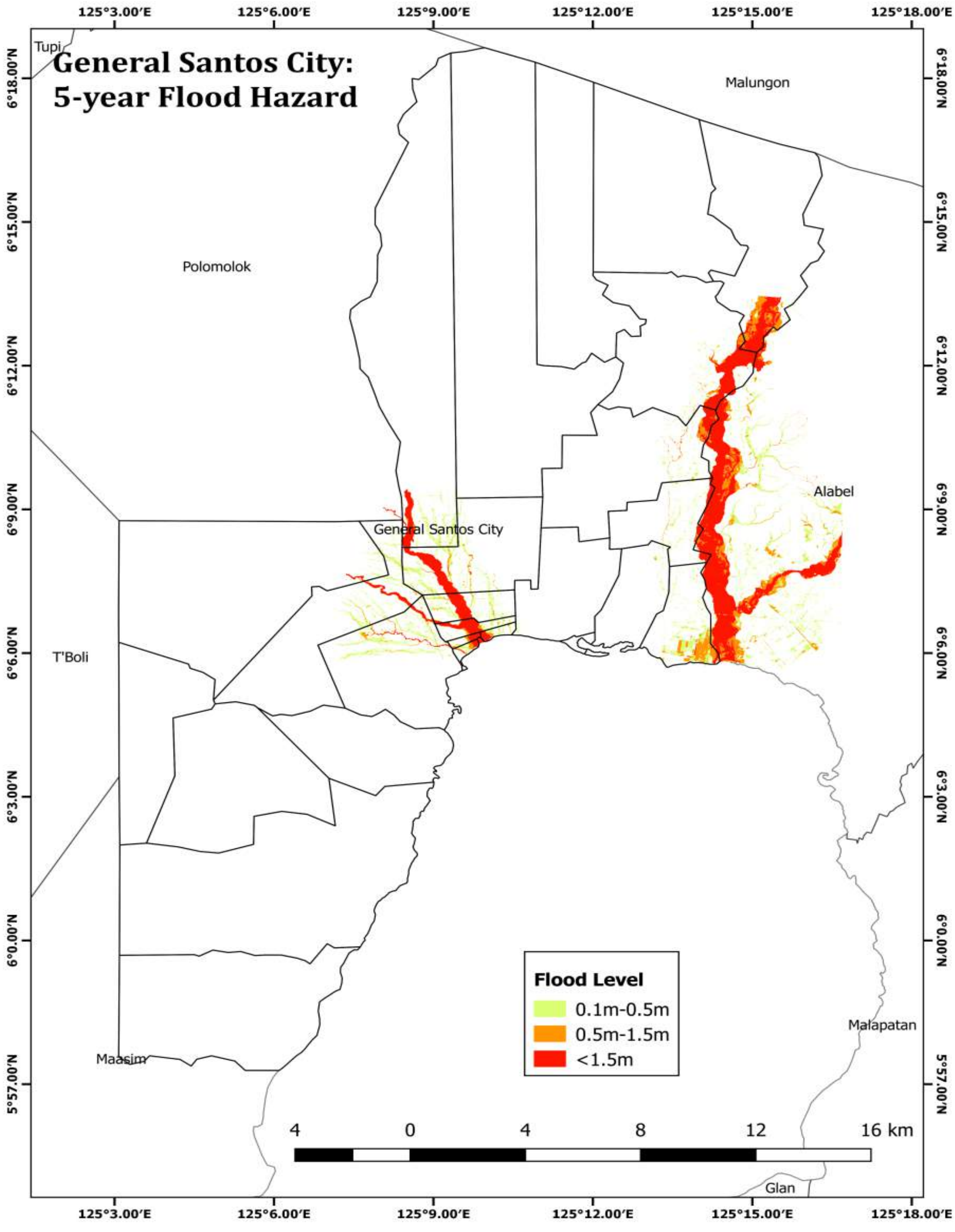
### *Flood Hazard*

Flood hazards in the city are brought on mainly by the low lying topography in certain portions and the presence of the four major rivers that traverse it ***(Map 3.2.1), (Maps 3.2.7-3.2.9)***.

The *barangays* that are most at risk of floods are Dadiangas North, Dadiangas South, Dadiangas East, Dadiangas West, Labagal, Apopong, San Isidro, and Mabuhay which are located near the center of the City and to the east are the *barangays* of Buayan, Ligaya, Katangawan, Tinagacan, and Batomelong.

### *Five (5) Year Return Period*

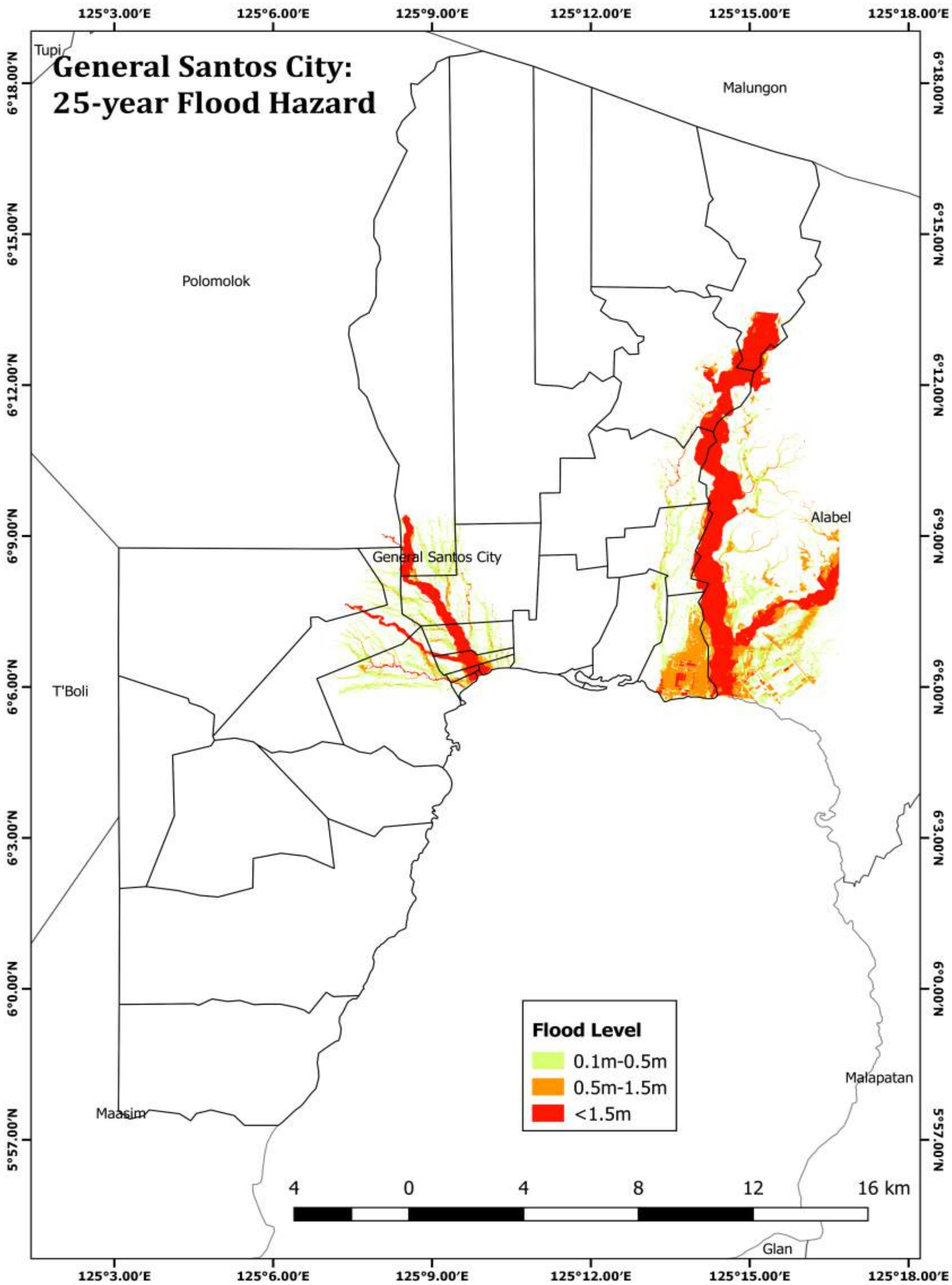
There is a 1/5 (20%) probability of a flood with 5-year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 102.700mm.




***Map 3.2.7.*** *5-year flood hazard map (Source: DREAM Project)*

### *25-Year Return Period*

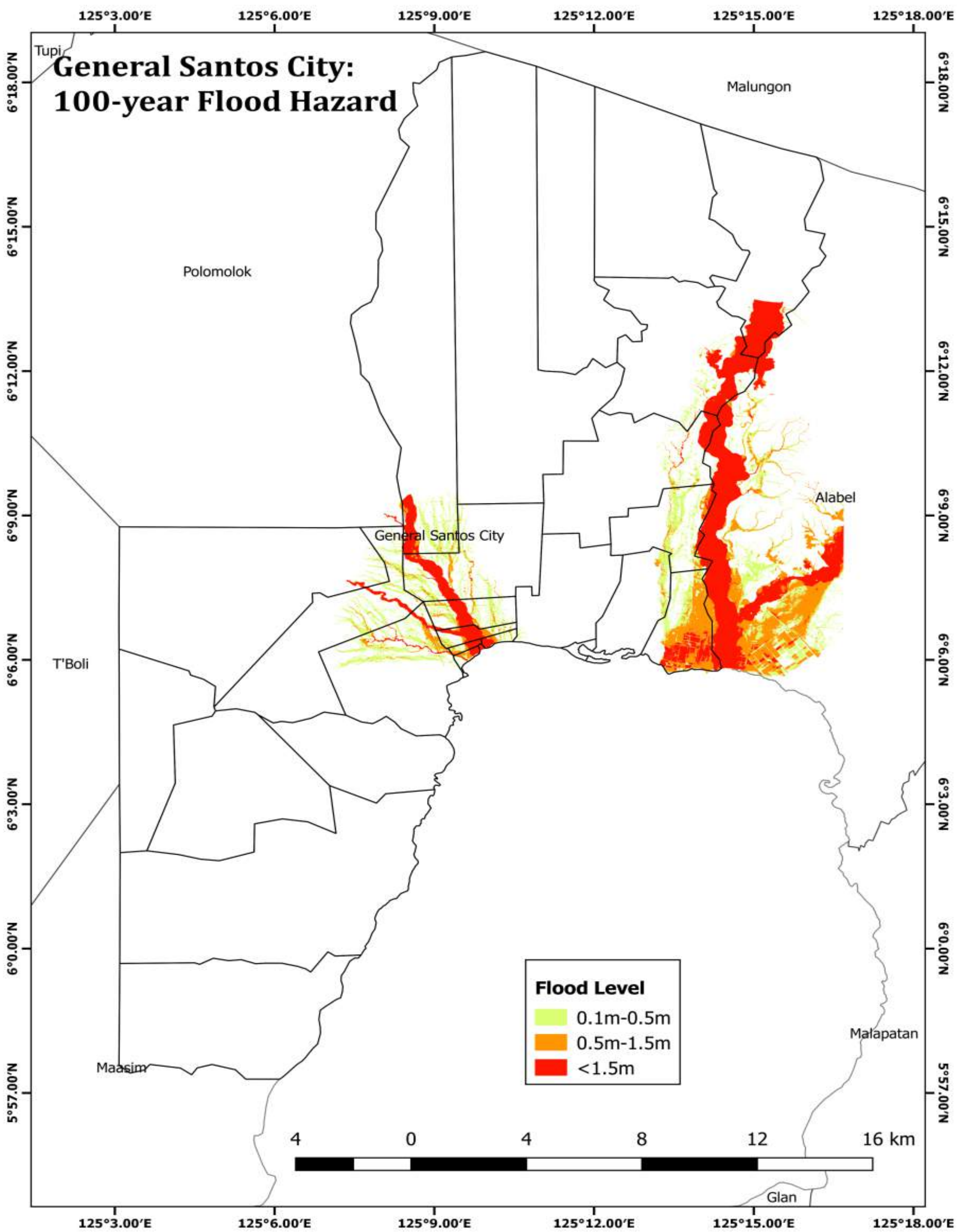
There is a 1/25 (4%) probability of a flood with 25 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 153.400mm.




***Map 3.2.8.*** *25-Year Flood Hazard Map (Source: DREAM Project)*

## *100-Year Return Period*

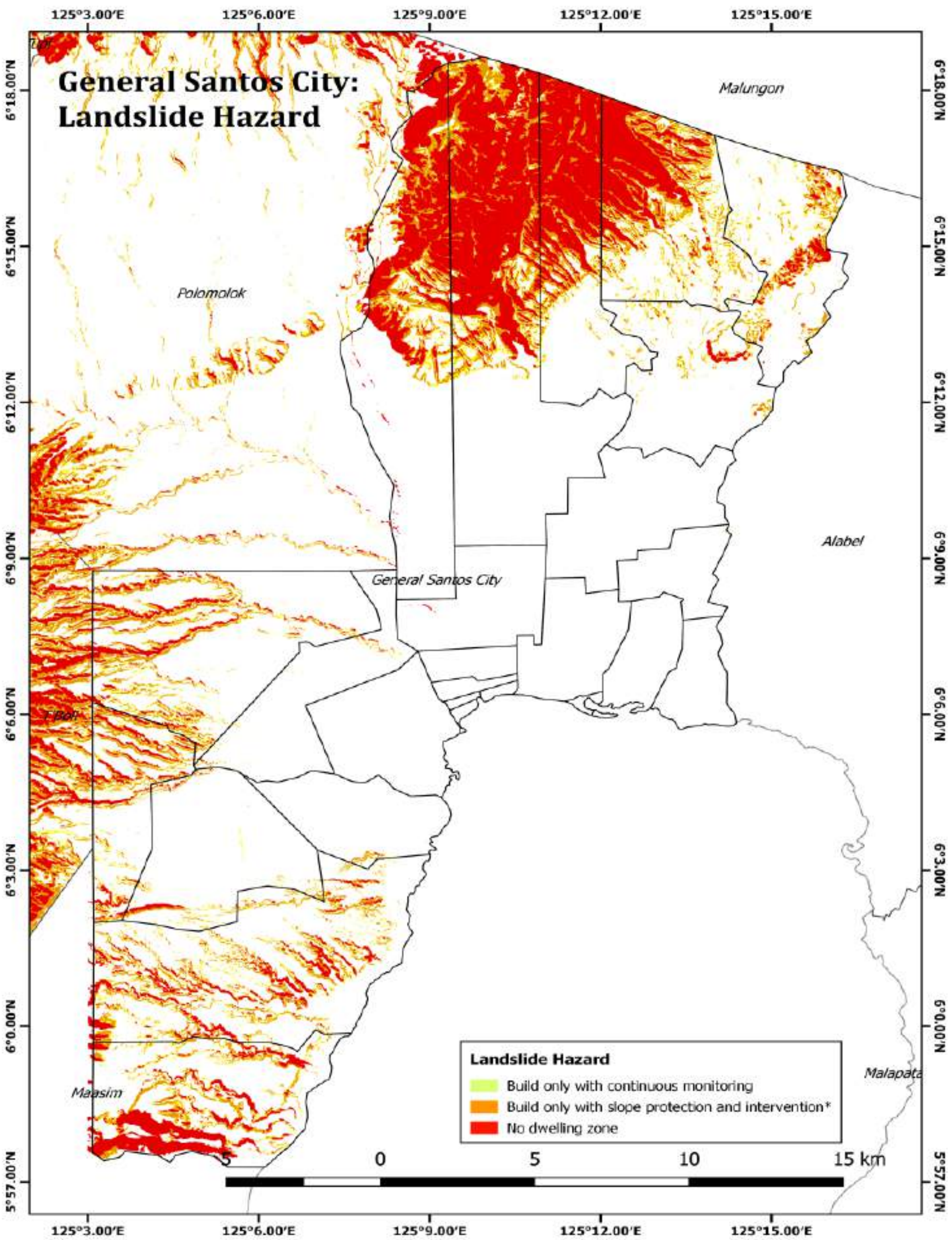
There is a 1/100 (1%) probability of a flood with 100 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 195.200mm.




***Map 3.2.9.*** *100-Year Flood Hazard Map (Source: DREAM Project)*

## Landslide Hazard

The landslide hazard is isolated in the northern and southern regions of the city where the greater slopes and higher elevations are located ***(Map 3.2.1 and 3.2.10)***. The *barangays* that are most at risk of this type of hazard are in the north: Mabuhay, Conel, Olympog, Upper Labay, and portions of Batomelong and the following *barangays* to the south: Sinawal, San Jose, Tambler, Siguel, and portions of Fatima.

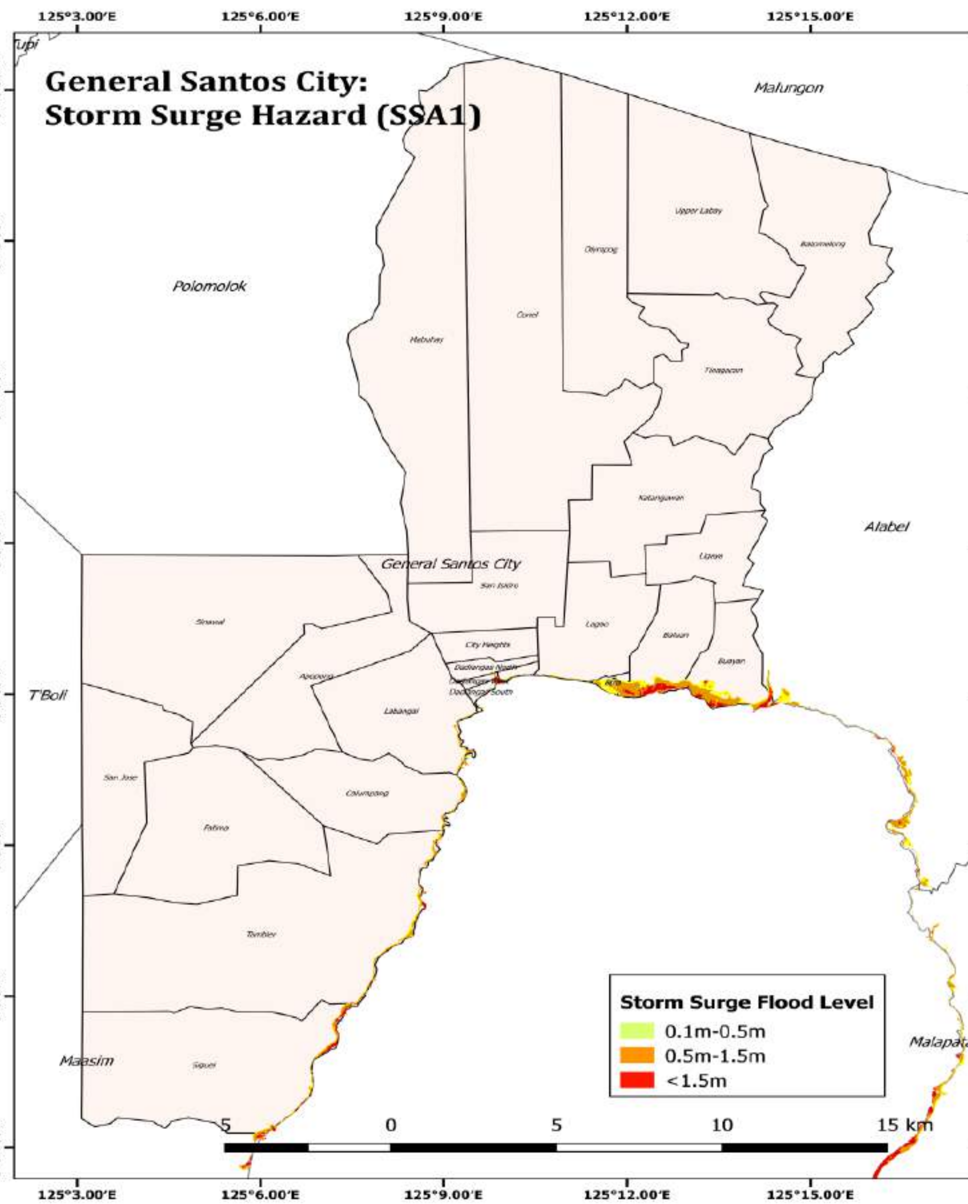



***Map 3.2.10.*** *Landslide Hazard Map (Source: DREAM Project)*

### Storm Surge Hazard (Maps 11-13), (Data from Project NOAH)

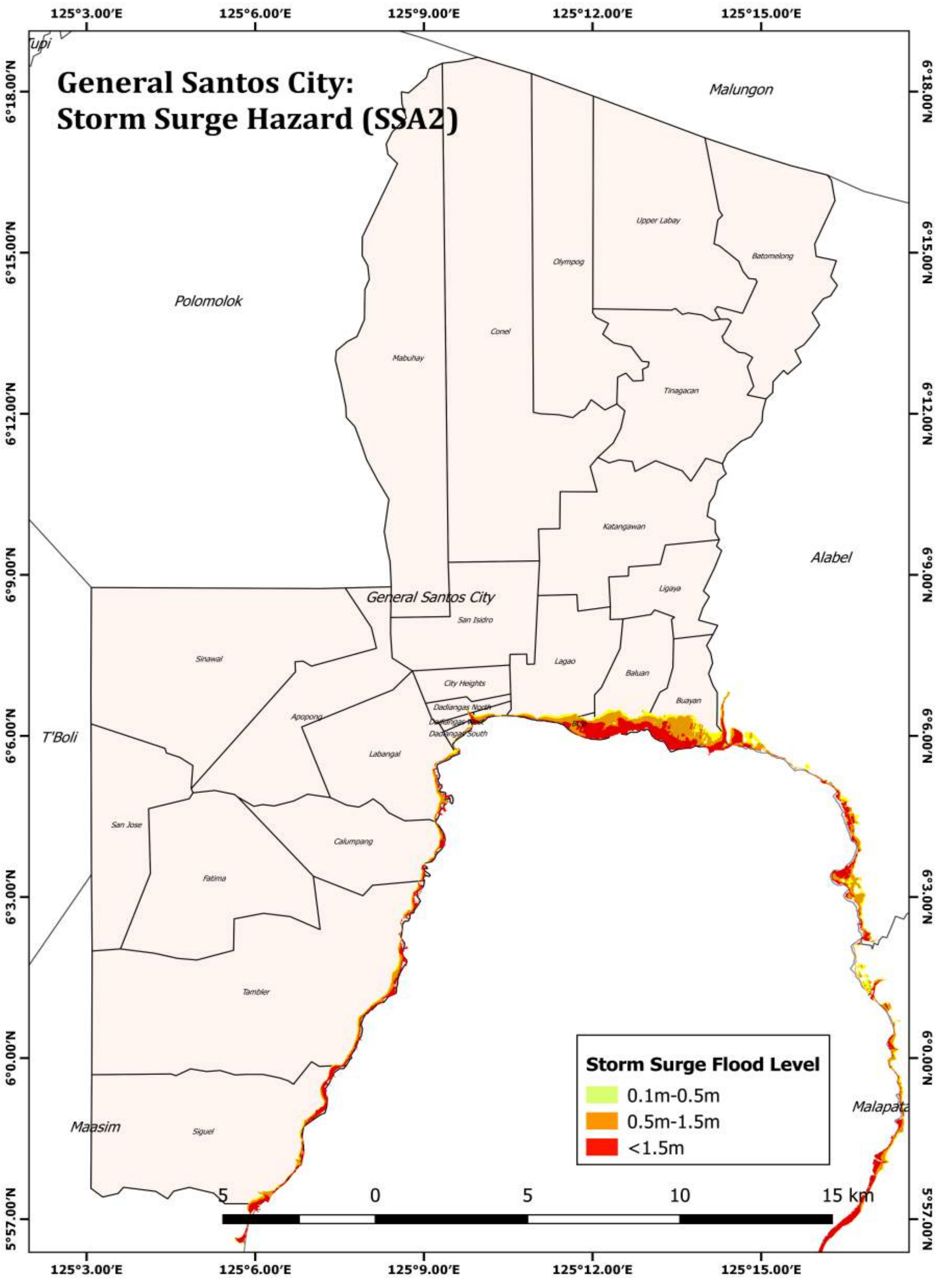
The storm surge hazards in the city are mostly isolated to the coastal *barangays*. The coastal *barangays* are: Baluan, Buayan, Bula, Dadiangas South, Dadiangas West, Calumpang, Labangal, Siguel and Tambler. In particular, the *barangays* of Lagao, Bula, Baluan, and Buayan have the largest area at risk of flooding due to storm surge.

*SSA 1 Storm Tide Level of 2.01 m to 3.0 m*



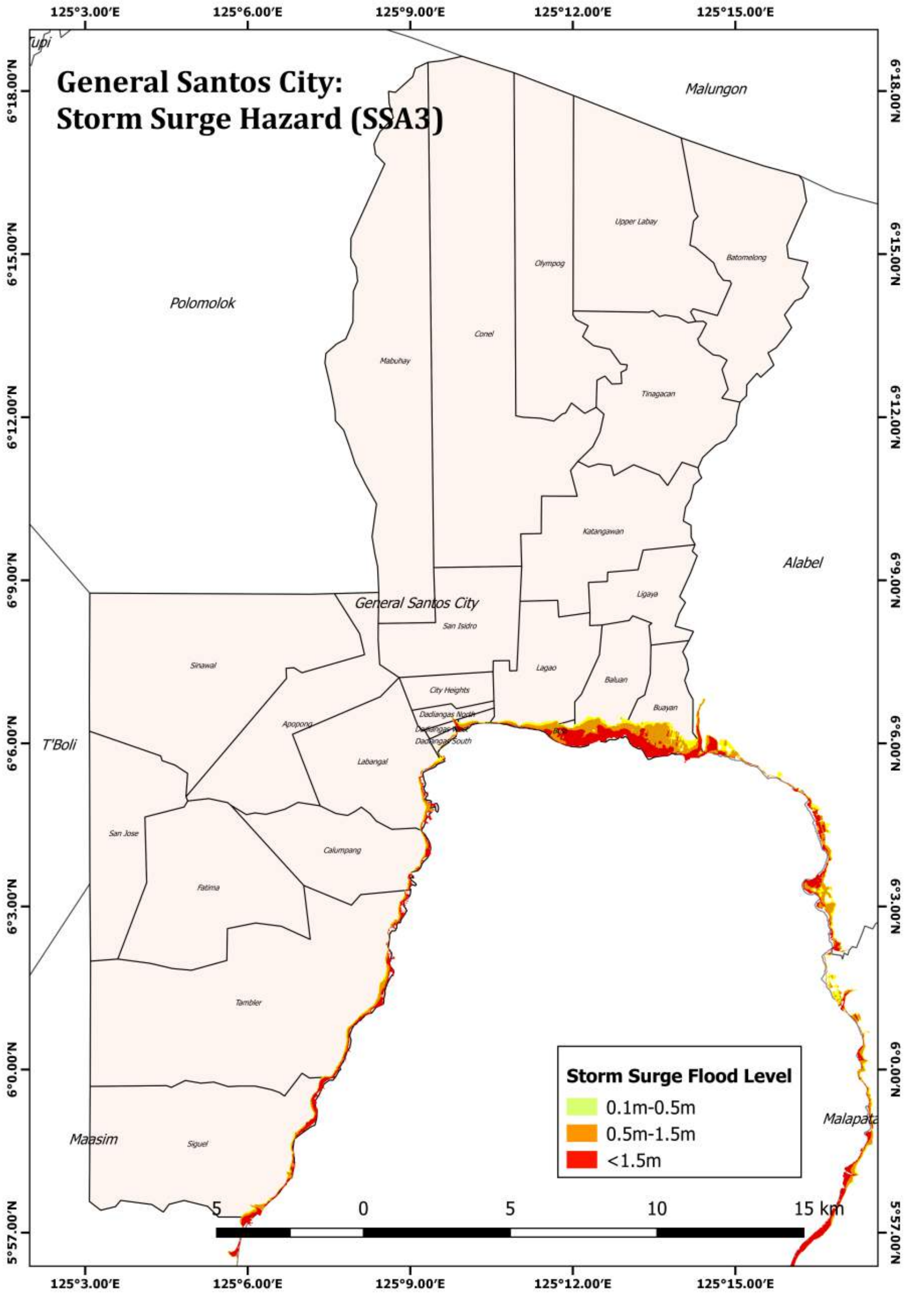

***Map 3.2.11.*** *Storm Surge (SSA 1) Hazard Map (Source: Project NOAH data)*

*SSA 2 Storm Tide Level of 3.01 m to 4.0 m*




***Map 3.2.12.*** *Storm Surge (SSA 2) Hazard Map (Source: Project NOAH data)*

## *SSA 3 Storm Tide Level of Greater than 4.0 m*




***Map 3.2.13.*** *Storm Surge (SSA 3) Hazard Map (Source: Project NOAH data)*

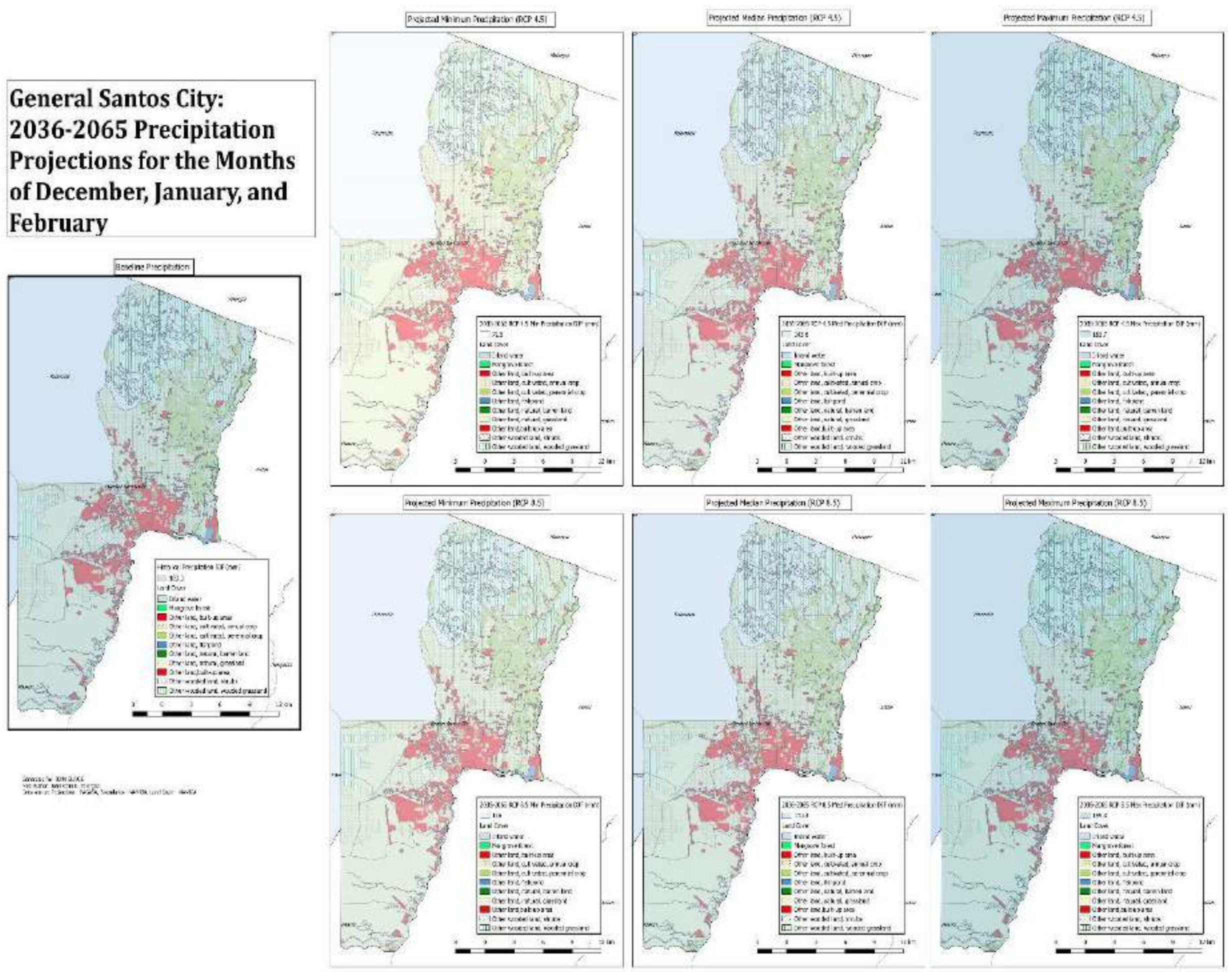
## Projections and Grid Extent (data on Projections come from PAGASA)

### *Change in Precipitation*

#### Mid-21st Century Projections (2036-2065), Maps 14-17

In the mid-century the months of December January, and February are projected to have a decrease in precipitation in both scenarios based on the projected median rainfall values ***(Map 3.2.14)***. The scenario under RCP 4.5 is drier than RCP 8.5 as can be seen in all the projected values.

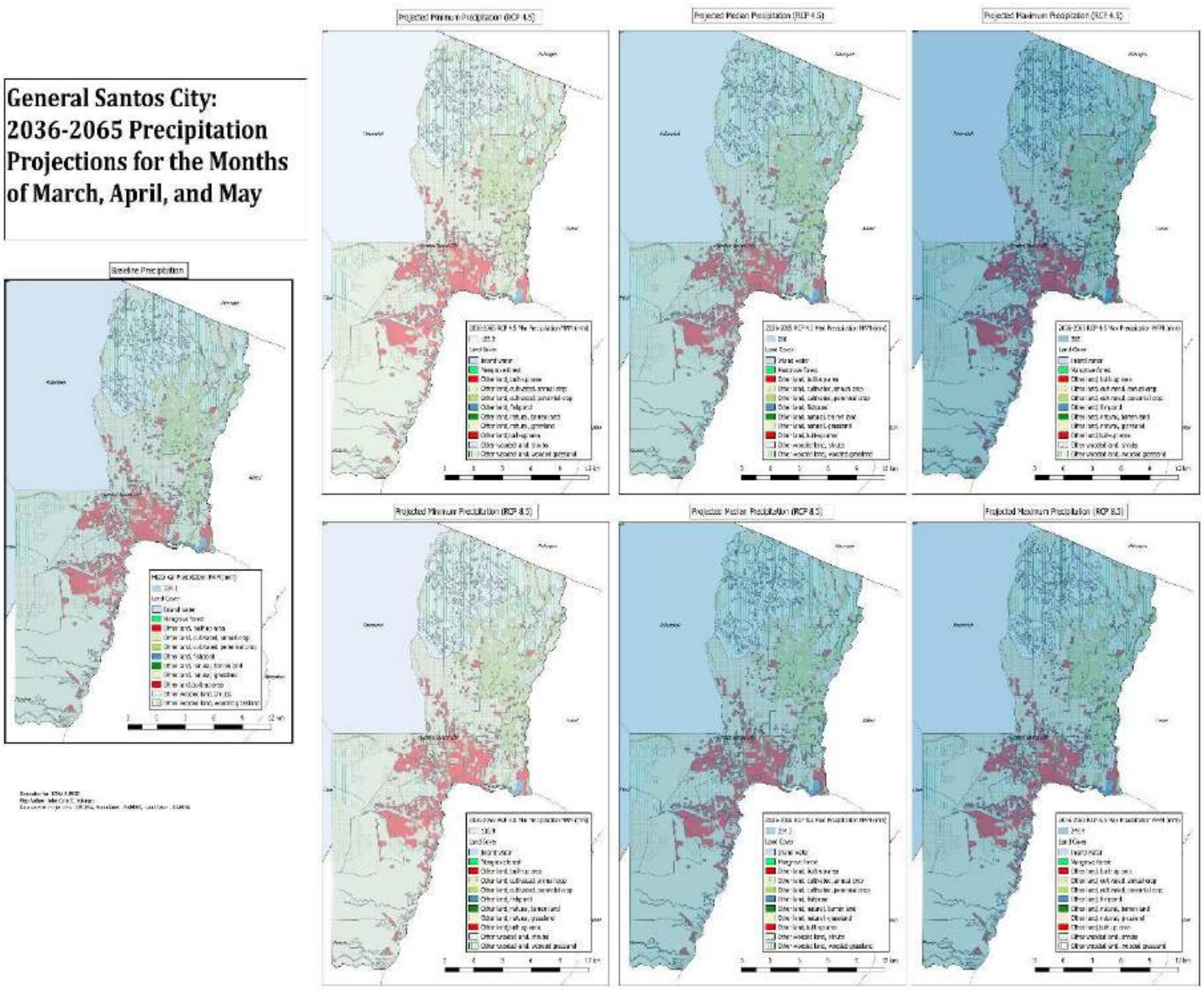
The projected median precipitation value for RCP 4.5 is a 21.7% decrease from the baseline while under RCP 8.5 the projected median value is a 7.1% decrease from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 60.4% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 31.3% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 1.3% increase from the baseline while under RCP 8.5 the projected maximum precipitation is an 8.8% increase from the baseline.




***Map 3.2.14.*** *2036-2065 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be drier under RCP 4.5 and marginally wetter under RCP 8.5 based on the projected median precipitation values ***(Map 3.2.15)***.

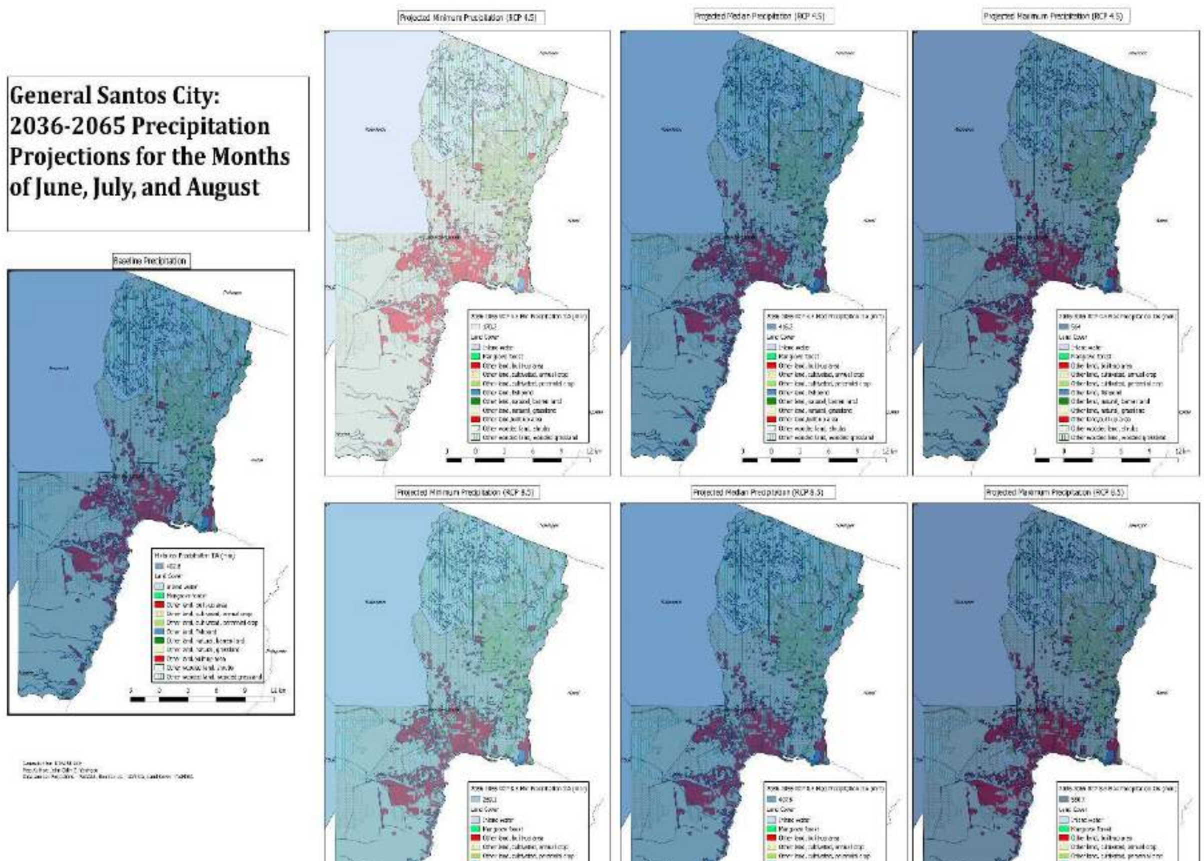
Though, under RCP 8.5 the minimum projected values still project a possibility of extreme dry events similar to RCP 4.5. Also, under RCP 4.5 the range of values project possibilities of extreme wet and extreme dry events. The projected median precipitation value for RCP 4.5 is a 12% decrease from the baseline while under RCP 8.5 the projected median value is a 0.1% increase from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 47.4% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 41.5% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 21.5% increase from the baseline while under RCP 8.5 the projected maximum precipitation is a 6.5% increase from the baseline.




***Map 3.2.15.*** *2036-2065 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August are projected to be marginally wetter than the baseline under both scenarios based on the projected median precipitation values ***(Map 3.2.16)***.

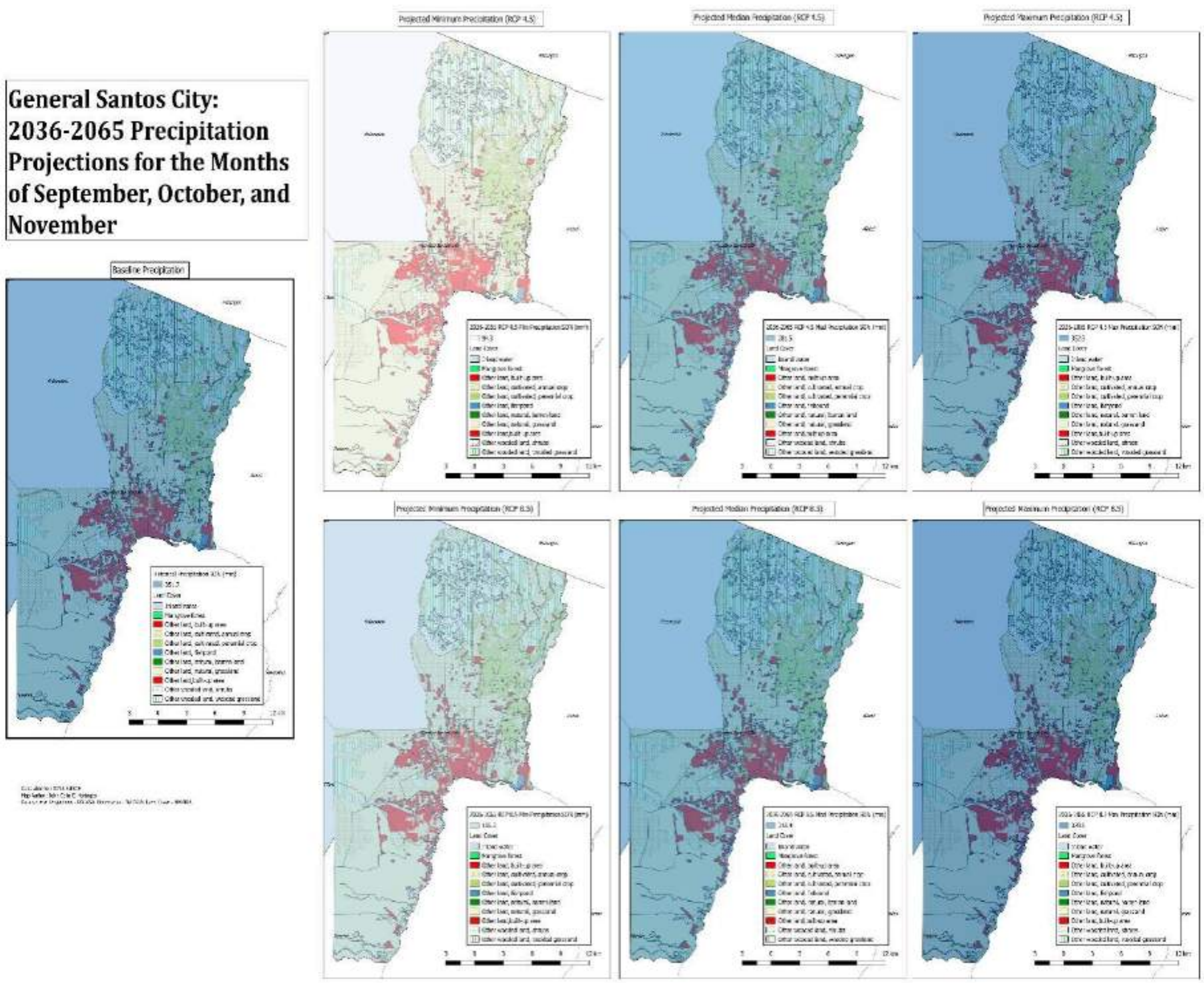
Furthermore, the range of projected values under both scenarios is wide which projects a possibility of both extreme wet and extreme dry events under the said months. The projected median precipitation value for RCP 4.5 is a 3.3% increase from the baseline while under RCP 8.5 the projected median value is a 1.2% increase from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 57.7% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 33.2% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 40% increase from the baseline while under RCP 8.5 the projected maximum precipitation is a 44.4% increase from the baseline.




***Map 3.2.16.*** *2036-2065 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to be drier under both scenarios based on the projected median precipitation values ***(Map 3.2.17)***.

Furthermore, under RCP 4.5 it is projected to be drier than RCP 8.5 based on the projected values. The projected median precipitation value for RCP 4.5 is a 20% decrease from the baseline while under RCP 8.5 the projected median value is a 9.5% decrease from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 73.2% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 47.3% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 0.3% increase from the baseline while under RCP 8.5 the projected maximum precipitation is a 7.6% increase from the baseline.

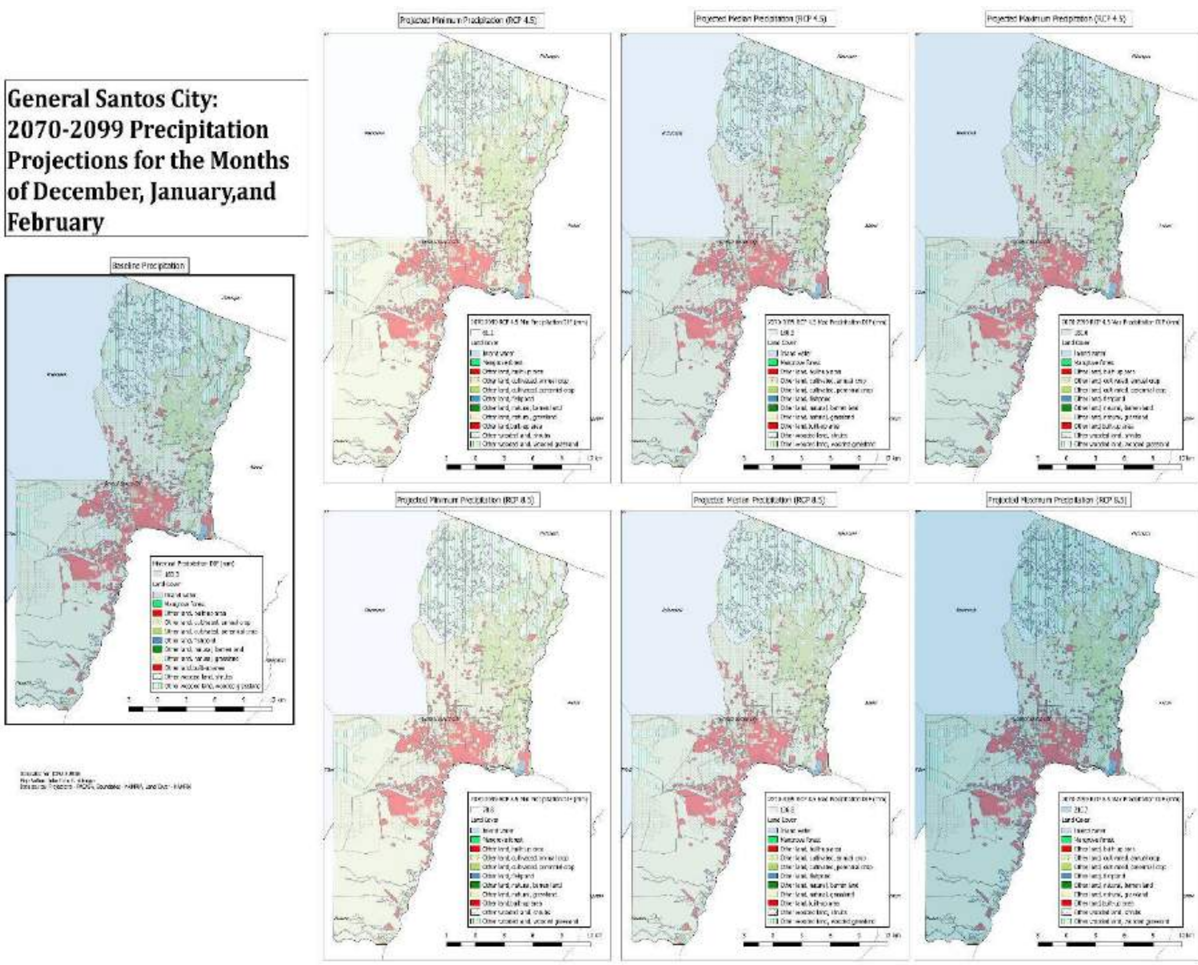



***Map 3.2.17.*** *2036-2065 Precipitation Projections for September, October and November (Source: PAGASA data)*

### Late 21st Century Projection (2070-2099), Maps 18-21

The late century projections for the months of December, January and February continue the trend of that in the mid-century, it is projected that these months will be drier than the baseline under both scenarios based on the median projected precipitation values ***(Map 3.2.18)***.

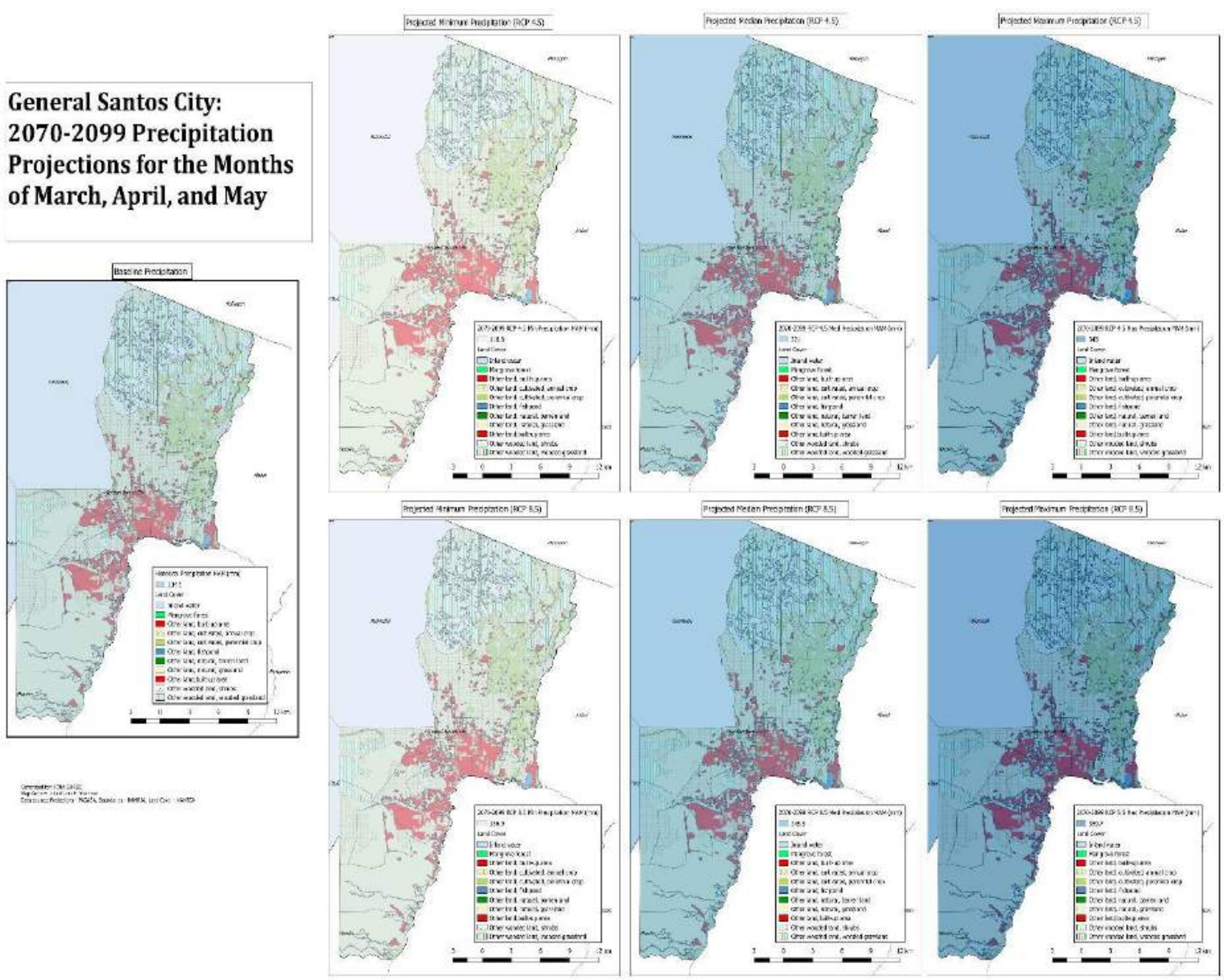
Furthermore, under RCP 4.5 the projected precipitation is significantly drier because its whole range of values is below the historical baseline. The projected median precipitation value for RCP 4.5 is a 12.5% decrease from the baseline while under RCP 8.5 the projected median value is a 25.4% decrease from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 66.6% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 57% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 0.9% decrease from the baseline while under RCP 8.5 the projected maximum precipitation is a 15% increase from the baseline.




***Map 3.2.18.*** *2070-2099 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be drier under RCP 4.5 and wetter under RCP 8.5 than the historical baseline based on their projected median precipitation values ***(Map 3.2.19)***.

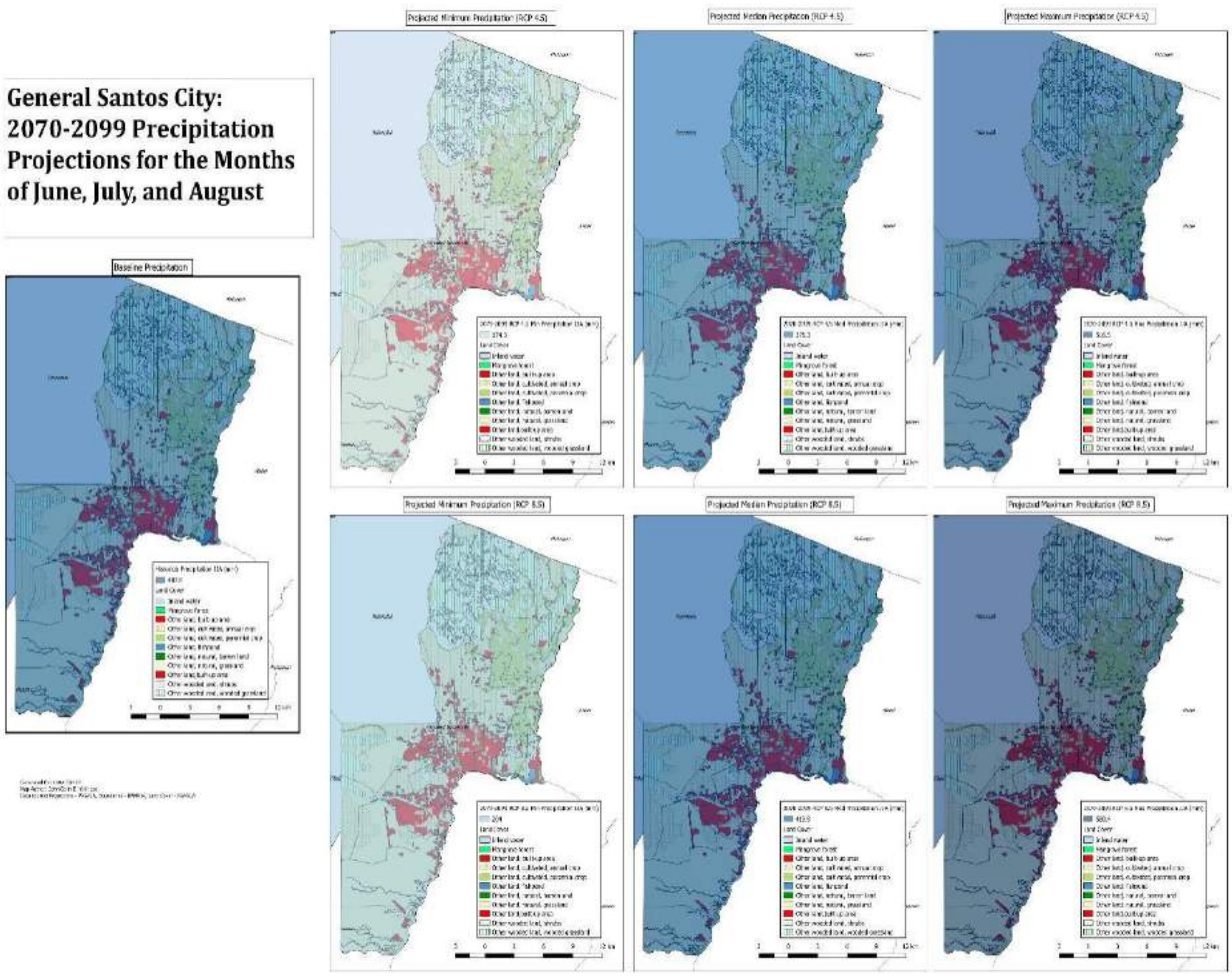
Under both scenarios, the projected range of possible values is particularly wide which projects the possibility of both extreme dry and extreme wet events during these months. The projected median precipitation value for RCP 4.5 is a 5.6% decrease from the baseline while under RCP 8.5 the projected median value is a 4.8% increase from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 50.1% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 41.5% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 46.5% increase from the baseline while under RCP 8.5 the projected maximum precipitation is a 53.6% increase from the baseline.




***Map 3.2.19.*** *2070-2099 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August follow the same trend as the previous quarter in that it is projected to be drier under RCP 4.5 and wetter under RCP 8.5 based on their median precipitation values. Furthermore, the said months are also projected to have a wide range of precipitation values which project the possibility of extreme wet and extreme dry events ***(Map 3.2.20)***.

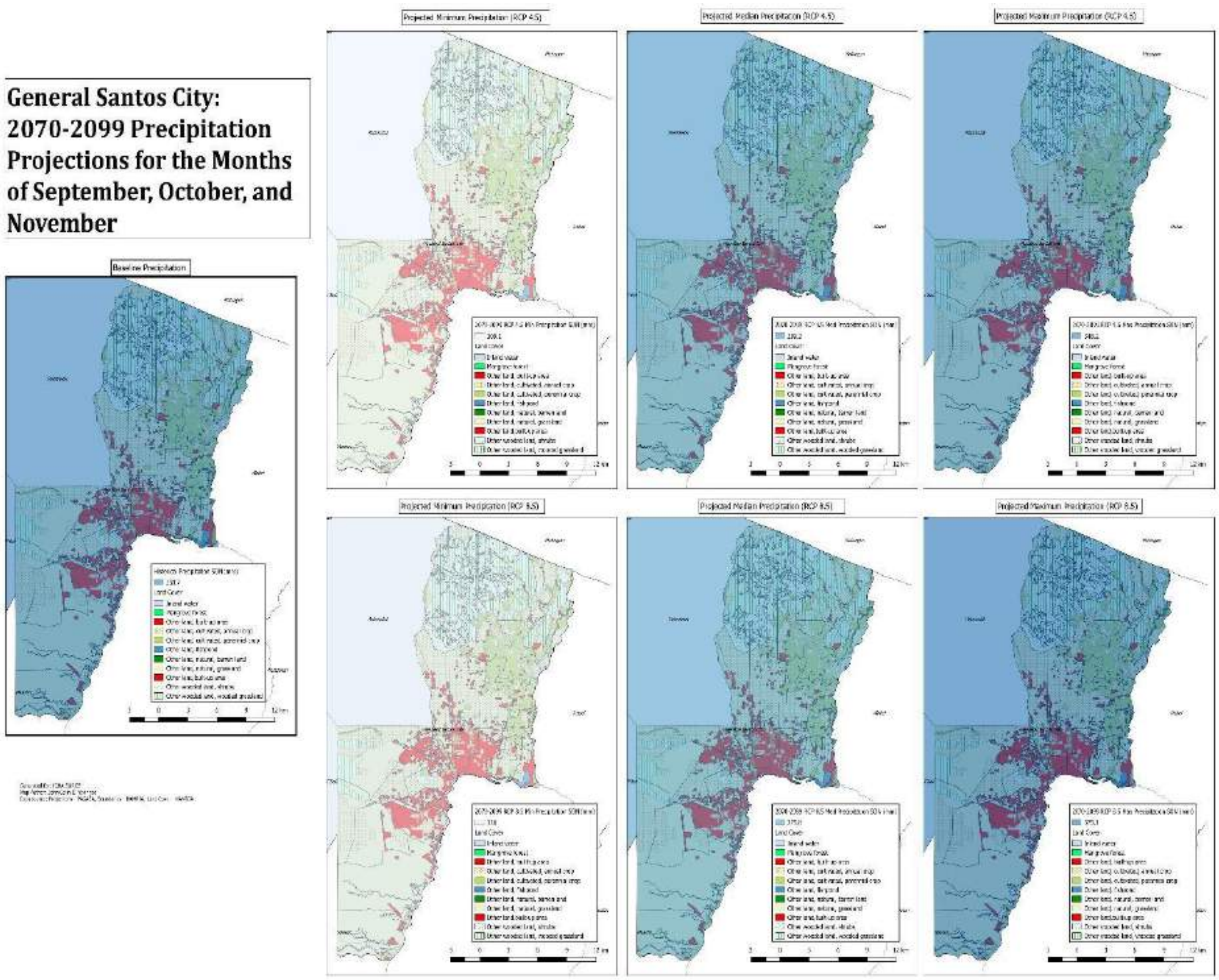
The projected median precipitation value for RCP 4.5 is a 6.1% decrease from the baseline while under RCP 8.5 the projected median value is a 4.3% increase from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 56.7% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 49.3% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 28.2% increase from the baseline while under RCP 8.5 the projected maximum precipitation is a 46.1% increase from the baseline.




***Map 3.2.20.*** *2070-2099 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September October and November are projected to be drier than the historical baseline under both scenarios. Furthermore, under RCP 4.5 it is projected to be significantly drier because the whole range of values under the scenario is below the historical baseline ***(Map 3.2.21)***.

The projected median precipitation value for RCP 4.5 is a 14.9% decrease from the baseline while under RCP 8.5 the projected median value is a 21.6% decrease from the baseline. The projected minimum precipitation on the other hand under RCP 4.5 is a 69% decrease from the baseline while under RCP 8.5 the projected minimum precipitation is a 64.2% decrease from the baseline. Lastly, the projected maximum precipitation under RCP 4.5 is a 1% decrease from the baseline while under RCP 8.5 the projected maximum precipitation is a 6.7% increase from the baseline.



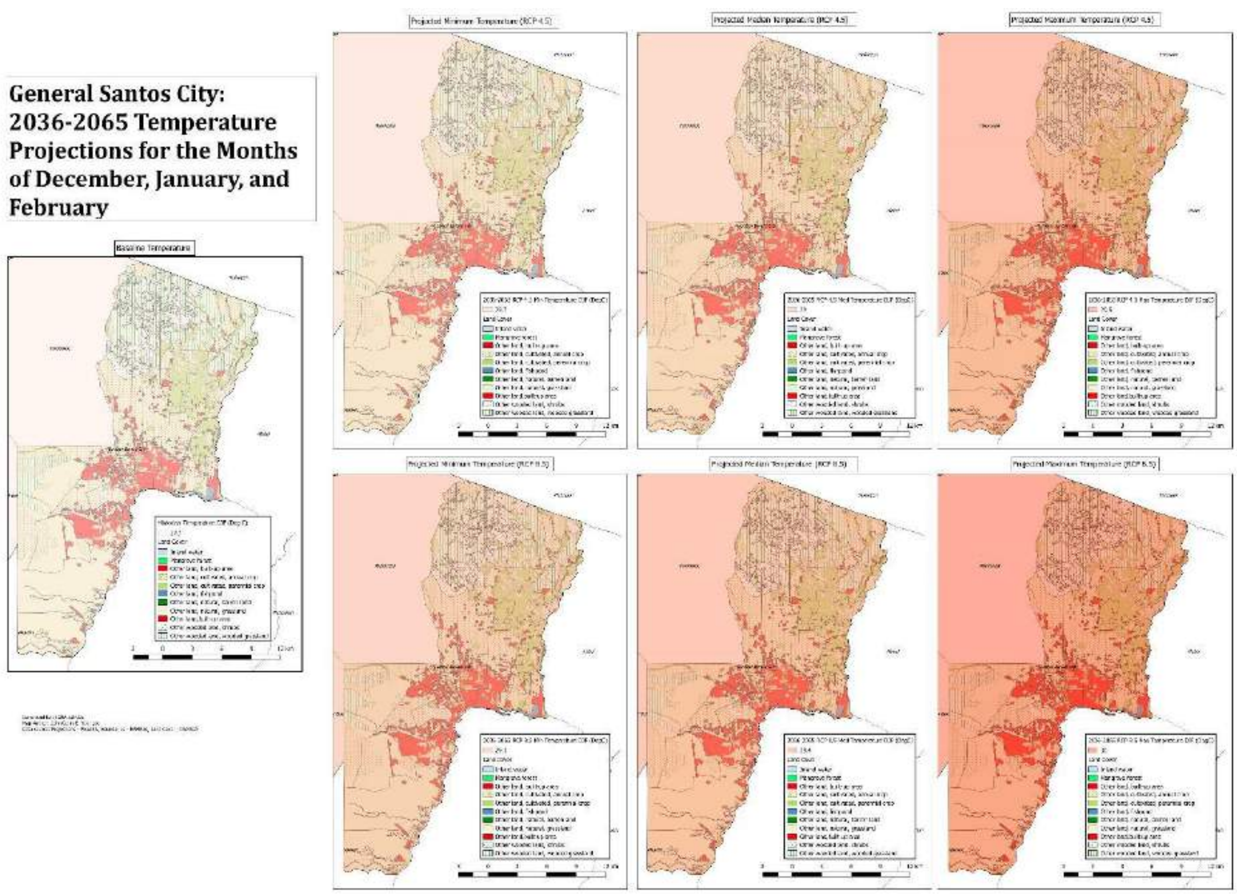

***Map 3.2.21.*** *2070-2099 Precipitation Projections for September, October and November (Source: PAGASA data)*

### *Change in Temperature*

Under all the scenarios and in both the mid and late centuries the projected temperatures are all higher than the historical baseline. The trend is RCP 8.5 is hotter than RCP 4.5 and that in the late century the temperatures will continue to rise under both scenarios. Furthermore, the projected temperatures for all months are projected to be higher than the historical hottest for the year. The details of these projections per season are listed below.

#### Mid-21st Century Projections (2036-2065), Maps 22-25

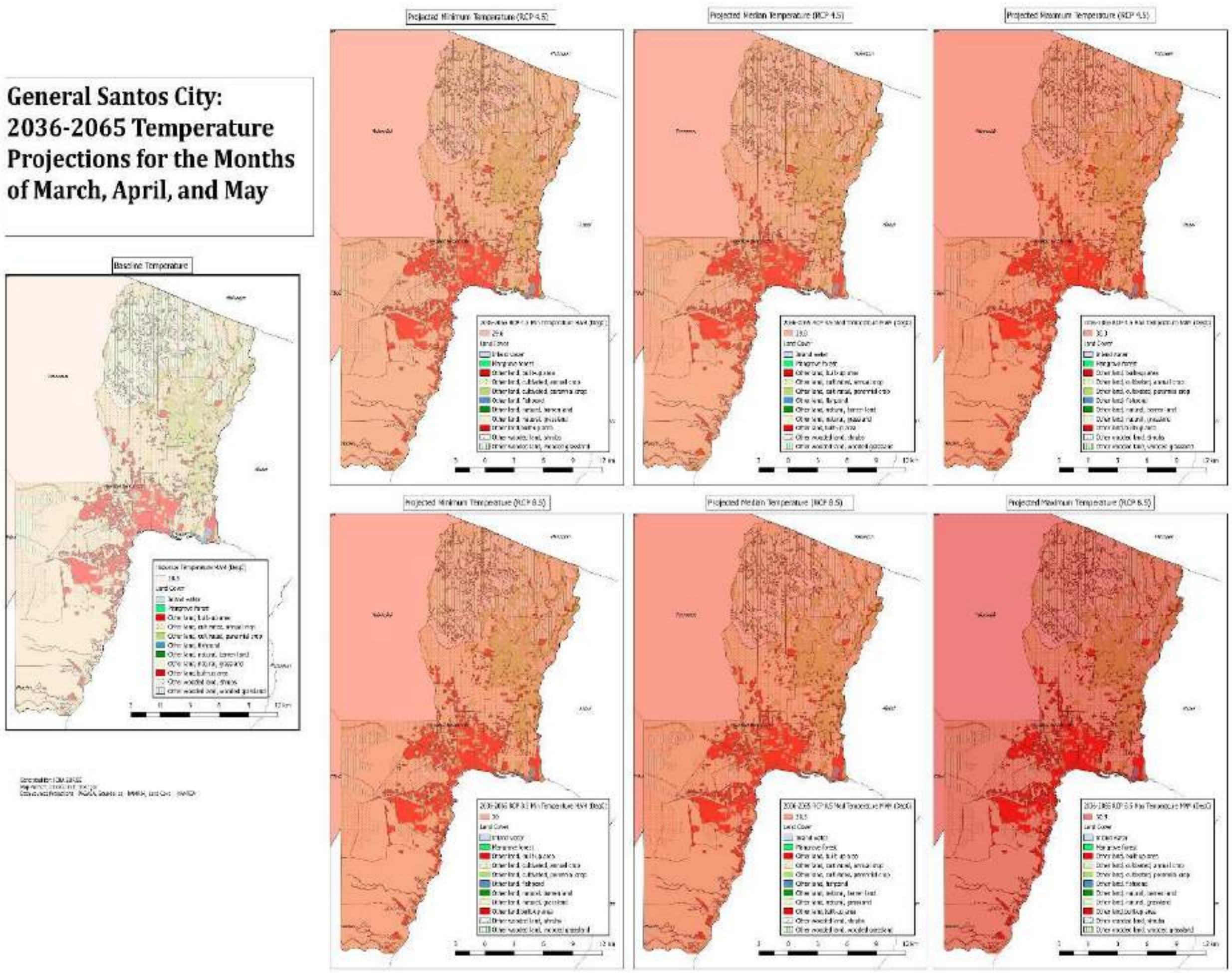
The months of December, January and February are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.22)***. The projected median temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 1.7 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.0 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 1.4 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 1.8 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.3 degrees.




***Map 3.2.22.*** *2036-2065 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.23)***.

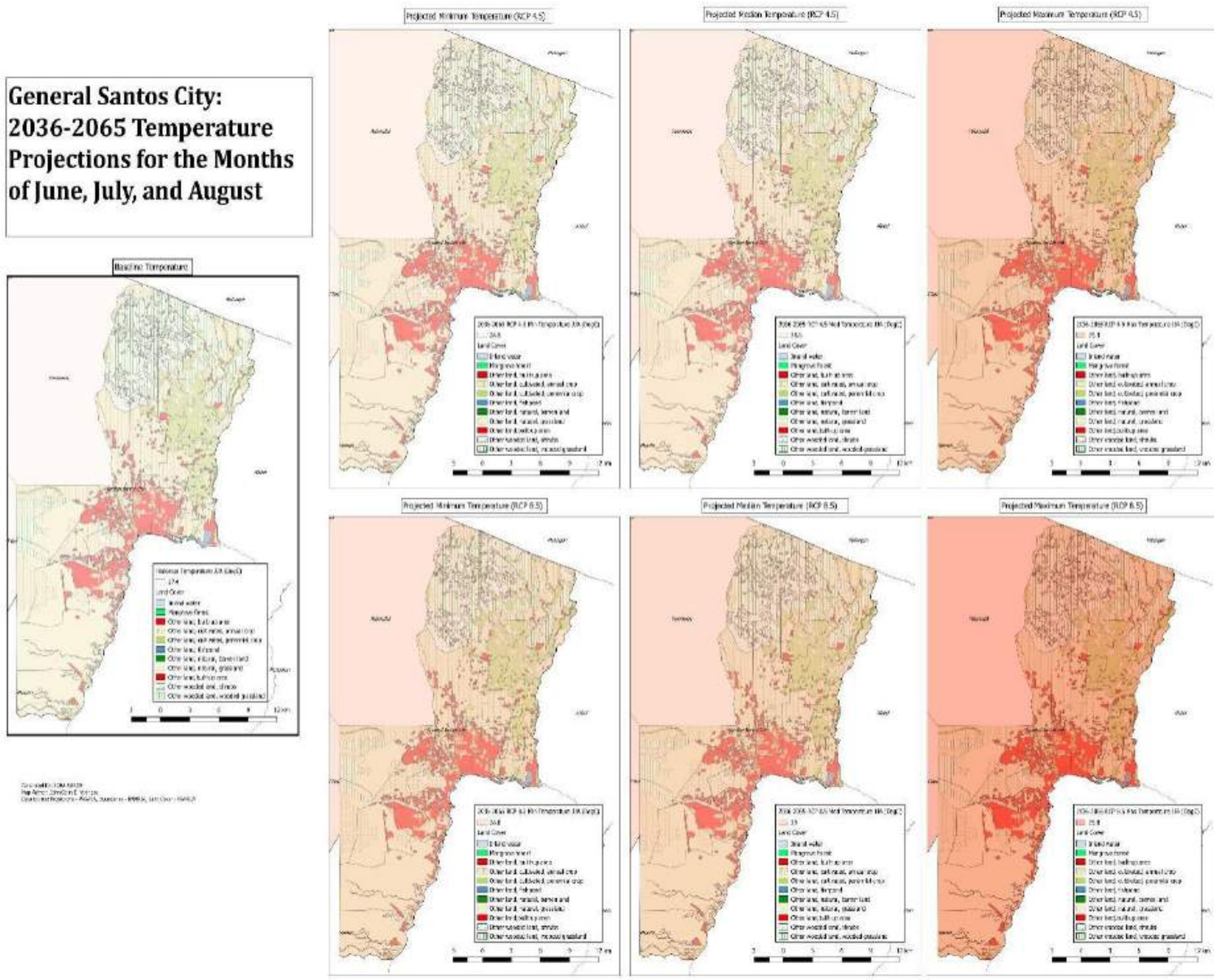
The said months are also projected to continue to be the hottest months of the year. The projected median temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 1.8 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.1 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 1.5 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 1.8 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.4 degrees.




***Map 3.2.23.*** *2036-2065 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.24)***.

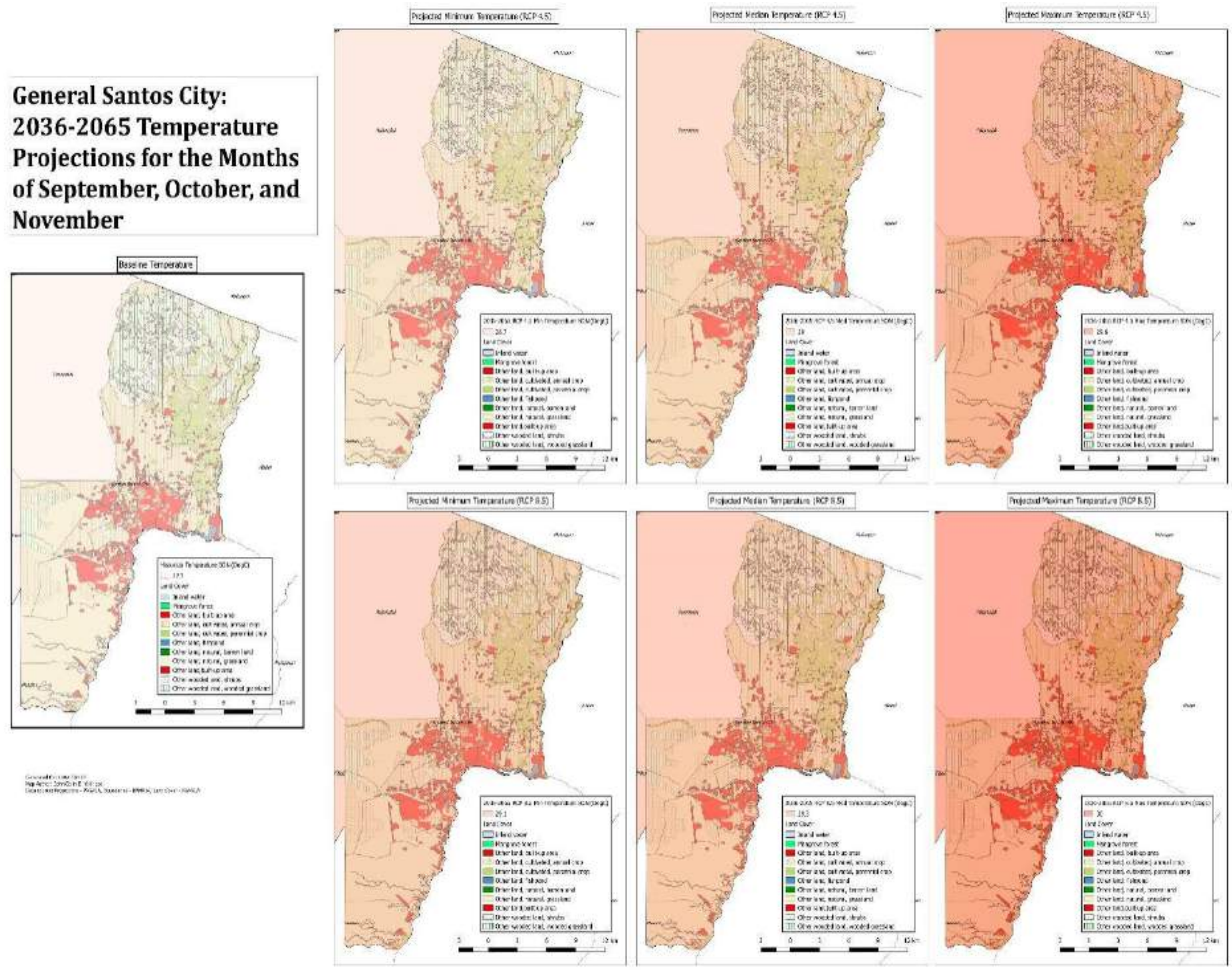
The said months will continue to be the coolest of the year under the said projections. The projected median temperature under RCP 4.5 is an increase of 1.2 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 1.6 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.1 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 1.4 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 1.9 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.4 degrees.




***Map 3.2.24.*** *2036-2065 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October, and November are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.25)***.

The projected median temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 1.6 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.0 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 1.4 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 1.9 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.3 degrees.

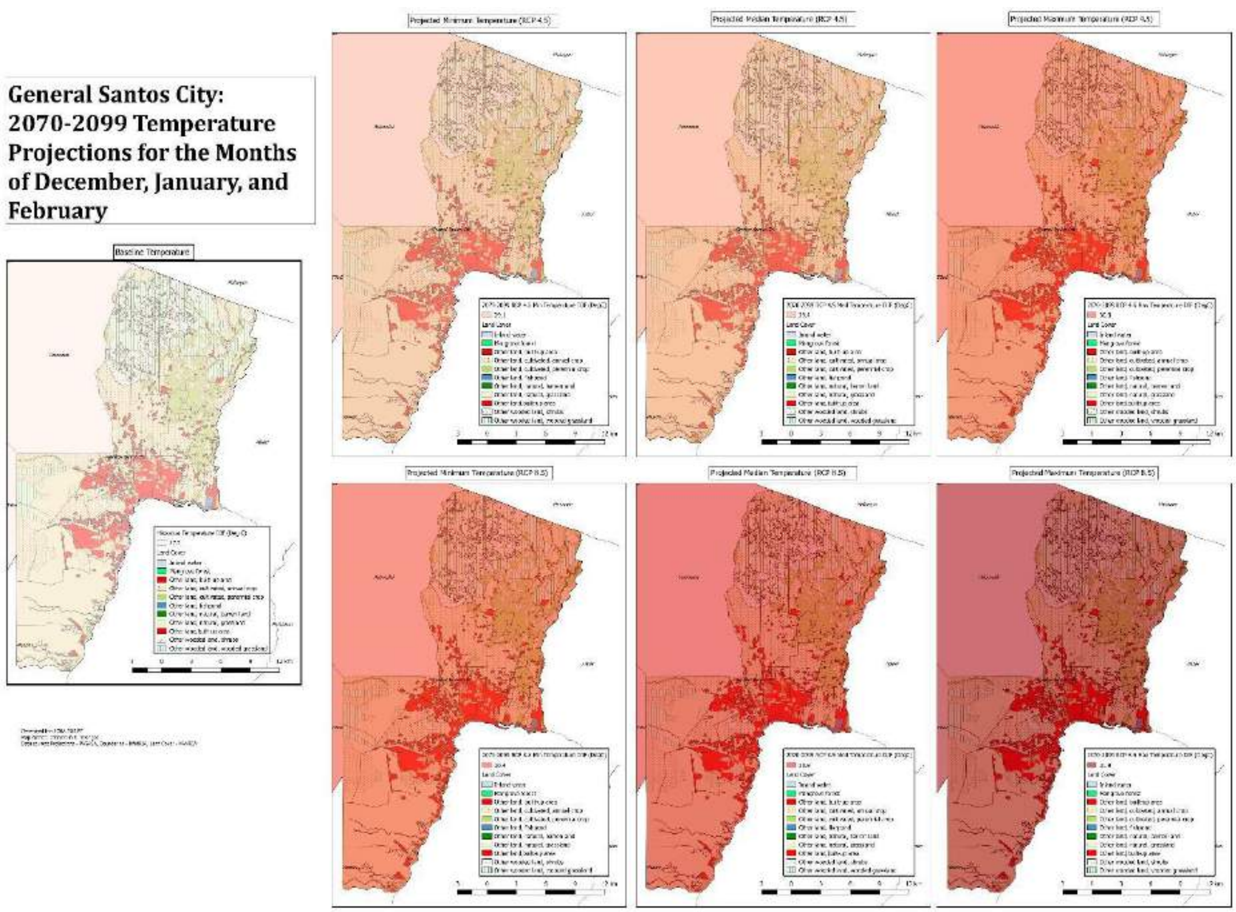



***Map 3.2.25.*** *2036-2065 Temperature Projections for September, October and November (Source: PAGASA data)*

## Late 21st Century Projections (2070-2099), Maps 26-29

The projected temperatures in the late century are higher than those projected in the mid-century under both scenarios. The temperature increase under RCP 8.5 is significantly higher than under RCP 4.5 in the late century. The projected temperature values under RCP 8.5 are above the range of values in RCP 4.5 in all seasons. Furthermore, the projected temperatures under General Santos are all above 30 degrees Celsius.

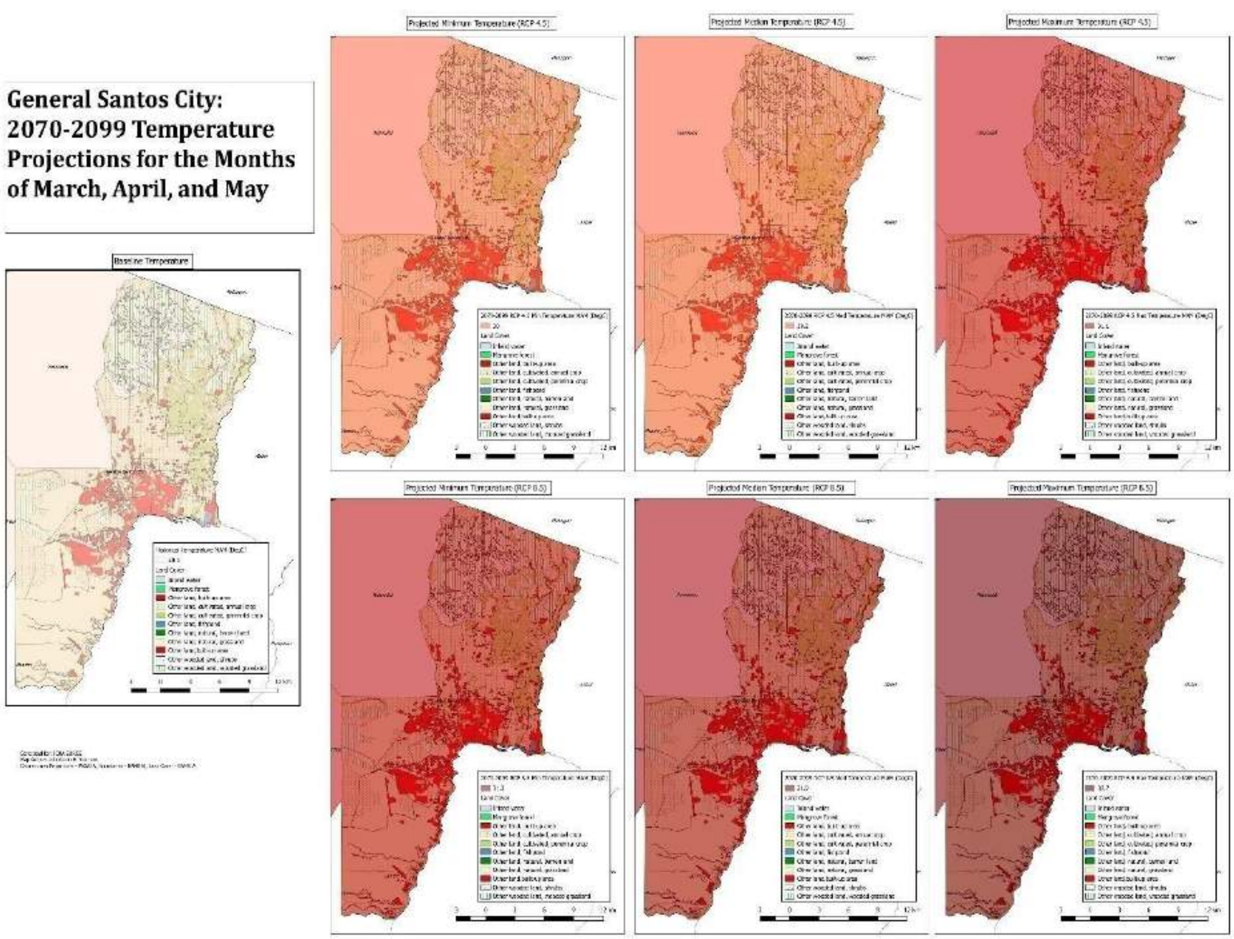
The months of December, January and February are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.26)***. The projected median temperature under RCP 4.5 is an increase of 1.7 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 3.2 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.4 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 2.7 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 2.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 4.2 degrees.




***Map 3.2.26.*** *2070-2099 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April, and May are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.27)***.

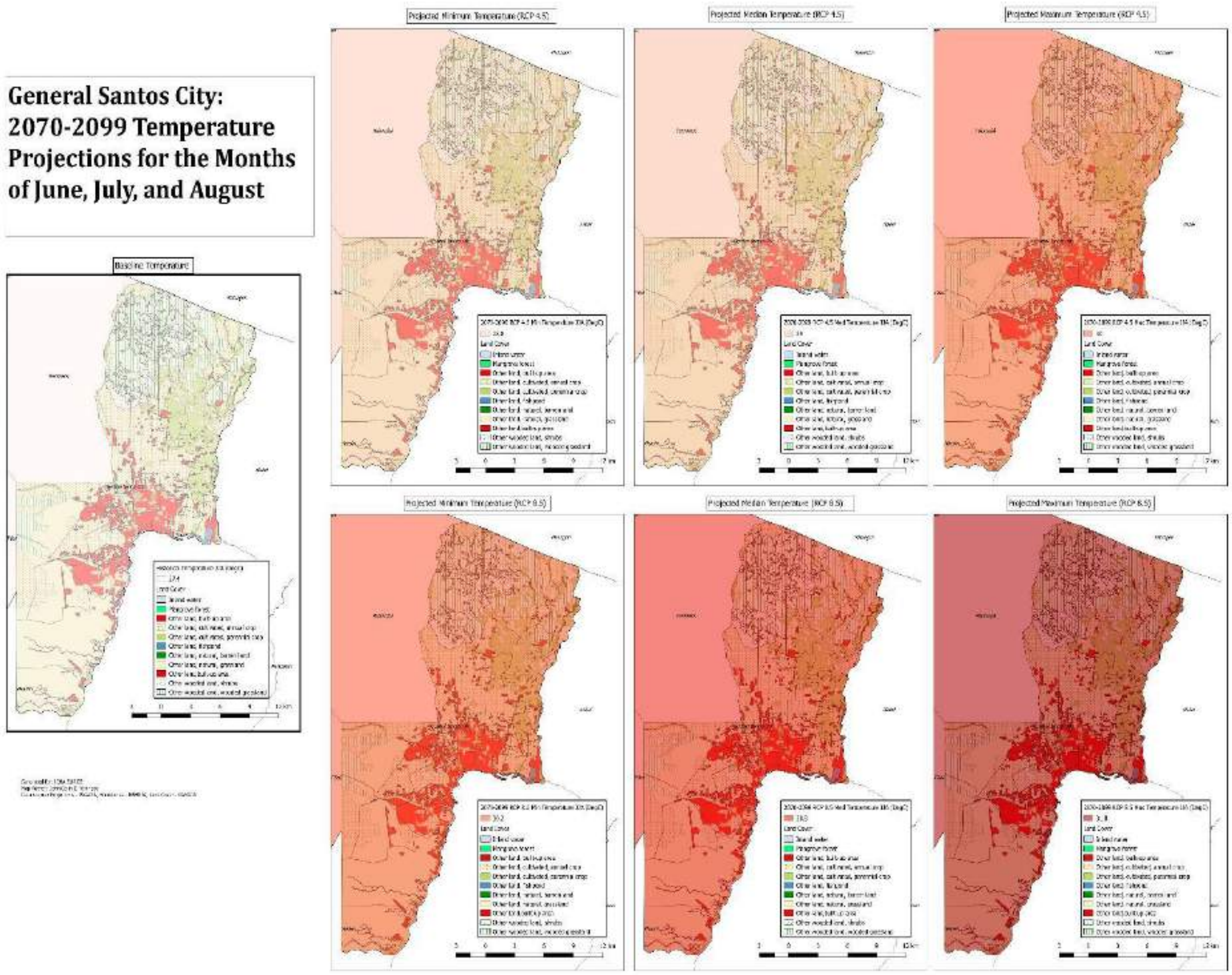
The projected median temperature under RCP 4.5 is an increase of 1.7 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 3.4 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.5 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 2.8 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 2.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 4.2 degrees.




***Map 3.2.27.*** *2070-2099 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.28)***.

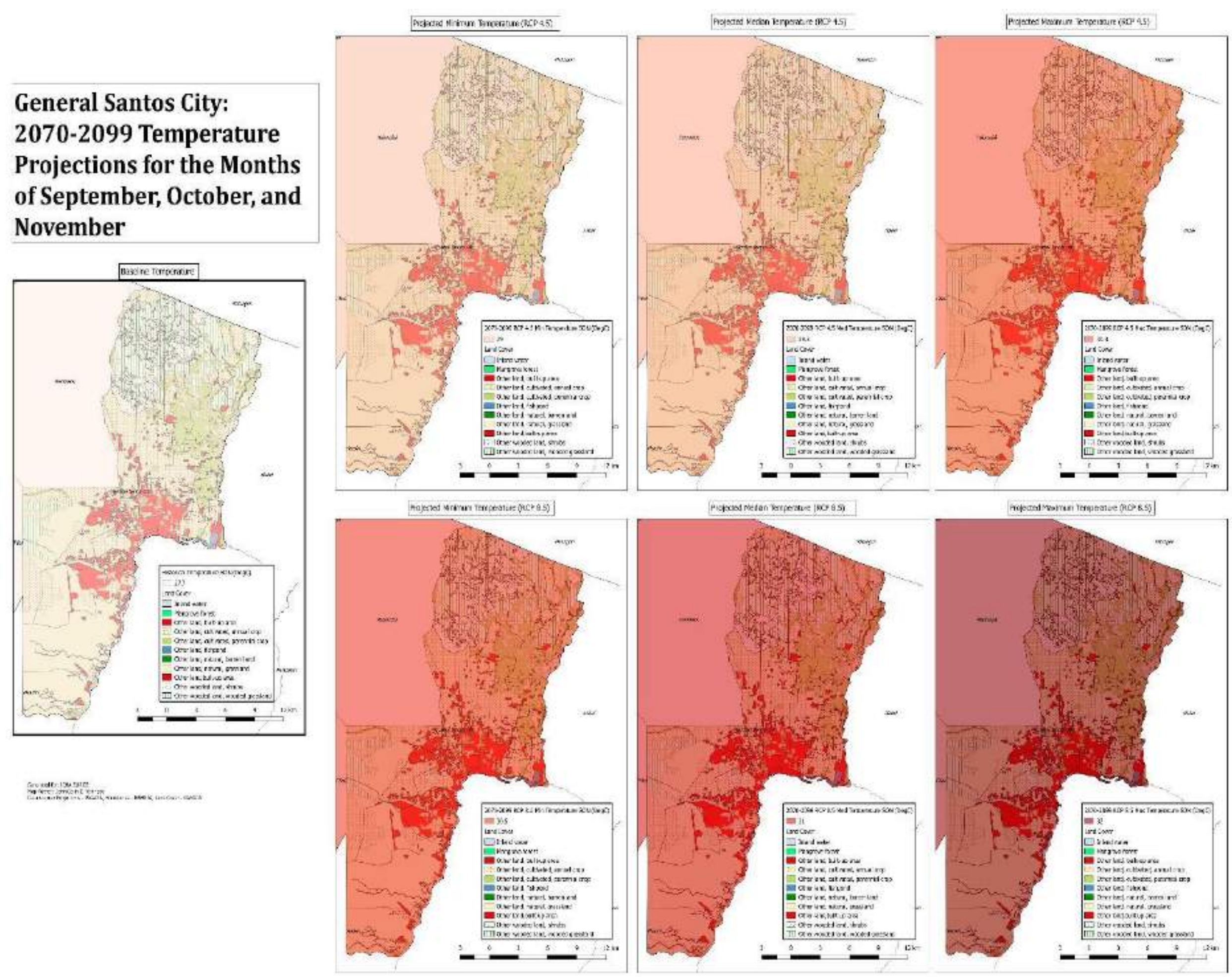
The projected median temperature under RCP 4.5 is an increase of 1.6 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 3.4 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.4 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 2.8 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 2.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 4.4 degrees.




***Map 3.2.28.*** *2070-2099 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to be hotter than the historical baseline under both scenarios based on the whole range of values ***(Map 3.2.29)***.

The projected median temperature under RCP 4.5 is an increase of 1.6 degrees from the historical baseline for the said months while under RCP 8.5 the projected median temperature is an increase of 3.3 degrees from the baseline. The minimum projected temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline while under RCP 8.5 the projected minimum temperature is a 2.8 degrees increase from the baseline. Lastly, the projected maximum temperature under RCP 4.5 is an increase of 2.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 4.3 degrees.




***Map 3.2.29.*** *2070-2099 Temperature Projections for September, October and November (Source: PAGASA data)*

## Impacts and Adaptation Options

General Santos City is a highly populated urban and rural landscape in South Cotabato. Found at its center is a highly built up area that coincides with the extensive network of roads and transportation. The agricultural and woodland areas of the city can be found in its northern and southern regions.

Furthermore, the south of the city is bound by the Moro Gulf and hence has an extensive relationship with marine fishing industries. The city can be seen as an industrial, transportation, and ecological center in the region. With this in mind, the impacts of the projected changes in precipitation and temperature will vary for each sector. The notable projections are the marked increases in temperature under both RCP 4.5 and RCP 8.5. Also, the projected decrease in precipitation under RCP 4.5 and projected wide range of possible precipitation values under both scenarios show the possibility of a generally dry climate with the possibility of extreme wet and extreme dry events. The impacts and adaptation options for each sector are listed below.

### *A. Demography*

The projected increase in temperature under both scenarios and the projected general decrease in precipitation under RCP 4.5 have possible health and livelihood related impacts to the population of the city. The highly built up and populated areas of the city are at risk of the urban heat island effect which magnifies the increase in temperature due to the nature of the materials and population in the city. These could lead to heat related health risks for the population such as heat stroke and dehydration (IPCC 2014). Those most at risk of these heat related impacts are children and the elderly. The heat-related risks are evident because of the fact that under the mid-century alone, and in both scenarios, all months are projected to have temperatures higher than the historical hottest months. This increase in temperature is magnified in the late century and in particular to RCP 8.5 because all temperatures for all months will exceed 30 degrees Celsius.

The projected slight increases in precipitation under RCP 8.5 in the months of March, April, and May and under both scenarios for the months of June, July, and August may prove beneficial to alleviate the heat brought on by the projected increase in temperatures. But, the wide range of precipitation values in the months of March, April and May under RCP 4.5 and June, July, and August may increase the risks of extreme wet and dry events such droughts and flooding. In the late century the same trend follows, but both scenarios have a wide range of possible precipitation values. The population that is found in flood prone areas and that have no capacity to adapt to such risks will be most affected. The variable changes in rain in both extreme wet and dry events have health risk such as water-borne disease and the aforementioned heat stroke and dehydration (IPCC 2014).

Also, the increase in temperature and variabilities in precipitation may cause shifts in population from the rural to urban centers where resources and livelihoods may be more abundant (Black et al. 2008). The city has initiated several programs to prepare and adapt to the possible impacts such as incorporating climate change adaptation into their plans, programs, policies, and activities as well as plans for increasing green areas within the city to reduce urban heat island effect. One of the possible adaptation options to help aid the population is the adoption and creation of policies that can adjust or change behaviour to adopt to the climate. These make take the form of policies regarding prescribed clothing as well as the adjustment of the days and time of class and work hours. Since there is a marked increase in temperature activities could be adjusted to the cooler hours of the day such as earlier in the mornings or latter in the afternoons towards the evenings to compensate for the heat. (Sabbag 2013). The city can also adopt education campaigns regarding climate change effects and adaptation options to inform their citizens.

### *B. Social*

In terms of social impacts, the projected increase in temperature, general decrease in precipitation under RCP 4.5 and some months under RCP 8.5, and the large range of variability may affect the livelihoods and the adaptive capacities of the population especially those found on the poverty line. Furthermore, loss of livelihood may decrease the accessibility of households to education, health, and other social services. The increased temperature may increase heat related health risks especially in the urban areas where most of the population can be found.

Moreover, the wide range of precipitation values may affect class hours due to suspensions brought about by extreme wet events and flooding. Water borne and heat related diseases may surface and put added stress to health facilities. Lastly, urban poor and citizens who may be located in flood risk zones may have an increased possibility of danger of loss of property lives due to the wide range of precipitation values especially during the months of June, July and August under both scenarios. The city has currently adopted socialized housing to address informal settlements that are in flood risk areas. Like what was suggested in the previous section, the city can adopt policies regarding clothing and class and work hours to adapt to the increases in temperature. The social services and public buildings also can adopt smart design and technologies in their construction to adopt measures such better ventilation to address the increases in temperature and reduce electricity use (Sabbag 2013).

### *C. Economic*

The economic impacts to the city based on the projections hinge primarily on the agricultural and fishery industries. The projected increase in temperature and the general decrease in precipitation under RCP 4.5 and in the June, July and August and September, October, November season under RCP 8.5 will affect the water supply necessary for the cultivation of crops reducing yield (IPCC 2014).

In particular corn and rice crops are projected to be negatively affected and have a decrease in yield (Eitzinger et al. 2017). Moreover, coconut plantations will also foresee negative impacts such as a reduction in yield and increased risk of disease (Hebbar et al. 2013). The wide range of possible precipitation values also reveal the possibility of flooding which also reduces yield to crops and can even cause extensive crop damage (Toda et al. 2017). The impact to fisheries may include reduced nutrient content to waters around the Moro Gulf due to the increase and temperature and the possibility of changes in nutrient circulation (Howden et al. 2007). This could affect species migration and the tuna industry of the city.

The increase in temperature can negatively affect livestock and poultry such as chickens and pigs due to the fact that it can cause heat stroke in those animals. The projected wide range of precipitation values also has the risk of extreme wet events which may induce respiratory related diseases in livestock and poultry.

Approximately 10,000 households rely on the economic activities and around 9,000 employees who may be affected by the possible impacts to fishery industry. The city has currently integrated their plans, programs, and activities in the economic sector with climate change adaptation measures which includes an ordinance and trainings on livelihood capacity building particularly for fisherfolk. The city has also conducted extensive activities for their agricultural sector to adapt to climate change. This includes distribution of drought tolerant varieties of vegetable crops, root crops, and others; improvement of water infrastructure, cloud seeding, and rainwater harvesting to improve water supply; and information education campaigns on of El Niño and La Niña events as well as distribution of corn and rice seeds to farmers affected by such events. The city has well prepared for the possible effects to dry climate on their agricultural activities.

Apart from drought tolerant vegetable and root crop varieties, the city can also adopt climate tolerant varieties which can tolerate flooding and or drought for crops such rice and the coconut plants (Toda et al. 2017; Hebbar et al. 2013; and Howden et al. 2007). The farmers in the city can also shift cropping calendars to take into account the projected marginal increase in precipitation during the months of June, July and August.

Lastly, the city can also adopt crops that are favourable to dry and hot environments such as cassava (Eitzinger et al. 2017). To address the effects of the possibility of increased temperatures on livestock and poultry, those who raise such can adopt climate appropriate shelters, water storage systems, and improved feeds (Howden et al. 2007). The fishery sector can also adopt ways to monitor fishing patterns and alternate fishing seasons to address changes in the circulation of nutrients and fish migration to allow replenishment of nutrients and species (Howden et al. 2007).

### *D. Infrastructure*

The increase in temperature may increase the costs for maintenance and repair for it can cause cracks and unevenness in pavement and asphalt (Sabbag 2013 & Schweikert et al. 2014). The increase in temperatures may also increase the demand for electricity which already has a few issues within the city since they have rotating brownouts due to the insufficient power supply.

Furthermore, the increase in temperature and general decrease in precipitation under RCP 4.5 and some of the months under RCP 8.5 will decrease the recharge rate of ground water which may lead to a lower water table and can cause salination in the coastal *barangays* (IPCC 2014). This is a great issue since the freshwater supply of the city mostly comes from ground water. The projected wide range of possible precipitation values in the months of March to August under RCP 4.5 in the mid-century and in the same months under both scenarios in the late century also show risks of extreme wet events and flooding which can also damage road and electrical infrastructure.

The city has addressed some of the risks to the projected impacts by adopting resilient infrastructure and design to their public buildings, roads, and drainage systems. They have also created an ordinance for rainwater, rain water harvesting, and the construction of spring water catchment to address the risk of lower water supply. The city can further augment their current plans by adopting infrastructure maintenance methods that can help monitor their roads and infrastructure appropriate to their climate such as the software 2100 (Schweikert et.al 2014). The city can also adopt policies to encourage the use and development of renewable energy sources to create an abundant and sustainable energy source for its needs (IPCC 2014).

### *E. Environment*

The increase in temperature may cause stress and increase the possibility of wildfires in the woodland and grassland areas in the northern and southern areas of the city (IPCC 2014). Furthermore, species distribution and vegetation composition in the woodlands may change due to the increased temperature (FAO 2008). Increase in precipitation under RCP 4.5 could also spell a lower survival rate for forests and reduction in natural spring water found in the said ecosystem (General Santo City Questionnaire 2017).

The projected wide range of possible precipitation values in the months of March to August under RCP 4.5 in the mid-century and in the same months under both scenarios in the late century also show risks of extreme wet events and flooding which can increase the risk of soil erosion in the higher slopes and riverbanks and reduce soil nutrients (General Santo City Questionnaire 2017). The city has currently planted *Sansevieria* species to establish forest fire lines to address the risks of forest fires. They are also conducting a spring water development plan to address the possible decrease in spring water and hydro mapping. The city has established the sloping agricultural land technology (SALT) and riverbank reforestation to address the impacts of soil erosion.

The city can also adopt protective infrastructure to reduce soil erosion (Puyallup 2016). They may also augment the spring water development plan by adopting more effective water storage systems to prevent overuse of the natural water source and to also provide a water supply to the forest to increase the survival rate (Howden et al. 2007).

### *F. Hazards*

The possible effects to hazards based on the projections stated above are increased risks of drought, flooding, and wildfires. This is due to the increased temperature and general decrease in precipitation in RCP 4.5 and some of the months in RCP 8.5 in the mid-century and under all scenarios in the late century (IPCC 2014). This is the same with the increased risk of wildfires (IPCC 2014), a risk particular to the woodland and grasslands located in the northern and southern portions of the city.

In terms of the increased of flooding, this may be caused by the projected wide range of possible precipitation values in the months of March to August under RCP 4.5 in the mid-century and in the same months under both scenarios in the late century which show increased risks of extreme wet events. The city has planted *Sansevieria* species to delineate fire zones. They have also relocated informal settlers in flood and landslide risk areas. Furthermore, they have dredged and desilted the rivers to mitigate overbank flooding as well as improved and retrofitted the drainage system in the city.

The city can further adopt wildfire fighting facilities to combat possible wild fires (Four Twenty-seven Climate Solutions 2017). The city can also adopt flood protection infrastructure to further mitigate flooding along riverbanks (Puyallup 2016).

## Adaptation Options

***Table 3.2.2.*** *Summary of Impacts and Adaptation Options for General Santos City*

| **Summary of Impacts and adaptation options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation options** |
| Increase in Temperature (Year-round and for all scenarios) and | Demography | Increased heat related health risk | incorporating climate change adaptation into plans, programs, policies, increasing green areas within the city, policies that can adjust or change behaviour to adopt |

| | | | |
|---|---|---|---|
| decrease in precipitation (Year round in RCP 4.5 and some months in RCP 8.5 in the mid-century and year round in both scenarios in the late century) | | to population, loss of livelihood | to the climate, adopt education campaigns regarding climate change effects and adaptation options, |
| | Social | Increased heat related health risk to population, increased health risk to urban poor, | Smart design and technologies to adopt to climatic needs and reduce energy consumption, policies that adapt attire to higher temperatures and adjustment of working and class hours, relocation of informal settlers in flood and landslide risk areas |
| | Economic | Reduction of water supply, increased demand for water, crop damage and yield reduction, higher risk of disease in coconut plants, loss of livelihood | integrate plans, programs, and activities in the economic sector with climate change adaptation measures, and trainings on livelihood, distribution of climate tolerant varieties of crops, improvement of water infrastructure, cloud seeding, rainwater harvesting, information education campaigns on of El Niño & La Niña events, distribution of corn and rice seeds to farmers affected by extreme events, shift cropping calendars to take into account the projected marginal increase in precipitation during the months of June, July, and August. Lastly, adopt crops that are favourable to dry and hot environments such as cassava, adopt climate appropriate shelters, water storage systems, and improved feeds for livestock, adopt ways to monitor fishing patterns and alternate fishing seasons |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, rain water harvesting, |
| | Environment | Deforestation, increased forest stress, | spring water development, hydro mapping, effective water storage systems |
| | Hazards | Increased possibility of drought and wildfires | firefighting measures, planting of *Sansevieria* species to delineate fire zones, |
| Wide range of possible precipitation values in the months of March to August under RCP 4.5 in the mid-century | Demography | Increased risk of water borne diseases | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |

| | | | |
|---|---|---|---|
| and in the same months under both scenarios in the late century; Possibility of extreme wet events | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of  methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Increased rate of erosion | Sloping agricultural land technology, riverbank reforestation |
| | Hazards | Increased risk of floods | relocation of at risk urban poor sector, improvement of drainage systems, dredging and desilting of rivers, flood protection infrastructure |

## References


Black, R.; Kniveton, D.; Skeldon, R.; Coppard, D.; Murata, A.; & Schmidt-Verkerk, K. (2008). Demographics and Climate Change: Future Trends and their Policy Implications for Migration. Working Paper, Development Research Center on Migration, Globalisation, and Poverty.

Eitzinger, A.; Laderach, P.; Giang Tuan, L.; Ramaraj, A.; Ng'ang'a, K.; Parker, L.; (2017) Learning and Coping with Change: Case Stories of Climate Change Adaptation in Southeast Asia. Case Story Book Vol. 1. Pp 83-97

Forest and Agriculture Organization of the United Nations (2008) Climate change impacts on forest health. Forest Health and Biosecurity Working Papers

Four Twenty-seven Climate Solutions (2017). Fremont Climate Hazard Assessment and Adaptation Options.

Hebbar K.B., Balasimha D., Thomas G.V. (2013) Plantation Crops Response to Climate Change: Coconut Perspective. In: Singh H., Rao N., Shivashankar K. (eds) Climate-Resilient Horticulture: Adaptation and Mitigation Strategies. Springer, India

Howden, S.M.; Soussana, J.; Tubiello, F.; Chhetri, N.; Dunlop, M.; & Meinke, H. (2007) Adaptingagriculture to climate change.Proceedings of the National Acadamy of Sciences of the United States of America. Vol 104 no. 50

IPCC, 2014: Climate Change 2014: Synthesis Report. Working Groups II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.IPCC, Geneva, Switzerland, 151 pp.

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Sabbag, L. (2013).Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation.From Sheltering from a Gathering Storm working paper No. 4. Institute for Social and Environmental Transition-International.

Schweikert, A.; Chinowsky, P.; Espinet, X.; & Tarbert, M. (2014). Climate Change and infrastructure impacts: comparing the impact on roads in ten countries through 2100. Procedia Engineering 78. pp 306-316.

Toda.L.L., Yokingco, J.C.E., Paringit, E.C., Lasco, R.D.L. (2017) A LiDAR based flood modelling approach for mapping rice cultivation areas in Apalit, Pampanga.Journal of Applied Geography.Vol. 80. Pp 34-47.

## Population Table (PSA, 2015)

| GENERAL SANTOS CITY Population 2015 (PSA) | Barangay Type | Total Population: 594,446 |
|---|---|---|
| Baluan | U | 7,611 |
| Buayan | U | 11,196 |
| Bula | U | 31,363 |
| Conel | U | 11,164 |
| Dadiangas East (Pob.) | U | 4,746 |
| Katangawan | U | 13,948 |
| Lagao (1st & 3rd) | U | 50,789 |
| Labangal | U | 61,713 |
| Ligaya | R | 5,298 |
| Mabuhay | U | 28,288 |
| San Isidro (Lagao 2nd) | U | 52,832 |
| San Jose | U | 11,333 |
| Sinawal | U | 13,285 |
| Tambler | U | 21,474 |
| Tinagacan | U | 6,322 |
| Apopong | U | 46,384 |
| Siguel | U | 12,757 |
| Upper Labay | R | 3,458 |
| Batomelong | R | 3,235 |
| Calumpang | U | 75,342 |
| City Heights | U | 24,014 |
| Dadiangas North | U | 8,056 |
| Dadiangas South | U | 6,199 |
| Dadiangas West | U | 13,827 |
| Fatima | U | 66,460 |
| Olympog | R | 3,352 |

## 3.3. LEGAZPI CITY

### Executive Summary

The city of Legazpi is a government unit that sees a blend of urbanized and rural landscapes. Located in the city is a densely urbanized locale of built-up areas in its north eastern portion. Juxtaposed to the urban portions of the city are the rural agricultural lands to the north and south as well as forested areas.

The city is the administrative center as well as a transportation hub of the Bicol Region. It is a highly populated area and a center for commerce and business. With these in mind the impacts of the projected changes in precipitation and temperature vary across the different sectors. The notable projections are the marked increase in temperature in both RCP 4.5 and RCP 8.5 and the marked decrease in precipitation in the historically wetter months of June to November. The impacts and adaptation options for each sector are summarized below.

| Summary of Impacts and Adaptation Options | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature (Year-round and for all scenarios) and decrease in precipitation (JJA and SON) | Demography | Increased heat related health risk to population, loss of livelihood | Family development sessions that integrate climate change adaptation and disaster risk reduction; information education campaigns on disaster preparedness and climate change adaptation and mitigation; disaster preparedness and climate change adaptation preparedness capability programs for the elderly and disabled; integration of climate change and disaster preparedness awareness in child welfare trainings; and disease prevention programs policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased heat related health risk to population, loss of livelihood, increased health risk to urban poor, | Nutrition program, policies enumerated in previous sector, policies that adapt attire to higher temperatures and adjustment of working and class hours, adoption of smart designs for residential and government facilities, establishment of green spaces |
| | Economic | Reduction of water supply, increased demand for water, | Climate, tolerant crop varieties, alternating crops, development of water storage systems and water usage management practices, shifting of cropping calendars for rice crops to coincide with the generally higher precipitation projected for the months from December to January. |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure |

| | | | |
|---|---|---|---|
| | | consequent increase in costs of maintenance, Lowering of groundwater table, | based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Deforestation, increased forest stress | Forest land use plan, intensification of green areas in urbanized areas, plans to protect protected areas and critical ecosystems, and multiple capacity building programs |
| | Hazards | Increased possibility of drought and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |
| General increase in precipitation in the months of (DJF and MAM) | Demography | Increased risk of water borne diseases | Family development sessions that integrate climate change adaptation and disaster risk reduction; information education campaigns on disaster preparedness and climate change adaptation and mitigation; disaster preparedness and climate change adaptation preparedness capability programs for the elderly and disabled; integration of climate change and disaster preparedness awareness in child welfare trainings; and disease prevention programs policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Increased rate of erosion | structural plans on flood control system |
| | Hazards | Increased risk of floods | Hazard risk assessment, relocation of at risk urban poor sector, structural plans on flood control systems, the multiple programs enumerated in the demography section |

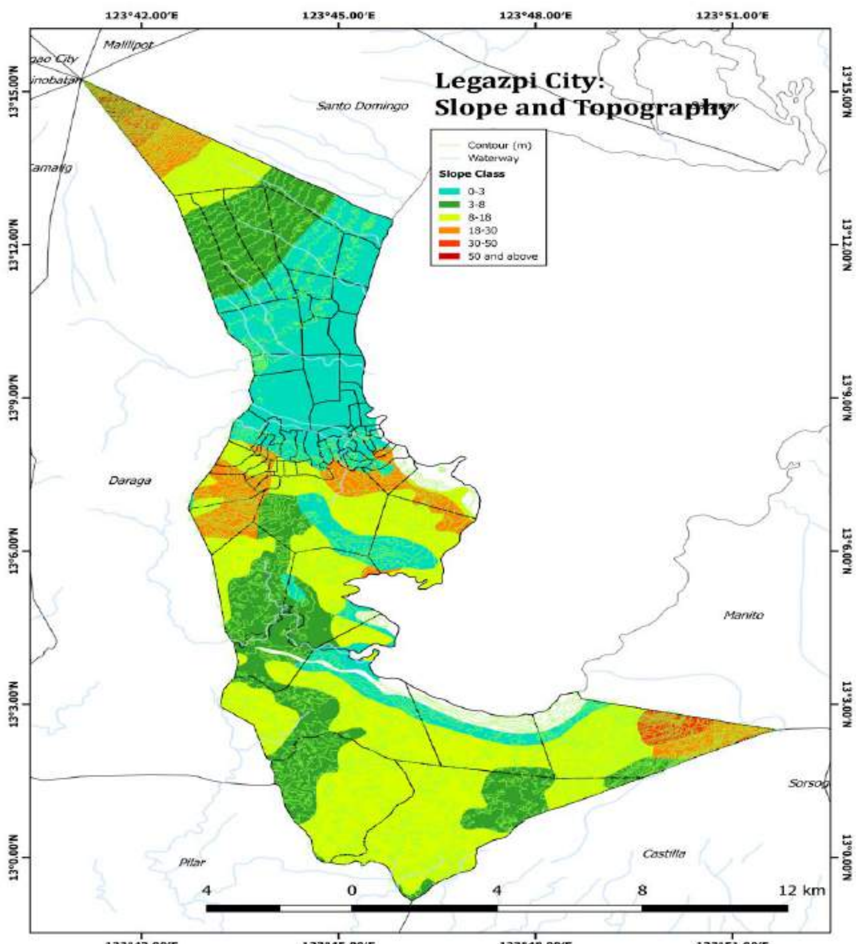
## Physical Geography

### *Location*

Legazpi City is located on the south eastern slope of Mount Mayon in the Bicol Region. The city is bound on the north by the municipality of Sto. Domingo; on the east by the Albay Gulf; on the south by the Municipalities of Manito, Albay, Pilar and Castilla, Sorsogon; and on the west by the municipality of Daraga. It has total area of approximately 20,437 hectares and is composed of 70 *barangays*.

### *Physical Characteristics*

The city has varying terrain from its northern to southern tips ***(Map 3.3.1)***. The city has flat terrain on its north eastern portion with slopes generally ranging from 0 to 3 percent. The southern end, on the other hand, is generally rolling and hilly with slopes ranging from 3 to 18 percent. The north western portion covers a portion of Mount Mayon and has slopes that gradually increase from 3 to 30 percent.



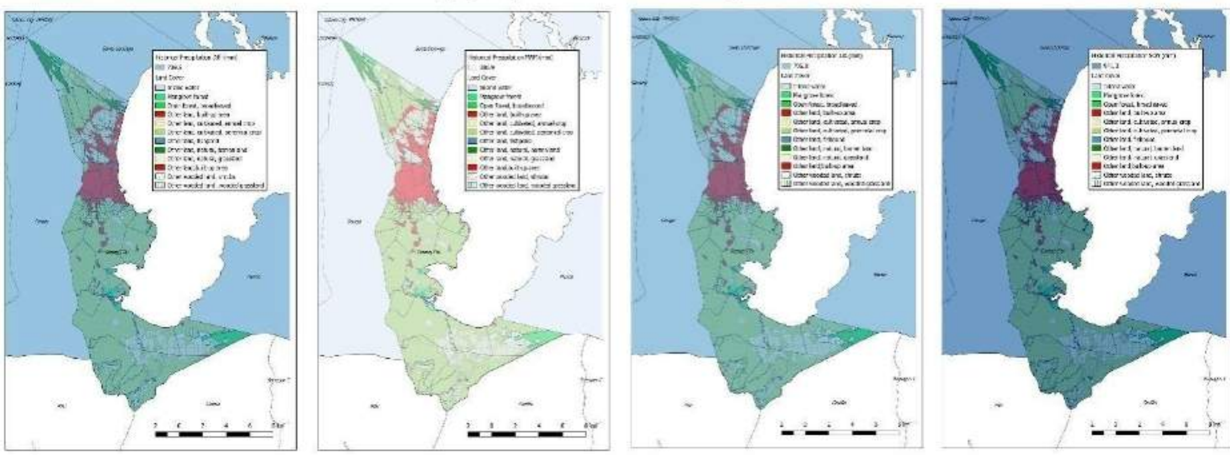

***Map 3.3.1.*** *Legazpi City Slope Class and Topography Map (Source: 30m GDEM)*

## *Climate*

The climate of Legazpi City is characterized by seasonal variations in precipitation and temperature ***(Maps 3.3.2 and 3.3.3)*** as modelled and recorded by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

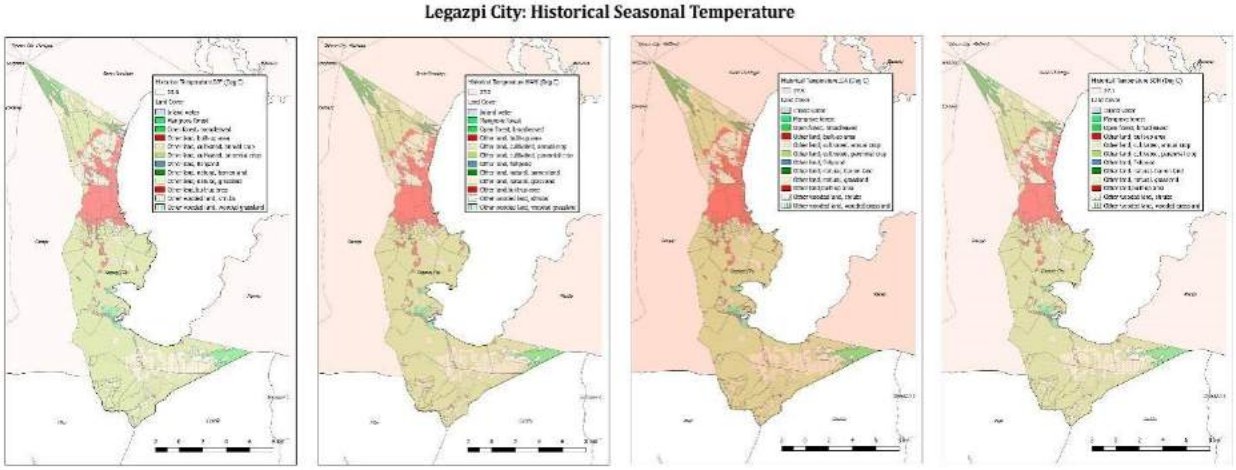
The months of December, January, and February are historically the coolest of the year with an average temperature of 25.6 degrees Celsius and are also the second wettest with an average cumulative rainfall amount of 739.8 mm. The months of March, April, and May are historically the second hottest with an average temperature of 27.2 degrees Celsius and are the driest months of the year with an average cumulative rainfall amount of 386.9 mm. The months of June, July, and August are historically the hottest of the year with an average temperature of 27.8 degrees Celsius and are comparatively wet with an average cumulative rainfall amount of 705.8 mm. The months of September, October, and November are historically the second coolest months of the year with an average temperature of 27.1 degrees Celsius and are the wettest of the year with an average cumulative rainfall amount of 941.3 mm.

**Legazpi City: Historical Seasonal Precipitation**



***Map 3.3.2**. Legazpi City Historical Seasonal Precipitation (Source: PAGASA data)*

**Legazpi City: Historical Seasonal Temperature**

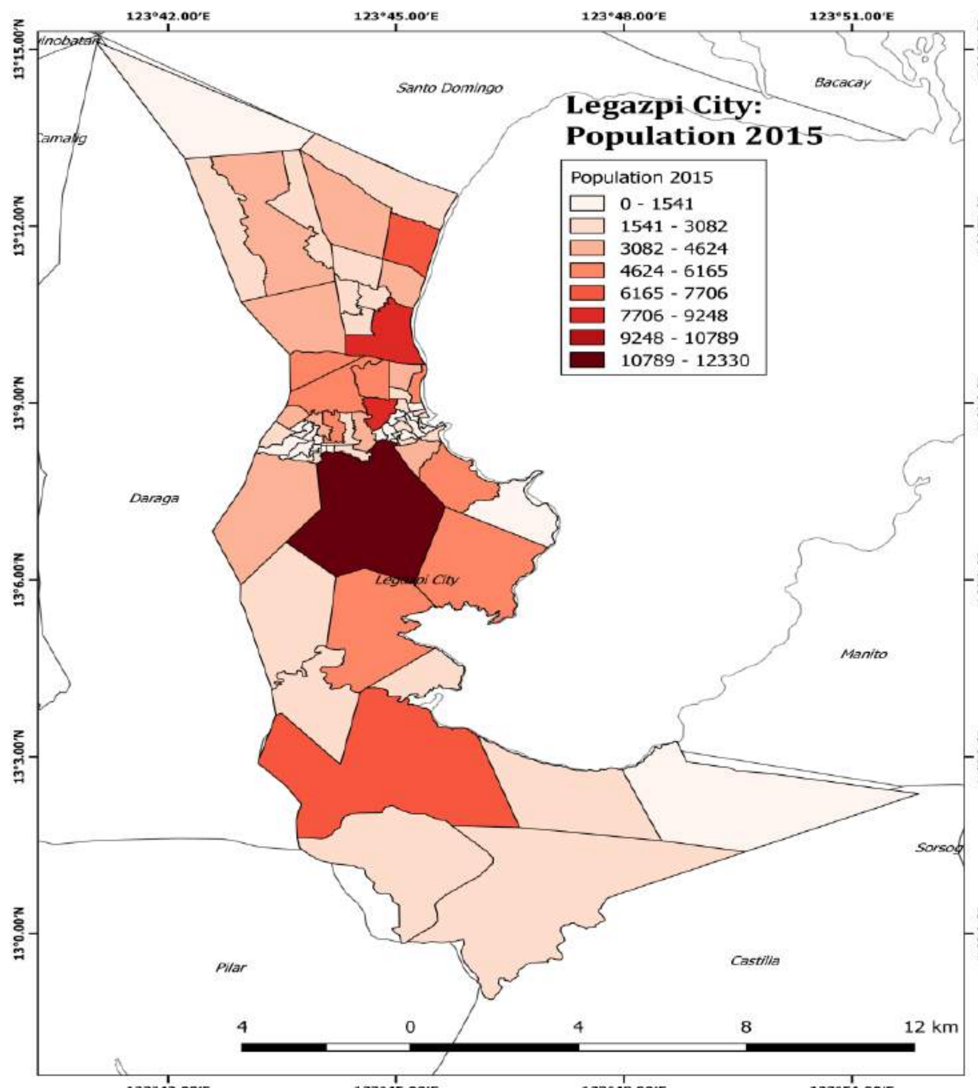


***Map 3.3.3**. Legazpi City Historical Seasonal Temperature (Source: PAGASA data)*

## Socio-Economic Characteristics

### *Population*

Legazpi City is the largest city in the Albay region and is also its administrative center. As such, it is a highly populated city with a total population of 196,639 as of 2015 with a total number of households of 36,091 with an average household size of four *(Legazpi City CBMS 200-2011)* and a population density of nine persons per hectare. The bulk of the population is found in the low lying areas ***(Map 3.3.1)*** in the north eastern portion where all the built up areas can also be found ***(Map 3.3.6)***. There are currently 26 urban *barangays* and 44 rural *barangays* in the city *(Annex-Population table)*. The most populated *barangay* is *Barangay* 56 Taysan which is found near the center of the city ***(Map 3.3.4)*** with a population of 12,330. This is followed by *Barangay* 42 Rawis with a population of 8,868; *Barangay* 37 Bitano with a population of 8,559; *Barangay* 66 Banquerohan with a population of 6,976; and *Barangay* 49 Bigaa with a population of 6,730 *(Annex-Population table)*.




***Map 3.3.4.*** *Barangay Population Map (Source: PSA data)*

### *Education*

Legazpi City is a center of education in the Bicol Region. A total of 189 educational institutions (DepEd City 2013-2014) can be found in the city inclusive of 60 pre-elementary schools, 71 elementary schools, 25 secondary schools, 15 vocational/technical schools, 3 special education schools, and 15 tertiary schools. The city is where two universities can be found namely Bicol University and University of Santo Tomas – Legazpi.

### *Economic Activities*

The number of establishments found in the city, based on its economic activity, is summed up in the *table below*. The majority of the establishments are wholesale and retailing establishments followed by community service industries. Real estate and hotel and restaurant establishments follow.

***Table 3.3.1.*** *Economic Activity in Legazpi City (Source: CPDO 2014)*

| **Economic Activity (2012)** | **No. of Establishments** |
|---|---:|
| Agri., Hunting & Forestry | 23 |
| Fishing | 8 |
| Mining and Quarrying | 11 |
| Manufacturing | 171 |
| Electricity, Gas & Water | 90 |
| Construction | 152 |
| Wholesale & Retail Trade | 2790 |
| Hotels and Restaurants | 416 |
| Transport, Comm. & Storage | 125 |
| Finance Intermediation | 242 |
| Real Estate & Renting | 451 |
| Health and Social Work | 183 |
| Other Community Services | 478 |
| | **Total 5,140** |

*Source: CPDO-Zoning Section, 2014*

- ***Agriculture***

The primary products produced in the city are rice and root crops while its secondary products are coconut. From the coconut the city is known for the production of coconut oil, copra, and abaca products.

- ***Tourism***

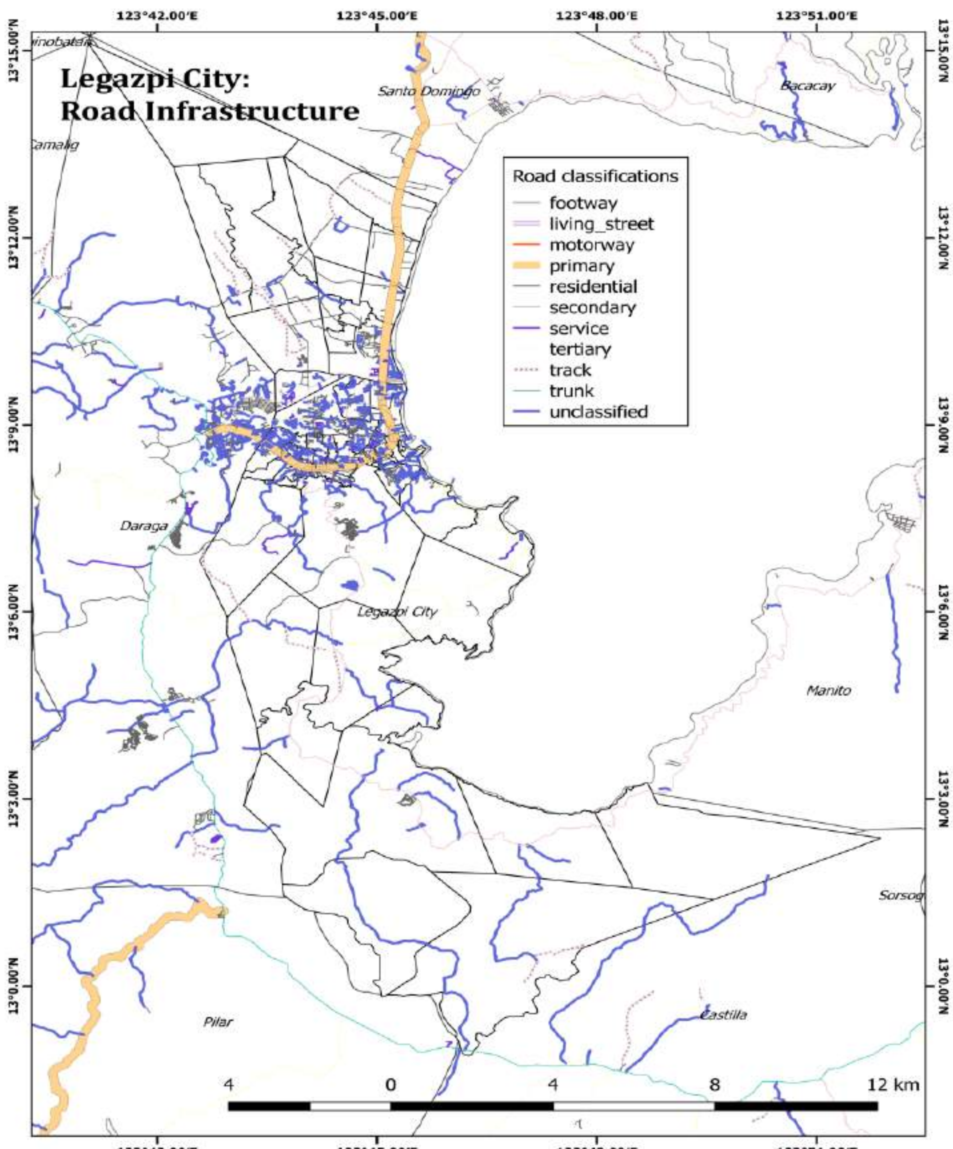
One of the notable industries found in the city is tourism. This is mostly attributed to its location on the southern slopes of Mt. Mayon. For the year of 2014 alone, approximately 666,210 tourists visited the city (Legazpi Ulat sa Bayan 2015). The establishments that cater to this industry include approximately 416 hotels and restaurants as of 2014 (Legazpi City Profile).

## Infrastructure

### *Transportation*

Legazpi City is a transportation hub in the Bicol Region. Several transport facilities can be found within the city which provide transportation through air, water, and sea. The Legazpi Airport is found within the city, as well as the port of Legazpi. The city has the Legazpi Grand Central Terminal which provides a hub for buses and other land utility vehicles. Moreover, the city is the location of the southernmost station for the Philippine National Railways rail transport system.

There is a total of approximately 221.718 kilometers worth of road networks found in the city ***(Map 3.3.5)***. Of these roads, 168.580 kilometers are paved with concrete; 8.643 kilometers are paved in asphalt; 20.238 kilometers are paved in gravel; and 24.257 remain unpaved.

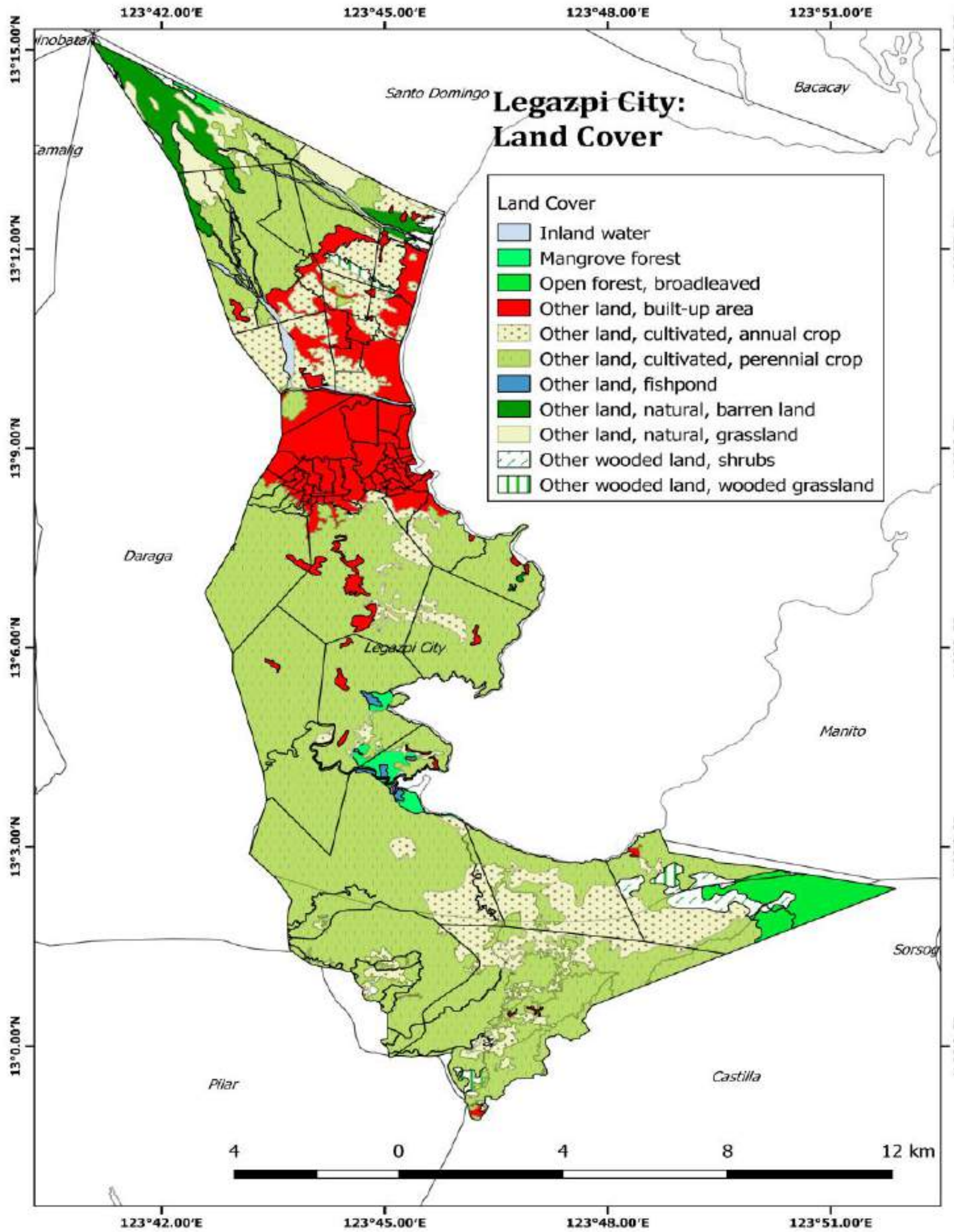



***Map 3.3.5**. Road Infrastructure Map*

### *Power and Water*

Power is mainly purchased by the Albay Electric Cooperative from the National Power Corporation. Water, on the other hand, is managed by the Legazpi City Water District, providing piped water under a water works system for the urban residence. Rural residences, on the other hand, obtain their water mainly from deep wells.

## Land Cover and Land Use




***Map 3.3.6.*** *Land Cover Class (Source GEDM 2010)*

***Table 3.3.2.*** *Legazpi City Land Cover (Source: GDEM 2010)*

| **Legazpi City Land Cover (2010)** | | |
|---|---|---|
| **Land Cover Class** | **Area (ha) Derived from GIS calculations** | **Percent** |
| Inland water | 1081.4 | 4.83% |
| Mangrove forest | 129.9672 | 0.58% |
| Open forest, broadleaved | 2315.123 | 10.34% |
| Other land, built-up area | 2816.019 | 12.57% |
| Other land, cultivated, annual crop | 2732.435 | 12.20% |
| Other land, cultivated, perennial crop | 11003.4 | 49.12% |
| Other land, fishpond | 64.22068 | 0.29% |
| Other land, natural, barren land | 996.6763 | 4.45% |
| Other land, natural, grassland | 633.4265 | 2.83% |
| Other wooded land, shrubs | 532.2018 | 2.38% |
| Other wooded land, wooded grassland | 94.01898 | 0.42% |
| **Total** | **22398.89** | **100%** |

The majority of the land cover ***(Map 3.3.6)*** of the city is crop land occupying an estimated 61.32% of its land area. Crop land is largely found in the southern portion of the city and on the slopes of Mt. Mayon on the north east. Built-up land is concentrated on the north eastern portion of the city where the terrain is largely flat ***(Map 3.3.1 & 3.3.4)*** and takes up approximately 12.57% of the land area of the city.

There is also a significant amount of land area of the city which is open forest occupying an estimated 10.34% of the land area. The forest land can be found on the north western portion of the city on the peak of Mt. Mayon.

## Climatic Hazards

### *Flood Hazard*

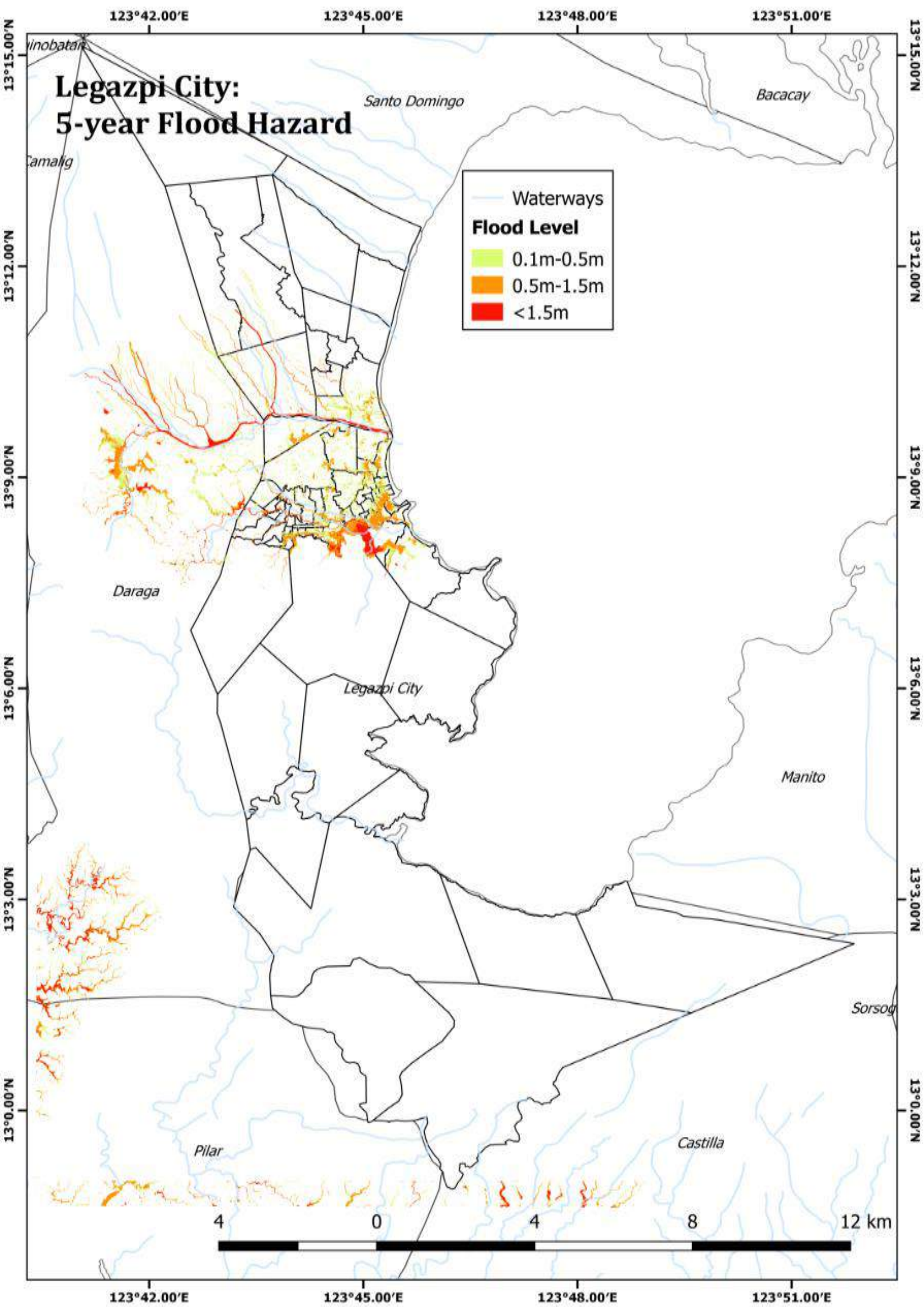
The flat terrain of the north eastern portion of the city as well as the water ways that traverse it contribute to the flood risk of the city ***(Map 3.3.1; Maps 3.3.7-3.3.9)***.

In particular, the floods will mostly affect the following *barangays* found south of the slopes of Mt. Mayon; Tamaoyan, Pawa, Rawis, Gogon, and Bonot and the following *barangays* found near the southern slopes of the city: Cruzada, Kapantawan, Rizal Street, Kawit East Washington, Cabagnan East, Binanuahan West, and Binanuahan East.

The rest of the city found on the higher slopes of the northern and southern portions are relatively unaffected by the floods.

### *Five (5) Year Return Period*

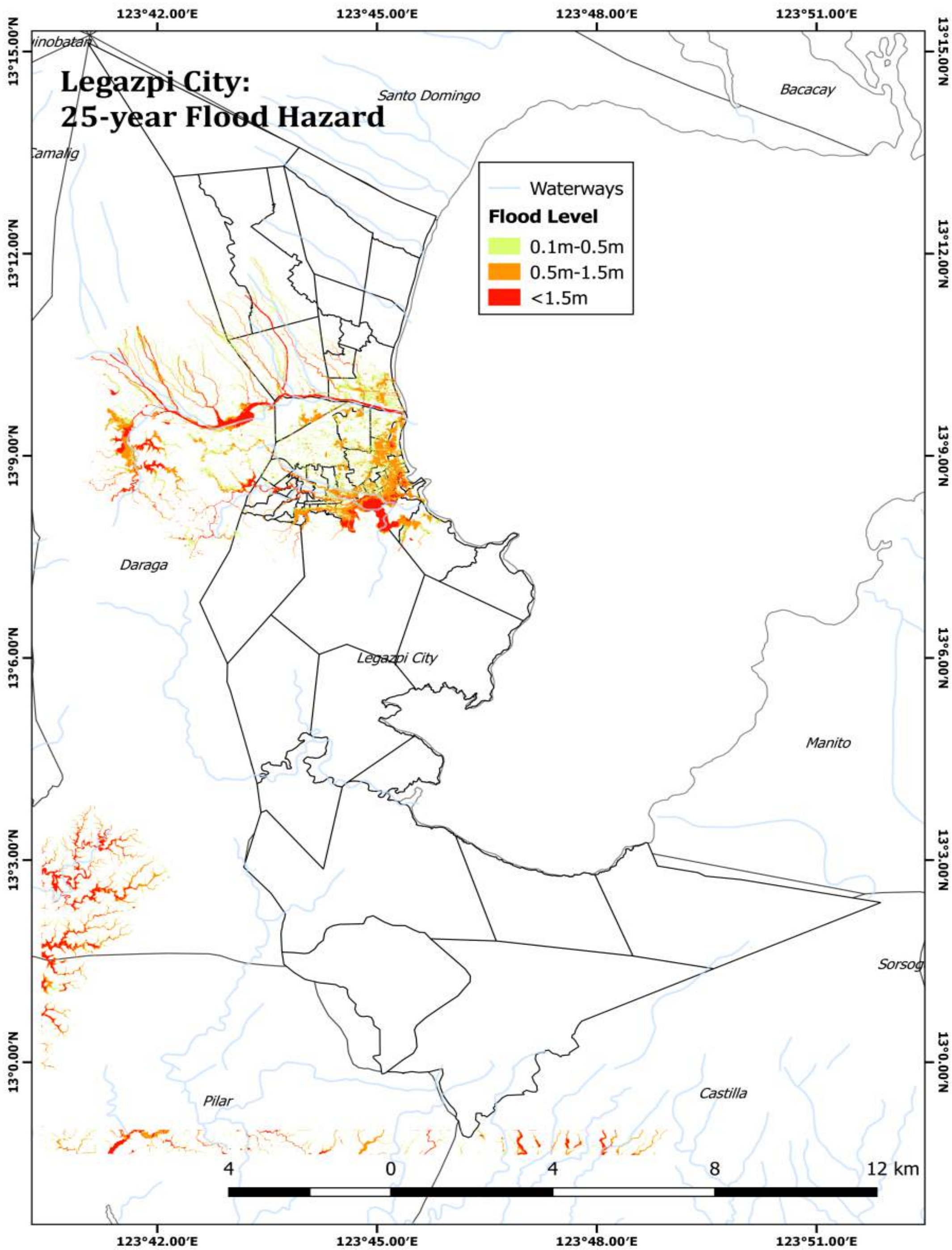
There is a 1/5 (about 20%) probability of a flood with 5-year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 260.500mm.




***Map 3.3.7.*** *5-year Flood Hazard Map (Source: DREAM Project)*

### *25 -Year Return Period*

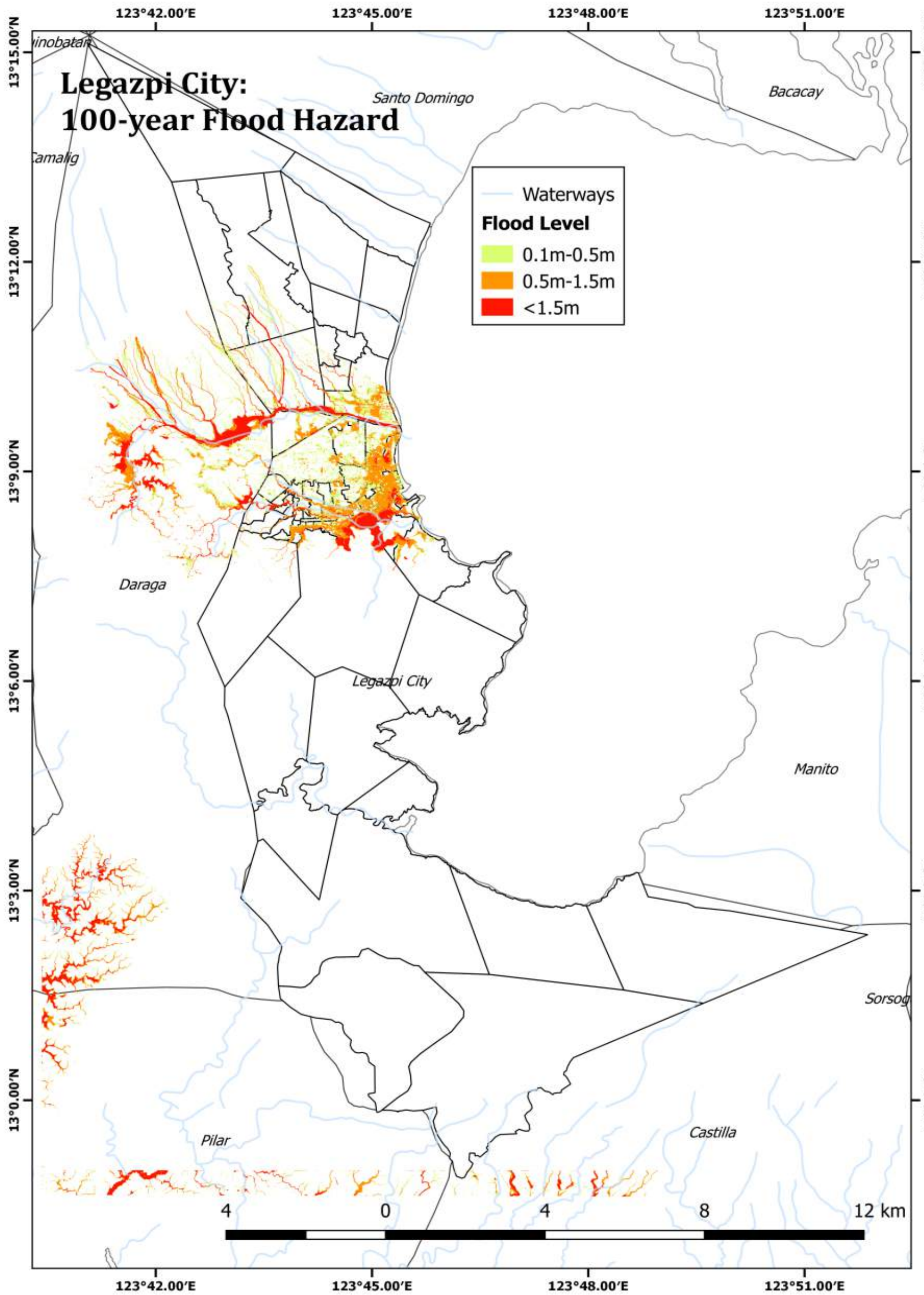
There is a 1/25 (about 4%) probability of a flood with 25 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 386.400mm.




***Map 3.3.8.*** *25-Year Flood Hazard Map (Source: DREAM Project)*

### *100-Year Return Period*

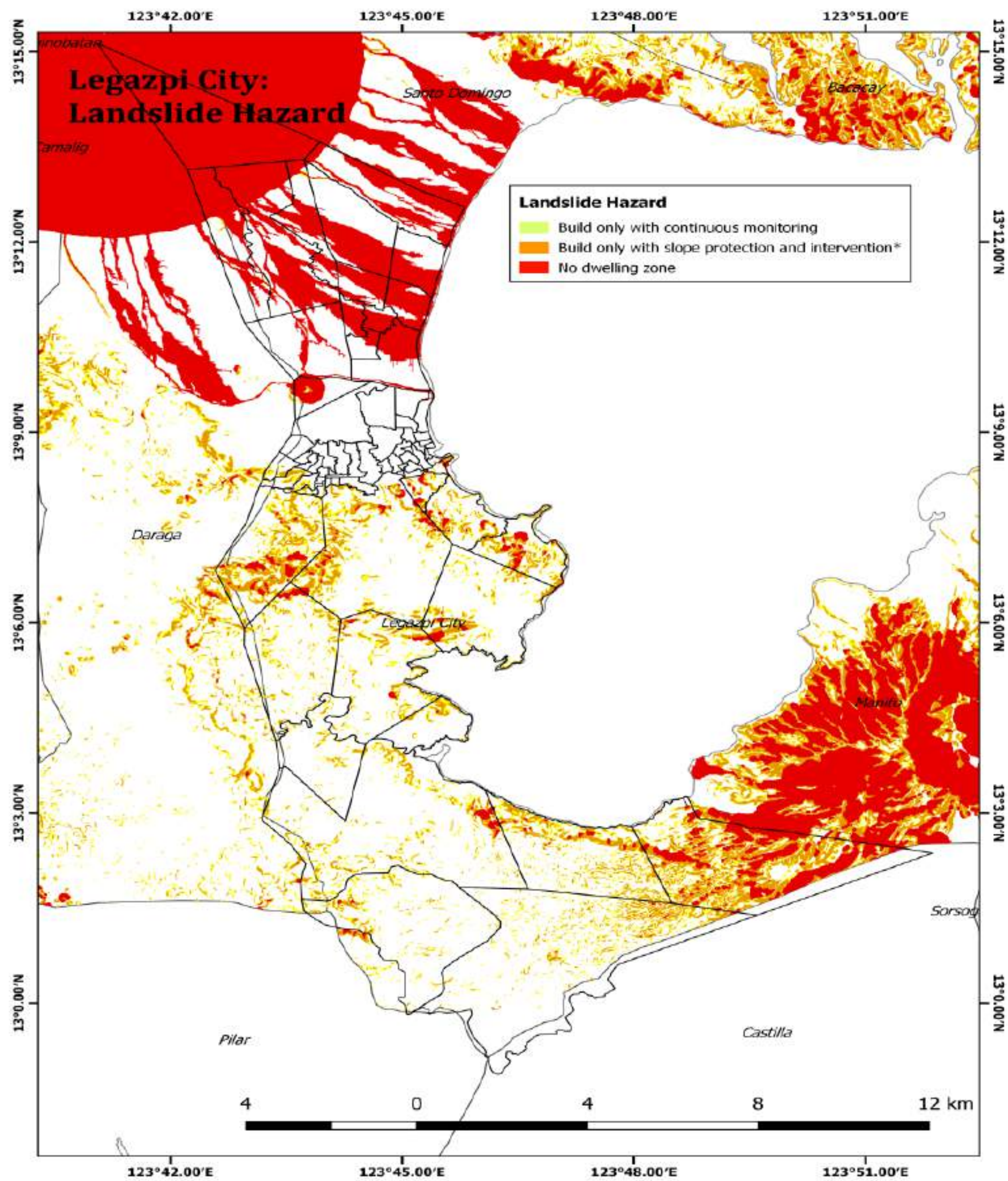
There is a 1/100 (about 1%) probability of a flood with 100 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 490.300 mm.




***Map 3.3.9.*** *100-Year Flood Hazard Map (Source: DREAM Project)*

### Landslide Hazard

Due to the sloping terrain and higher elevations of the southern and northern portions of the city, landslide hazards can be found therein ***(Map 3.3.10)***. The northern tip of the city which covers the slopes of Mt. Mayon are a strict no dwelling zone. In particular, the following *barangays* found near the slopes of Mt. Mayon are no dwelling zones: Padang, Buyuan, Bigaa, Bagong Abre, Arimbay, San Joaquin, Dita, Tamaoyan, Rawis, Matanag, Bogna, Mabinit, and Pawa. Lastly, there are several areas in the southern portion of the city which are no dwelling zones, but these are not as expansive as those found on the slopes of Mt. Mayon.

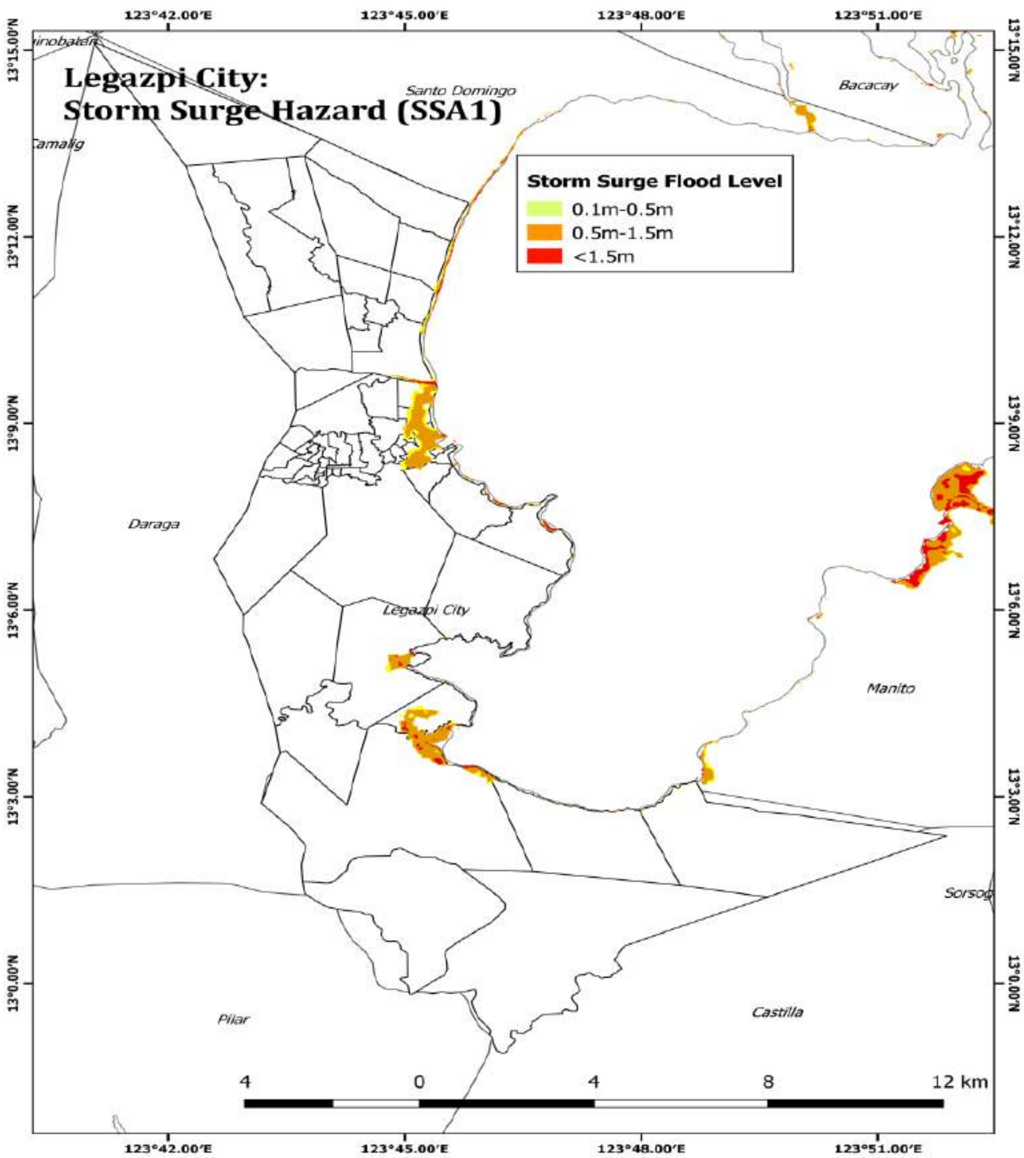



***Map 3.3.10.*** *Landslide Hazard Map (Source: DREAM Project)*

### Storm Surge Hazard (Maps 11-13), (Data from Project NOAH)

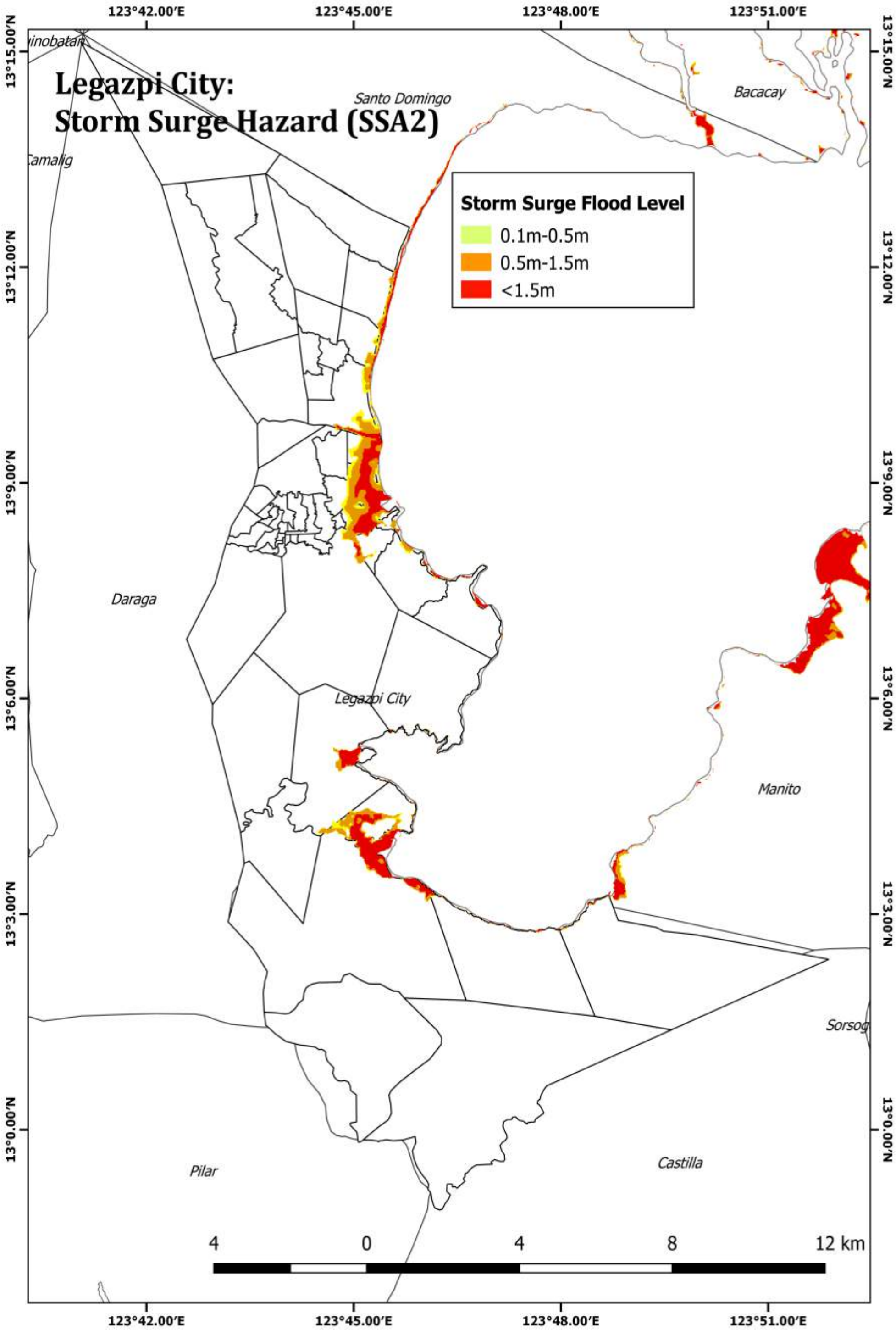
The storm surge hazard of the city affects the *barangays* that are found along the Albay Gulf ***(Maps 3.3.11-3.3.13)***. The areas at risk of storm surge cover the whole north eastern coast of the city and several *barangays* in the southern portion of the city. The *barangays* in the south that are at particular risk are: Homapon, Bagacy, and Banquerohan. The *barangays* to the north that are at a particular risk on the other hand are: Rawis, Arimbay, Centro Baybay, Oro Site Magallanes, San Roque, PNR-Penarada, Kapantawan Bitano, Gogon, and Bonot.

*SSA 1 Storm Tide Level of 2.01 m to 3.0 m*



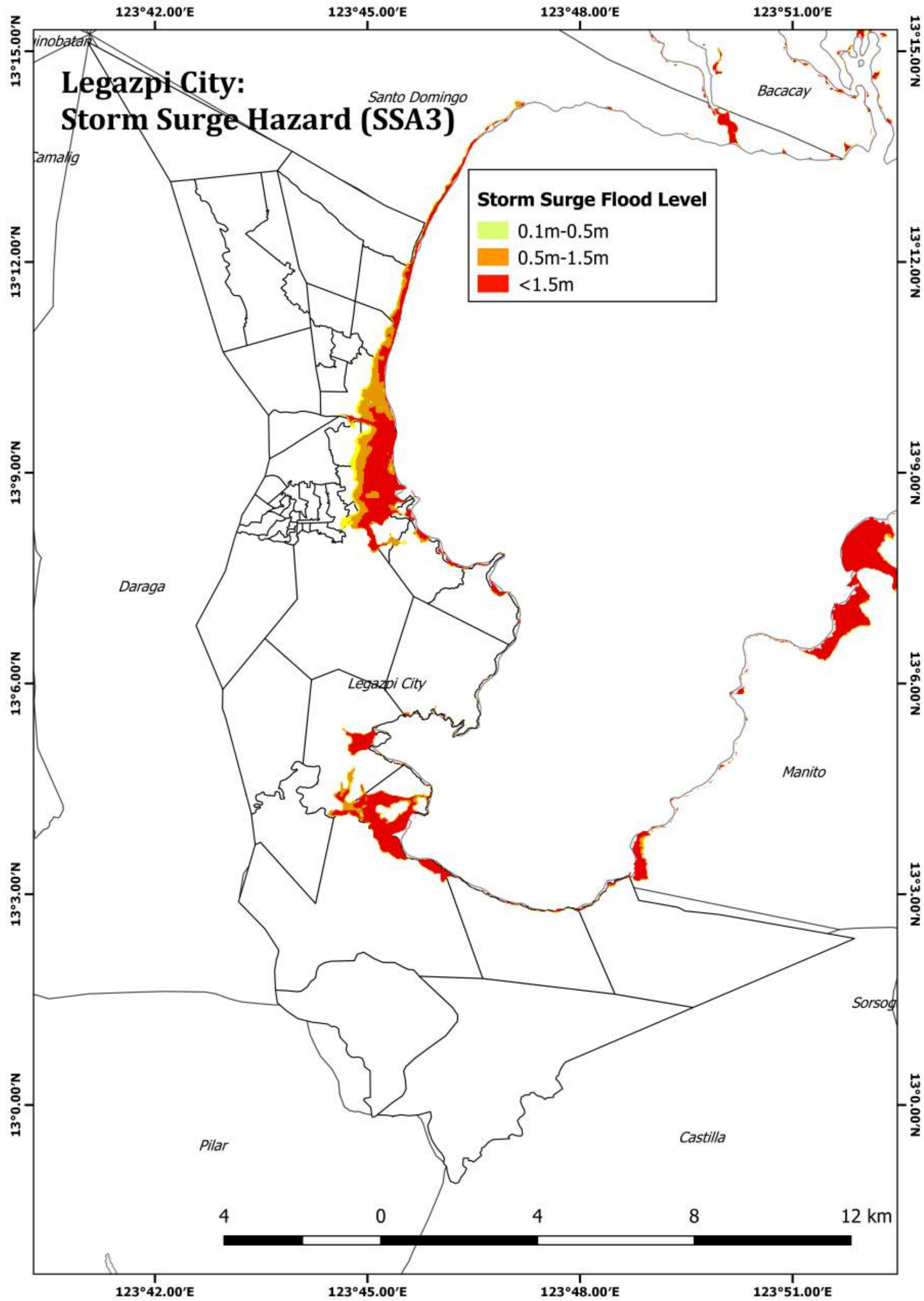

***Map 3.3.11.*** *Storm Surge (SSA 1) Hazard Map (Source: Project NOAH data)*

*SSA 2 Storm tide level of 3.01 m to 4.0 m*




***Map 3.3.12.*** *Storm Surge (SSA 2) Hazard Map (Source: Project NOAH data)*

*SSA 3 Storm Tide Level of Greater than 4.0 m*




***Map 3.3.13.*** *Storm Surge (SSA 3) Hazard Map (Source: Project NOAH data)*

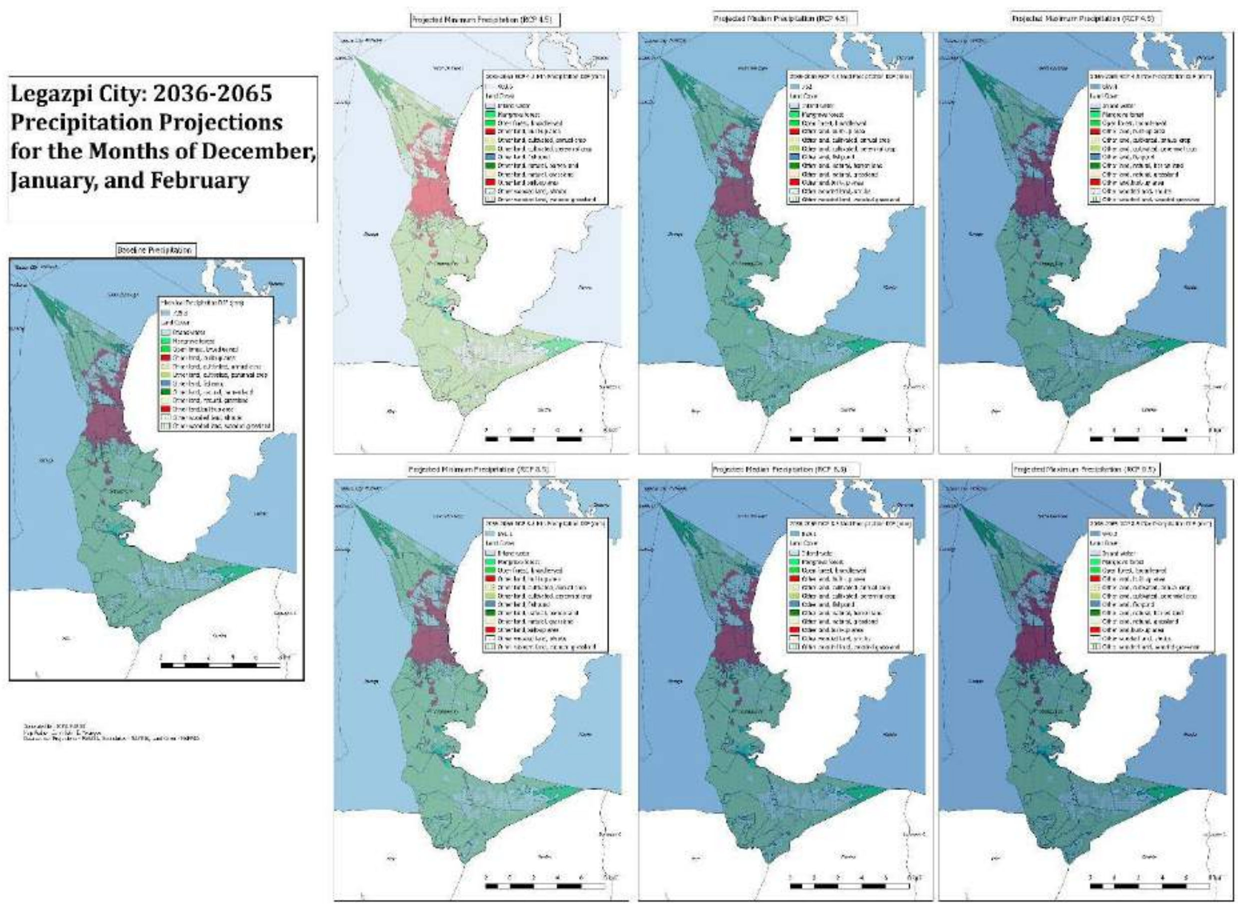
## Projections and Grid Extent (data on Projections come from PAGASA)

### *Change in Precipitation*

### Mid-21st Century Projections (2036-2065), Maps 14-17

The month of December, January, and February are projected to be wetter than the historical baseline based on the projected median rainfall amount in both scenarios ***(Map 3.3.14)***. In RCP 8.5 the said months are projected to wetter than on RCP 4.5. Furthermore, RCP 4.5 is projected to have a wider range of projected possible rainfall amounts with a significantly drier minimum possible amount than on RCP 8.5.

The median projected rainfall amount for RCP 8.5 is an increase of 12.1% from the baseline while for RCP 4.5 it is an increase of 1.7% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 6.6% decrease from the baseline while for RCP 4.5 it is a decrease of 45.4% from the baseline. Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 27.1% from the baseline while for RCP 4.5 it is an increase of 17.5% from the baseline.

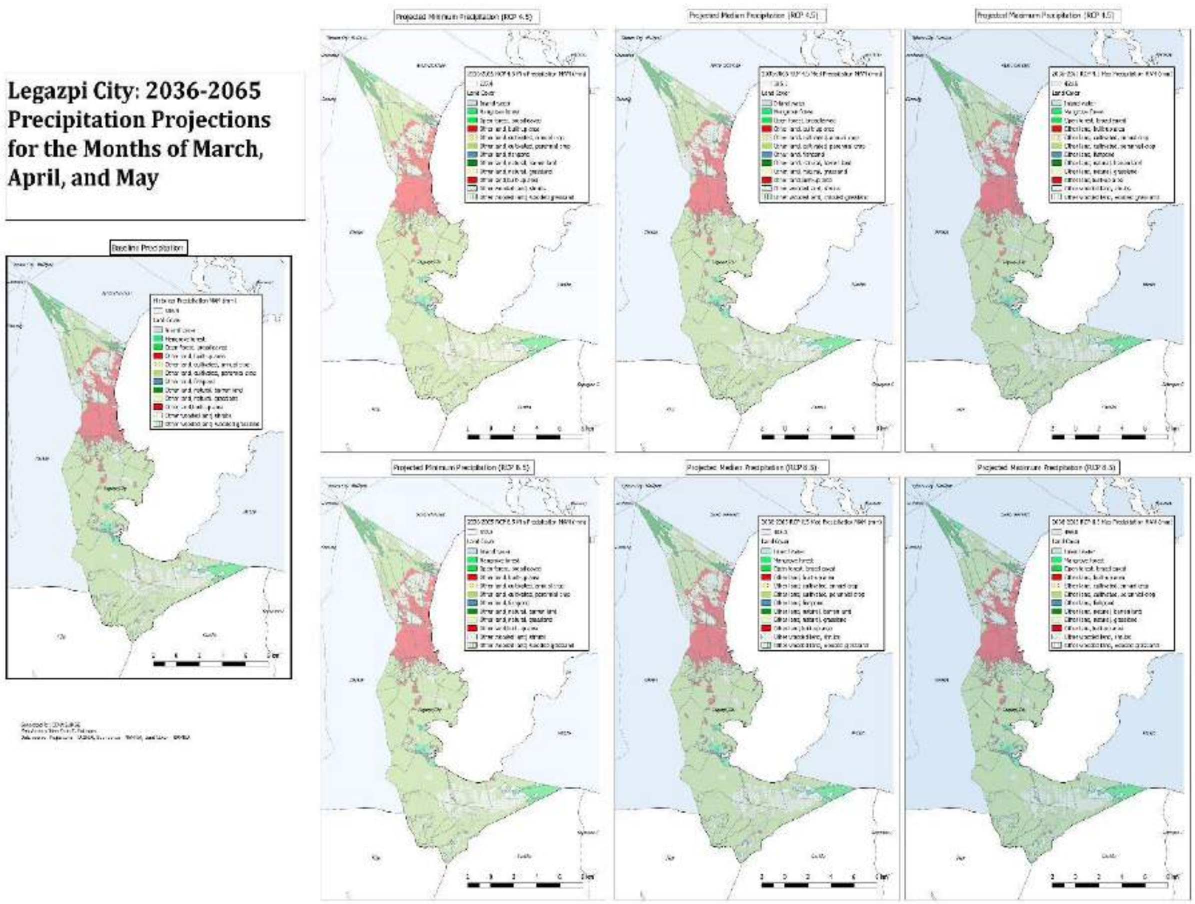



***Map 3.3.14.*** *2036-2065 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April, and May are projected to be drier in RCP 4.5 and wetter in RCP 8.5 than the historical baseline for those months based on the median projected rainfall amounts of each scenario ***(Map 3.3.15)***.

The trend is also reflected in the maximum and the minimum projected rainfall amounts for each scenario, the projections under RCP 8.5 are wetter than on RCP 4.5 for the said months. The median projected rainfall amount for RCP 8.5 is an increase of 5.5% from the baseline while for RCP 4.5 it is a decrease of 0.5% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 20.6% decrease from the baseline while for RCP 4.5 it is a decrease of 41.2% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 18.1% from the baseline while for RCP 4.5 it is an increase of 10.8% from the baseline.

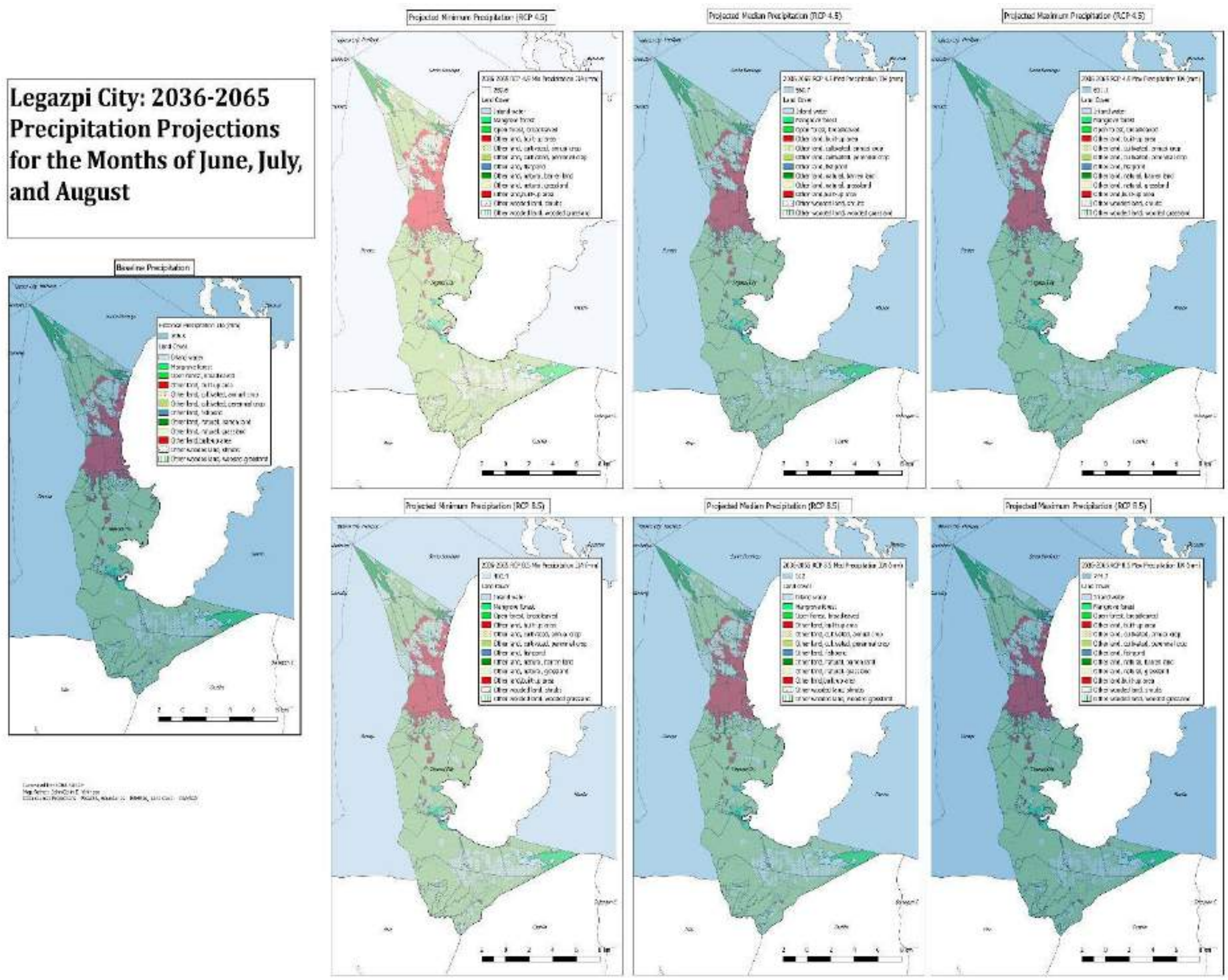



***Map 3.3.15.*** *2036-2065 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to be drier for both scenarios based on the projected median rainfall amounts for both scenarios ***(Map 3.3.16)***. In RCP 4.5 the said months are projected to be significantly drier than the baseline compared to RCP 8.5 as evidenced by the fact that even the maximum projected rainfall amount in RCP 4.5 is lower than the historical baseline.

The median projected rainfall amount for RCP 8.5 is a decrease of 13.3% from the baseline while for RCP 4.5 it is a decrease of 20.6% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 34.8% decrease from the baseline while for RCP 4.5 it is a decrease of 59.0% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 5.5% from the baseline while for RCP 4.5 it is a decrease of 10.6% from the baseline.

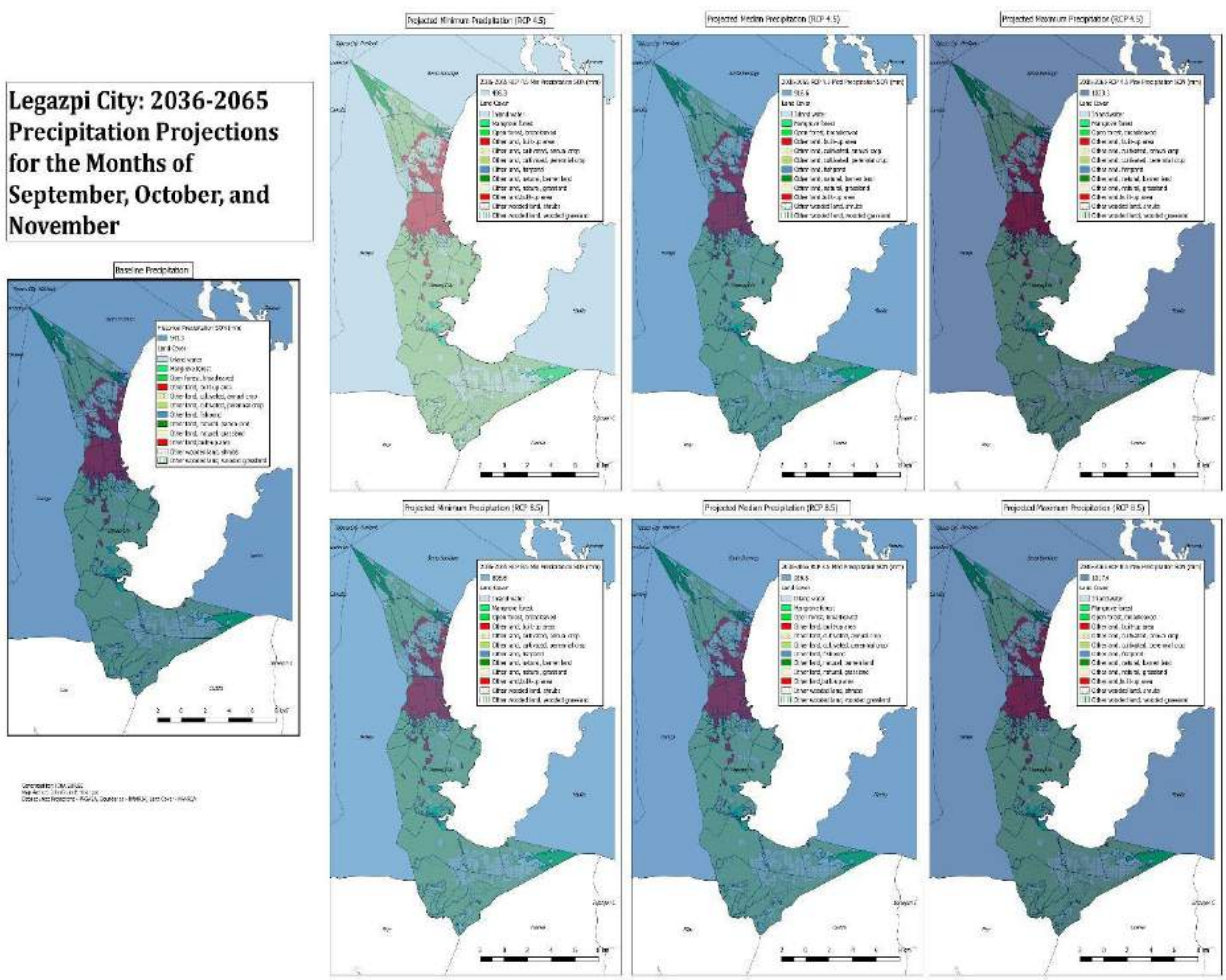



***Map 3.3.16.*** *2036-2065 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October, and November are projected to be drier than the historical baseline for both scenarios based on the projected median rainfall amount. In RCP 4.5 the said months are projected to be drier than in RCP 8.5.

Furthermore, RCP 4.5 has a wider range of values with a significantly drier projected rainfall amount than RCP 8.5. The median projected rainfall amount for RCP 8.5 is a decrease of 1.5% from the baseline while for RCP 4.5 it is a decrease of 2.6% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 14.4% decrease from the baseline while for RCP 4.5 it is a decrease of 47.1% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 8.1% from the baseline while for RCP 4.5 it is an increase of 8.7% from the baseline.

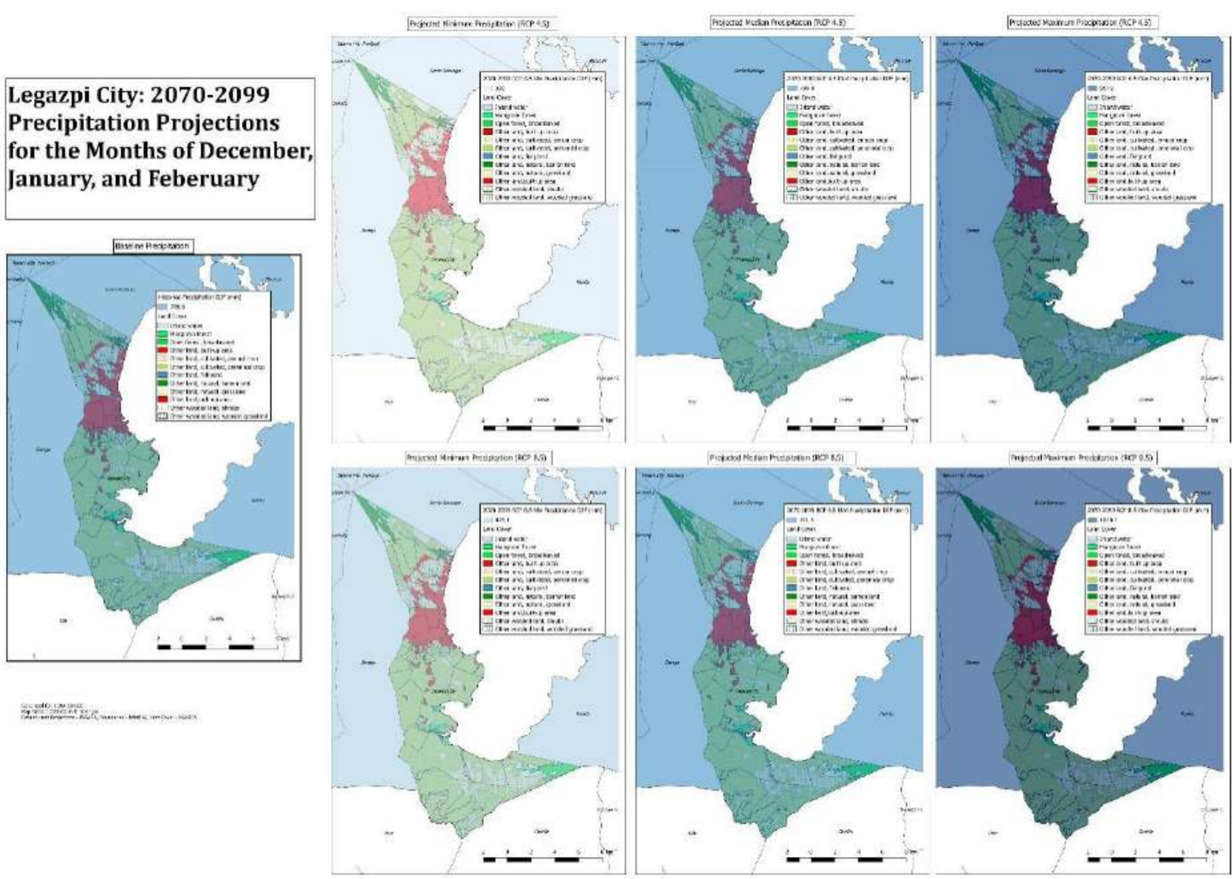



***Map 3.3.17.*** *2036-2065 Precipitation Projections for September, October and November (Source: PAGASA data)*

## Late 21st Century Projection (2070-2099), Maps 18-20

The months of December, January, and February are projected to continue the trend projected in the mid-century ***(Map 3.3.18)***. The said months are projected to be wetter than the historical baseline based on the median projected rainfall amount of both scenarios. The late century differs to the mid-century in that for the said months, RCP 4.5 is projected to be wetter than RCP 8.5. The amount of rainfall for the projected median is only slightly wetter than the baseline for both scenarios.

What is notable for the late century for the said months is that in both scenarios the range of possible rainfall amounts as signified by the projected maximum and minimum amounts is larger which may project the possibility of extreme dry and extreme wet events during these months. The median projected rainfall amount for RCP 8.5 is an increase of 1.6% from the baseline while for RCP 4.5 it is an increase of 8.1% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 35.8% decrease from the baseline while for RCP 4.5 it is a decrease of 47.0% from the baseline. Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 37.9% from the baseline while for RCP 4.5 it is an increase of 29.5% from the baseline.

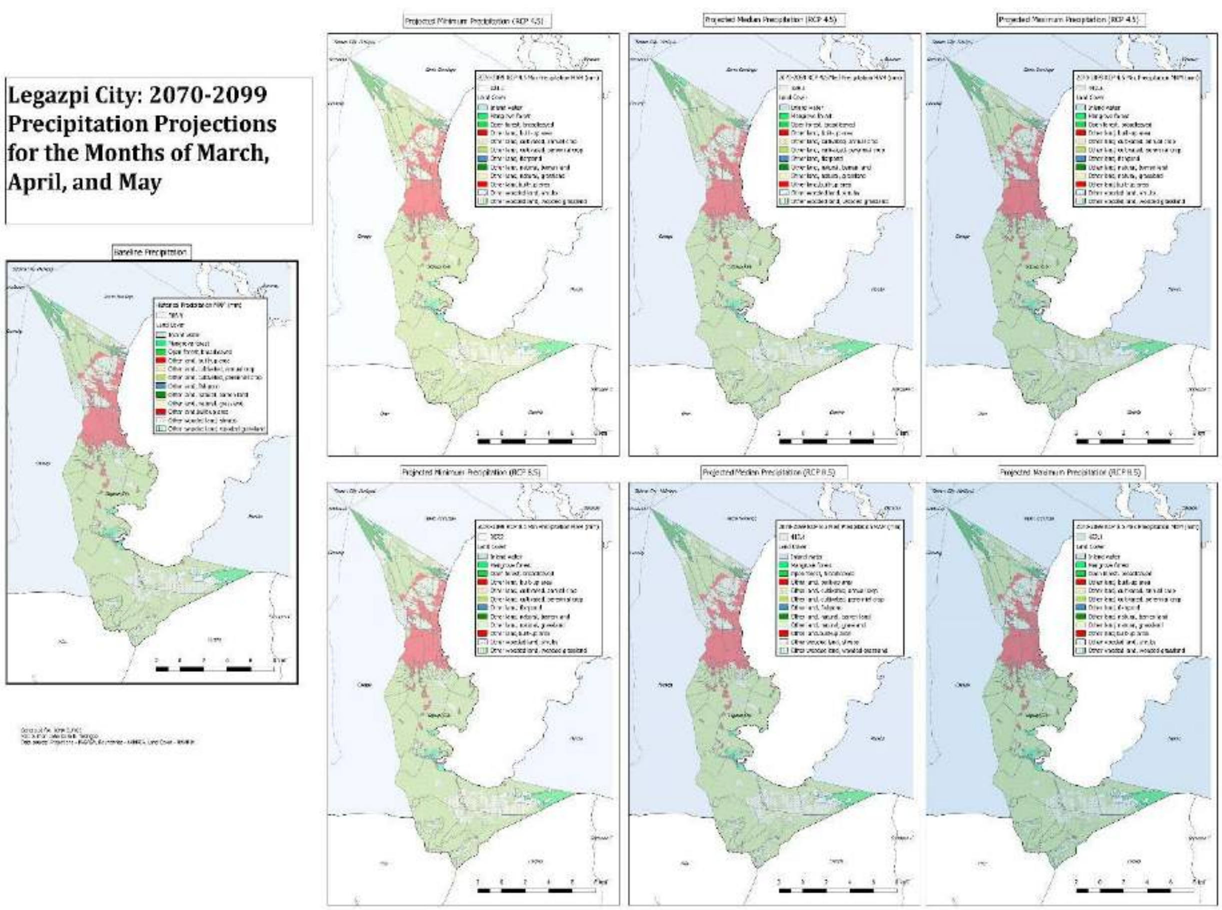



***Map 3.3.18.*** *2070-2099 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be slightly wetter than the historical baseline based on the median projected rainfall amounts for the late century ***(Map 3.3.19)***. In the late century, the said months are projected to be drier under RCP 4.5 than under RCP 8.5.

Furthermore, under RCP 4.5 the minimum projected rainfall amount is significantly drier than that of RCP 8.5 which may signify the possibility of extreme dry events under the said scenario. The median projected rainfall amount for RCP 8.5 is an increase of 6.6% from the baseline while for RCP 4.5 it is an increase of 0.6% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 20.6% decrease from the baseline while for RCP 4.5 it is a decrease of 42.8% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is an increase of 19.4% from the baseline while for RCP 4.5 it is an increase of 14.3% from the baseline.

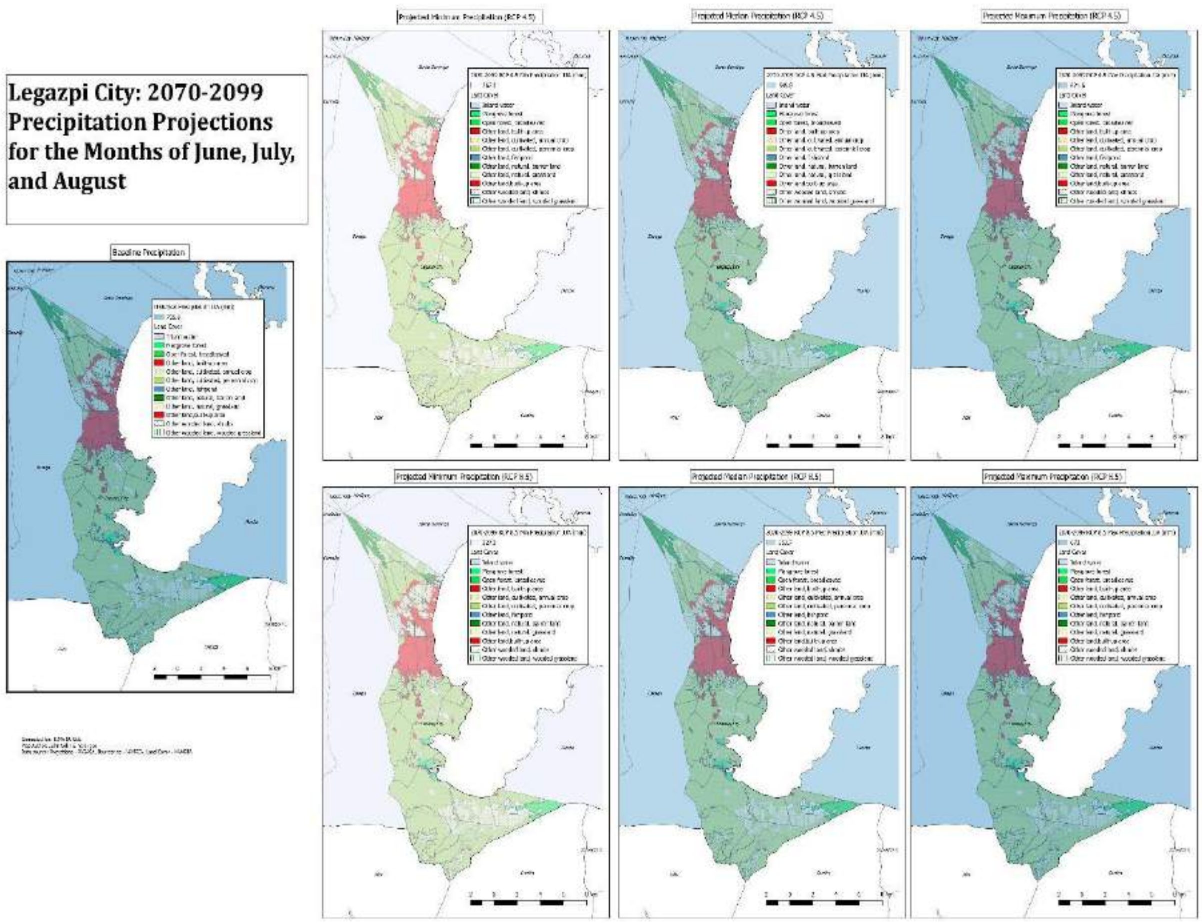



***Map 3.3.19.*** *2070-2099 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to be significantly drier than the historical baseline for the said months under both scenarios based on the whole range of values ***(Map 3.3.20)***. They are said to be projected to be drier because the projected maximum rainfall amounts for both scenarios are drier than the historical baseline, provided that RCP 4.5 is slightly drier than RCP 8.5. Thus, a general decrease in precipitation is projected for the said months with a possibility of extreme dry events.

The median projected rainfall amount for RCP 8.5 is a decrease of 21.6% from the baseline while for RCP 4.5 it is a decrease of 22.7% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 53.6% decrease from the baseline while for RCP 4.5 it is a decrease of 62.1% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is a decrease of 4.6% from the baseline while for RCP 4.5 it is a decrease of 11.9% from the baseline.

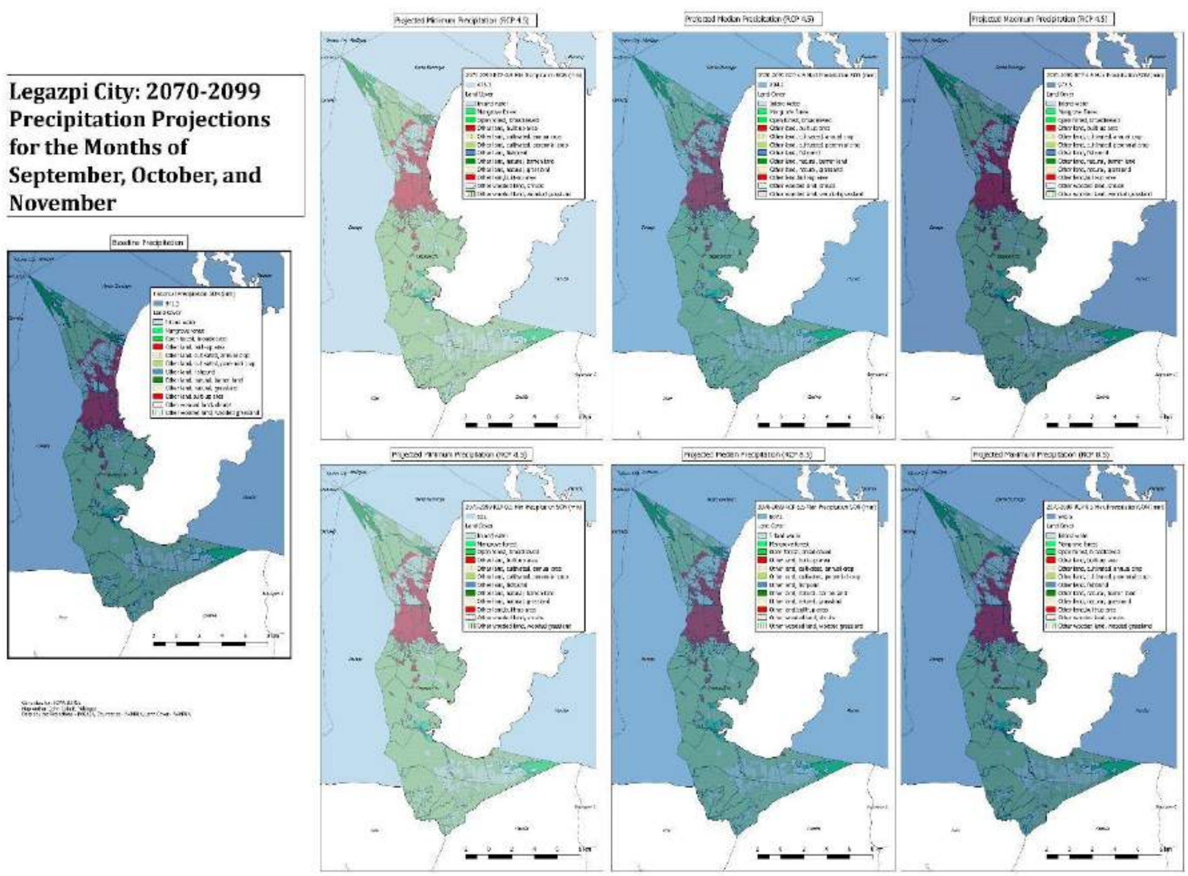



***Map 3.3.20****. 2070-2099 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October, and November are projected to be drier than the historical baseline based on the median projected rainfall amounts of both scenarios ***(Map 3.3.21)***. In particular, under RCP 8.5 the said months are projected to be drier than the historical baseline in its whole range of values, its maximum projected rainfall amount being drier than the baseline.

Under RCP 4.5 on the other hand, the range of possible rainfall values are larger than that under RCP 8.5, its maximum and minimum values being respectively wetter and drier than RCP 8.5. The median projected rainfall amount for RCP 8.5 is a decrease of 14.3% from the baseline while for RCP 4.5 it is a decrease of 14.6% from the baseline. The minimum projected rainfall amount for RCP 8.5 is a 44.5% decrease from the baseline while for RCP 4.5 it is a decrease of 49.4% from the baseline.

Lastly, the maximum projected rainfall amount for RCP 8.5 is a decrease of 0.1% from the baseline while for RCP 4.5 it is an increase of 3.3% from the baseline.



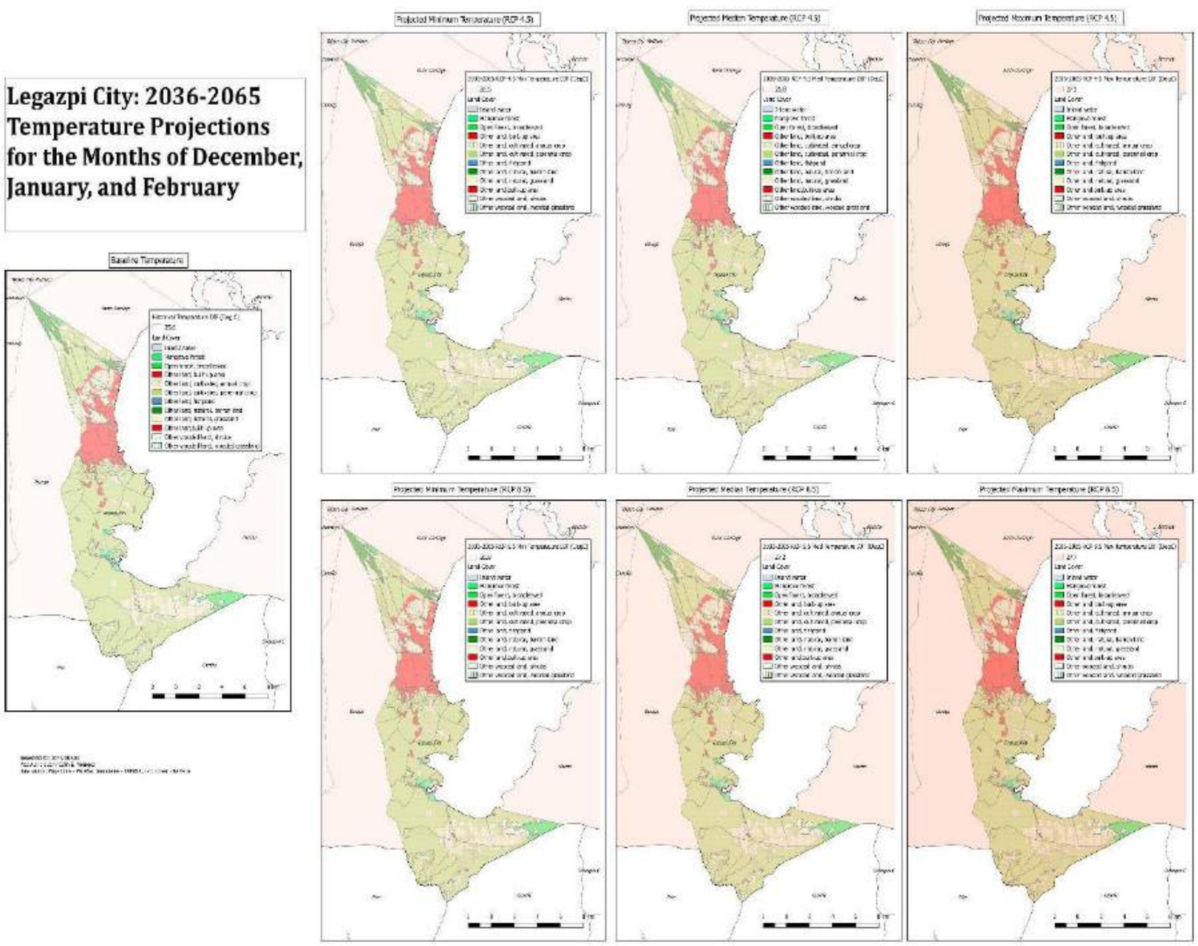

***Map 3.3.21.*** *2070-2099 Precipitation Projections for September, October and November (Source: PAGASA data)*

### *Change in Temperature*

The general trend for all scenarios and throughout the mid and late century is an increase from the baseline temperature differing only for each quarter. The details are specified below.

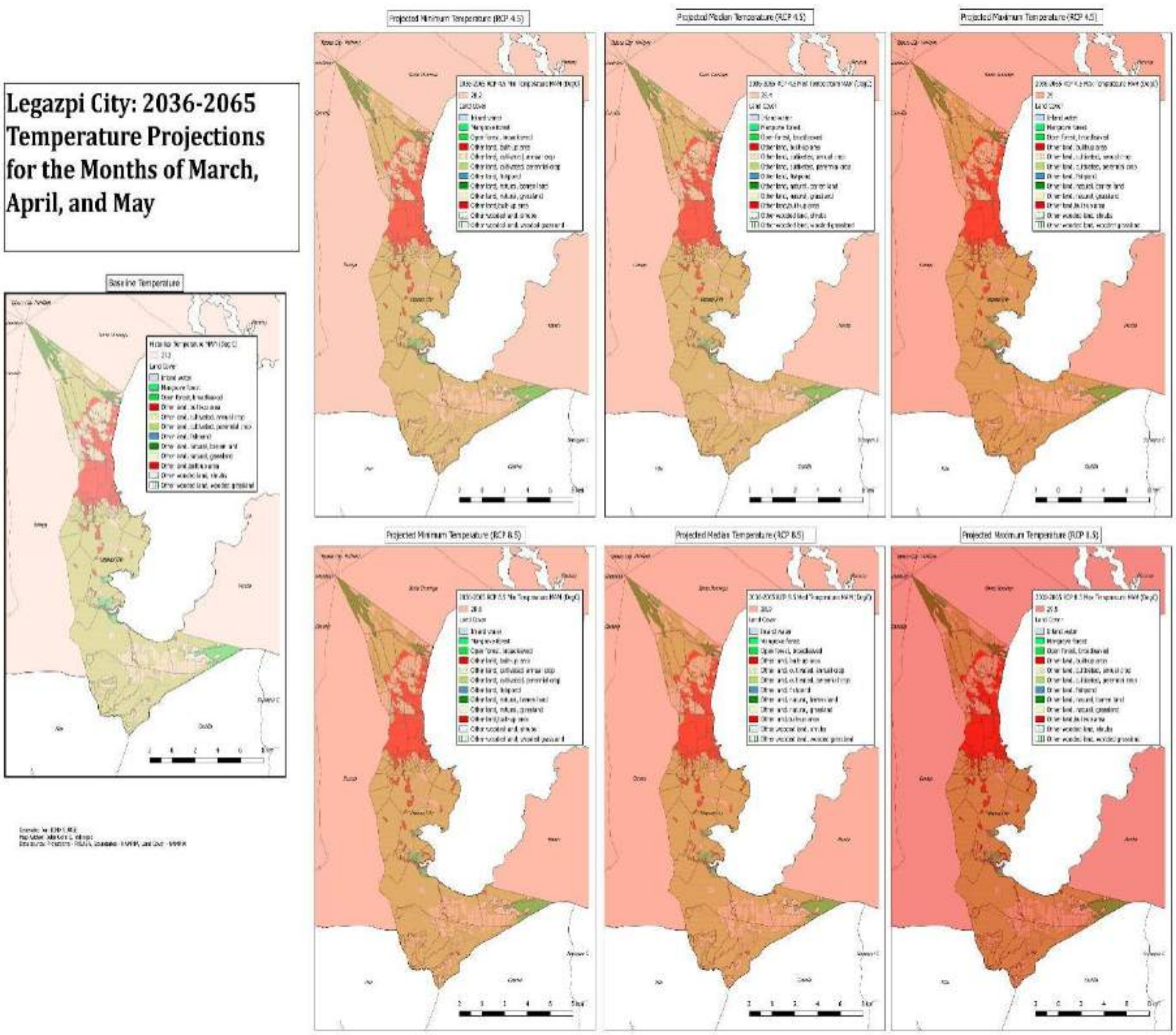
#### Mid-21st Century Projections (2036-2065), Maps 22-25

The months of December, January, and February are projected to have an increase in temperature with RCP 8.5 being hotter than RCP 4.5 ***(Map 3.3.22)***. The projected median temperature for RCP 8.5 will be an increase of 1.6 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.2 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase of 2.1 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.7 degrees.




***Map 3.3.22.*** *2036-2065 Temperature Projections for December, January and February (Source: PAGASA data)*

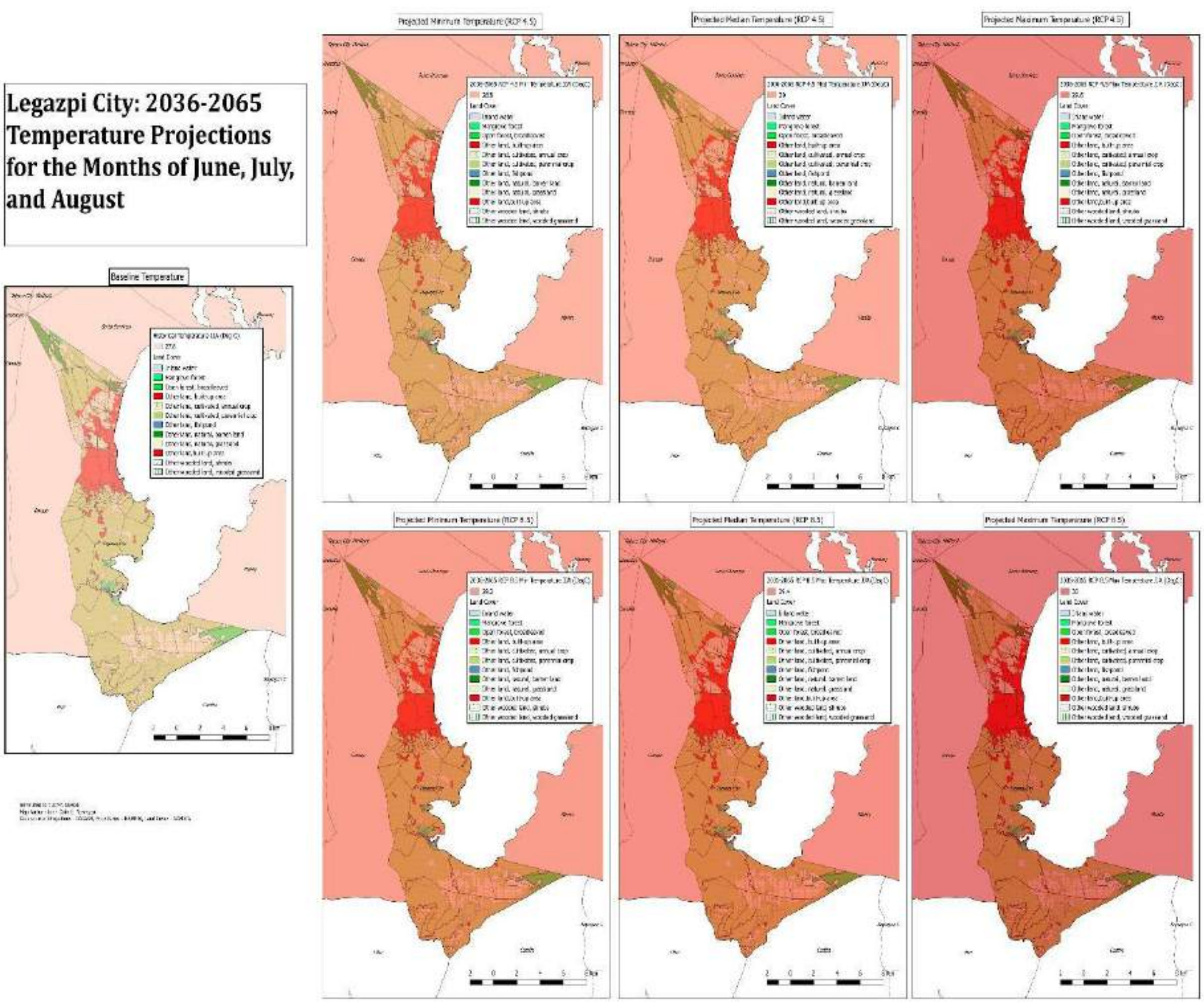
The months of March, April, and May are projected to be hotter than the baseline temperature in both scenarios ***(Map 3.3.23)***. The whole range of values for both scenarios are projected to be hotter than the historical hottest for the year. The projected median temperature for RCP 8.5 will be an increase of 1.7 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase of 2.3 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.8 degrees.




***Map 3.3.23.*** *2036-2065 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to be hotter than their historical baseline for both scenarios ***(Map 3.3.24)***. The said months continue the trend from the previous in that the whole range of values are projected to be hotter than the historical hottest for the year. The said months under the projections will continue to be the hottest of the year.

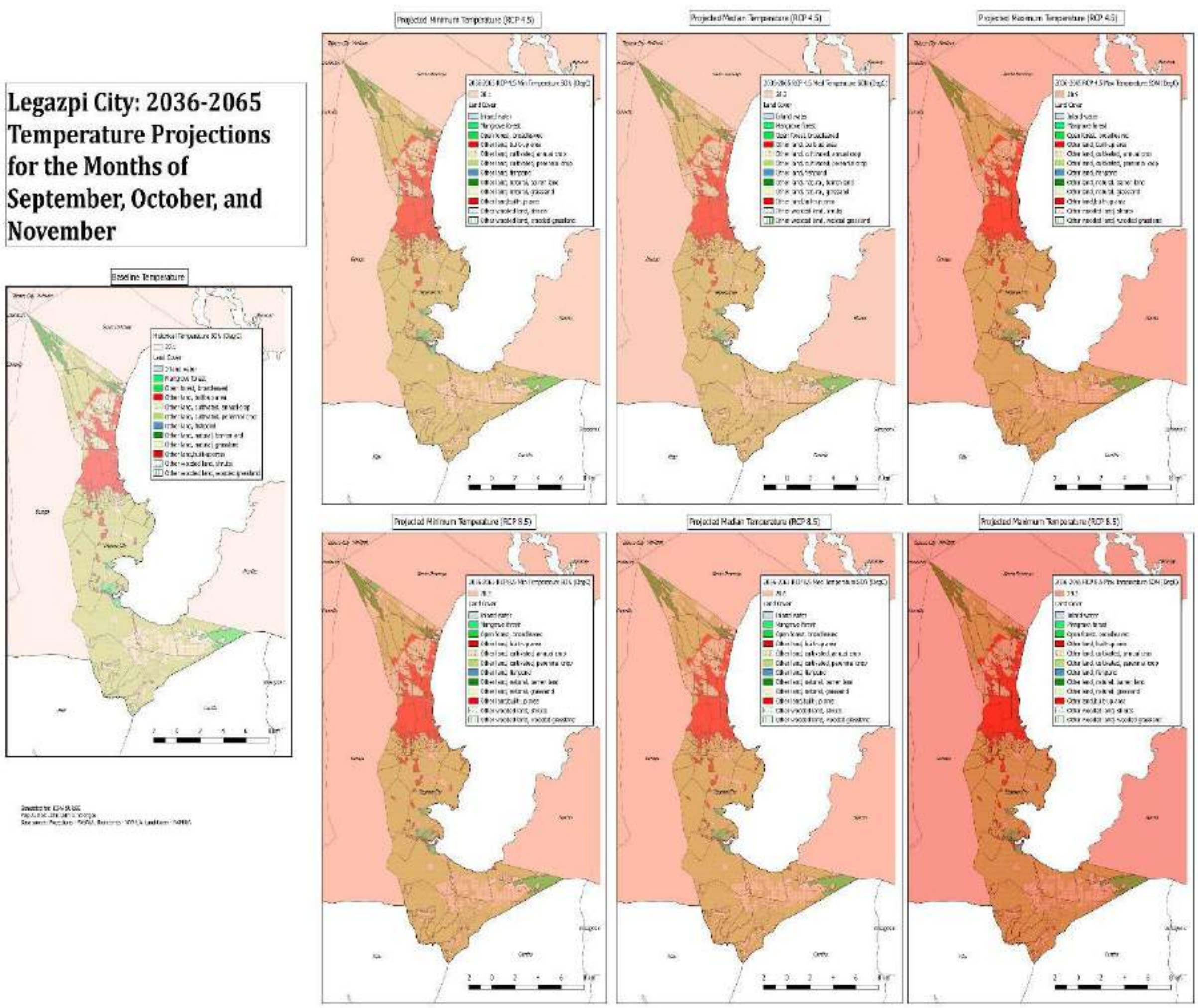
The projected median temperature for RCP 8.5 will be an increase of 1.6 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase of 2.2 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.8 degrees.




***Map 3.3.24.*** *2036-2065 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October, and November are projected to be hotter than their historical baseline with RCP 8.5 being hotter than RCP 4.5 ***(Map 3.3.25)***. Furthermore, the said are projected to have temperatures higher than that of the historical hottest of the year for both scenarios. The projected median temperature for RCP 8.5 will be an increase of 1.5 degrees from the historical baseline while for RCP 4.5 there is a projected 1.1 degrees increase from the historical baseline.

The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase of 2.2 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.8 degrees.

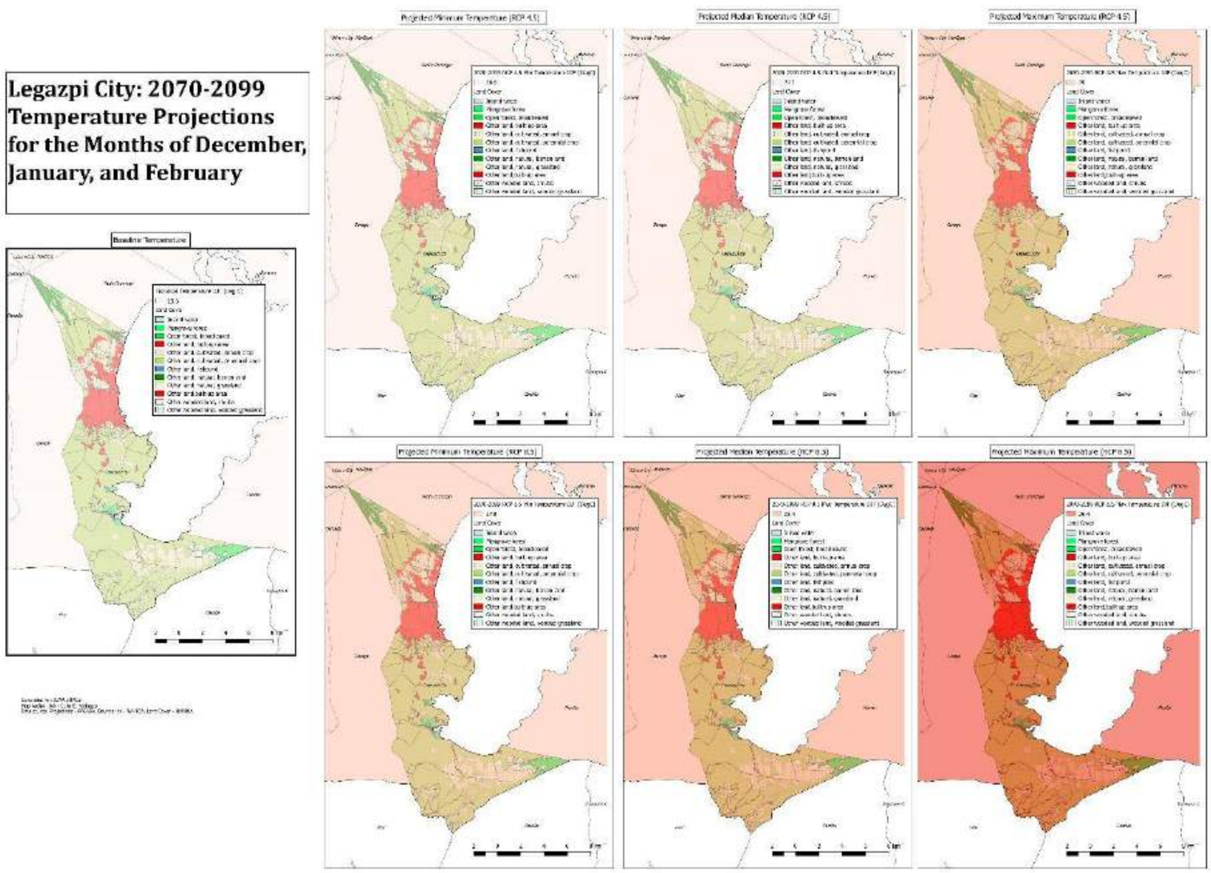



***Map 3.3.25.*** *2036-2065 Temperature Projections for September, October and November (Source: PAGASA data)*

### Late 21st Century Projections (2070-2099), Maps 26-29

The projections for the late century continue the trend of the mid-century in that the temperatures will be higher than the historical baseline and that RCP 8.5 will be hotter than RCP 4.5. The only difference is that the projected temperatures for the late century are higher than that for the mid-century. Furthermore, under RCP 8.5 the temperatures for all quarters are projected to be higher than the historical hottest average temperature.

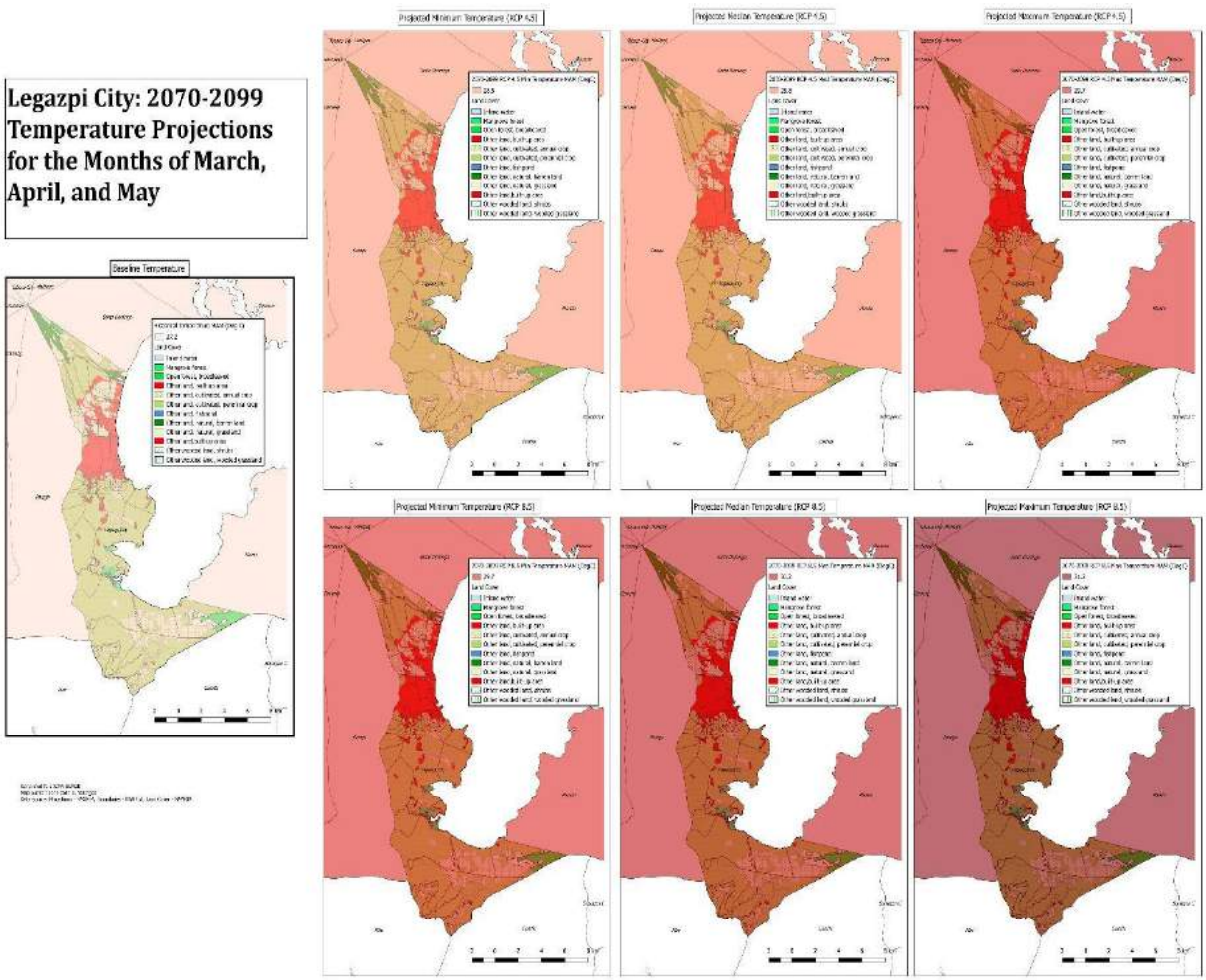
The months of December, January, and February are projected to hotter than their historical baseline for both scenarios ***(Map 3.3.26)***. Under RCP 8.5 the range of projected temperatures are hotter than the historical hottest average for the year. While under RCP 4.5, the median and minimum projected temperatures for the said months remain to be lower than the historical hottest average temperature, with the maximum projected temperature the only projected temperature to be higher than the historical hottest average temperature. The projected median temperature for RCP 8.5 will be an increase of 2.8 degrees from the historical baseline while for RCP 4.5 there is a projected 1.5 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.2 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.2 degrees. The maximum projected temperature of RCP 8.5 is an increase of 3.8 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 2.4 degrees.




***Map 3.3.26.*** *2070-2099 Temperature Projections for December, January and February (Source: PAGASA data)*

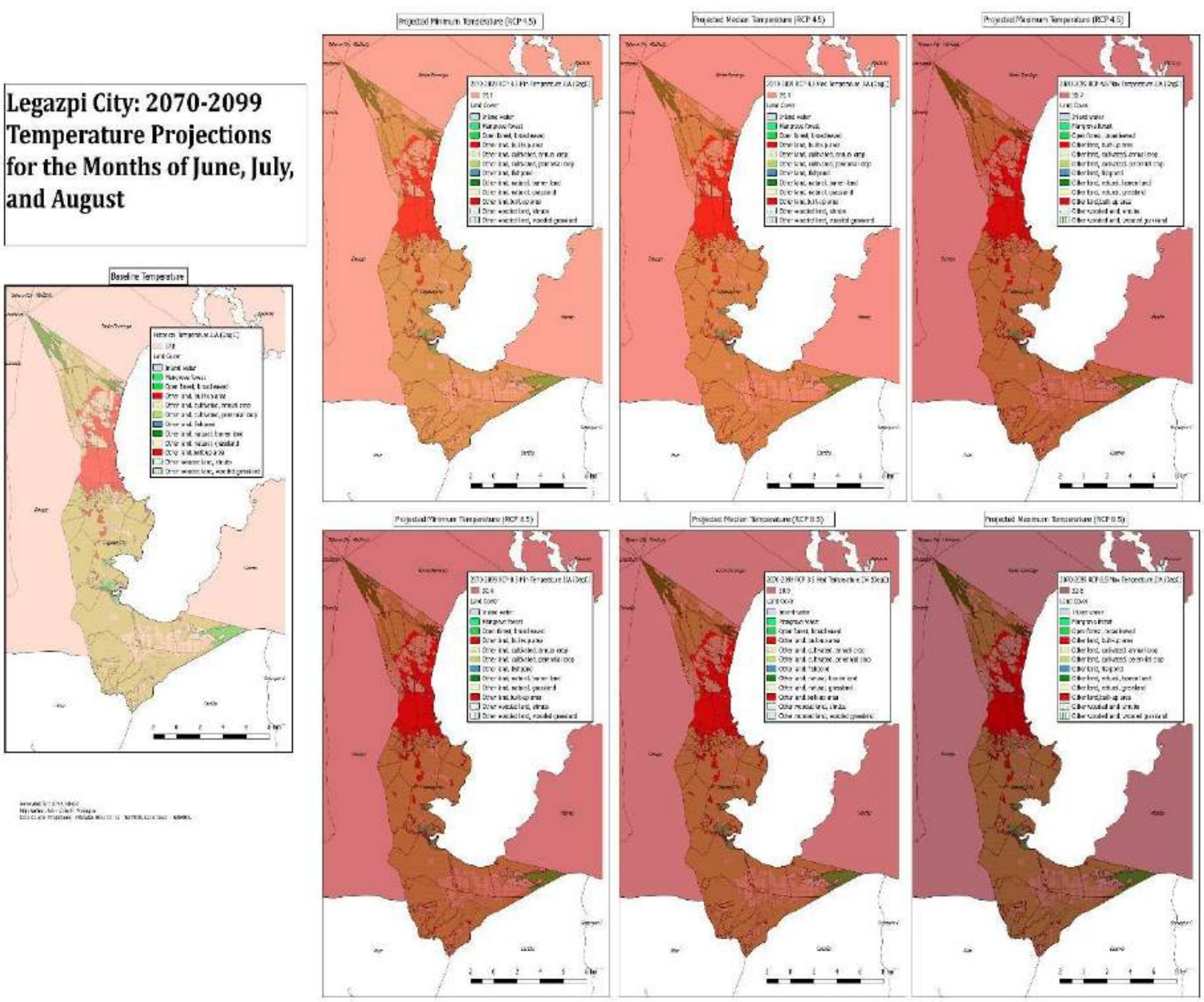
The months of March, April, and May are projected to have temperatures higher than that of the historical hottest average temperature under both scenarios ***(Map 3.3.27)***. The said months are projected to be the second hottest of the year in the late century. Under RCP 8.5 the temperatures are projected to be hotter than that of the temperatures under RCP 4.5.

Furthermore, the projected increases under RCP 8.5 are almost twice that of RCP 4.5. The projected median temperature for RCP 8.5 will be an increase of 3.0 degrees from the historical baseline while for RCP 4.5 there is a projected 1.6 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.5 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase of 4.0 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 2.5 degrees.




***Map 3.3.27.*** *2070-2099 Temperature Projections for March, April, and May (Source: PAGASA data)*

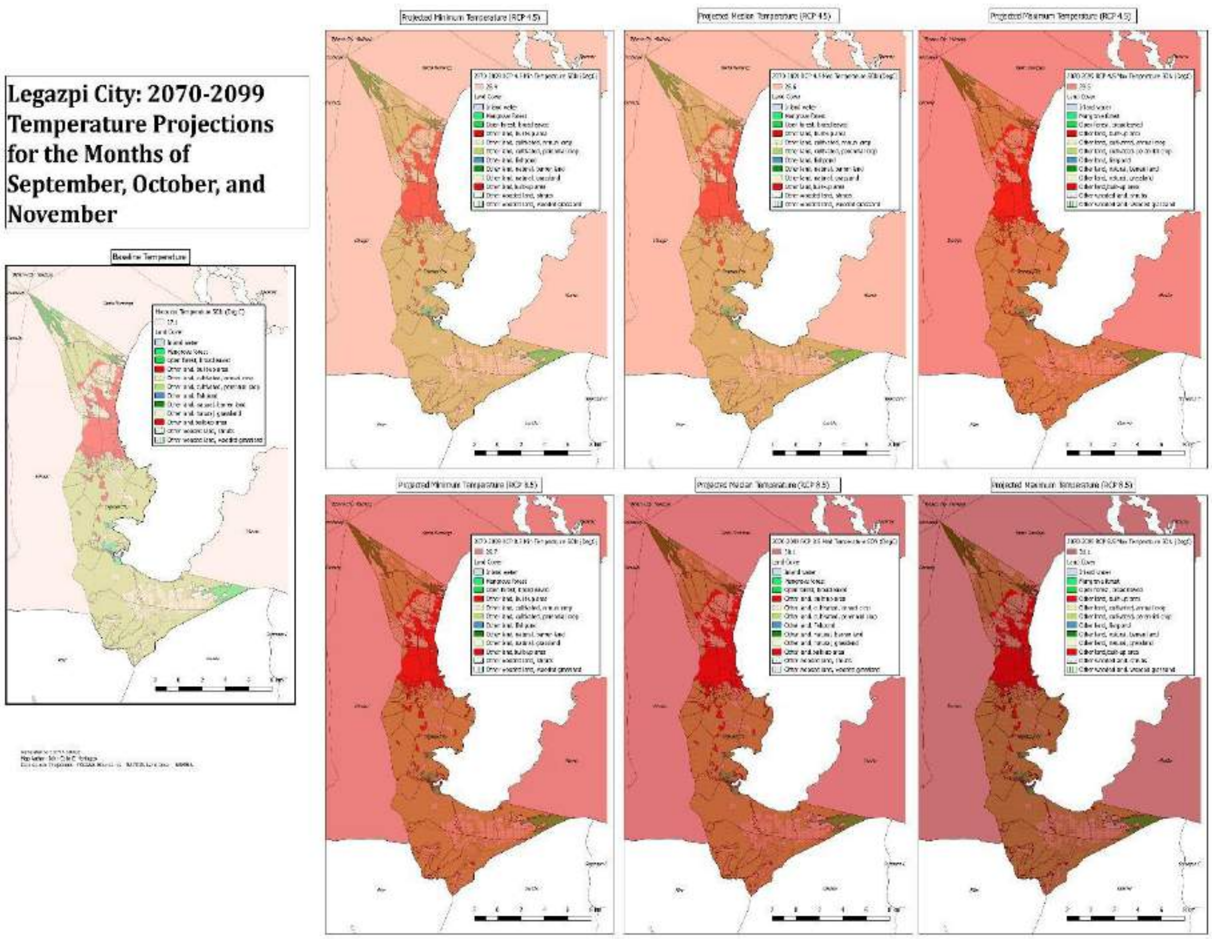
The months of June, July and August are projected to have the hottest temperatures for the year, with temperatures exceeding the historical hottest average temperature under both scenarios ***(Map 3.3.28)***. The temperatures projected under RCP 8.5 are significantly higher than that of RCP 4.5, with increases in temperature being almost twice that of RCP 4.5. The projected median temperature for RCP 8.5 will be an increase of 3.1 degrees from the historical baseline while for RCP 4.5 there is a projected 1.6 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.6 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase of 4.0 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 2.4 degrees.




***Map 3.3.28.*** *2070-2099 Temperature Projections for June, July, and, August (Source: PAGASA data)*

The months of September, October, and November are projected to have temperatures higher than that of the historical hottest average temperature ***(Map 3.3.29)***. The temperatures projected under RCP 8.5 are higher than that of RCP 4.5, with the increases of the median and minimum temperatures under RCP 8.5 being twice that of the increases under RCP4.5. The projected median temperature for RCP 8.5 will be an increase of 3.0 degrees from the historical baseline while for RCP 4.5 there is a projected 1.5 degrees increase from the historical baseline.

The projected minimum temperature for RCP 8.5 is a 2.6 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase of 4.0 degrees from the historical baseline for the quarter while for RCP 2.4 there is a projected increase of 1.7 degrees.




***Map 3.3.29.*** *2070-2099 Temperature Projections for September, October, and November (Source: PAGASA data)*

## Impacts and Adaptation Options

The City of Legazpi is a government unit that sees a blend of urbanized and rural landscapes. Located in the city is a densely urbanized locale of built-up areas in its north eastern portion. Juxtaposed to the urban portions of the city are the rural agricultural lands to the north and south as well as forested areas.

The city is the administrative center as well as a transportation hub of the Bicol Region. It is a highly populated area and a center for commerce and business. With these in mind the impacts of the projected changes in precipitation and temperature vary across the different sectors. The notable projections are the marked increase in temperature in both RCP 4.5 and RCP 8.5 and the marked decrease in precipitation in the historically wetter months of June to November. The impacts and adaptation options for each sector are detailed below.

### *A. Demography*

The projected increase in temperature for both scenarios may bring impacts to the highly urbanized and populated portions of the city. Given the number of establishments in the city, heat related diseases such as heat stroke and dehydration are a notable risk under the said projections because of the heat island effect (IPCC 2014). The said risk is evident given that under RCP 8.5 the projected temperatures for the late century will far exceed that of the highest historical average temperature.

The mid-century projections, though cooler, still project that the temperature for the months from March to November will have temperatures higher than the highest historical average temperature. These projected impacts are further supplanted by the projected decrease in precipitation for the months from June to November. The variable range of precipitation in the months from December to May, particularly the possibility of high precipitation, have additional projected impacts of increased risk of floods and water borne diseases for those particular months.

The city has so far implemented extensive trainings and information education campaigns to raise awareness on the effects of climate change and the possible disaster risks. In particular, there have been family development sessions that integrate climate change adaptation and disaster risk reduction; information education campaigns on disaster preparedness and climate change adaptation and mitigation; disaster preparedness and climate change adaptation preparedness capability programs for the elderly and disabled; integration of climate change and disaster preparedness awareness in child welfare trainings; and disease prevention programs.

As can be gleaned from the list of programs the city has programs that can raise awareness and address some of the risks of the projected impacts. The city has also relocated informal settlers that were located in high risk zones and established danger zones. An adaptation option the city can further adopt to augment their own plans is the development of policies that are aimed towards adapt behaviour and local customs to the projected impacts (Sabbag 2013). These can take the form of changing the usual attire of employees and students to that appropriate for the projected increase in temperature. Another example of such a policy is the change of working and class hours to the cooler hours of the day.

### *B. Social*

The impacts to the social sector were partly discussed in the section above. The projected increase in temperature, decrease in precipitation for the historically wettest months, and the variable changes in precipitation will particularly take its toll on the health facilities and education institutions in the city. There will be possible health risks related to higher temperatures such as heat stroke and dehydration to the faculty, staff, and students of the said educational institutions.

The variable changes in precipitation in the months of December to May also have possible risks of class cancellations due to the possibility of extreme wet events. The health facilities located in the city may not have the capacity to address the heat related health risks. The population also of the city such as the urban poor may not have the capacity to fully access the facilities that may aid in mitigating the risks of heat related diseases. The city has adopted a *barangay* nutrition program as well as the numerous trainings that were enumerated in the section above to help address the said possible impacts. Furthermore, the city is currently constructing and improving school facilities and amenities. Similar to what was suggested above, policies to change behaviour and custom may be adopted to adapt to the impacts (Sabbag 2013).

Smart design and technologies can also be adopted in the construction of housing and government facilities such as improving indoor ventilation can aid in addressing the projected increase in temperatures (Sabbag 2013).

### *C. Economic*

The projected increase in temperature and decrease in precipitation will mostly affect the agricultural sector. In particular, rice and root crops will have a decrease in yield due to the increase in temperature and the decrease in much needed water supply (IPPC 2014 & Eitzinger et al. 2017). The general increase in precipitation in the months from December to May might increase yield, but the range of possible rainfall amounts in the same months also have risks of both floods and drought which can lead to damage to crops and decrease in yield (Toda et al. 2017 & Eitzinger et al. 2017).

The coconut plantations found in the city and the industries that rely on them will also be negatively affected by the increase in temperatures, reducing their yield and increasing their risk of disease (Hebbar et al. 2013). The decrease in precipitation also run the risk of salt water intrusion the water table that have been evident in the *barangays* of Bagacay and Banquerohan as drawn from the respondents from the city. The adaptation options that could be adopted by the city in particular with the agricultural sector is the adoption of climate tolerant varieties for both their coconut plantations and rice crops (Toda et al. 2017; Hebbar et al. 2013; and Howden et al. 2007).

Adoption of best practices also such as shifting of cropping calendars for rice crops to coincide with the generally higher precipitation projected for the months from December to January. The development of water storage systems and better irrigation can help augment the adoption of best practices and the climate tolerant varieties (Howden et al. 2007). Furthermore, alternative crops are a viable way to maintain the livelihoods of those dependent on crops that are vulnerable to increases in temperature and decreases in precipitation such as cassava (Eitzinger et al. 2017).

### *D. Infrastructure*

The projected increase in temperature has a possibility of increasing the cost of maintenance for road infrastructure due to damage caused by cracks and unevenness in materials such as concrete and asphalt (Sabbag 2013 & Schweikert et al. 2014).

The projected increase in temperature and decrease in precipitation may also respectively increase the demand for electricity and water throughout the city. The decrease in precipitation and increase in temperature may also prevent the ground water supply from recharging (IPCC 2014). The wider range of projected values in the months from December to May might see the risk of floods which can cause damage to areas with poor drainage systems. The city has implemented structural plans on flood control system as well as water systems that may address the possible impacts of the lack of water supply and flood damage. The city may also choose to adopt planning systems such as 2100 that help monitor and maintain roads depending on the climate variable faced (Schweikert et.al 2014). The city may also adopt more climate resilient infrastructure materials and designs (Sabbag 2013).

Adoption of alternative and renewable energy systems may also help improve the demand for energy in the city as well as the development of policies that will encourage adoption such as the provision of incentives (IPCC 2014).

### *E. Environment*

The projected increase in temperature and decrease in precipitation may cause stress and increase the possibility of wildfires in the forest and grasslands found in the city particularly in the areas near Mt. Mayon and the areas in the southern region of the city (IPCC 2014).

The increase in temperature may also affect the time of seed collection, increase the rate of seedling mortality and out plantings, and may change the species distribution/vegetation type or composition (Legazpi City Responses 2017 & FAO 2008). The wider range of possible rainfall amounts in the months from December to May might increase the possibility of high precipitation events which can increase erosion in higher sloped areas as well as increase siltation in rivers. The city has current plans that seek to address the environmental concerns mentioned above as well as other impacts mentioned above. These include plans to formulate a forest land use plan, a plan to intensify green areas in urbanized areas, plans to protect protected areas and critical ecosystems, and multiple capacity building programs to improve and address the environment of the city.

### *F. Hazards*

In terms of hazards, the wide range of projected rainfall amounts in the months from December to May and the general higher projected rainfall may increase the risk of floods in the said months.

On the other hand, the increased temperature and decreased precipitation for the months from June to November may increase the possibility of droughts. The increase in temperature may also cause an increased in wildfires in the forest and grassland areas in the city (IPCC 2014). The city has implemented plans that aid in mitigating the risk of hazards in the city such as hazard risk assessments as well as multiple programs which inform, educated, and train the citizens on disaster preparedness as enumerated in the previous sections. The city can further adopt wildfire fighting facilities in areas that may be at risk and may also identify fire zones to monitor (Four Twenty-seven Climate Solutions 2017).

## Adaptation Options

***Table 3.3.3.*** *Summary of Impacts and Adaptation Options for Legazpi City*

| **Summary of Impacts and Adaptation Options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature (Year-round and for all scenarios) and decrease in precipitation (JJA and SON) | Demography | Increased heat related health risk to population, loss of livelihood | Family development sessions that integrate climate change adaptation and disaster risk reduction; information education campaigns on disaster preparedness and climate change adaptation and mitigation; disaster preparedness and climate change adaptation preparedness capability programs for the elderly and disabled; integration of climate change and disaster preparedness awareness in child welfare trainings; and disease prevention programs policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased heat related health risk to population, loss of livelihood, increased health risk to urban poor, | Nutrition program, policies enumerated in previous sector, policies that adapt attire to higher temperatures and adjustment of working and class hours, adoption of smart designs for residential and government facilities, establishment of green spaces |
| | Economic | Reduction of water supply, increased demand for water, | Climate, tolerant crop varieties, alternating crops, development of water storage systems and water usage management practices, shifting of cropping calendars for rice crops to coincide with the generally higher precipitation projected for the months from December to January. |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Deforestation, increased forest stress | Forest land use plan, intensification of green areas in urbanized areas, plans to protect protected areas and critical ecosystems, and multiple capacity building programs |
| | Hazards | Increased possibility of drought and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |

| | | | |
|---|---|---|---|
| General increase in precipitation in the months of (DJF and MAM) | Demography | Increased risk of water borne diseases | Family development sessions that integrate climate change adaptation and disaster risk reduction; information education campaigns on disaster preparedness and climate change adaptation and mitigation; disaster preparedness and climate change adaptation preparedness capability programs for the elderly and disabled; integration of climate change and disaster preparedness awareness in child welfare trainings; and disease prevention programs policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased possibility of class cancellations and work suspensions | policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Economic | Flood damage and waterborne disease on agricultural crops | Adoption of climate resilient varieties and flood management practices |
| | Infrastructure | Increased possibility of floods in poorly drained areas, flood damage to infrastructure | adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems |
| | Environment | Increased rate of erosion | structural plans on flood control system |
| | Hazards | Increased risk of floods | Hazard risk assessment, relocation of at risk urban poor sector, structural plans on flood control systems, the multiple programs enumerated in the demography section |

## References

Black, R.; Kniveton, D.; Skeldon, R.; Coppard, D.; Murata, A.; & Schmidt-Verkerk, K. (2008). Demographics and Climate Change: Future Trends and their Policy Implications for Migration. Working Paper, Development Research Center on Migration, Globalisation, and Poverty.

Eitzinger, A.; Laderach, P.; Giang Tuan, L.; Ramaraj, A.; Ng'ang'a, K.; Parker, L.; Learning and Coping with Change: Case Stories of Climate Change Adaptation in Southeast Asia. Case Story Book Vol. 1. Pp 83-97

Four Twenty-seven Climate Solutions (2017). Fremont Climate Hazard Assessment and Adaptation Options.

Hebbar K.B., Balasimha D., Thomas G.V. (2013) Plantation Crops Response to Climate Change: Coconut Perspective. In: Singh H., Rao N., Shivashankar K. (eds) Climate-Resilient Horticulture: Adaptation and Mitigation Strategies. Springer, India

Howden, S.M.; Soussana, J.; Tubiello, F.; Chhetri, N.; Dunlop, M.; & Meinke, H. (2007) Adaptingagriculture to climate change.Proceedings of the National Acadamy of Sciences of the United States of America. Vol 104 no. 50

IPCC, 2014: Climate Change 2014: Synthesis Report. Working Groups II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.IPCC, Geneva, Switzerland, 151 pp.

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Sabbag, L. (2013).Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation. From Sheltering from a Gathering Storm working paper No. 4. Institute for Social and Environmental Transition-International.

Schweikert, A.; Chinowsky, P.; Espinet, X.; & Tarbert, M. (2014). Climate Change and infrastructure impacts: comparing the impact on roads in ten countries through 2100. Procedia Engineering 78. pp 306-316.

Toda.L.L., Yokingco, J.C.E., Paringit, E.C., Lasco, R.D.L. (2017) A LiDAR based flood modelling approach for mapping rice cultivation areas in Apalit, Pampanga.Journal of Applied Geography.Vol. 80. Pp 34-47.

## Population Table (PSA, 2015)

| LEGAZPI CITY (Capital) | Type<br>U- Urban<br>R- Rural | 196,639 |
|---|---|---|
| Bgy. 56 - Taysan (Bgy. 68) | U | 12,330 |
| Bgy. 42 - Rawis (Bgy. 65) | U | 8,868 |
| Bgy. 37 - Bitano (Pob.) | U | 8,559 |
| Bgy. 66 - Banquerohan (Bgy. 43) | U | 6,976 |
| Bgy. 49 - Bigaa (Bgy. 44) | U | 6,730 |
| Bgy. 40 - Cruzada (Bgy. 52) | U | 5,853 |
| Bgy. 38 - Gogon (Bgy. 54) | U | 5,752 |
| Bgy. 32 - San Roque (Bgy. 66) | U | 5,632 |
| Bgy. 16 - Kawit-East Washington Drive (Pob.) | U | 5,372 |
| Bgy. 62 - Homapon (Bgy. 55) | R | 4,832 |
| Bgy. 61 - Maslog (Bgy. 58) | R | 4,796 |
| Bgy. 59 - Puro (Bgy. 63) | R | 4,756 |
| Bgy. 41 - Bogtong (Bgy. 45) | U | 4,753 |
| Bgy. 58 - Buragwis | R | 4,549 |
| Bgy. 55 - Estanza (Bgy. 53) | R | 4,237 |
| Bgy. 51 - Buyuan (Bgy. 49) | R | 3,895 |
| Bgy. 18 - Cabagñan West (Pob.) | R | 3,856 |
| Bgy. 47 - Arimbay | U | 3,753 |
| Bgy. 1 - Em's Barrio (Pob.) | R | 3,725 |
| Bgy. 39 - Bonot (Pob.) | U | 3,521 |
| Bgy. 53 - Bonga (Bgy. 48) | R | 3,503 |
| Bgy. 44 - Pawa (Bgy. 61) | R | 3,469 |
| Bgy. 8 - Bagumbayan (Pob.) | R | 3,400 |
| Bgy. 15 - Ilawod East Pob. (Ilawod 3) | U | 2,879 |
| Bgy. 70 - Cagbacong (Bgy. 50) | R | 2,776 |
| Bgy. 33 - PNR-Peñaranda St.-Iraya (Pob.) | R | 2,773 |
| Bgy. 24 - Rizal Street | U | 2,695 |
| Bgy. 12 - Tula-tula (Pob.) | R | 2,586 |
| Bgy. 68 - San Francisco (Bgy. 62) | R | 2,479 |
| Bgy. 28 - Victory Village North (Pob.) | R | 2,399 |
| Bgy. 57 - Dap-dap (Bgy. 69) | R | 2,287 |
| Bgy. 46 - San Joaquin (Bgy. 64) | R | 2,260 |
| Bgy. 65 - Imalnod (Bgy. 57) | R | 2,146 |
| Bgy. 17 - Rizal Street., Ilawod (Pob.) | U | 2,048 |
| Bgy. 52 - Matanag | R | 1,895 |
| Bgy. 2 - Em's Barrio South (Pob.) | R | 1,820 |
| Bgy. 67 - Bariis (Bgy. 46) | R | 1,812 |
| Bgy. 45 - Dita (Bgy. 51) | R | 1,791 |
| Bgy. 30 - Pigcale (Pob.) | R | 1,688 |
| Bgy. 63 - Mariawa (Bgy. 56) | R | 1,664 |
| Bgy. 29 - Sabang (Pob.) | R | 1,656 |
| Bgy. 50 - Padang (Bgy. 60) | R | 1,653 |
| Bgy. 43 - Tamaoyan (Bgy. 67) | R | 1,642 |
| Bgy. 54 - Mabinit (Bgy. 59) | R | 1,640 |
| Bgy. 34 - Oro Site-Magallanes St. (Pob.) | U | 1,633 |
| Bgy. 48 - Bagong Abre (Bgy. 42) | R | 1,627 |
| Bgy. 22 - Binanuahan East (Pob.) | R | 1,619 |
| Bgy. 64 - Bagacay (Bgy. 41 Bagacay) | R | 1,616 |
| Bgy. 9 - Pinaric (Pob.) | R | 1,493 |
| Bgy. 19 - Cabagñan | U | 1,427 |
| Bgy. 27 - Victory Village South (Pob.) | U | 1,418 |
| Bgy. 31 - Centro-Baybay (Pob.) | U | 1,415 |
| Bgy. 25 - Lapu-lapu (Pob.) | U | 1,398 |
| Bgy. 6 - Bañadero Pob. (Sagpon 3) | R | 1,390 |

| | | |
|---|---|---|
| Bgy. 5 - Sagmin Pob. (Sagpon 2) | R | 1,375 |
| Bgy. 60 - Lamba | R | 1,352 |
| Bgy. 69 - Buenavista (Bgy.47) | R | 1,319 |
| Bgy. 11 - Maoyod Pob. (Bgy. 10 & 11) | R | 1,110 |
| Bgy. 4 - Sagpon Pob. (Sagpon 1) | R | 953 |
| Bgy. 21 - Binanuahan West (Pob.) | U | 917 |
| Bgy. 3 - Em's Barrio East (Pob.) | R | 900 |
| Bgy. 14 - Ilawod Pob. (Ilawod 2) | R | 854 |
| Bgy. 26 - Dinagaan (Pob.) | U | 798 |
| Bgy. 23 - Imperial Court Subd. (Pob.) | R | 746 |
| Bgy. 13 - Ilawod West Pob. (Ilawod 1) | U | 721 |
| Bgy. 7 - Baño (Pob.) | U | 645 |
| Bgy. 36 - Kapantawan (Pob.) | U | 644 |
| Bgy. 20 - Cabagñan East (Pob.) | R | 641 |
| Bgy. 10 - Cabugao | R | 547 |
| Bgy. 35 - Tinago (Pob.) | U | 375 |

## 3.4. PUERTO PRINCESA CITY

### Executive Summary

Puerto Princesa City is a unique ecosystem dominated largely by forested mountains that cut across its whole length. The city is surrounded by large bodies of water that are home to large marine ecosystems from which major industries such as fishing play a pivotal role in. The city also has vast area which plays a significant factor in resource distribution.

The densely populated areas in the city are concentrated in a single area at its eastern coast. With these in mind, the particular projections that are key in understanding the impacts to the city are the projected decreases in precipitation and the projected increases in temperature. The projections coupled with the vastly forested and rich marine ecosystem of the city may provide challenges for the city. The impacts and adaptation options are summarized below.

| **Summary of Impacts and Adaptation Options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature and decrease in precipitation | Demography | Increased heat related health risk to population, migration from rural to urban areas | IEC on the health risk of climate change, capability building workshops and trainings, identification and profiling of vulnerable families, financial assistance, relocation of informal settlers from hazard risk areas, housing, provision of medicine and other supplies to affected individuals, policies that can adapt customs and habits of the citizens to the increase in temperatures, investment in improving health facilities in handling heat related diseases. |
| | Social | Increased heat related health risk to population, increased health risk to urban poor, loss of livelihood | IEC on the health risk of climate change, capability building workshops and trainings, identification and profiling of vulnerable families, financial assistance, relocation of informal settlers from hazard risk areas, housing, provision of medicine and other supplies to affected individuals, policies that can adapt customs and habits of the citizens to the increase in temperatures, investment in improving health facilities in handling heat related diseases. |
| | Economic | Reduction of water supply, increased demand for water, crop damage and yield reduction, higher risk of disease in coconut plants, loss of livelihood, coral bleaching, risk of livestock to heat | IEC and capability trainings to their farmers, fishermen, and livestock raisers to mitigate the impacts of climate change; climate tolerant varieties of vegetable, corn, rice, and fruit trees; climate tolerant livestock breeds; improved irrigation and watering facilities; financing and insurance to fishermen and farmers; vitamins for livestock; rehabilitation to coral reefs |

| | | | |
|---|---|---|---|
| | | stroke and dehydration, change of fish migration and nutrient circulation, | through coral transplanting and constant monitoring; seaweed planting materials; construction of climate appropriate shelters for livestock; adoption of cassava as an alternative to some crops; research and observe new migration patterns of fish to manage fishing patterns |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, rain water harvesting, |
| | Environment | Deforestation, increased forest stress, land conversion pest infestation, | forest land use plan; coastal bay monitoring for their marine ecosystems; introduction of drought and disturbance-tolerant species or genotypes, planning to reduce disease losses through monitoring and sanitation harvests, managing stand structure to reduce impacts on water availability and implementing silvicultural techniques to promote stand vigour; improvement of water supply systems to forest through protective and drainage structures |
| | Hazards | Increased possibility of drought and wildfires | firefighting measures |

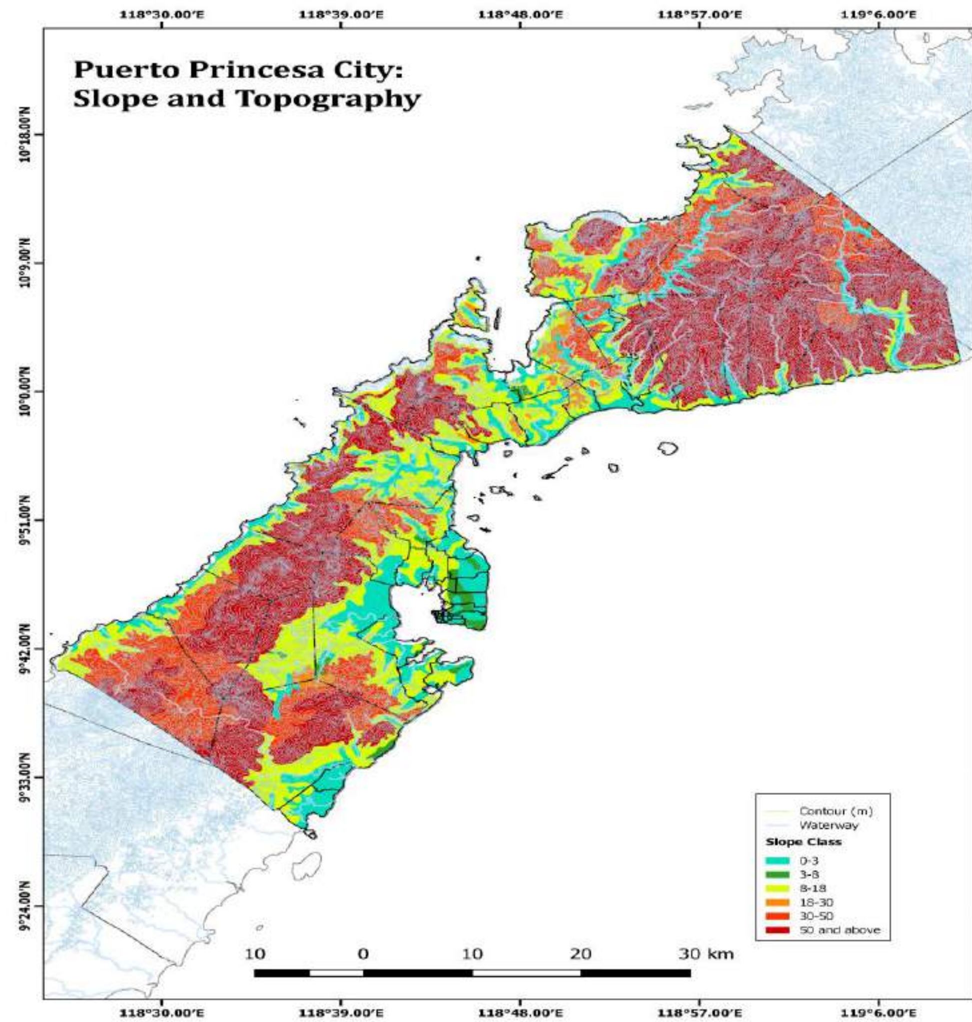
## Physical Geography

### *Location*

Puerto Princesa City is located in the island province of Palawan. It has an area of approximately 219, 339.40 hectares, making it the second largest city in the country after Davao City.The city is bound on the by the municipalities of San Vicente and Roxas, to the south by the municipality of Aborlan, to the east by the Sulu Sea, and to the west by the West Philippine Sea.

### *Physical Characteristics*

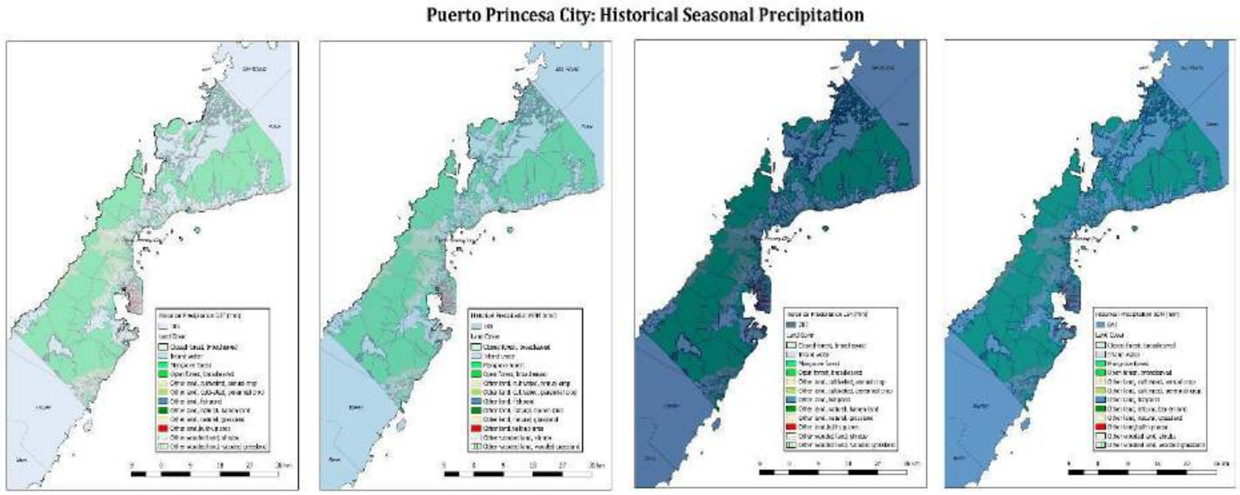
The terrain of the city is largely mountainous, occupying a majority of its entire area ***(Map 3.4.1)***. The highest point of the city lies 1,529 meters above sea level. The mountainous areas of the city divide it into its eastern and western coasts. The eastern coast has flat to hilly terrain. The west coast on the other hand is mostly mountainous. Approximately 65% of the city has slopes exceeding 18% also known as rugged terrain up to broken slopes (Puerto Princesa City Annual Report 2015). The remaining 35% is flat to moderate slopes.



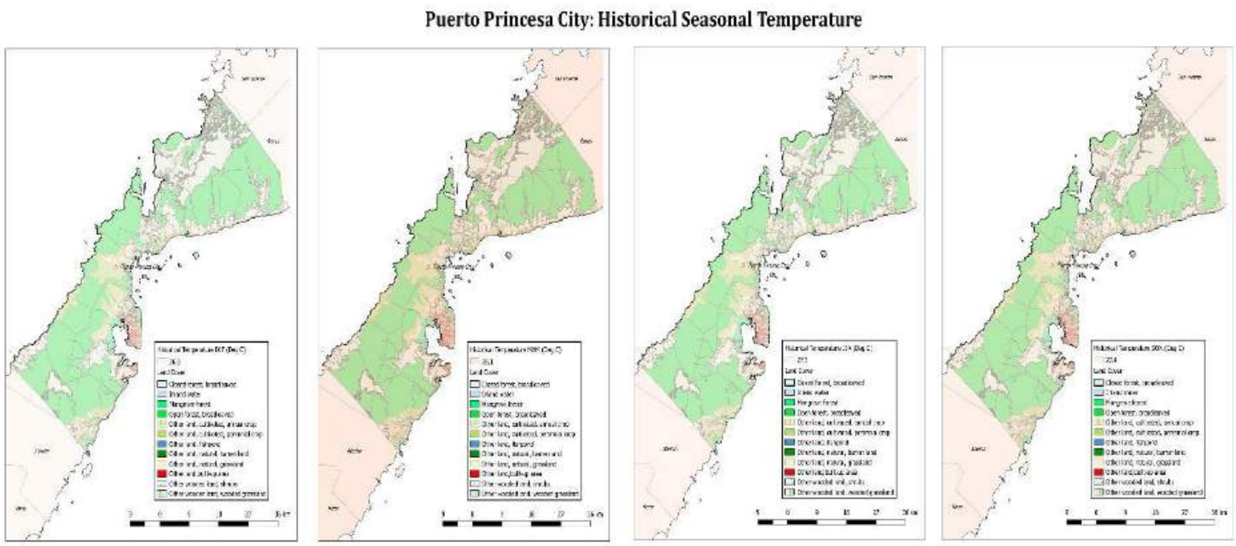

***Map 3.4.1.*** *Puerto Princesa City Slope Class and Topography Map (Source: 30m GDEM)*

### *Climate*

The climate of Puerto Princesa City is characterized by seasonal variations in precipitation and temperature ***(Maps 3.4.2 and 3.4.3)*** as modelled and recorded by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The months of December, January, and February are historically the driest of the year and also the coolest with an average cumulative rainfall amount of 102 mm and an average temperature of 26.9 degrees Celsius. The months of March, April, and May on the other hand are historically the hottest of the year and the second driest with an average temperature of 28.1 degrees Celsius and an average cumulative rainfall amount of 189 mm. The months of June, July, and August are historically the second coolest and the wettest of the year with an average temperature of 27.3 degrees Celsius and an average cumulative rainfall amount of 782 mm. The months of September, October, and November are the second wettest and the second hottest of the year with an average cumulative rainfall amount of 641 mm and an average temperature of 27.4 degrees Celsius.




***Map 3.4.2****. Puerto Princesa City Historical Seasonal Precipitation (Source: PAGASA data)*

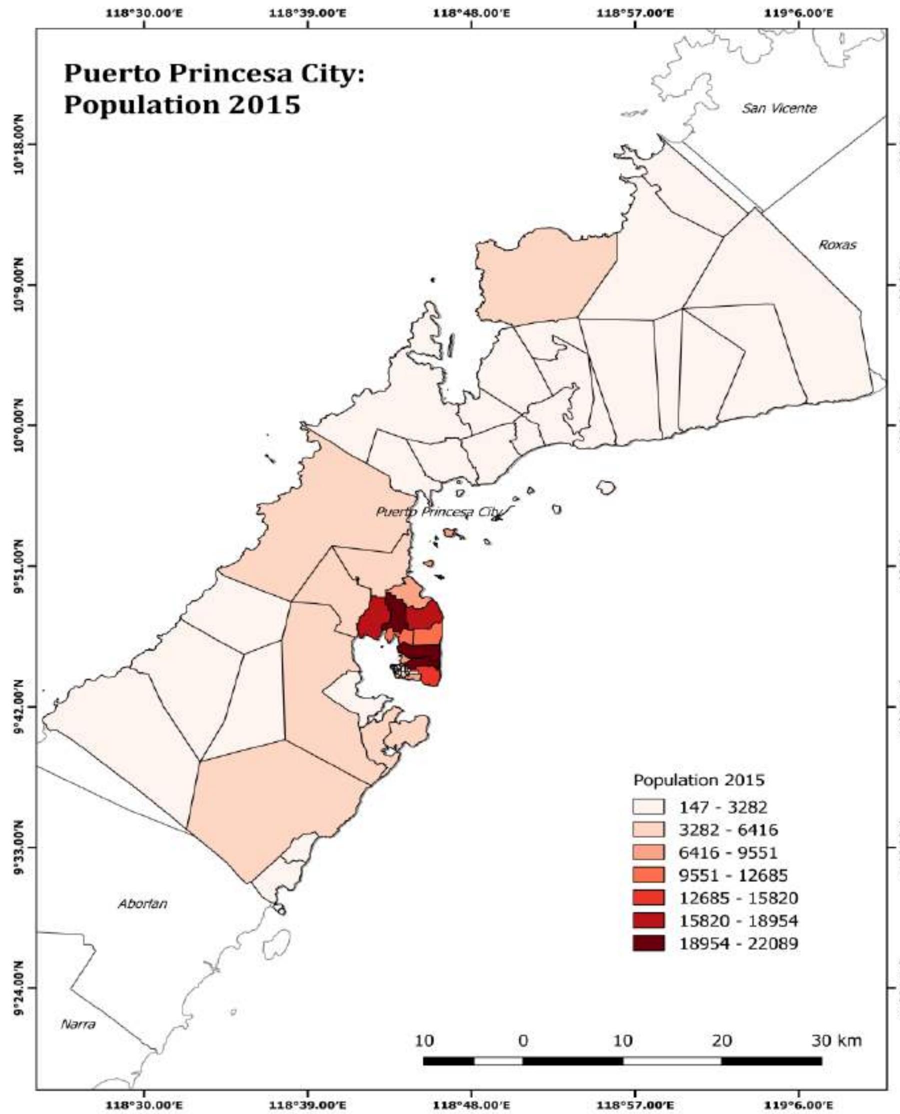



***Map 3.4.3****. Puerto Princesa City Historical Seasonal Temperature (Source: PAGASA data)*

## Socio-Economic Characteristics

### *Population*

The city has a total of 66 *barangays*,35 of which are urban and the rest are rural *(Population Table Annex)*. The majority of the city's population is concentrated on the eastern coast of the city, these are where the urban *barangays* can be found and where the built up areas are located ***(Map 3.4.4 and 3.4.6)***. As of 2015 the city has total population of 255,116 with an estimated population density of 116 persons per square kilometer. The most populous *barangays* are: San Pedro with a population of 22,089; *Barangay* Santa Monica with a population of 20,094; *Barangay* San Miguel with a population 19,649; *Barangay* San Jose with a population of 17,521; and *Barangay* Sicsican with a population of 15,861[1].




***Map 3.4.4.*** *Barangay Population Map (Source PSA data)*

## *Education*

At the tertiary level, Puerto Princesa City has two state universities, the Palawan State University in *Barangay* Tiniguiban and the Western Philippines University in *Barangay* Sta. Monica. In addition, six private colleges and universities and 14 private technical vocational schools exist in the city. In the secondary level, three were seven schools in the urban area and the remaining distributed among rural *barangay* clusters. There are 75 elementary schools 23 of which are located in urban *barangays* and 52 in the rural. This yields a classroom-student ration of 1:46, slightly over the national standard of 1:45. In terms of urban-rural comparison, the urban area

[1]Philippine Statistics Authority, 2015

schools had an enrollment of 22,050 housed in 433 classrooms or a ratio of 1 classroom for every 51 students. In the rural areas there were 9,357 pupils sharing 255 classrooms or a ratio of 1:37.

### *Economic Activities*

- ***Agriculture***

Major crops grown in the city are classified as permanent and annual/seasonal crops. Permanent crops covering 68% of the total area planted in 2012 (13,556.03 has.) include fruit trees, plantation crops and agro-forest, while the remaining 32% planted to seasonal crops is dominated by irrigated, non-irrigated and upland rice, corn, vegetables and root crops.

- ***Livestock***

The city produces five major livestock and poultry such as carabaos, cattle, chickens, goats, and hogs. Two multinational poultry enterprises operate in the city: Swift food Inc. and Magnolia Food Inc. It continued to grow in the succeeding years with the help of two multinational poultry enterprises namely Swift Food Inc. and Magnolia Food, Inc.

- ***Fisheries***

Puerto Princesa City is surrounded by bodies of water and 79% or 52 of its 66 *barangays* are located in coastal fringes. There approximately 5,991 fishermen in the city with an estimated fish harvest of 16,690 Metric tons. The fish harvests are marketed to export business as well as locals. Furthermore, the city has approximately 134 fishponds found within it.

- ***Tourism***

The city is home to a UNESCO World Heritage site which is the Puerto Princesa Subterranean River National Park also known as the Underground River. The underground river covers approximately 22,000 hectares of the land area of the city and is home to unique flora and fauna. The said site has been known as a frequented tourist area.

## Infrastructure

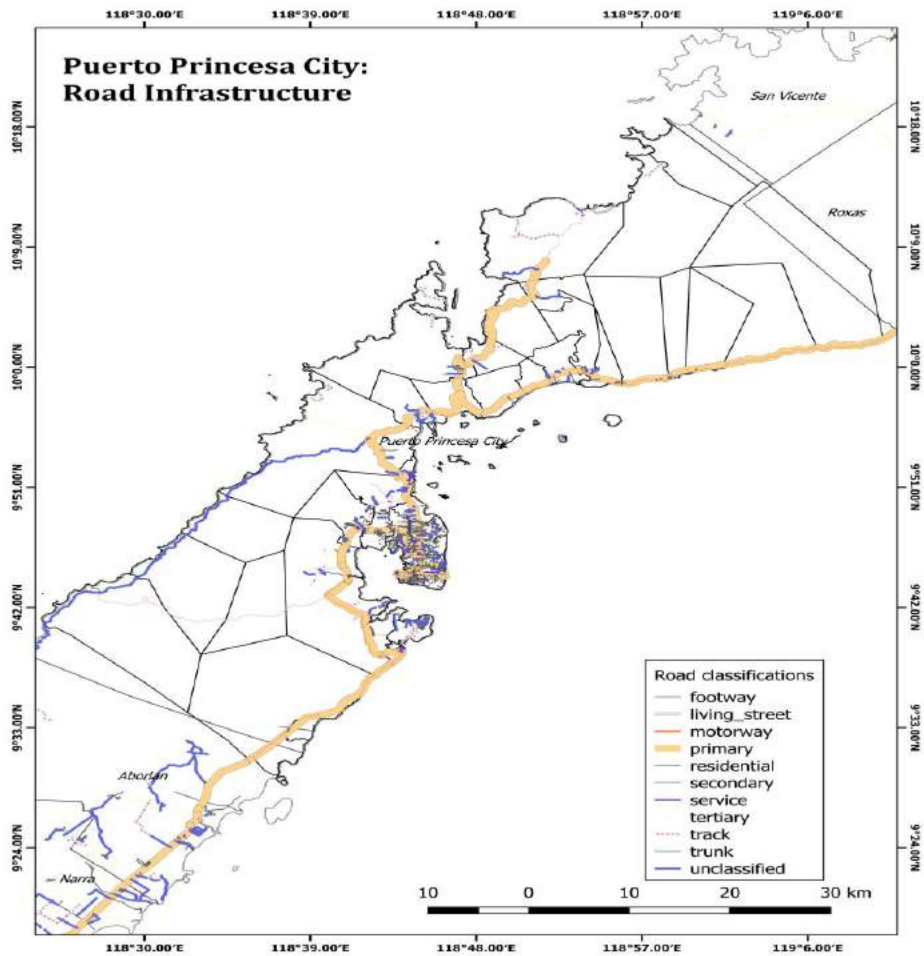
### *Transportation*

The city of Puerto Princesa is a transportation hub and the main gateway to the rest of Palawan. The city offers air, land, and sea transportation. The Puerto Princesa City Port is located at the Puerto Princesa Strait and is considered a first class port. The city also has the Fish Port Complex located at Barangay Matahimik wherein the commercial and municipal fishers are catered able to accommodate up to 30 fishing boats. Along with these ports, the city also features seven fish wharves in the *barangays* of Mangingisda, Bancao, Bancao, Macarascas, Bahile, Cabuyugam, Sta. Lourdes, and Bagong Sikat. The Puerto Princesa airport offers daily flight in hourly intervals.

The main means of land transportation in the city are tricycles and multi-cabs with registered tricycles number 3,622. Taxis have also begun transportation in the city. Shuttle vans, buses, and jeepneys provided transportation within the city and to other municipalities *(Puerto Princesa City ECAN Resource Management Plan 2016).*

### *Roads*

The total road network in the city covers approximately 861.31 kilometers. These roads consist of 28.39% national road, 30.28% city road, and 41.33% rural road. The two main roads that pass through the city are the Puerto Princesa North and South Roads. In terms of coverage, 59% of the roads are covered in gravel, 34% of the roads are covered in concrete, 5% are covered in asphalt, and 3% are covered in earth.




***Map 3.4.5.*** *Road Infrastructure Map*

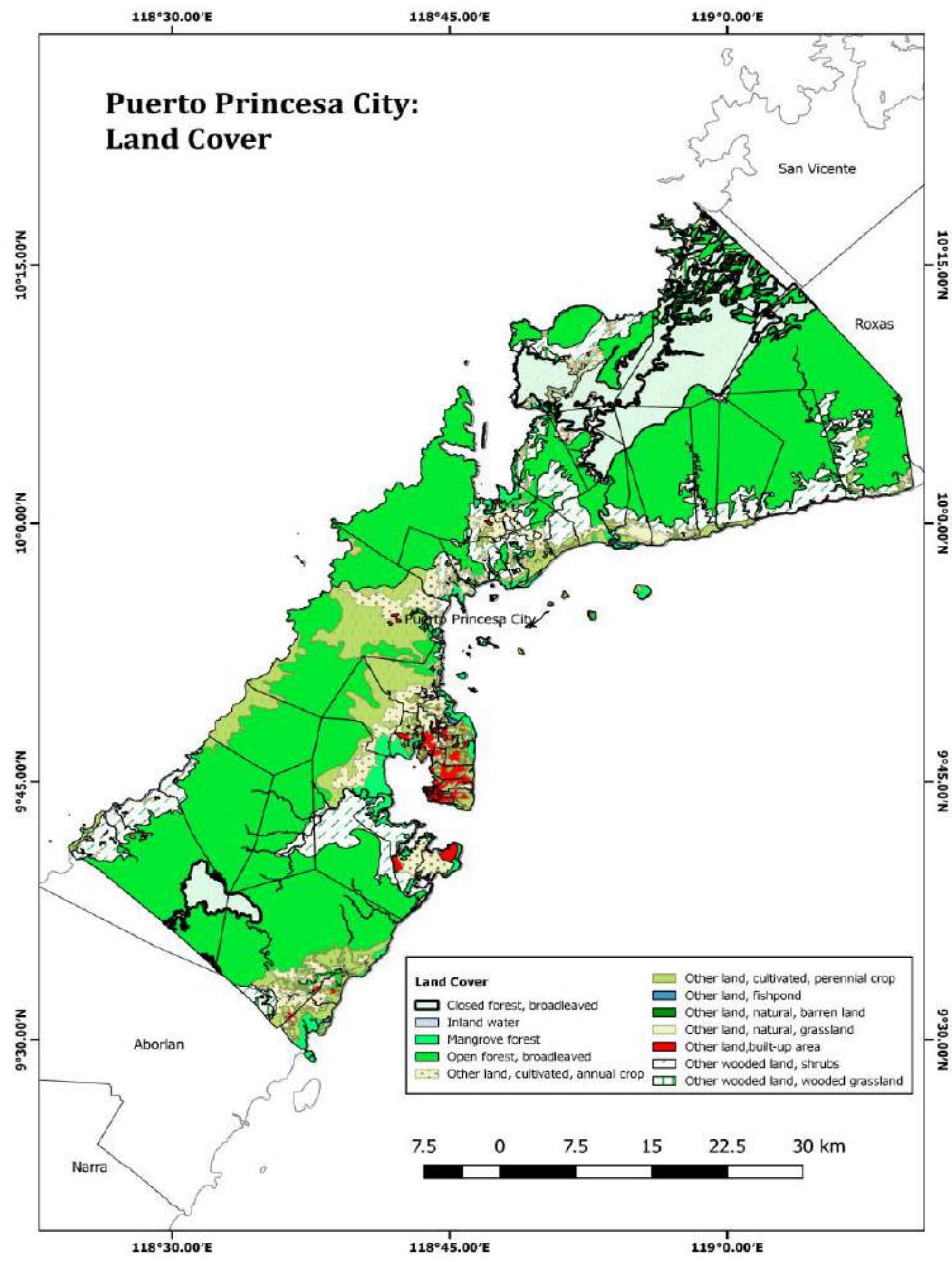
### *Water*

The main sources of water in the city are 21 deep wells, a fresh water spring, and a surface water supply source which is mainly available in the built up areas in the city. Only 3.85% of households in the city are supplied with safe water *(Puerto Princesa City ECAN Resource Management Plan 2016).*

### *Electricity*

The city's electricity is provided by PALECO and the Sabang Renewable Electric Corporation. PALECO provides for 58 of the 66 barangays with one barangay being serviced by the Sabang Renewable Electric Corporation. The remaining 7 barangays rural and are located in west coast if the city.

## Land Cover




***Map 3.4.6.*** *Land Cover Class (Source: GDEM 2010)*

***Table 3.4.1.*** *Puerto Princesa Land Cover (Source: GDEM 2010)*

| **Puerto Princesa City Land Cover (2010)** | | |
|---|---|---|
| **Land Cover Class** | **Area (ha) Derived from GIS calculations** | **Percent** |
| Other land, cultivated, annual crop | 11345.81 | 5.21% |
| Other land,built-up area | 3357.647 | 1.54% |
| Closed forest, broadleaved | 25842.79 | 11.86% |
| Other land, fishpond | 256.6916 | 0.12% |
| Other land, natural, grassland | 1560.38 | 0.72% |
| Inland water | 859.684 | 0.39% |
| Mangrove forest | 6217.3 | 2.85% |
| Open forest, broadleaved | 118936.7 | 54.60% |
| Other land, natural, barren land | 22.85058 | 0.01% |
| Other land, cultivated, perennial crop | 18780.11 | 8.62% |
| Other wooded land, shrubs | 27265.46 | 12.52% |
| Other wooded land, wooded grassland | 3394.249 | 1.56% |
| **Total** | **217839.6** | **100.00%** |

The city as covered primarily in forest and wooded land, occupy approximately 80.544 percent of its total land area, with an isolated area in the eastern coast of the city as built up ***(Map 3.4.6)***. The forest land is composed of broadleaved open forest, wooded grassland, shrub land, and broadleaved closed forest. Crop land in the city occupies approximately 13.83 percent of the city with a larger portion of the percentage belonging to perennial crops. The built-up area in the city makes up only 1.54 percent of its total area and is only isolated in small portions on the eastern coast of the city. This is largely attributed to flat terrain and gentle slopes found on this part of the city ***(Map 3.4.1)***. The approximate area covered by mangrove forests is even larger than that of the built-up, occupying 2.85% of the city's land area.

Beyond the largely forest covered land mass of the city, there are coral reefs and rich coastal resources found within the seas next to the city. There are areas in the western coast of the city that have coral cover which are frequented by various marine animals such as sea turtles and shark particularly in the Ulugan Bay. The eastern seaboard of the city has good to excellent conditions, in particular large areas of soft corals can be found in the Honda Bay. Hard corals can also be found in the eastern coast of the city. Within the Honda Bay and the Puerto Princesa Bay, seagrass communities can also be found *(Puerto Princesa City LGU 2014)*.

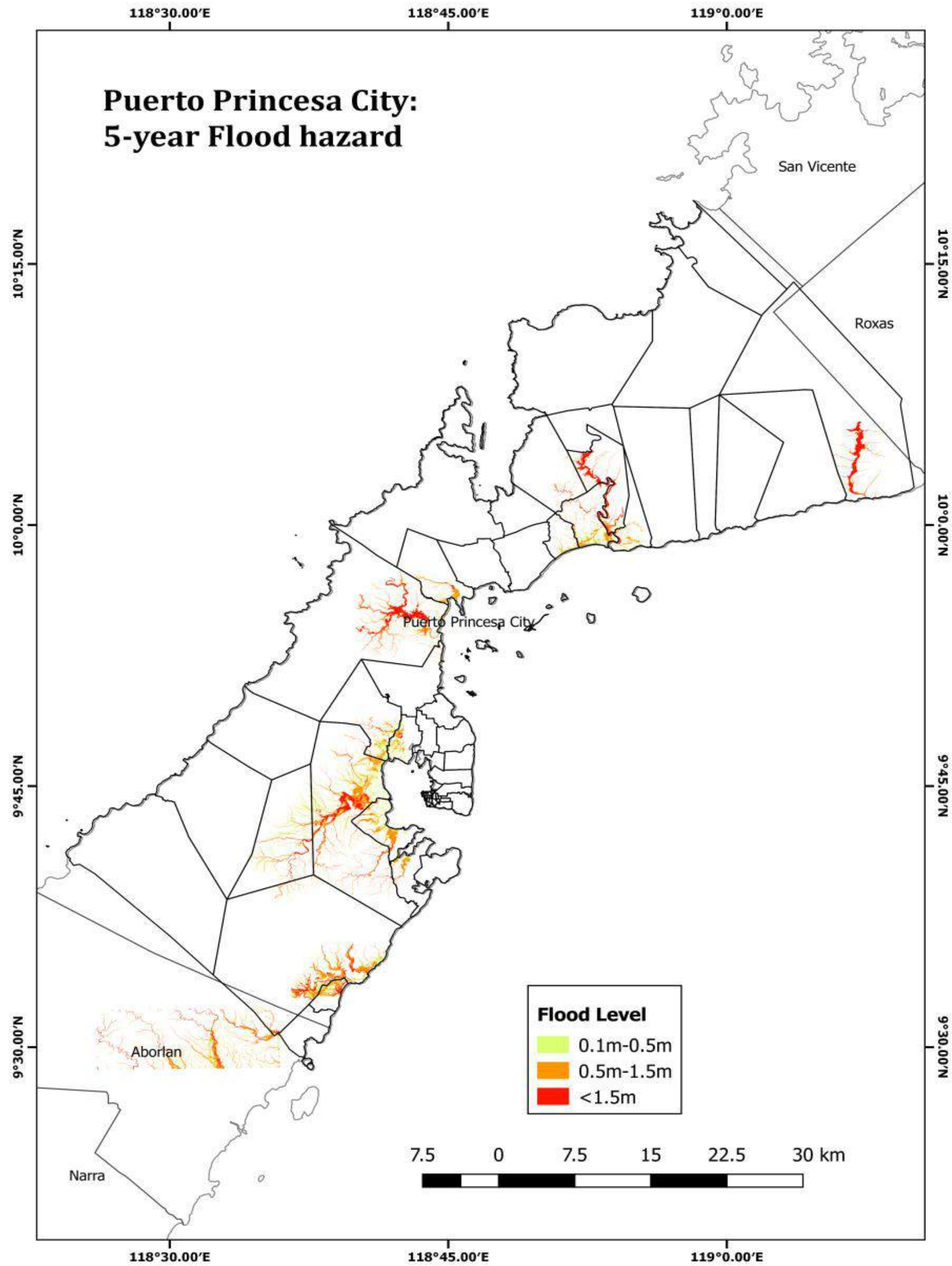
## Climatic Hazards

### *Flood Hazard*

The flood hazards in the city are primarily found on its eastern coasts. The eastern coasts are where the gentle slopes and flat terrain is located as well as four major rivers; hence floods empty out in this region.

### *Five (5) Year Return Period*

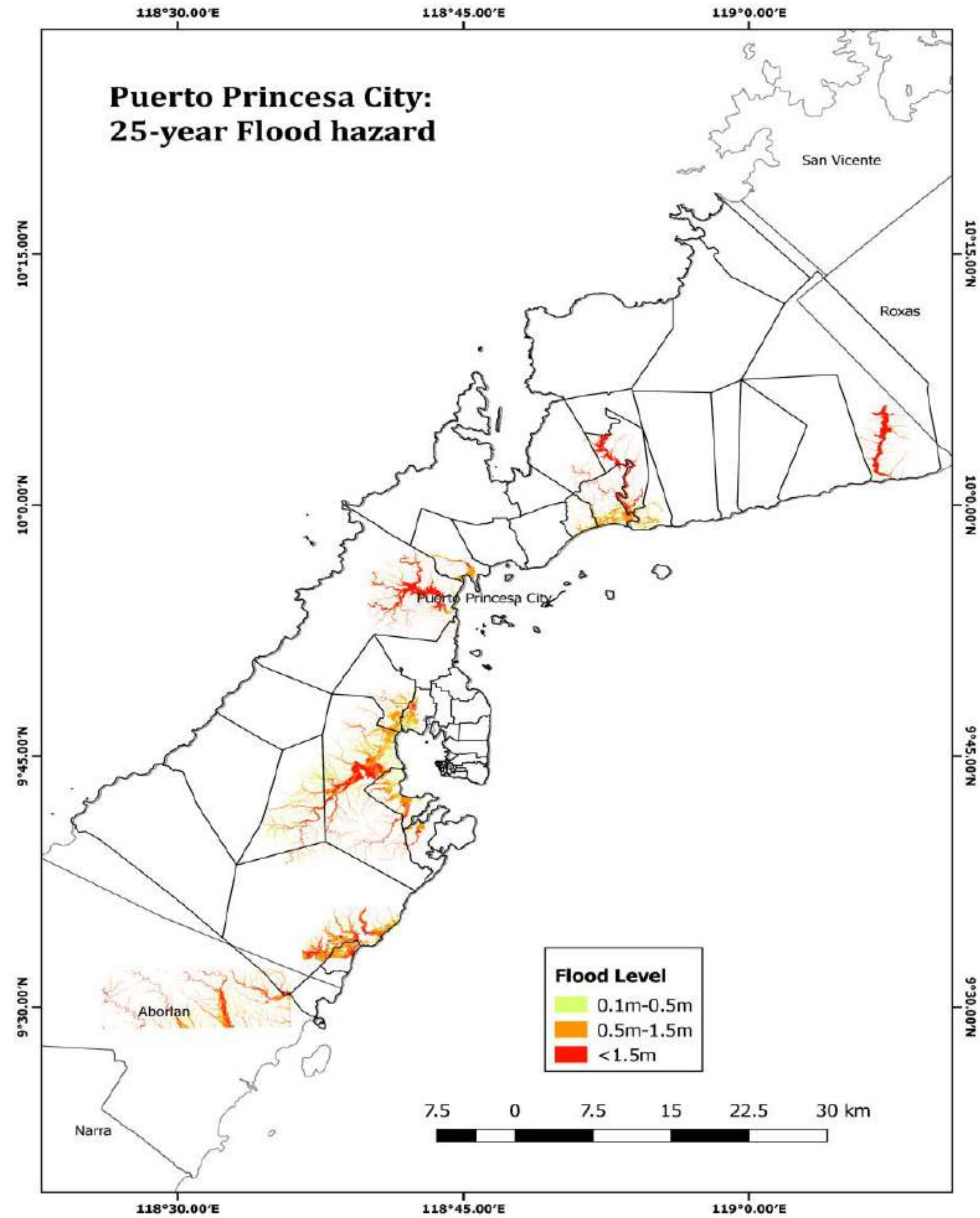
There is a 1/5 (20%) probability of a flood with 5 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 156.400 mm.




***Map 3.4.7.*** *5-Year Flood Hazard Map (Source: DREAM Project)*

*25 Year-Return Period*

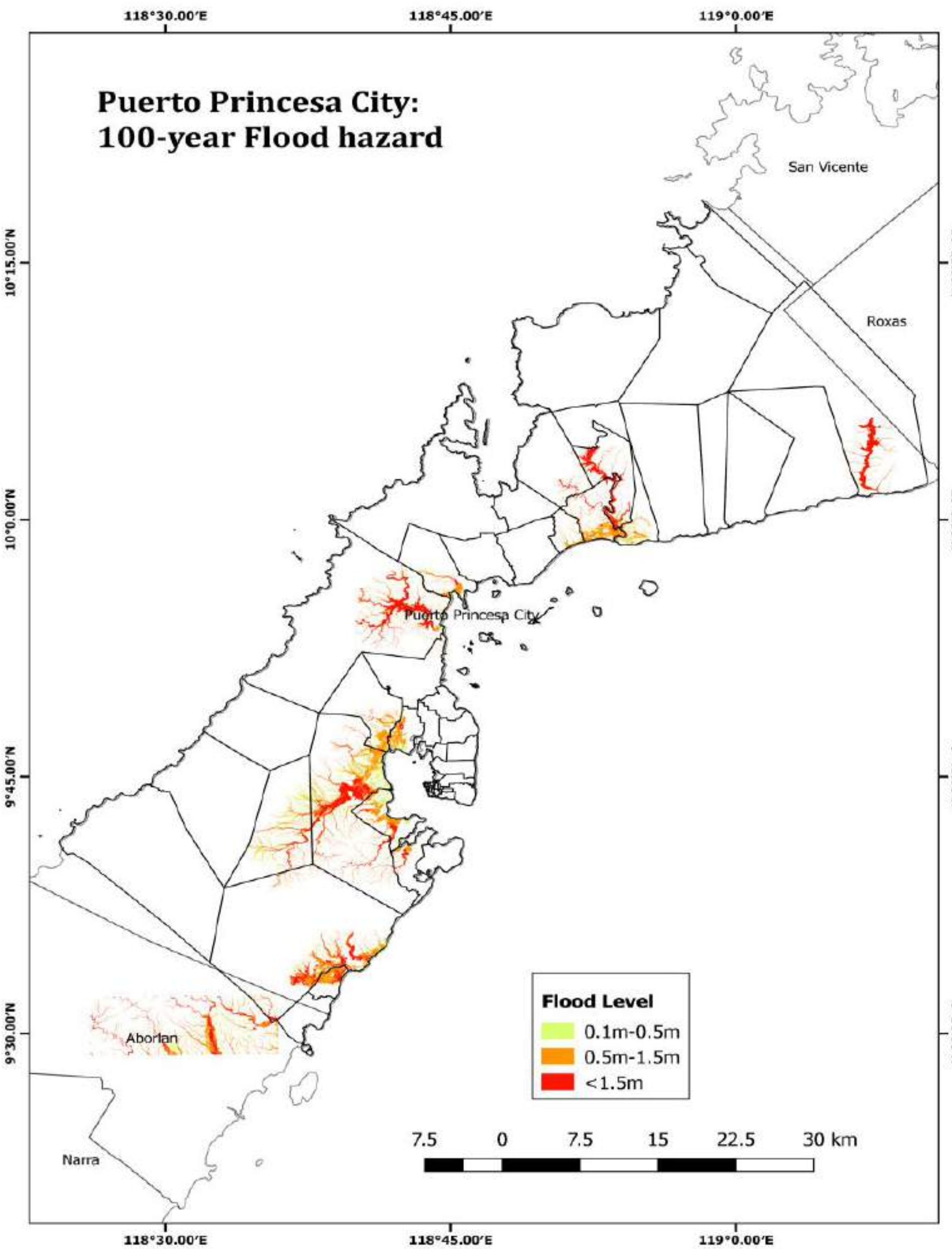
There is a 1/25 (4%) probability of a flood with 25 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 234.900 mm.




***Map 3.4.8**. 25-Year Flood Hazard Map (Source: DREAM Project)*

*100-Year Return Period*

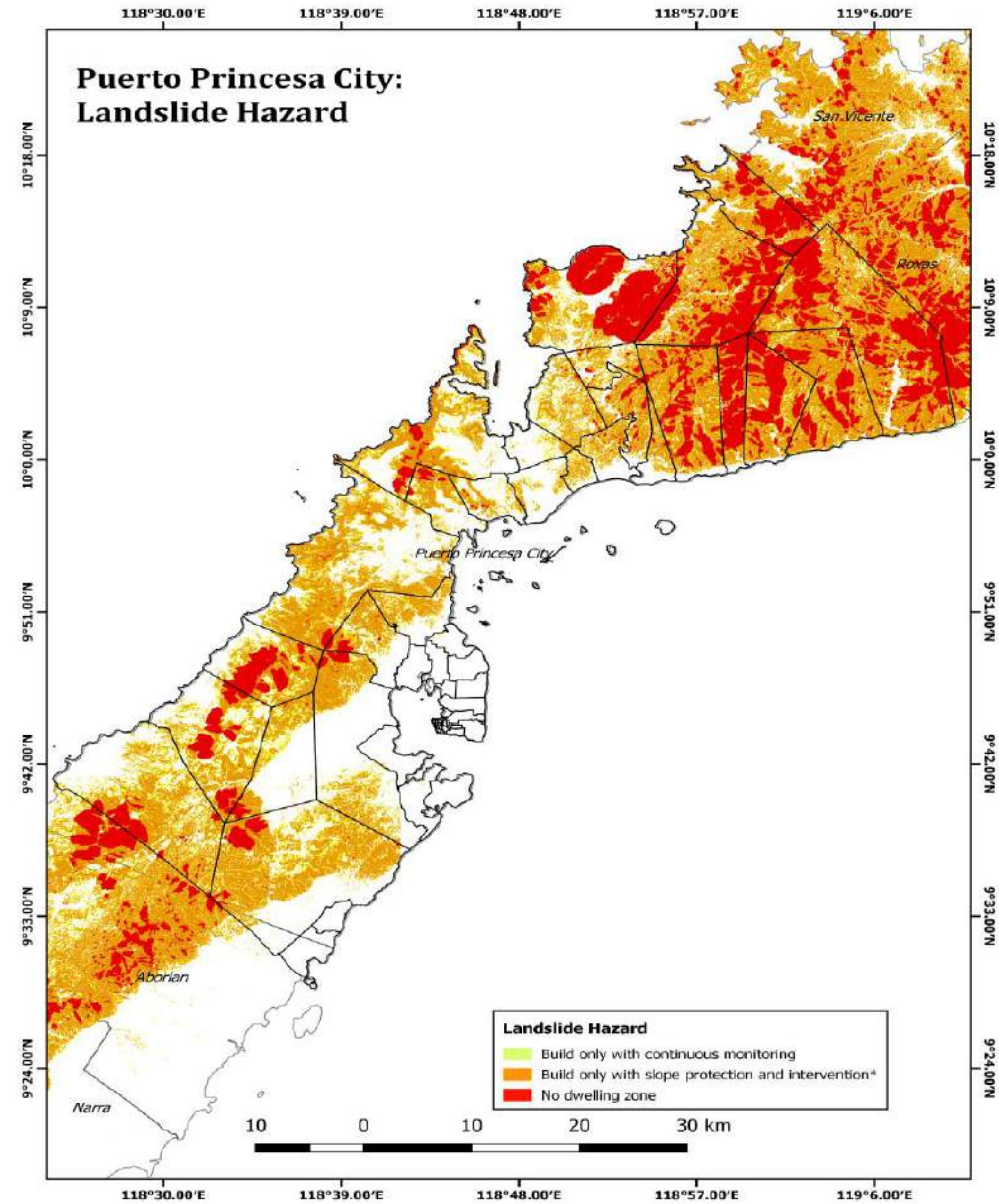
There is a 1/100 (1%) probability of a flood with 100 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 299.600mm.




***Map 3.4.9.*** *100-Year Flood Hazard Map (Source: DREAM Project)*

### Landslide Hazard

Landslide hazards cover a large portion of the city. This is mainly because of the mountainous and highland areas that cut across the city ***(Map 3.4.10)***. Fortunately, these hazards are isolated in the rural areas of the city near its western coast and are not found within the highly urbanized areas found in its eastern coast.




***Map 3.4.10.*** *Landslide Hazard Map (Source: DREAM Project)*

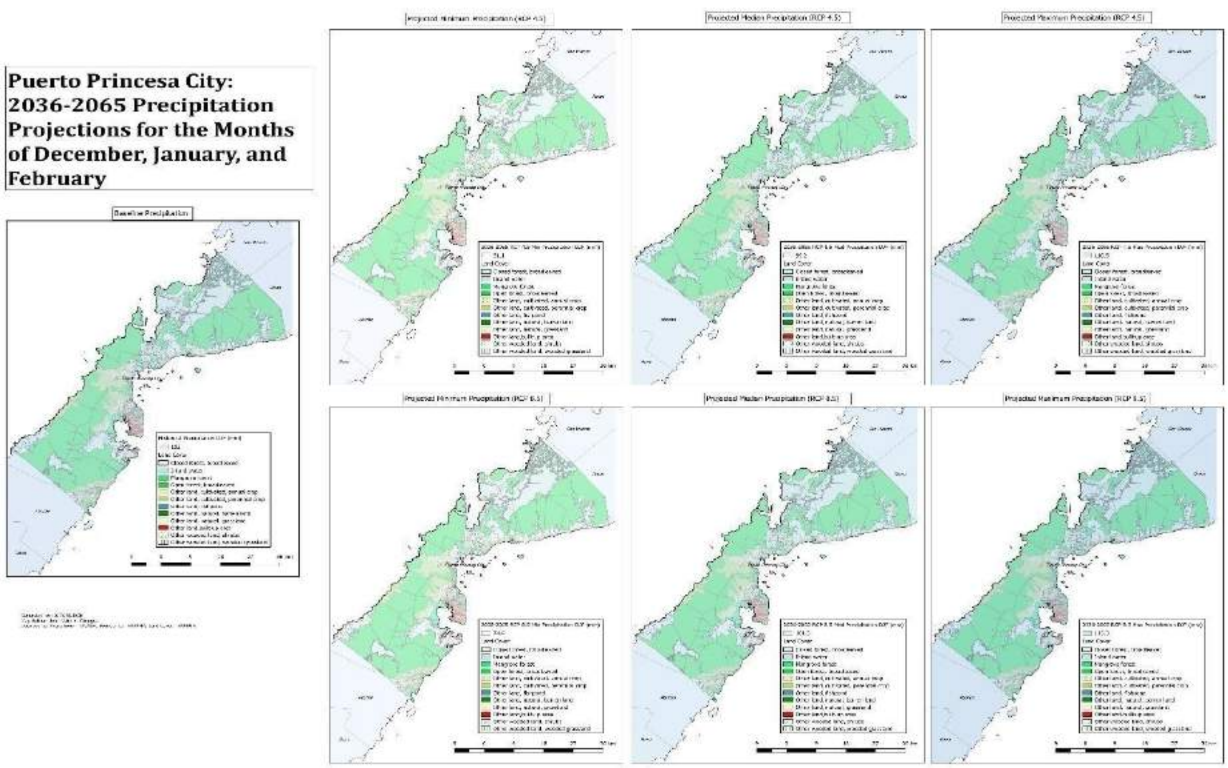
### Projections and Grid Extent (data on Projections come from PAGASA)

*Change in Precipitation*

The general trend through all the projections is a decrease of precipitation, particularly in the late century. Most of the projections, under both scenarios in most of the months,show that the whole range of values below the historical baseline. The details of these projections are found below.

#### Mid-21st Century Projections (2036-2065), Maps 11-14

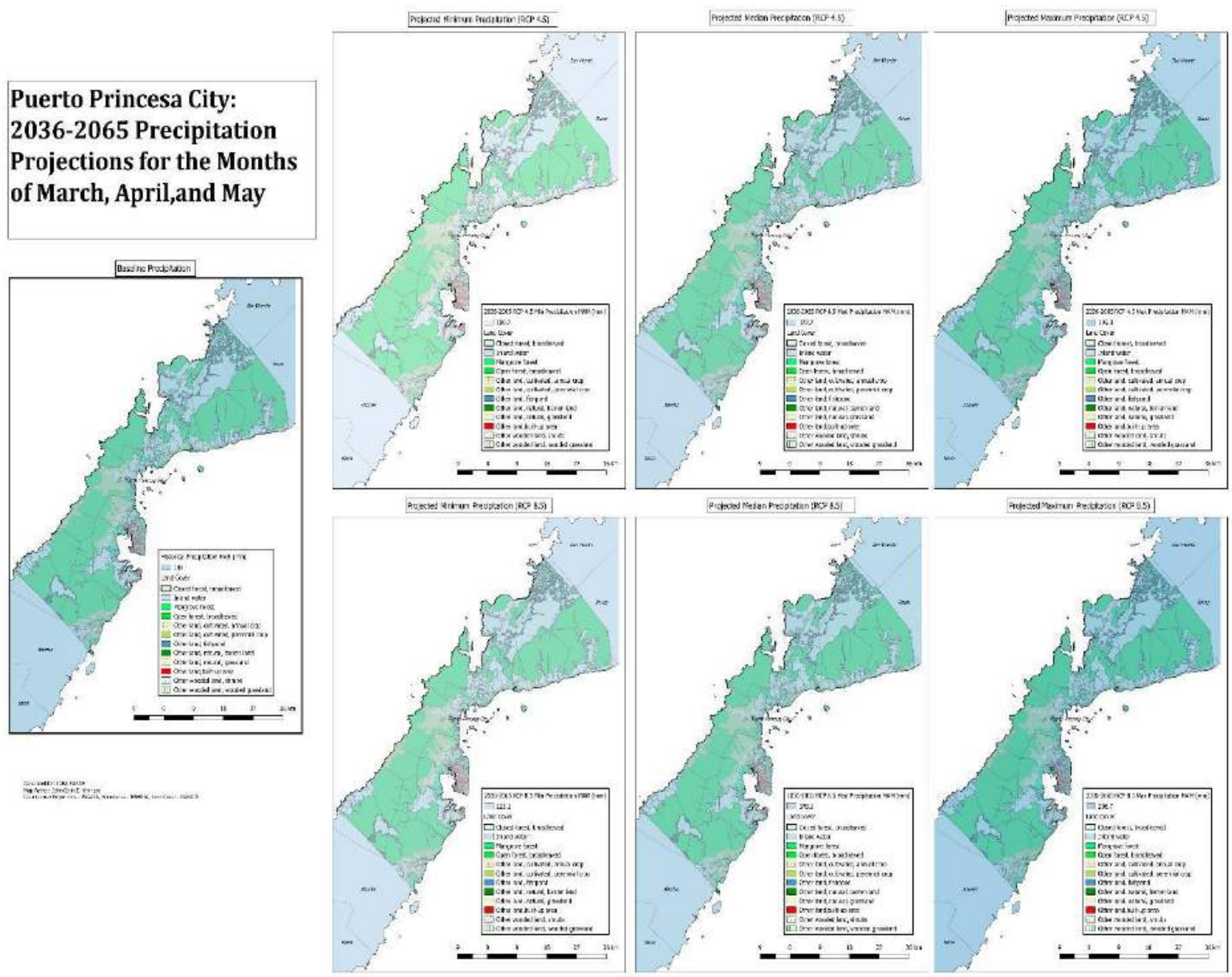
The months of December, January, February are projected to be drier than the historical baseline based on the projected median values under both scenarios ***(Map 3.4.11)***. The projected decrease is only slightly below the base line with RCP 4.5 being drier than RCP 8.5. What is notable is that the projected minimum values significantly below the historical baseline which projects the possibility of extreme dry events. The projected median precipitation value under RCP 4.5 is a decrease of 2.6% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 0.5%. On the other hand, the projected minimum precipitation value for RCP 4.5 is a 49.8% decrease from the historical baseline while under RCP 8.5 there is a projected 26.9% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is an 8.5% increase from the historical baseline while under RCP 8.5 there is a projected 13.3% increase from the baseline.




***Map 3.4.11.*** *2036-2065 Precipitation Projections for December, January, and February (Source: PAGASA data)*

The months of March, April, and May are projected to be drier than the historical baseline based on the projected median values under both scenarios ***(Map 3.4.12)***. The trend for these months continue that of the previous months in that RCP 4.5 is drier than RCP 8.5 and that the projected minimum values project the possibility of extreme dry events. The projected median precipitation value under RCP 4.5 is a decrease of 8.8% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 5.9%.

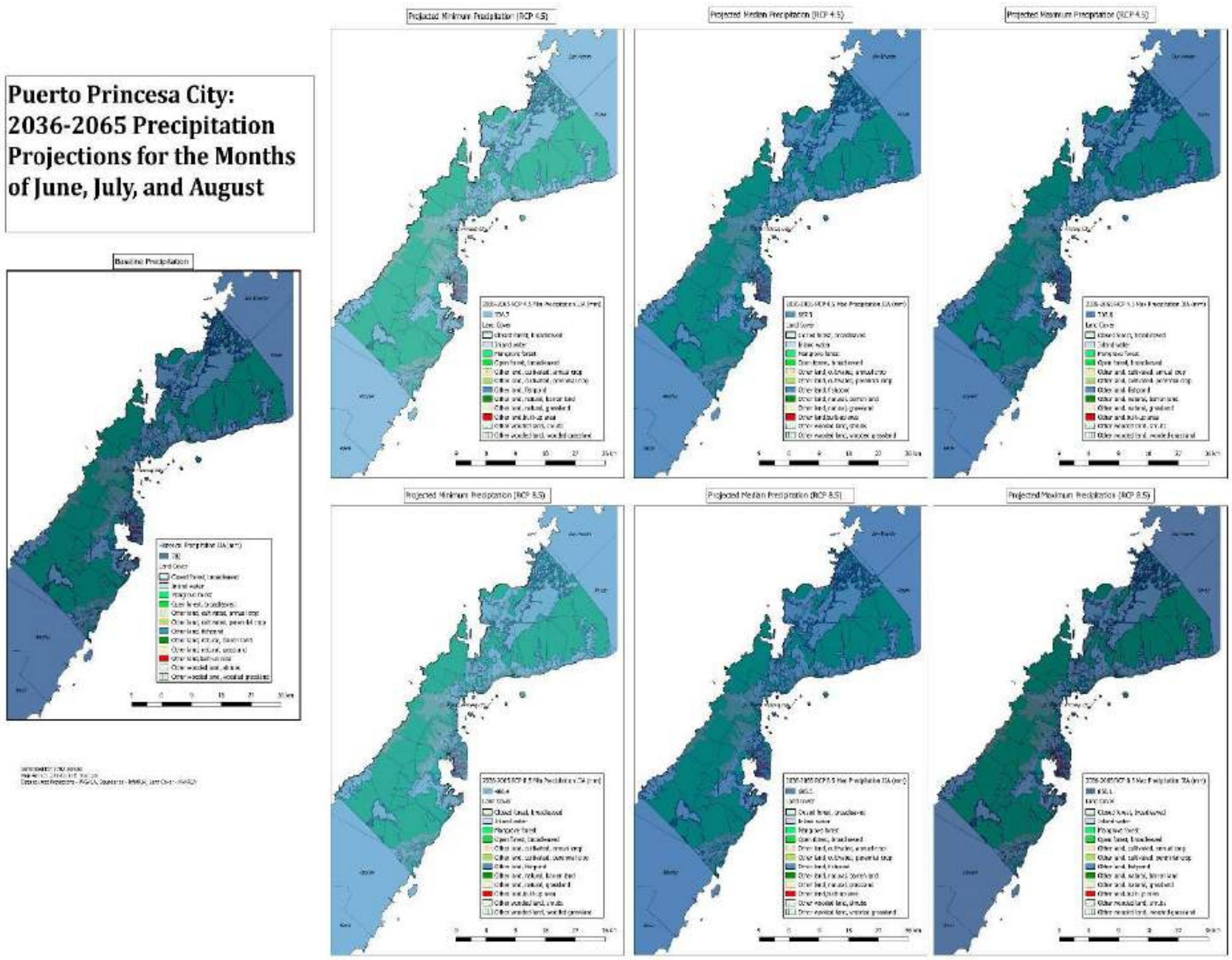
On the other hand, the projected minimum precipitation value for RCP 4.5 is a 46.8% decrease from the historical baseline while under RCP 8.5 there is a projected 35% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 3.1% increase from the historical baseline while under RCP 8.5 there is a projected 9.2% increase from the baseline.




***Map 3.4.12.*** *2036-2065 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are projected to have a marked decrease from historical baseline based on the projected values under both scenarios ***(Map 3.4.13)***. In particular, RCP 4.5 is projected to be significantly drier because its whole range of values is found below the historical baseline. The projected median precipitation value under RCP 4.5 is a decrease of 14.6% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 11%.

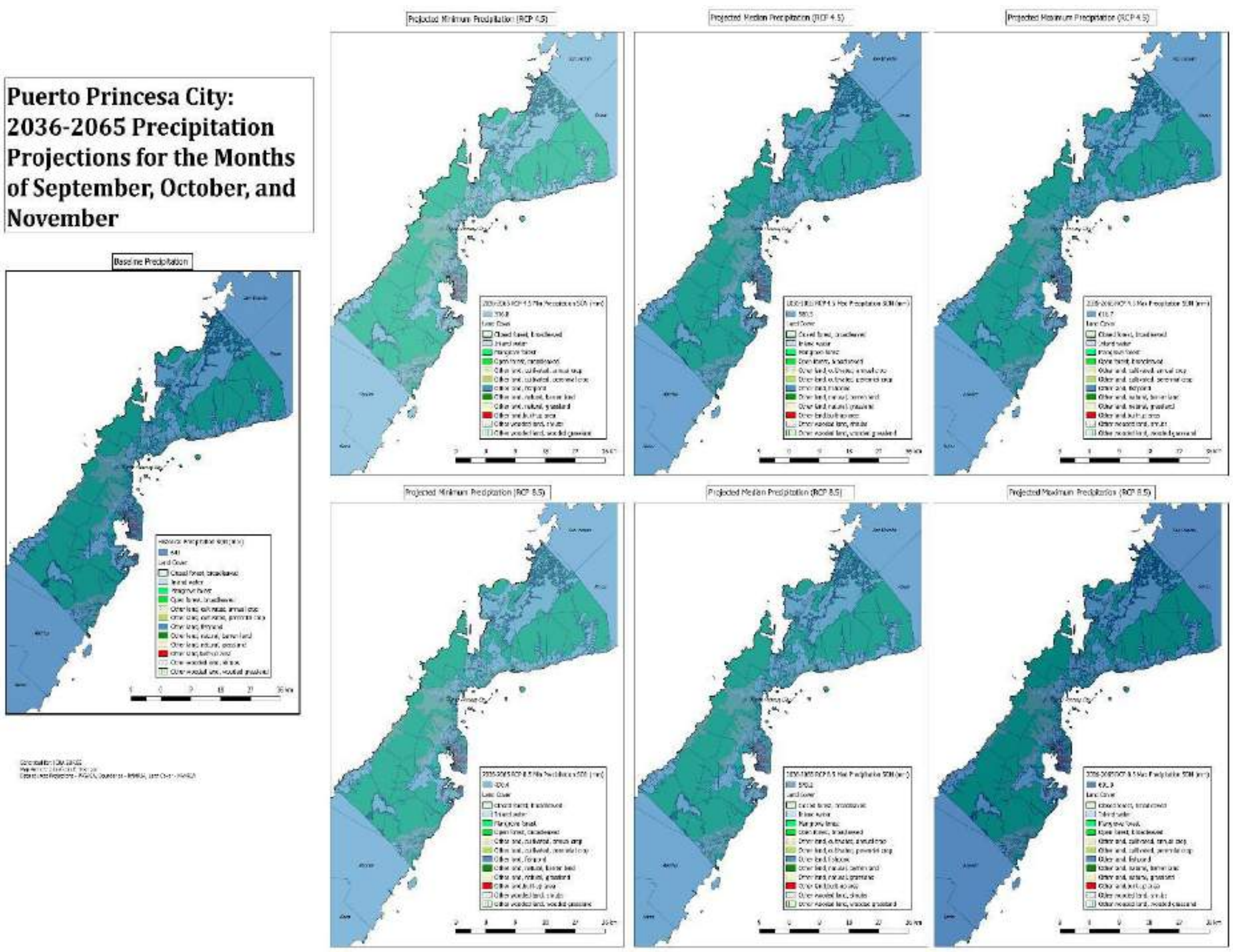
On the other hand, the projected minimum precipitation value for RCP 4.5 is a 56.9% decrease from the historical baseline while under RCP 8.5 there is a projected 37.8% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 10.1% decrease from the historical baseline while under RCP 8.5 there is a projected 8.7% increase from the baseline.




***Map 3.4.13.*** *2036-2065 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to be drier than their historical baseline based on the projected median values under both scenarios ***(Map 3.4.14)***. Similar to the previous months, the scenario under RCP 4.5 is significantly drier because its whole range of values is below the historical baseline. The projected median precipitation value under RCP 4.5 is a decrease of 8.4% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 9.7%.

On the other hand, the projected minimum precipitation value for RCP 4.5 is a 50.5% decrease from the historical baseline while under RCP 8.5 there is a projected 26.6.8% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 3.7% decrease from the historical baseline while under RCP 8.5 there is a projected 8% increase from the baseline.



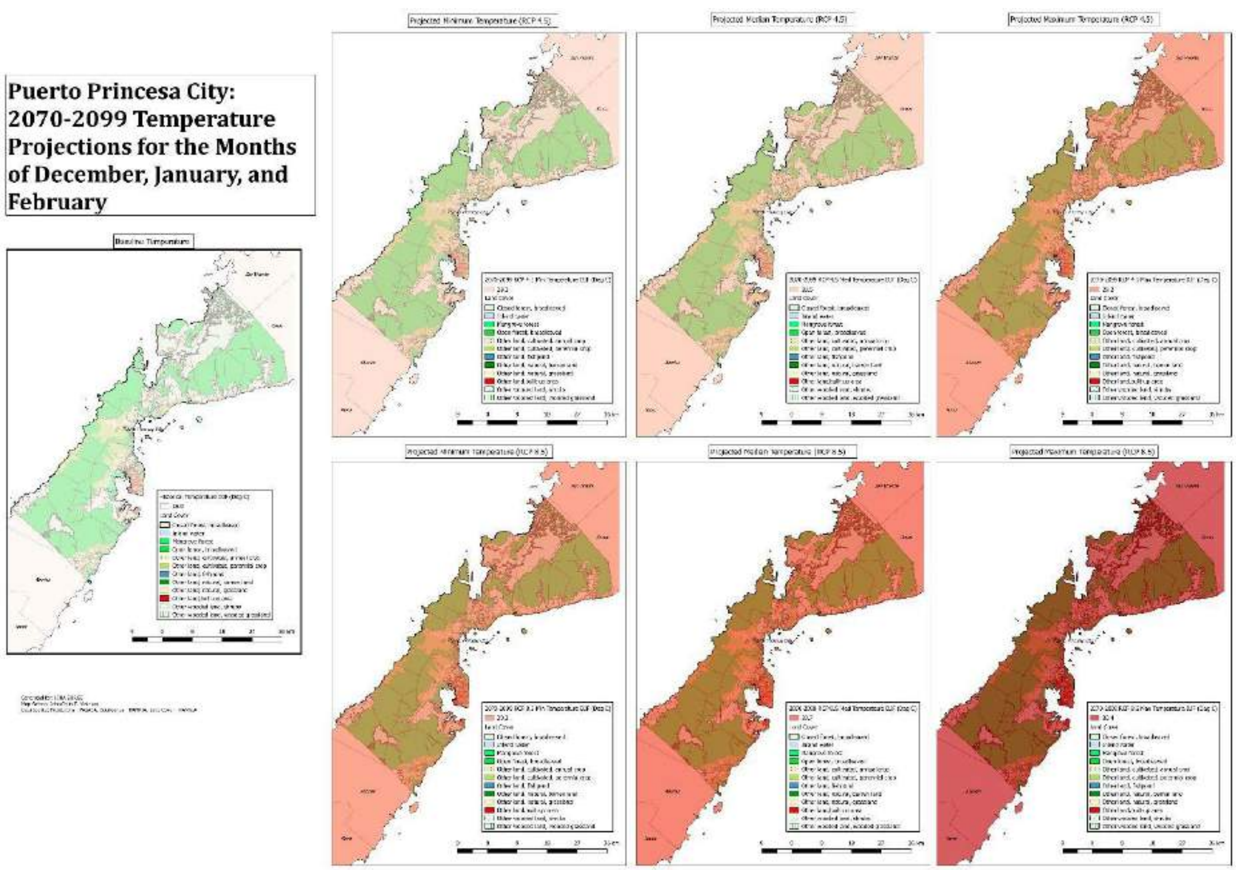

***Map 3.4.14.*** *2036-2065 Precipitation Projections for September, October, and November (Source: PAGASA data)*

### Late 21st Century Projection (2070-2099), Maps 15-17

The projections in the late century for precipitation are significantly drier than the historical baseline. For both scenarios, most months are projected to have the whole range of values below the historical baseline. The details of these projections are found below.

The months of December, January, and February are projected to be significantly drier than the historical baseline based on the projected median values of both scenarios ***(Map 3.4.15)***. In particular, the months under RCP 8.5 are projected be drier. The projections under RCP 4.5 on the other hand a has wider range of values which show the possibility of both extreme wet and dry events during the said months. The projected median precipitation value under RCP 4.5 is a decrease of 7.4% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 22.3%.

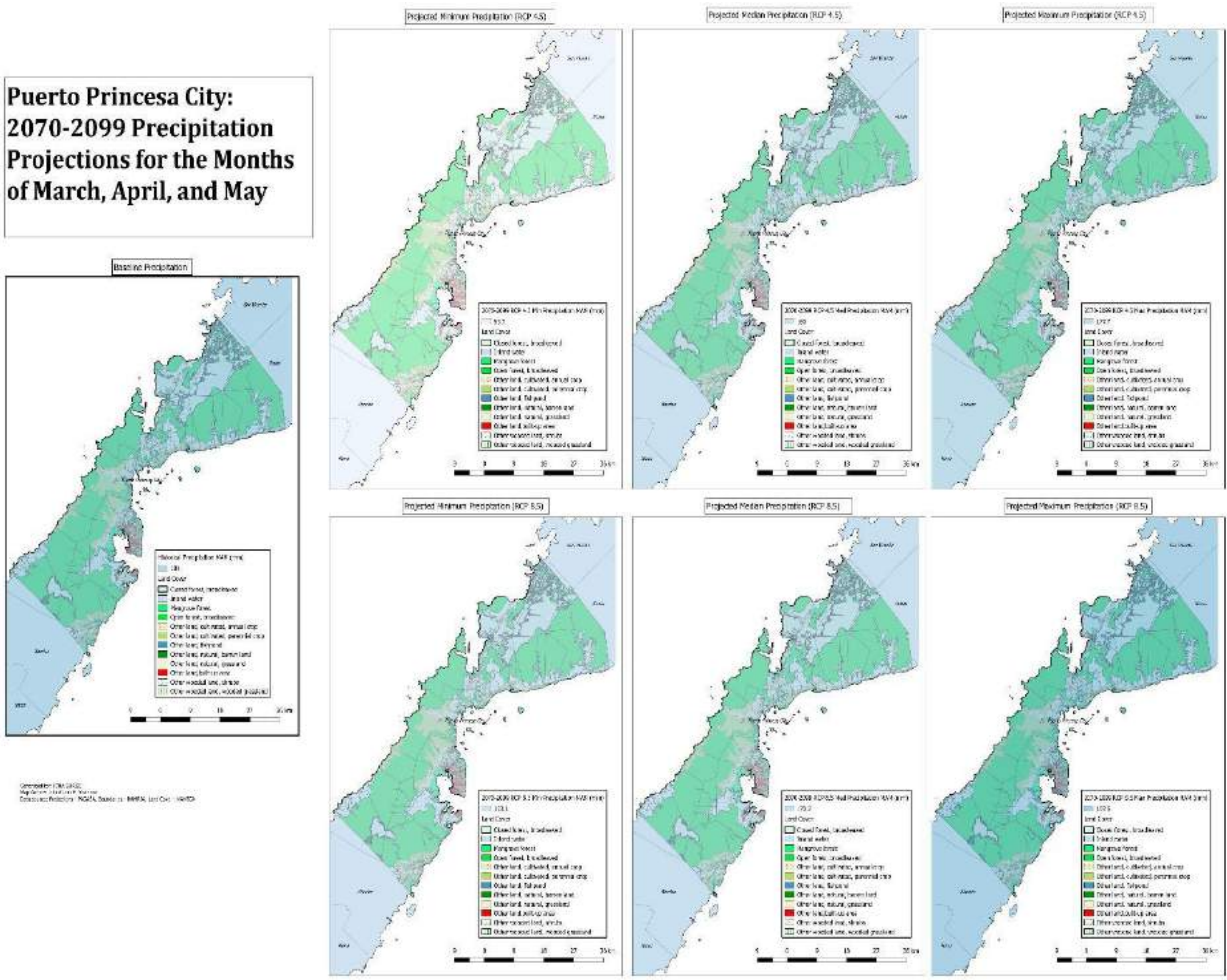
On the other hand, the projected minimum precipitation value for RCP 4.5 is a 55.1% decrease from the historical baseline while under RCP 8.5 there is a projected 54.4% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 12.3% increase from the historical baseline while under RCP 8.5 there is a projected 8.9% increase from the baseline.




***Map 3.4.15.*** *2070-2099 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April, and May are projected to be significantly drier than the historical baseline based on the projected median values of both scenarios ***(Map 3.4.16)***. In particular, under RCP 4.5 the said months are drier because the whole range of values is below the historical baseline. The projected median precipitation value under RCP 4.5 is a decrease of 15.5% from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 10.1%.

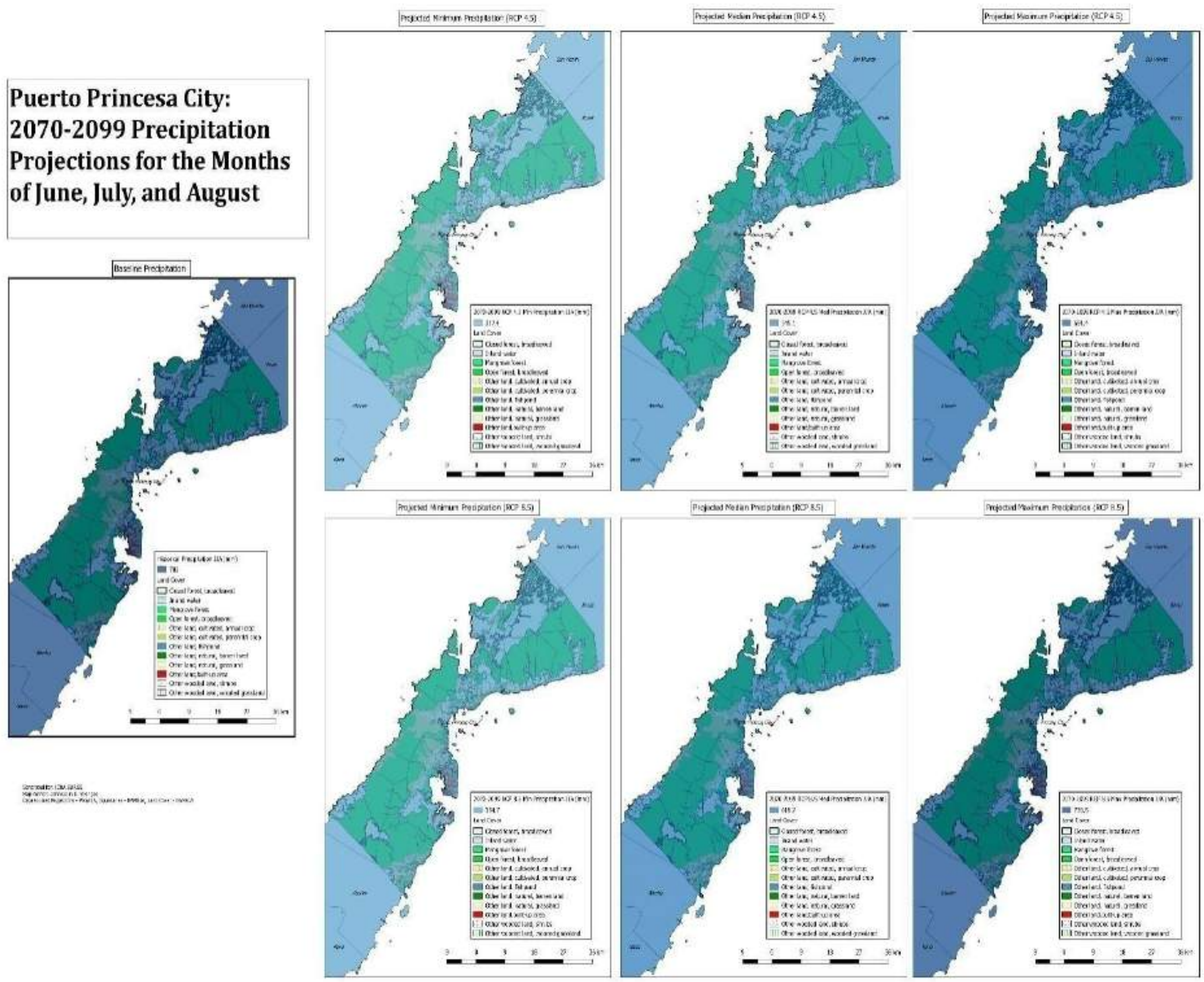
On the other hand, the projected minimum precipitation value for RCP 4.5 is a 50.5% decrease from the historical baseline while under RCP 8.5 there is a projected 35% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 6.2% decrease from the historical baseline while under RCP 8.5 there is a projected 4.3% increase from the baseline.




***Map 3.4.16.*** *2070-2099 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July, and August are significantly drier than the historical baseline based on the whole range of values of both scenarios ***(Map 3.4.17)***. Under RCP 4.5 and RCP 8.5 their whole range of values all fall below the historical baseline for the said months. The scenario under RCP 4.5 is projected to be drier than that under RCP 8.5. The projected median precipitation value under RCP 4.5 is a decrease of 30.3% from the historicalbaseline of the said months while under RCP 8.5 it is a projected decrease of 20.9%.

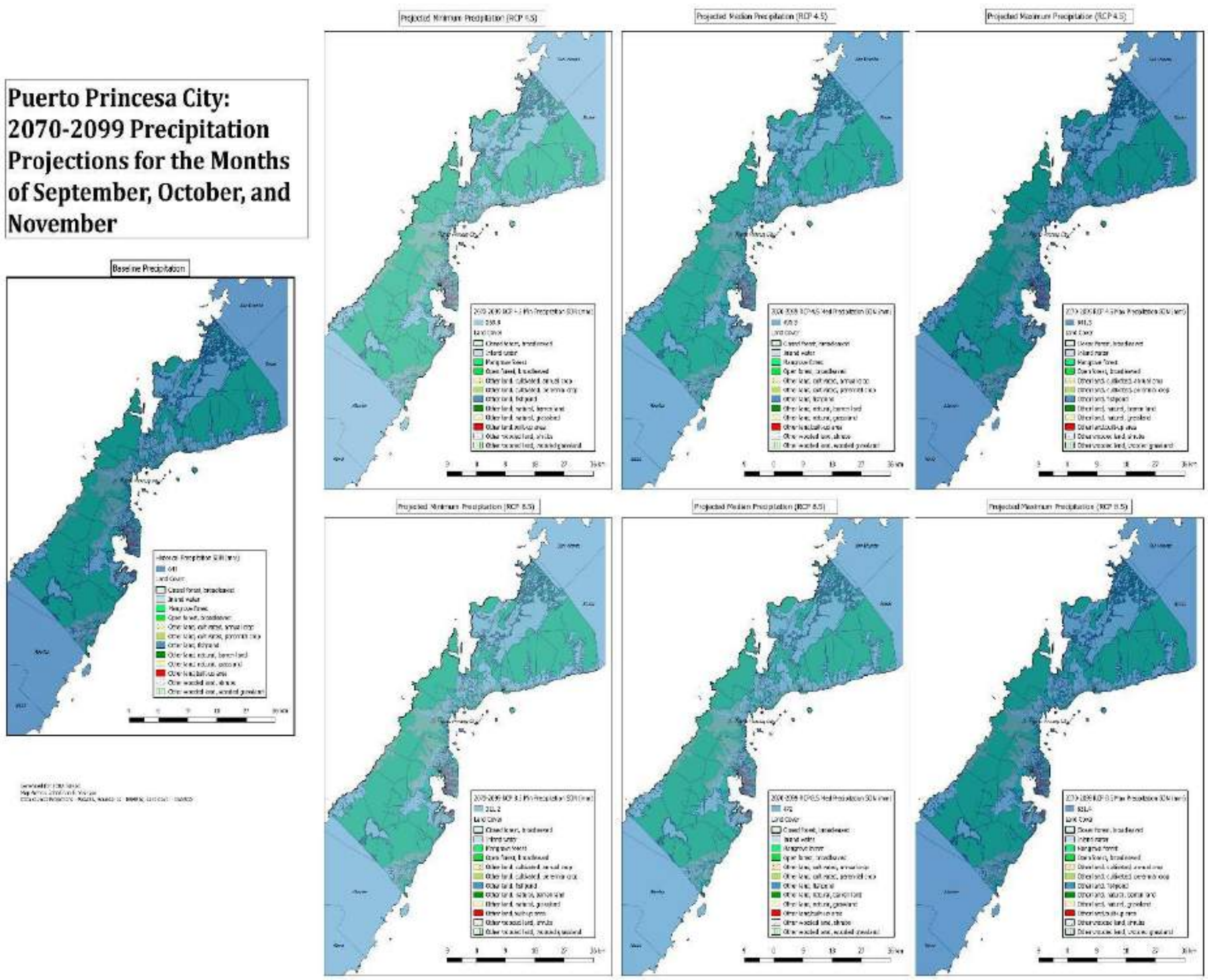
On the other hand, the projected minimum precipitation value for RCP 4.5 is a 59.4% decrease from the historical baseline while under RCP 8.5 there is a projected 54.6% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 11.6% decrease from the historical baseline while under RCP 8.5 there is a projected 5.9% decrease from the baseline.




***Map 3.4.17.*** *2070-2099 Precipitation Projections for June, July, and August (Source: PAGASA data)*

The months of September, October and November are projected to be significantly drier than their historical baseline based on the whole range of values under both scenarios ***(Map 3.4.18)***. In particular, the scenario under RCP 8.5 is projected to be drier because its whole range of values is drier than the historical baseline; also its median value is drier than RCP 4.5. However, the range of values under RCP 4.5 is slightly wider. The projected median precipitation value under RCP 4.5 is a decrease of 23.5 from the historical baseline of the said months while under RCP 8.5 it is a projected decrease of 26.3%.

On the other hand, the projected minimum precipitation value for RCP 4.5 is a 55.4% decrease from the historical baseline while under RCP 8.5 there is a projected 49.9% decrease from the baseline. Lastly, the maximum projected precipitation value under RCP 4.5 is a 0.1% increase from the historical baseline while under RCP 8.5 there is a projected 1.4% decrease from the baseline.




***Map 3.4.18.*** *2070-2099 Precipitation Projections for September, October and November (Source: PAGASA data)*

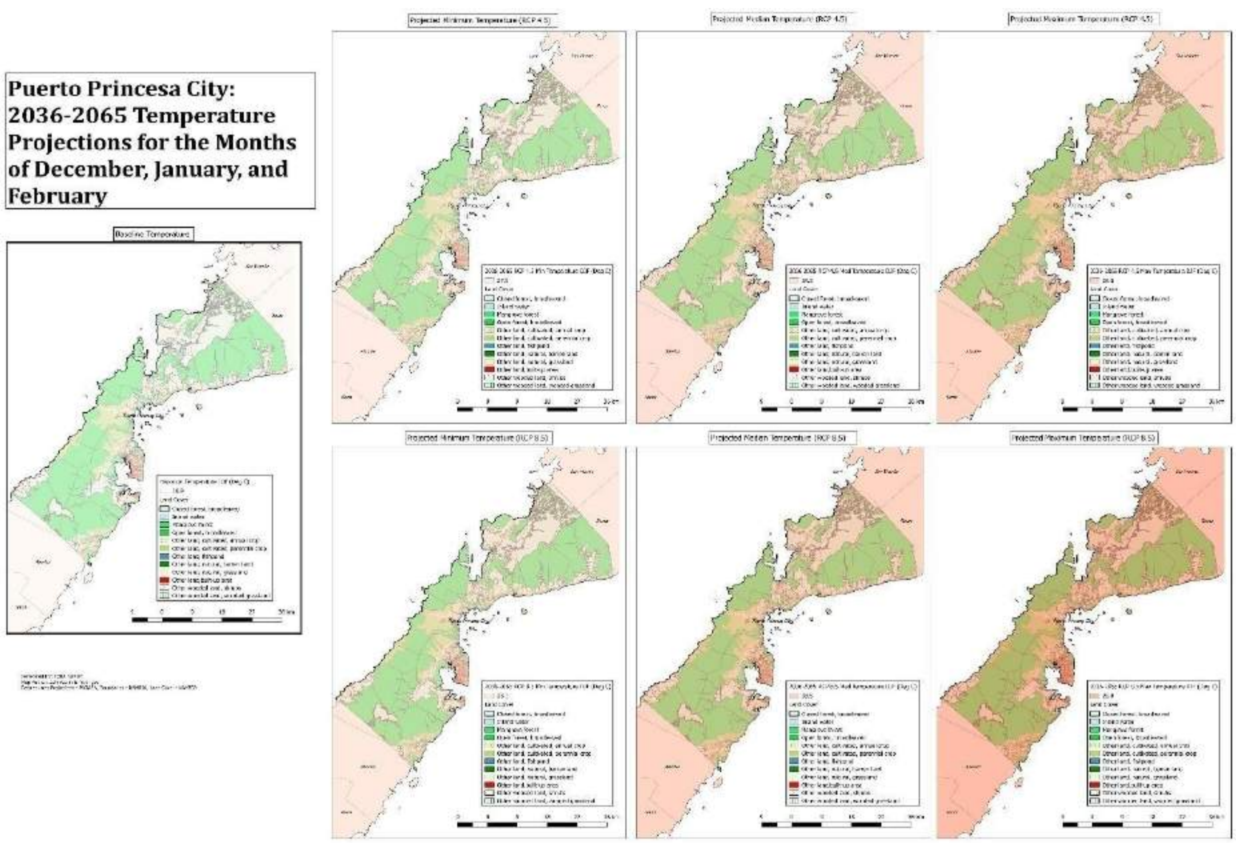
### *Change in Temperature*

The general trend of projections for all scenarios in both the mid and late century is an increase in temperature. The scenario under RCP 8.5 is hotter than that under RCP 4.5. Furthermore, under RCP 8.5 all the monthsin both the mid and late century exceed the historical hottest of the year. The details of these projections are found below.

#### Mid-21st Century Projections (2036-2065), Maps 19-22

The months of December, January, and February are projected to have temperatures higher than their historical baseline ***(Map 3.4.19)***. The scenario under RCP 8.5 is projected to be hotter than that under RCP 4.5. The temperatures under both scenarios are projected to be higher than the historical hottest temperatures of the year. However, under RCP 4.5 the projected minimum temperature is still below that of the historical hottest. The projected median temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline while in RCP 8.5 it is an increase of 1.6 degrees.

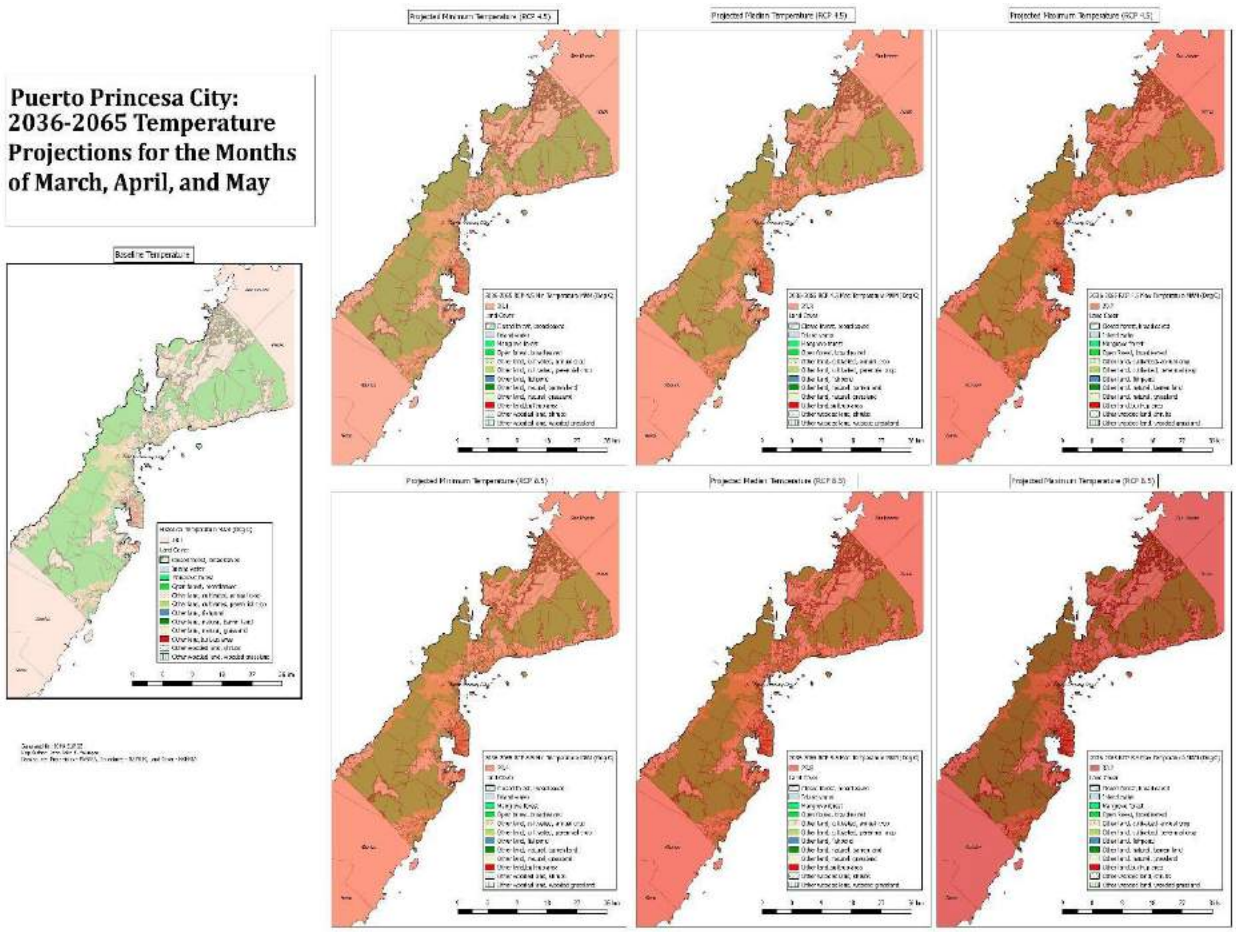
On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1 degree from the historical baseline while in RCP 8.5 it is an increase of 1.2 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 1.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 1.9 degrees.




***Map 3.4.19.*** *2036-2065 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be hotter than the historical baseline of not only the said months, but also the historical hottest months for the whole year ***(Map 3.4.20)***. The whole ranges of temperature under both scenarios are hotter than the historical hottest months. The said months are historically the hottest and will continue to be so. The projected median temperature under RCP 4.5 is an increase of 1.2 degrees from the historical baseline while in RCP 8.5 it is an increase of 1.7 degrees.

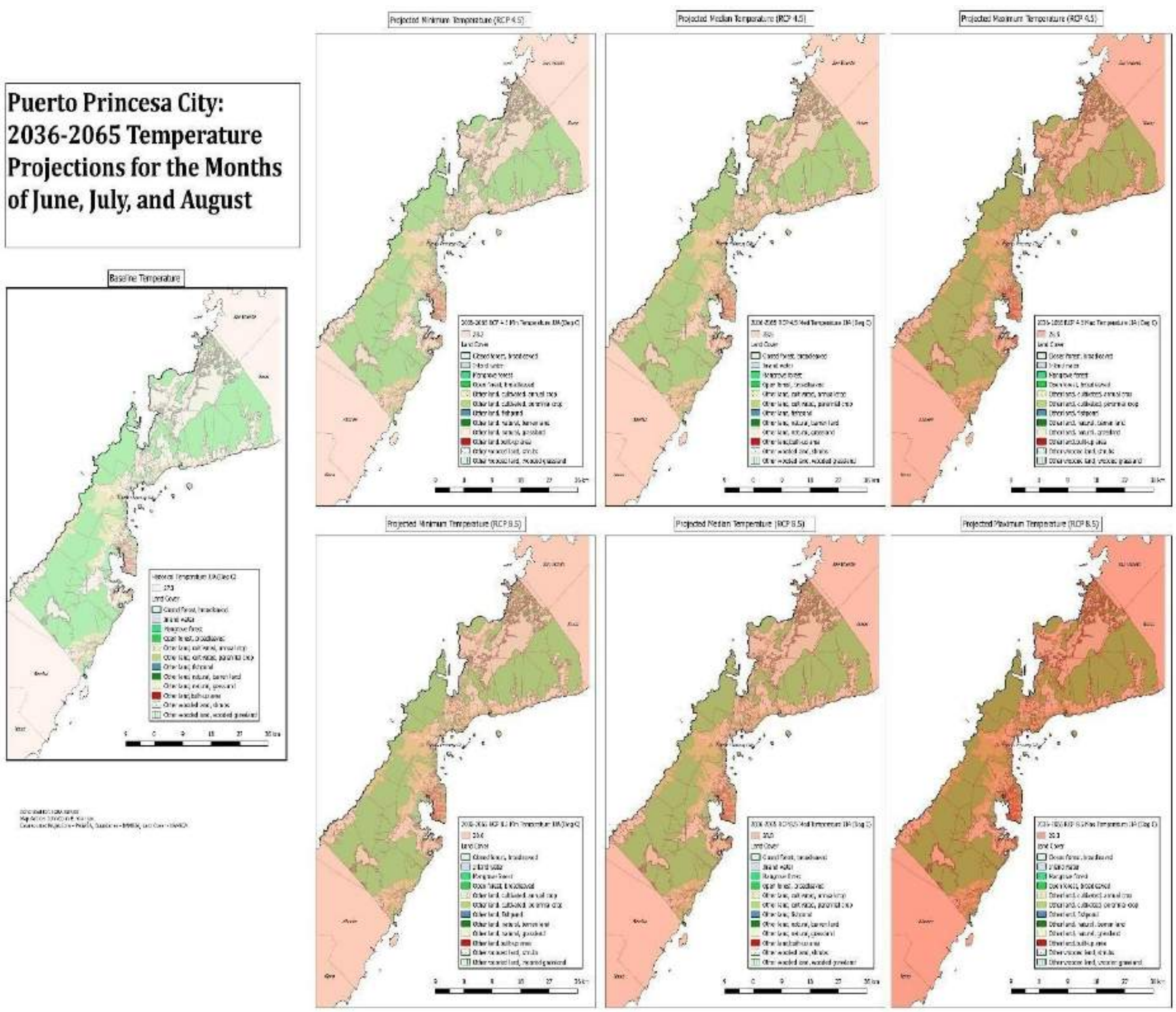
On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1 degree from the historical baseline while in RCP 8.5 it is an increase of 1.3 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 1.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.1 degrees.




***Map 3.4.20.*** *2036-2065 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August continue the same trend as the previous months in that they are projected to be hotter than the historical baseline as well as exceeding the temperatures of the historical hottest ***(Map 3.4.21)***. The projected median temperature under RCP 4.5 is an increase of 1.2 degrees from the historical baseline while in RCP 8.5 it is an increase of 1.5 degrees.

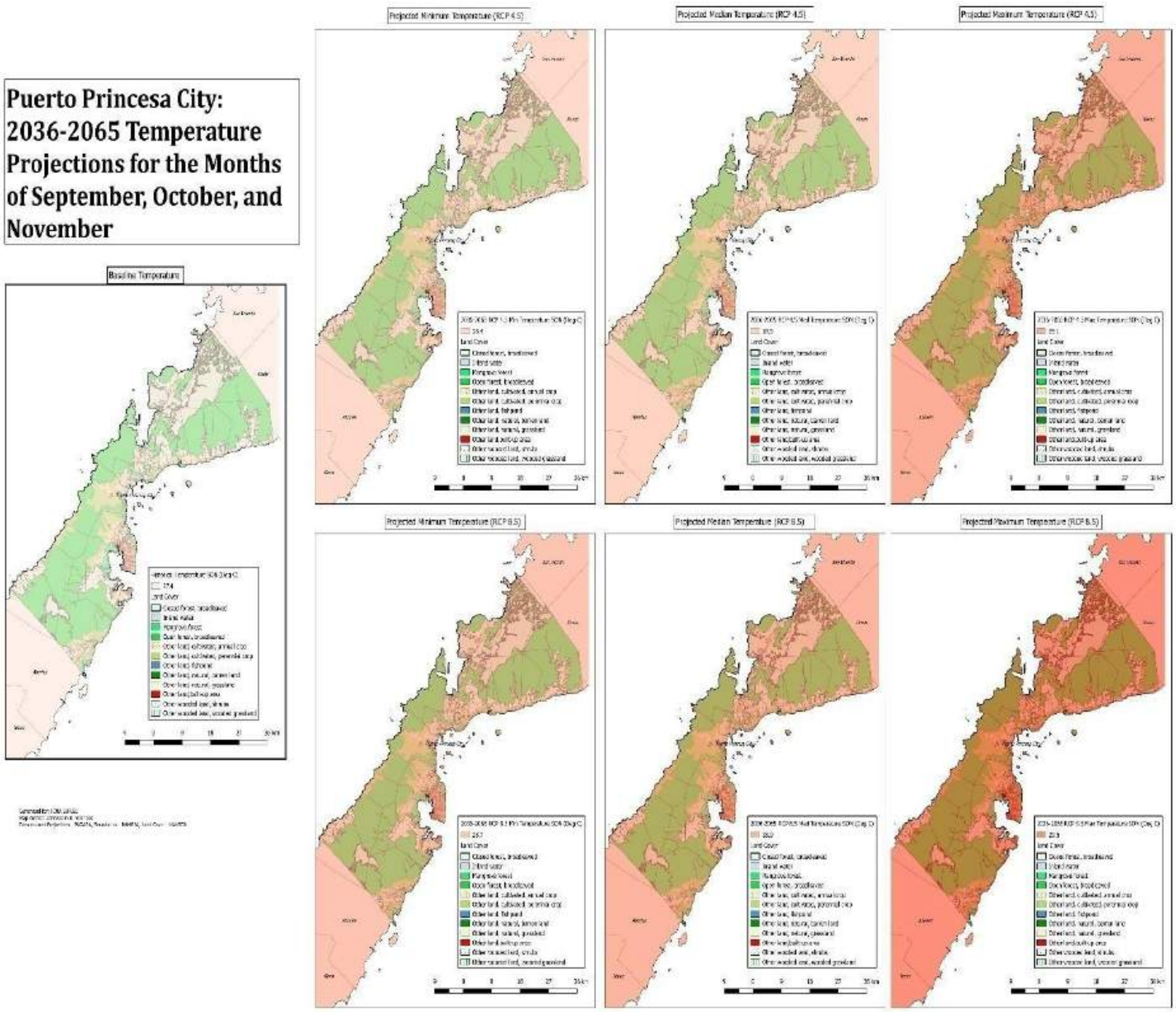
On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 0.9 degree from the historical baseline while in RCP 8.5 it is an increase of 1.3 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 1.6 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.0 degrees.




***Map 3.4.21.*** *2036-2065 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November continue the same trend as the previous months ***(Map 3.4.22)***. The temperatures are projected to be higher than the historical hottest months. The projected median temperature under RCP 4.5 is an increase of 1.1 degrees from the historical baseline while in RCP 8.5 it is an increase of 1.5 degrees.

On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1 degree from the historical baseline while in RCP 8.5 it is an increase of 1.3 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 1.7 degrees from the historical baseline while under RCP 8.5 it is an increase of 2.1 degrees.

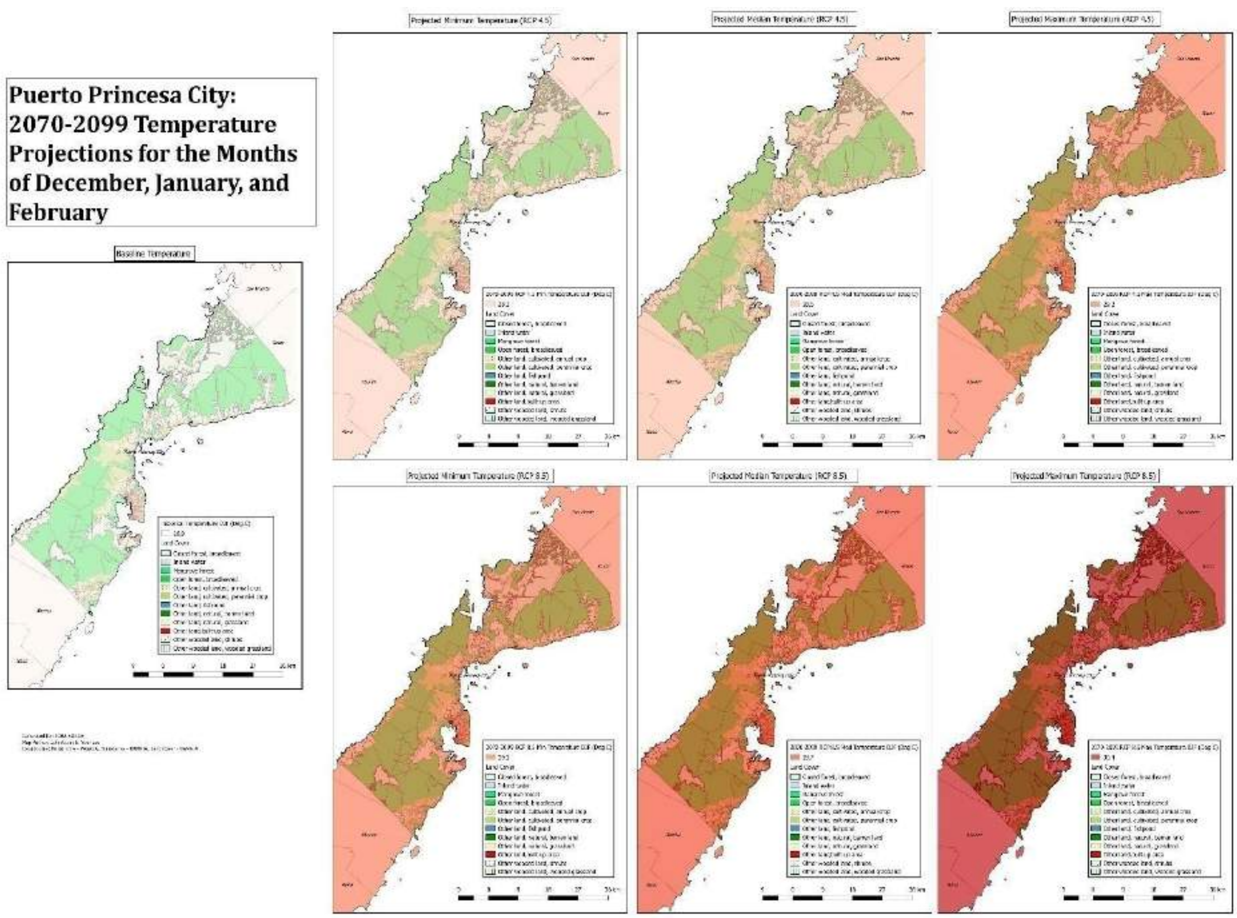



***Map 3.4.22.*** *2036-2065 Temperature Projections for September, October and November (Source: PAGASA data)*

## Late 21st Century Projections (2070-2099), Maps 23-26

The projections in the late century have drastic temperature increases compared to the mid-century. Under both scenarios, temperatures are projected to be higher than the historical highest. The projected temperatures under RCP 4.5 for the late century exceed the projected temperatures under RCP 8.5 under the mid-century. Furthermore, the range of temperatures for all months under RCP 8.5 in the late century exceeds even the projected temperatures under RCP 4.5 in the late century. Hence, there is a significant difference in projected temperatures between RCP 4.5 and RCP 8.5 in the late century.

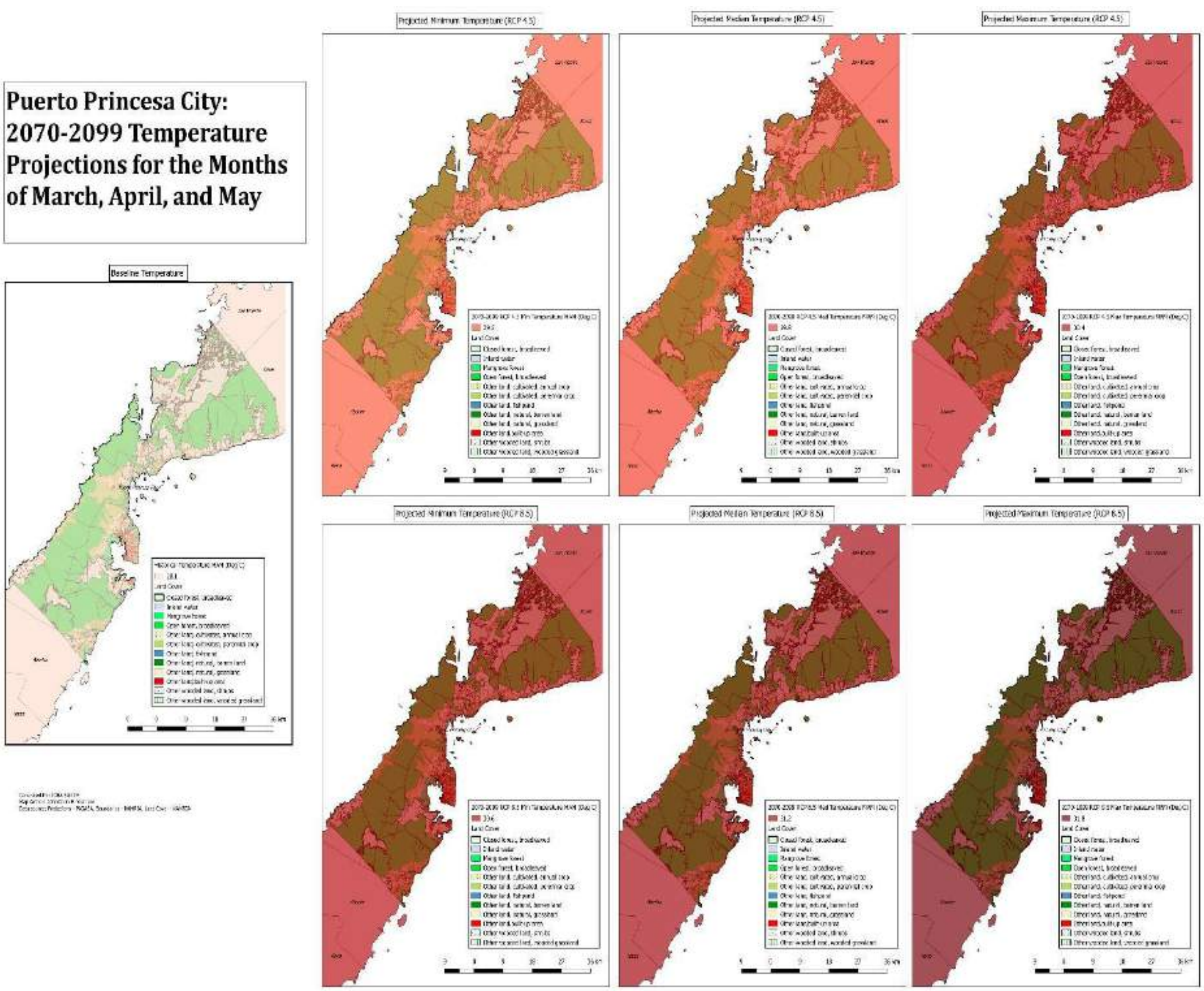
The months of December, January and February are projected to have temperatures significantly higher than the historical hottest under both scenarios ***(Map 3.4.23)***. The projected median temperature under RCP 4.5 is an increase of 1.6 degrees from the historical baseline while in RCP 8.5 it is an increase of 2.8 degrees. On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline while in RCP 8.5 it is an increase of 2.3 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 2.3 degrees from the historical baseline while under RCP 8.5 it is an increase of 3.5 degrees.




***Map 3.4.23.*** *2070-2099 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to have temperatures significantly higher than the historical hottest under both scenarios ***(Map 3.4.24)***. The projected median temperature under RCP 4.5 is an increase of 1.7 degrees from the historical baseline while in RCP 8.5 it is an increase of 3.1 degrees.

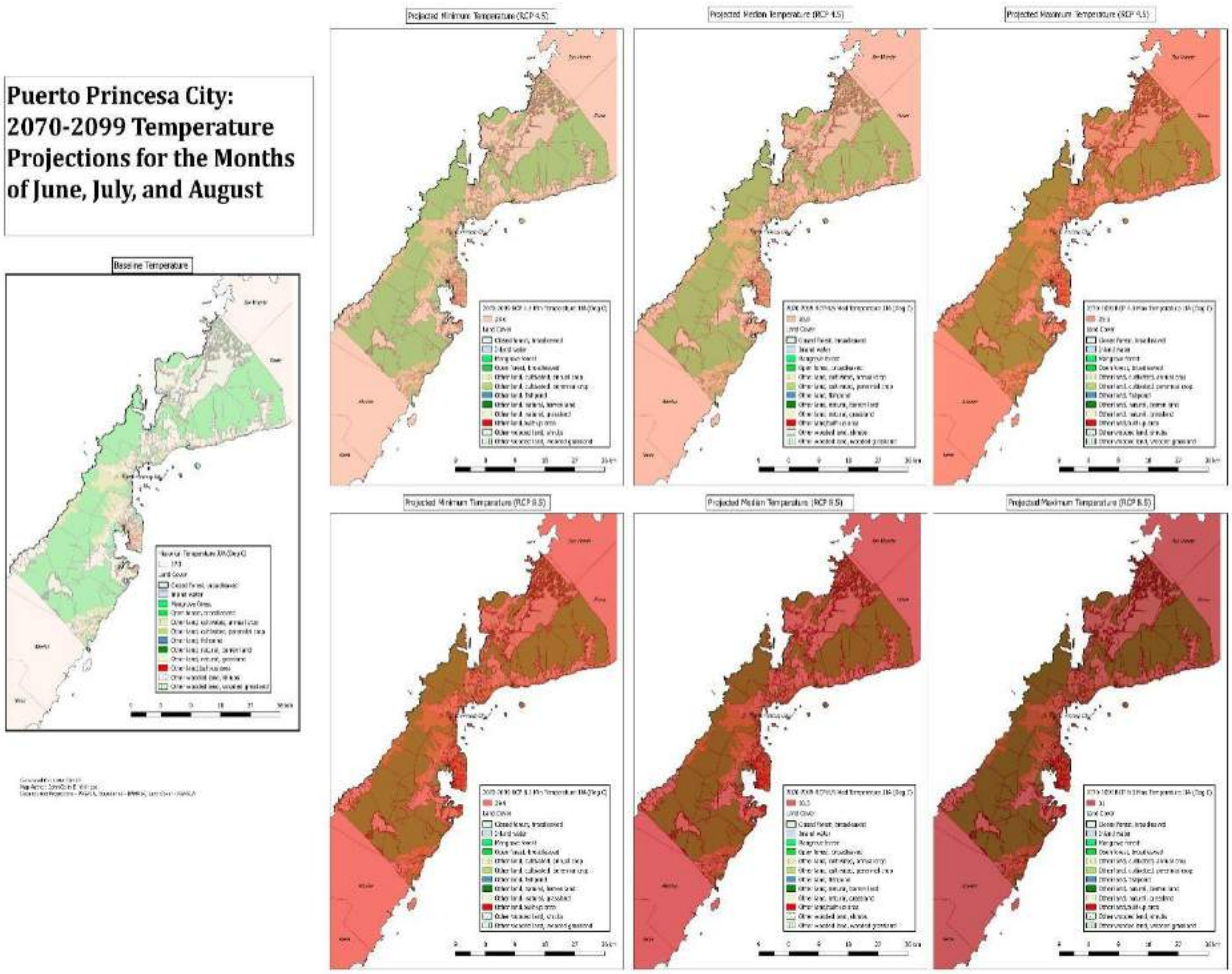
On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1.4 degrees from the historical baseline while in RCP 8.5 it is an increase of 2.5 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 2.3 degrees from the historical baseline while under RCP 8.5 it is an increase of 3.7 degrees.




***Map 3.4.24.*** *2070-2099 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August are projected to have temperatures significantly higher than the historical hottest under both scenarios ***(Map 3.4.25)***. The projected median temperature under RCP 4.5 is an increase of 1.5 degrees from the historical baseline while in RCP 8.5 it is an increase of 3 degrees.

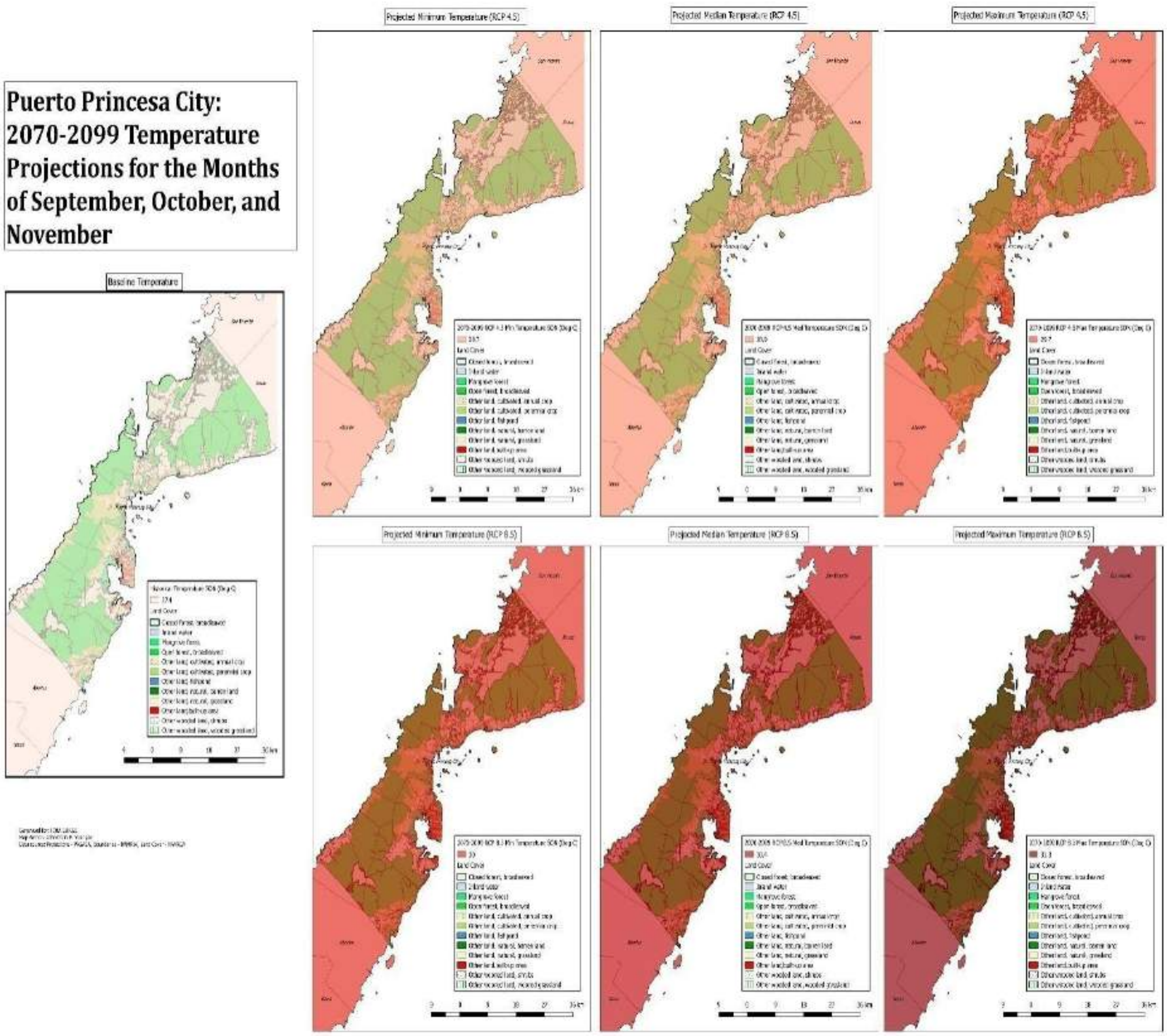
On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline while in RCP 8.5 it is an increase of 2.6 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 2.2 degrees from the historical baseline while under RCP 8.5 it is an increase of 3.7 degrees.




***Map 3.4.25.*** *2070-2099 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to have temperatures significantly higher than the historical hottest under both scenarios ***(Map 3.4.26)***. The projected median temperature under RCP 4.5 is an increase of 1.5 degrees from the historical baseline while in RCP 8.5 it is an increase of 3 degrees.

On the other hand, the projected minimum temperature under RCP 4.5 is an increase of 1.3 degrees from the historical baseline while in RCP 8.5 it is an increase of 2.6 degrees. Lastly, under RCP 4.5 the projected maximum temperature is an increase of 2.3 degrees from the historical baseline while under RCP 8.5 it is an increase of 3.9 degrees.




***Map 3.4.26.*** *2070-2099 Temperature Projections for September, October and November (Source: PAGASA data)*

## Impacts and Adaptation Options

Puerto Princesa City is a unique ecosystem dominated largely by forested mountains.The city is surrounded by large bodies of water that are home to large marine ecosystems from which major industries such as fishing play a pivotal role in. The city also has vast area which plays a significant factor in resource distribution. The densely populated areas in the city are concentrated in a single area at its eastern coast. The particular projections that are key in understanding the impacts to the city are the projected decreases in precipitation and the projected increases in temperature. The projections coupled with the vastly forested and rich marine ecosystem of the city may provide challenges for the city.

### *A. Demography*

In terms of demography, one of the impacts of the increase in temperature and decrease in precipitation are the health risks. Heat related diseases such as heat stroke and dehydration are possible risks under the given projections especially in the urbanized areas due to the heat island effect (IPCC 2014). Furthermore, given the difficulty of distributing resources such as water and electricity to the more rural barangays the highly populated and urbanized sectors of the city may see an increase in population due to migration of people from the rural barangays. (Black et al. 2008). The possibilities of increase in population the urbanized areas may also magnify the population at risk of the heat related diseases.

In terms of adaptation plans and strategies, the city has conducted information education campaigns on the health risk of climate change to their citizens as well as the vulnerable sectors of the city. There could also be an increase in urban poor and that basic facilities for human habitation will become a serious issue that the city government might encounter given the impacts of these projections. Rising of property prices in the urban areas, and the recent policy changes such as increase in real property tax will also play a part such that access to lands within the urban area is not easily availed of by the low income families, who are expected to migrate in the medium to long term. The other adaptation plans the city has employed for their population as well as the other suggested adaptation options are discussed in the next sector.

### *B. Social*

The social impacts of the projected increase in temperature and decrease in precipitation cover a wide range. One of the primary impacts is the heat related health risks which not only impact the vulnerable population such as the elderly and children, but also households who do not have access to health facilities and resources (IPCC 2014). Furthermore, the projections will impact the livelihoods of the citizens of the city such as the fisheries and agricultural industries. The decrease of water supply may lead to loss of livelihoods (IPCC 2014). The possibility of migration (Black et al. 2008), the health risks, and the loss of livelihoods will put a strain on social services and will put at risk the vulnerable sectors of the city such as the urban poor and those who are reliant on the agriculture and fisheries (IPCC 2014).

The city has employed capability building workshops and trainings to their citizens to mitigate the impacts of climate change. They have also identified and profiled the vulnerable families in their city as well as provided financial assistance to the same. They have relocated informal settlers from hazard risk areas and provided housing for the same. The city also provides medicine and other supplies to affected individuals. The city can further augment their current plans by adopting policies that can adapt customs and habits of the citizens to the increase in temperatures such as changing the suggested clothing and uniforms in schools and offices as well as changing work and class hours to cooler times of the day (Sabbag 2013). The city can also invest in improving their health facilities in handling heat related diseases.

### *C. Economic*

The economic sector of the city covers activities that are largely rooted on primary activities such as agriculture and the fisheries which are reliant on the climate of the area. As such, the agricultural, livestock, and fisheries sectors will be heavily impacted by the decrease in precipitation and increase in temperature. The decrease in precipitation and increase in temperature project the possibility of a marked decrease in water supply which will reduce the yield of crops planted in the city such as rice, corn, and the root crops (Eitzinger et al. 2017).

Plantation crops such as coconut may also have reduced yields and increase the risk of disease (Hebbar et al. 2013). Livestock and poultry may also run the risk of heat related disease such as heat stroke and dehydration in relation the said projections (Howden et al. 2007). The fisheries sector may also see a decrease in productivity and change in fish species migration due to the increase in temperature. This is because the changes in temperature may change the circulation of nutrients within the seas (Howden et al. 2007 & IPCC 2014).

Moreover, the increase in temperature may also trigger coral bleaching in the large expanse of corals found within the municipal waters of the city (IPCC 2014). The city is currently conducting comprehensive plans to mitigate the impacts of climate change to their economic sectors. In particular, the city has conducted information education campaigns and capability trainings to their farmers, fishermen, and livestock raisers to mitigate the impacts of climate change to their respective activities. The city has also provided climate tolerant varieties of vegetable, corn, rice, and fruit trees for their farmers as well climate tolerant breeds to their livestock raisers. The city has also established improved irrigation and watering facilities as well as financing and insurance to fishermen and farmers. The city has also provided for vitamins and electrolytes to their livestock raisers. The city has conducted rehabilitation to their coral reefs through coral transplanting and constant monitoring as well as seaweed planting materials.

The livestock raisers can also construct climate appropriate shelters to further augment the already comprehensive plans of the city (Howden et al. 2007). Farmers can also try and adopt cassava as an alternative to some crops (Eitzinger et al. 2017), and the fisheries industry can research and observe new migration patterns of fish to manage fishing patterns (Howden et al. 2007).

### *D. Infrastructure*

In terms of infrastructure the cost of maintenance and repair of roads may increase due to the increase in temperature. This is because the higher temperatures may cause cracks and unevenness in concrete and asphalt covered roads (Sabbag 2013). The increase in temperatures may also increase the demand of electricity in the city as well as lower the water table and hence decrease the water supply since the city is dependent on deep wells for their water supply (Sabbag 2013 & IPCC 2014). The increase in demand of electricity and decrease in water supply may prove difficult for the city since at its current state not all barangays are even supplied with electricity and water. The city has conducted electrification projects to provide electricity to certain areas as well as conducted road inventories to maintain and manage roads. The city has adopted climate resilient design and materials to their farm to market roads. The city can also adopt the same design and materials to their other roads (Sabbag 2013).

The city can also adopt the use of software such as 2100 to aid in maintaining and monitoring road conditions (Schweikert et al. 2014). The city can observe ground water management practices as well as rain harvesting techniques to augment water supply and to aid in groundwater recharge (IPCC 2014 & Howden et al. 2007). In terms of energy the city can invest in developing renewable energy sources throughout the city to aid in energy distribution (IPCC 2014).

### *E. Environment*

One of the largest possible impacts to the city involves the forest ecosystem which dominates the majority of the total area of the city. The increase in temperature and decrease in precipitation may reduce rainforest growth by half (Hopkin 2007). Furthermore, the projections also show the possibility of increased deforestation rates and increased forest mortality due to drought, pest infestation, land conversion, and fires. (Andregg, Kane, &Andregg 2012).

The ecosystem within the forest may also change drastically because of the increase in temperature changing vegetation composition and species distribution (FAO 2008). The marine ecosystem found in the municipal waters of the city may also experience impacts such as coral bleaching and vast changes in fish migration patterns due to the increased temperatures (IPCC 2014).

The city is currently implementing their forest land use plan to aid in mitigating the effects of climate change as well as coastal bay monitoring for their marine ecosystems. The city can further adopt forest management practices such as introduction of drought and disturbance-tolerant species or genotypes, planning to reduce disease losses through monitoring and sanitation harvests, managing stand structure to reduce impacts on water availability and implementing silvicultural techniques to promote stand vigour (Keenan and Nitschke 2016). Furthermore, the city can improve water supply systems to forest through protective and drainage structures (Howden et al. 2007; Puyallup 2016).

### *F. Hazards*

The primary hazards that may occur in relation to the projections are wildfires and drought. The increase in temperature and decrease in precipitation coupled with the prominent forest ecosystem increase the risk of the said wildfires (IPCC 2014). The impacts of drought in the city have been laid out in the previous sections above as well as their adaptation options. The city can adopt firefighting facilities and plans to mitigate the risk of wildfires (Four Twenty-seven Climate Solutions 2017).

## Adaptation Options

***Table 3.4.2.*** *Summary of Impacts and Adaptation Options for Puerto Princesa City*

| Summary of Impacts and Adaptation Options | | | |
|---|---|---|---|
| **Climate Variable** | **Sector** | **Impacts** | **Adaptation Options** |
| Increase in Temperature and decrease in precipitation | Demography | Increased heat related health risk to population, migration from rural to urban areas | IEC on the health risk of climate change, capability building workshops and trainings, identification and profiling of vulnerable families, financial assistance, relocation of informal settlers from hazard risk areas, housing, provision of medicine and other supplies to affected individuals, policies that can adapt customs and habits of the citizens to the increase in temperatures, investment in improving health facilities in handling heat related diseases. |
| | Social | Increased heat related health risk to population, increased health risk to urban poor, loss of livelihood | IEC on the health risk of climate change, capability building workshops and trainings, identification and profiling of vulnerable families, financial assistance, relocation of informal settlers from hazard risk areas, housing, provision of medicine and other supplies to affected individuals, policies that can adapt customs and habits of the citizens to the increase in temperatures, investment in improving health facilities in handling heat related diseases. |
| | Economic | Reduction of water supply, increased demand for water, crop damage and yield reduction, higher risk of disease in coconut plants, loss of livelihood, coral bleaching, risk of livestock to heat stroke and dehydration, change of fish migration and nutrient circulation, | IEC and capability trainings to their farmers, fishermen, and livestock raisers to mitigate the impacts of climate change; climate tolerant varieties of vegetable, corn, rice, and fruit trees; climate tolerant livestock breeds; improved irrigation and watering facilities; financing and insurance to fishermen and farmers; vitamins for livestock; rehabilitation to coral reefs through coral transplanting and constant monitoring; seaweed planting materials; construction of climate appropriate shelters for livestock; adoption of cassava as an alternative to some crops; research and observe new migration patterns of fish to manage fishing patterns |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance, Lowering of groundwater table, | Adoption of renewable energy sources and policies to encourage it, adoption of methods that will aid in the monitoring and maintenance of road infrastructure based on the climate variable such as 2100, adoption of climate appropriate infrastructure materials, development of water storage systems, rain water harvesting, |
| | Environment | Deforestation, increased forest stress, land conversion pest infestation, | forest land use plan; coastal bay monitoring for their marine ecosystems; introduction of drought and disturbance-tolerant species or genotypes, planning to reduce disease losses through monitoring and sanitation harvests, managing stand structure to reduce impacts on water availability and implementing silvicultural techniques to promote stand vigour; improvement of water supply systems to forest through protective and drainage structures |
| | Hazards | Increased possibility of drought and wildfires | firefighting measures |

## References


Anderegg, W; Kane, J; and Anderegg, L. (2012).Consequences of widespread tree mortality triggered by drought and temperature stress. Nature Climate Change 9 september 2012 doi: 10.1038/nclimate1635

Black, R.; Kniveton, D.; Skeldon, R.; Coppard, D.; Murata, A.; & Schmidt-Verkerk, K. (2008). Demographics and Climate Change: Future Trends and their Policy Implications for Migration. Working Paper, Development Research Center on Migration, Globalisation, and Poverty.

Eitzinger, A.; Laderach, P.; Giang Tuan, L.; Ramaraj, A.; Ng'ang'a, K.; Parker, L.; (2017) Learning and Coping with Change: Case Stories of Climate Change Adaptation in Southeast Asia. Case Story Book Vol. 1. Pp 83-97

Forest and Agriculture Organization of the United Nations (2008) Climate change impacts on forest health. Forest Health and Biosecurity Working Papers

Four Twenty-seven Climate Solutions (2017). Fremont Climate Hazard Assessment and Adaptation Options.

Hebbar K.B., Balasimha D., Thomas G.V. (2013) Plantation Crops Response to Climate Change: Coconut Perspective. In: Singh H., Rao N., Shivashankar K. (eds) Climate-Resilient Horticulture: Adaptation and Mitigation Strategies. Springer, India

Hopkin, M. (2007). Rising temperatures "will stunt rainforest growth". Nature International Weekly Journal of Science.

Howden, S.M.; Soussana, J.; Tubiello, F.; Chhetri, N.; Dunlop, M.; &Meinke, H. (2007) Adaptingagriculture to climate change.Proceedings of the National Acadamy of Sciences of the United States of America.Vol 104 no. 50

IPCC, 2014: Climate Change 2014: Synthesis Report. Working Groups II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.IPCC, Geneva, Switzerland, 151 pp.

Rodney, K; & Nitschke, C.(2016). Forest management options for adaptation to climate change: a case study of tall, wet eucalypt forests in Victoria’s Central Highlands region. Australian Forestry.Vol 79.No. 2. pp 96-107

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Sabbag, L. (2013).Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation.From Sheltering from a Gathering Storm working paper No. 4. Institute for Social and Environmental Transition-International.

Schweikert, A.; Chinowsky, P.; Espinet, X.; &Tarbert, M. (2014). Climate Change and infrastructure impacts: comparing the impact on roads in ten countries through 2100. Procedia Engineering 78. pp 306-316.

Toda.L.L., Yokingco, J.C.E., Paringit, E.C., Lasco, R.D.L. (2017) A LiDAR based flood modelling approach for mapping rice cultivation areas in Apalit, Pampanga.Journal of Applied Geography.Vol. 80. Pp 34-47.

**Population Table (PSA, 2015)**

| PUERTO PRINCESA CITY (Capital) | Urban or Rural | POPULATION (Total: 255,116) |
|---|---|---|
| San Pedro | U | 22,089 |
| Santa Monica | U | 20,094 |
| San Miguel | U | 19,649 |
| San Jose | U | 17,521 |
| Sicsican | U | 15,861 |
| Bancao-bancao | U | 13,612 |
| San Manuel | U | 12,510 |
| Tiniguiban | U | 12,285 |
| Mandaragat | U | 9,210 |
| BagongSikat (Pob.) | U | 7,497 |
| Tagburos | U | 7,045 |
| Irawan | R | 6,142 |
| Barangay ngmgaMangingisda | R | 5,350 |
| BagongSilang (Pob.) | R | 5,296 |
| Santa Lourdes | U | 5,171 |
| Bacungan | R | 4,555 |
| Iwahig (Pob.) | R | 4,527 |
| Inagawan Sub-Colony | R | 4,052 |
| Maunlad (Pob.) | R | 3,865 |
| Luzviminda | R | 3,473 |
| Cabayugan | R | 3,368 |
| Milagrosa (Pob.) | R | 3,100 |
| Babuyan | R | 2,472 |
| Bahile | R | 2,339 |
| Manalo | R | 2,143 |
| Langogan | R | 2,067 |
| Kamuning | R | 1,978 |
| Masipag (Pob.) | R | 1,971 |
| San Rafael | R | 1,836 |
| Napsan | R | 1,797 |
| Tanglaw (Pob.) | U | 1,739 |
| Inagawan | R | 1,623 |
| Macarascas | R | 1,609 |
| Maruyogon | R | 1,450 |
| Concepcion | R | 1,418 |
| Lucbuan | R | 1,401 |
| Binduyan | R | 1,293 |
| Maoyon | R | 1,281 |
| Simpocan | R | 1,272 |
| Matahimik (Pob.) | U | 1,228 |
| Buenavista | R | 1,212 |

| | | |
|---|---|---|
| Liwanag (Pob.) | R | 1,202 |
| Salvacion | R | 1,197 |
| Tagabinit | R | 1,170 |
| Pagkakaisa (Pob.) | R | 1,131 |
| Princesa (Pob.) | R | 1,015 |
| Masikap (Pob.) | R | 958 |
| Santa Cruz | R | 840 |
| Bagong Bayan | R | 827 |
| Maningning (Pob.) | U | 791 |
| BagongPag-Asa (Pob.) | R | 750 |
| Kalipay (Pob.) | R | 725 |
| Tanabag | R | 700 |
| Manggahan (Pob.) | U | 644 |
| New Panggangan | R | 629 |
| Marufinas | R | 609 |
| Masigla (Pob.) | R | 609 |
| Tagumpay (Pob.) | U | 465 |
| Matiyaga (Pob.) | R | 413 |
| Magkakaibigan (Pob.) | R | 375 |
| Montible (Pob.) | R | 362 |
| Model (Pob.) | U | 327 |
| Seaside (Pob.) | R | 312 |
| Maligaya (Pob.) | U | 311 |
| Mabuhay (Pob.) | R | 206 |
| Santa Lucia (Pob.) | R | 147 |

## 3.5. TAGBILARAN CITY

### Executive Summary

Tagbilaran City is a relatively small city characterized by a high level of urbanization with small areas for agriculture and wooded grassland. One of the key features of the city is that a number of its *barangays* and the majority of its settlements are located along the coasts.

In terms of the projections, the general trend for all scenarios show that in either scenario the climate will both be drier and hotter than the historical baseline. The relatively uniform projected trend in turn indicates similar impacts differing in degrees of intensity from each scenario and from mid to late centuries. The impacts and adaptation options are summarized below.

| Summary of Impacts and Adaptation Options | | | |
|---|---|---|---|
| **Climate Variable** | **Sector Characteristic** | **Impacts** | **Adaptation Options** |
| Increase in Temperature and decrease in precipitation (Year-round and for all scenarios) | Demography | Increased heat related health risk to population, possibility of out migration, loss of livelihood | Education campaign, introduction of alternate livelihoods, policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased heat related health risk to population, possibility of out migration, loss of livelihood, increased health risk to urban poor, | Education campaign, introduction of alternate livelihoods, policies that adapt attire to higher temperatures and adjustment of working and class hours, adoption of smart designs for residential and government facilities, establishment of green spaces |
| | Economic | Reduced yield of crops and fish catch, reduction of water supply, increased demand for water, projected increase of price of commodities, | Introduction of alternate livelihoods, climate tolerant crop varieties, alternating crops, development of water storage systems and water usage management practise, monitoring and management of fishing patterns |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance. | Incentives for the use of renewable energy, adoption of infrastructure planning methods, adoption of climate appropriate infrastructure materials |
| | Environment | Lowering of groundwater table, deforestation, coral bleaching | Adoption of a green building code, implementation of waste management plan, development of water storage systems |
| | Hazards | Increase of probability of droughts and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |

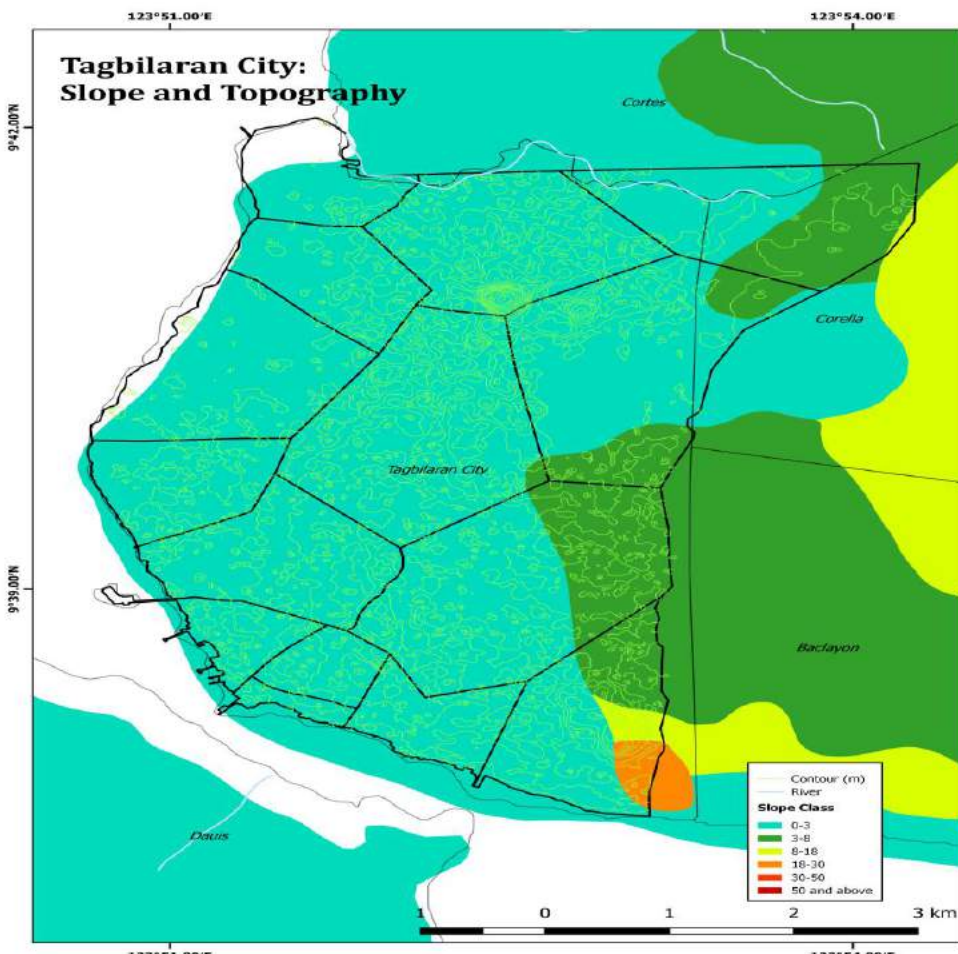
## Physical Geography

### *Location*

Tagbilaran City located in the south western portion of the province of Bohol. It is the capital and also a component city of the said province. It is bounded on the west by the Maribijoc Bay, on the south by the Tagbilaran Strait, on the east by the municipalities of Baclayon and Corella, and on the north by the municipality of Cortes. The said city is composed of 15 *barangays* and has an estimated area of 3270 hectares.

### *Physical Characteristics*

The terrain of Tagbilaran city is largely level with slopes ranging from 0-3% ***(Map 3.5.1)***. Ridges run parallel along the shoreline along the length of the city terminating at each end with the highest peaks of the city are Elley Hill on the north (100 m) and Banat-I on the south (145 m). The city is only traversed by a single river running on the northern border of the city.

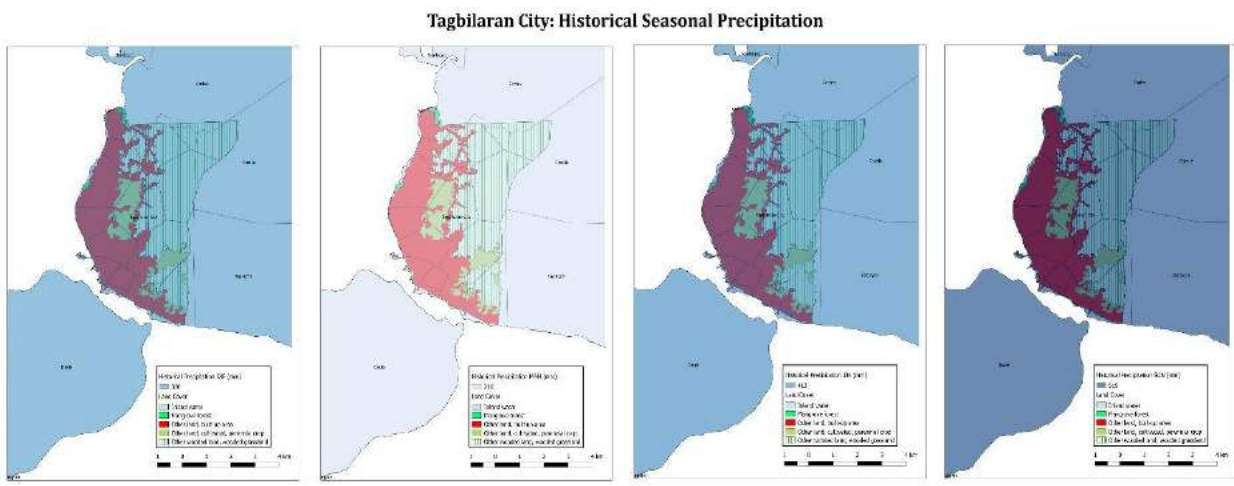



***Map 3.5.1.*** *Tagbilaran City Slope Class and Topography Map (Source: 30m GDEM)*

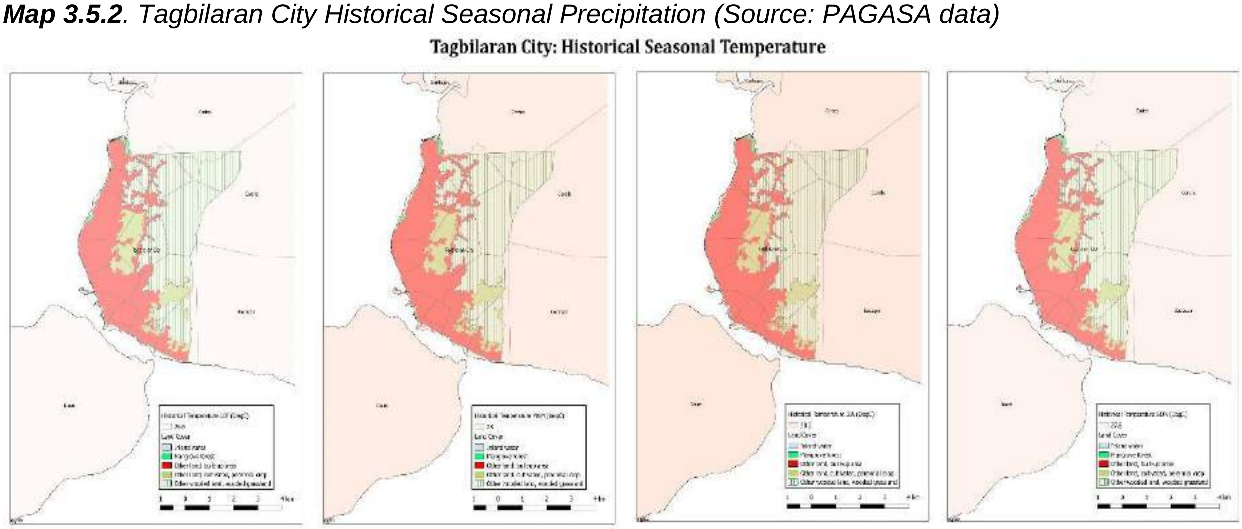
*Climate*

The climate of Tagbilaran City is characterized by four seasonal variations in precipitation and temperature ***(Maps 3.5.2 and 3.5.3)*** as modelled and recorded by the Philippine Atmospheric, Geophysical and Astronomical Services Administration.

The months of December, February and January are historically the coolest of the year with an average temperature of 26.6 degrees Celsius and is relatively wet with an average cumulative amount of 378 mm of rainfall. The months of March, April and May are historically the driest and the second to the hottest with an average cumulative rainfall amount of 210 mm and an average temperature of 28 degrees Celsius. The months of June, July and August are historically the hottest and the second wettest with an average temperature of 28.2 degrees Celsius and an average accumulated rainfall amount of 413 mm. The months of September, October, and November are the second coolest and is historically the wettest of the year with an average cumulative rainfall amount of 515 mm.




***Map 3.5.2****. Tagbilaran City Historical Seasonal Precipitation (Source: PAGASA data)*

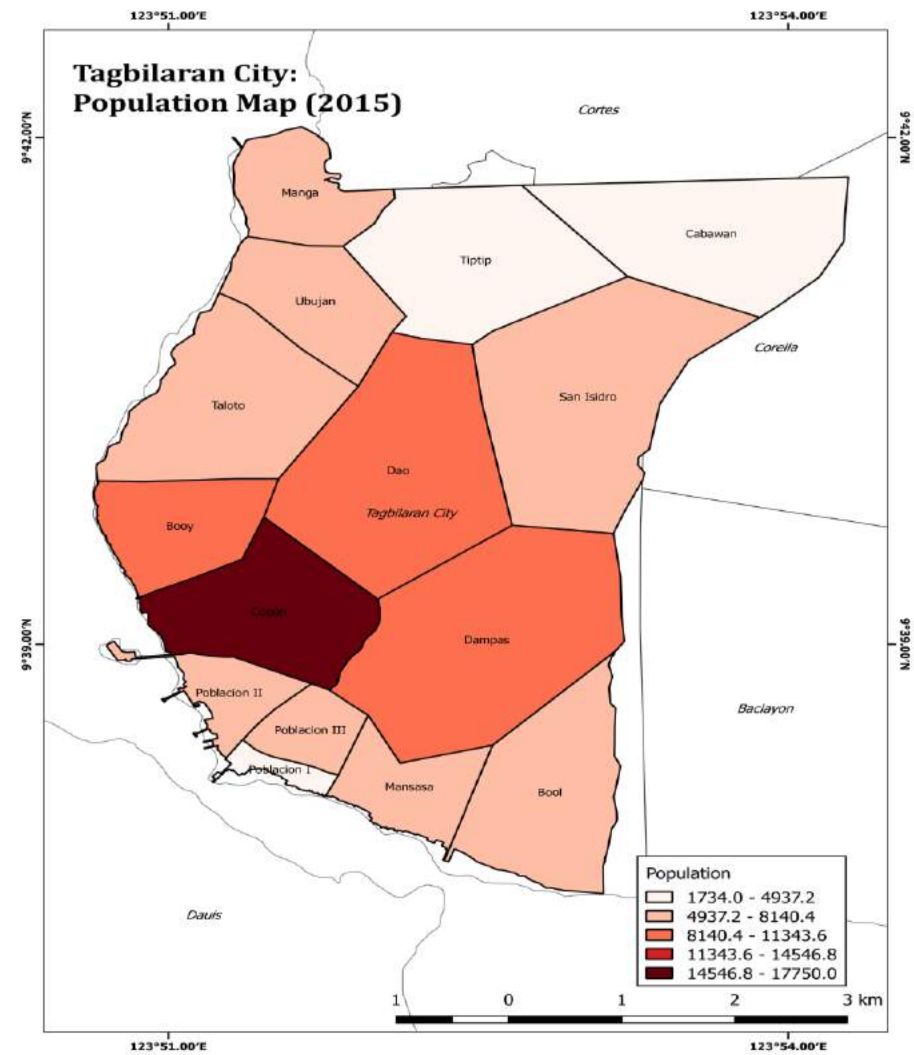



***Map 3.5.3****. Tagbilaran City Historical Seasonal Temperature (Source: PAGASA data)*

## Socio-Economic Characteristics

### *Population*

As of 2015, the total population of Tagbilaran City is 105,051 ***(Map 3.5.4)***. More than 60% of the population are 30 years old and below and the gender ratio is almost 1:1 (96 males per 100 females). The total number of households is 18,039 and the average household size is 5 (City Health Office, 2006). About 41% of the population lives in the 4 urban *barangays* of the City, while the other 59% lives in the 11 rural *barangays*. The four urban *barangays* are Cogon, Booy, Dampas, and Dao with Cogon being the most populated in the city. These four *barangays* are found next to each other near the center of the city, with the population concentrated in Cogon and radiating outwards. The average population density in the whole city is 28 persons per hectare with the urban *barangays* having a higher density (99.6 persons per hectare) than rural *barangays* (18.71 persons per hectare) (City Health Office, 2006).




***Map 3.5.4**. Barangay Population Map (Source: PSA data)*

### *Education*

Tagbilaran City is considered the center of education for the province of Bohol (Tagbilaran Environmental Profile 2000) with around 24 educational institutions found in the city. The city is where all the provinces universities are located. Notable institutions that are found in the city are Tagbilaran City Science High School, the University of Bohol, and Bohol Island State University.

### *Economic Activities*

Majority or 66% of the households in Tagbilaran City earn below Php15,000 monthly (based on the 1995 NCSO population data of 12,428 households). The average monthly income is around Php 12,700. The 2004 Local Poverty Reduction Action Program (LPRAP) survey results showed that 29% of the households live below the income threshold and around 17% of the labor force, which is 64% of the total population (2000 data), is unemployed.

- ***Agriculture***

There are 2,662 farmers in the City (Tagbilaran City's Socioeconomic Profile, 2002). Majority of farmers (1,375) are involved in fruit trees (e.g., mango, pineapple, citrus), while others are involved in root crops (338 farmers), corn (299 farmers), and rice (18 farmers). Most crops are grown for sustenance while commercial crops for livelihood (such as rootcrops –e.g., ube, cassava, camote, gabi) are very limited. Industrial crops such as coffee, cacao, and spices are also grown but are very negligible.

- ***Fishery***

The fishery industry of the city is largely benefitted by the proximity of the coral reefs in the coasts which act as marine reservoirs. There are 2,095 fishermen in the City (Tagbilaran City's Socioeconomic Profile, 2002). There are three barangays in the City that uses fishing vessels (e.g., motorized and non-motorized bancas for near shore fishing and commercial boat for deep sea fishing). They are *Barangays* Manga (80 motorized and 28 non-motorized), Ubujan (15 motorized and 19 non-motorized), and Poblacion I (13 commercial fishing boats registered). Those without fishing vessels or gears collect shells or harvest other sea products (e.g., gozo, lokot, leto, and others) for livelihood purposes.

- ***Livestock***

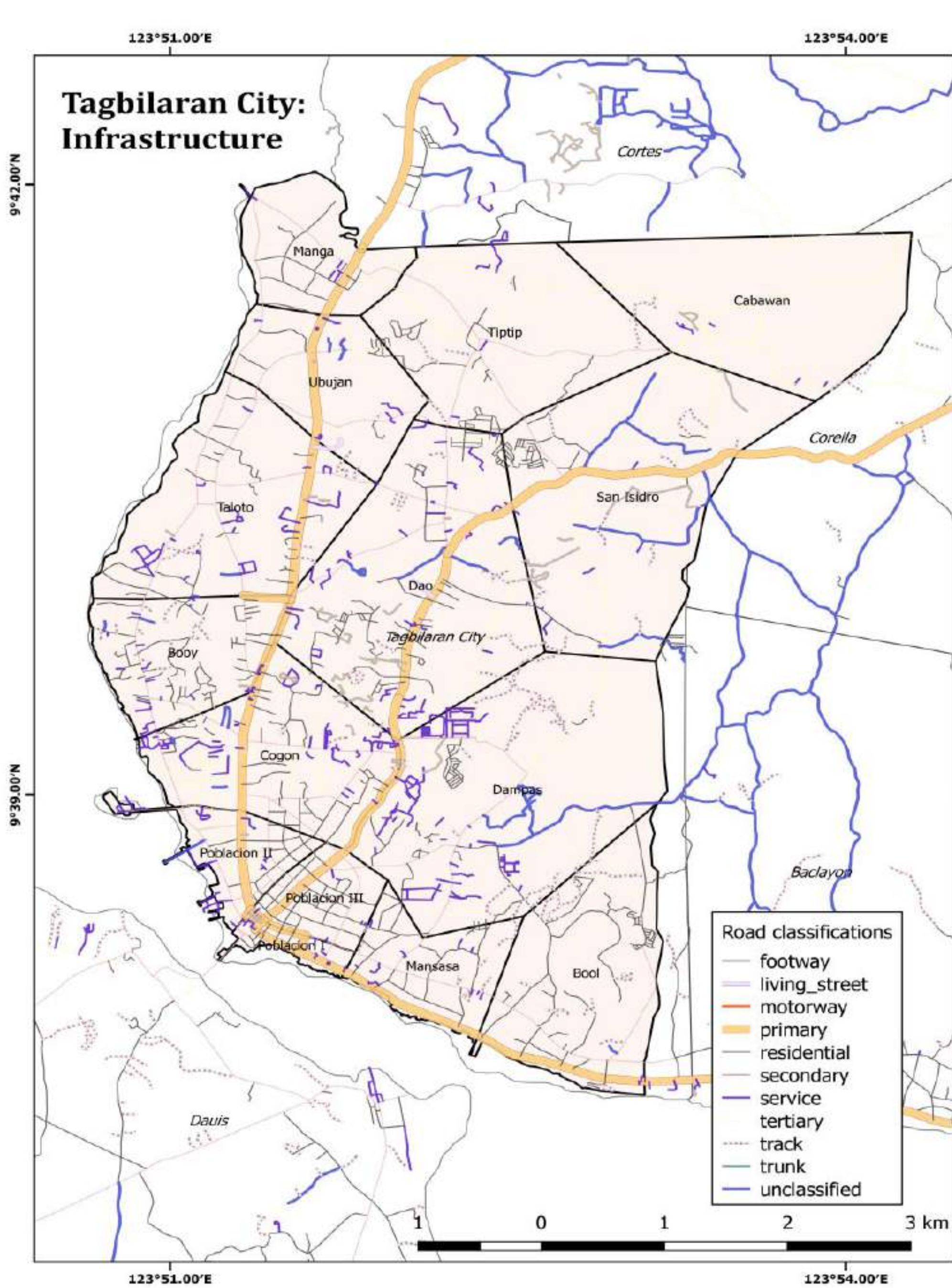
The livestock and poultry industry is more prominent in Barangays Cabawan, Tiptip, and Dampas. In 1997 (Tagbilaran CLUP), there were 943 cattle; 9,220 swine; 1,552 goats; and 33,549 chickens.

## Infrastructure

### *Transportation*

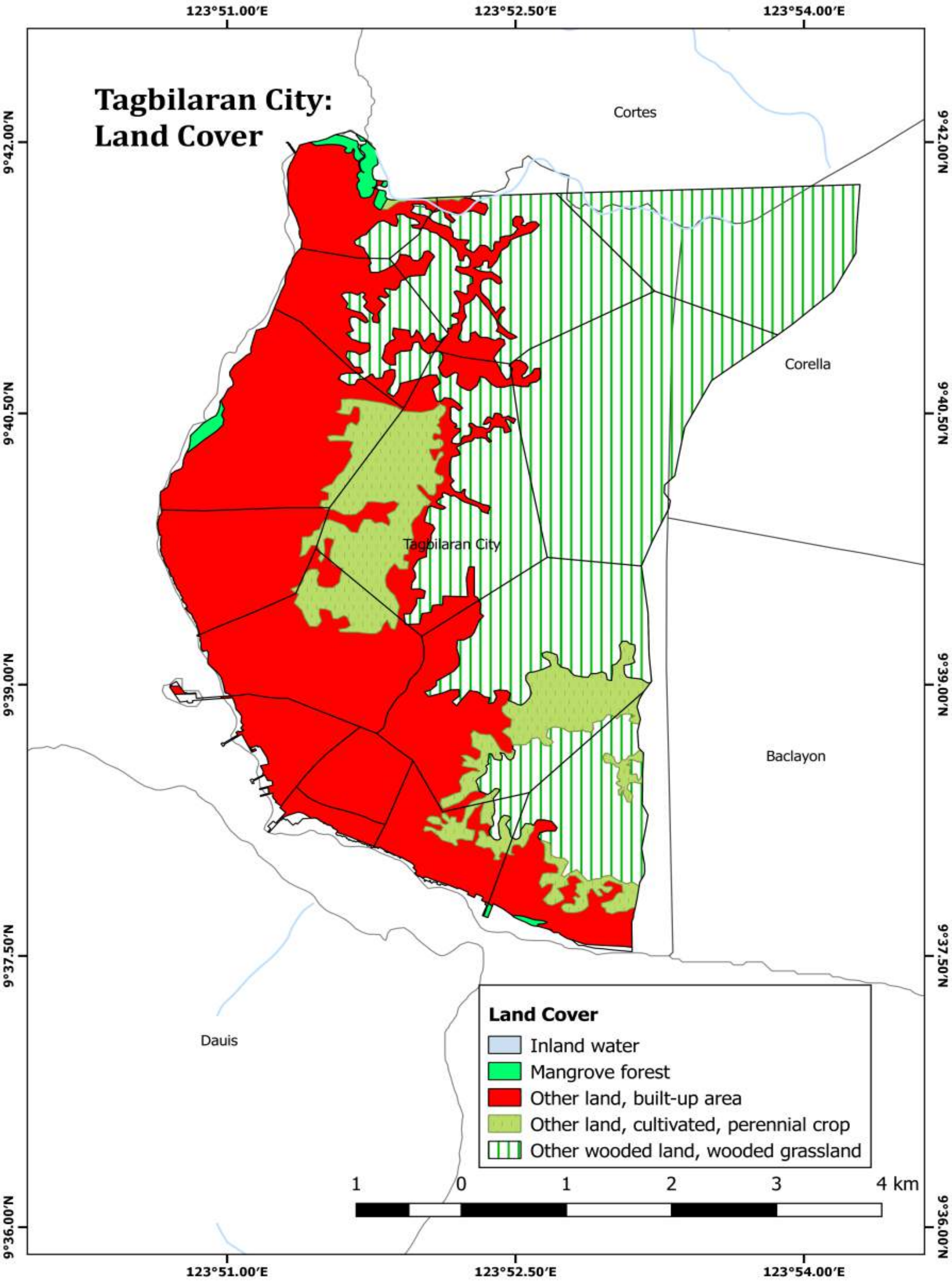
Tagbilaran City is one of the transportation hubs of the province of Bohol. The city supports land, sea, and air transportation systems supporting a network of roads, ports, and an airport. The airport is located in *barangay* Taloto and is an all-weather type airport supporting short and medium range flights. The total length of roads as of 2006 is 145.502 kms of which 18.587 kms.

are national roads, 66.064 kms are city roads and 60.851 kms are *barangay* roads. The map below features the road networks digitized through Open Street Map as of 2017 ***(Map 3.5.5)***.




***Map 3.5.5.*** *Road Infrastructure Map*

## Land Cover and Land Use




***Map 3.5.6.*** *Land Cover Class (Source: GDEM 2010)*

***Table 3.5.1.*** *Tagbilaran City Land Cover (Source: GDEM 2010)*

| **Tagbilaran City Land Cover (2010)** | | |
|---|---|---|
| Land Cover Class | Area (ha) Derived from GIS calculations | Percent |
| Built up | 1297.448 | 40.84% |
| Inland Water | 0.447986 | 0.01% |
| Mangrove Forest | 21.93147 | 0.69% |
| Perennial Crop | 326.9071 | 10.29% |
| Wooded Grassland | 1530.143 | 48.17% |
| Total | 3176.877 | 100% |

Tagbilaran City is characterized largely by built up areas and wood grassland ***(Map 3.5.6)***. An estimated 40.84 % of the city is built-up, the areas being largely found on its western and south western portion in a strip along the shoreline. The wooded grassland makes up an estimated 48.17% of the city found in its north eastern, eastern, and southern portions.

Mangrove forests can be found in the *barangays* of Manga and Ubujan and Taloto on the north and north western portions of the city with an estimated area of 21.93 hectares. Perennial crops can be found in the western and southern portions of the city covering an estimated 10.29 % of the city.

Apart from the terrestrial land cover that is characterized in the city there are also coral reefs that can be found near the coastal *barangays* and are characterized by the following (Tagbilaran Environmental Profile 2006):

• 25 genera of coral reefs identified in 6 coastal *barangays*
• coral reefs found patch distribution 100-1,000 meters from the shore at 10-25 foot depths
• coral reef average live hard cover 43.36%
• 233 individuals per 500 sq. m on fish population
• 32 fish species

## Climatic Hazards

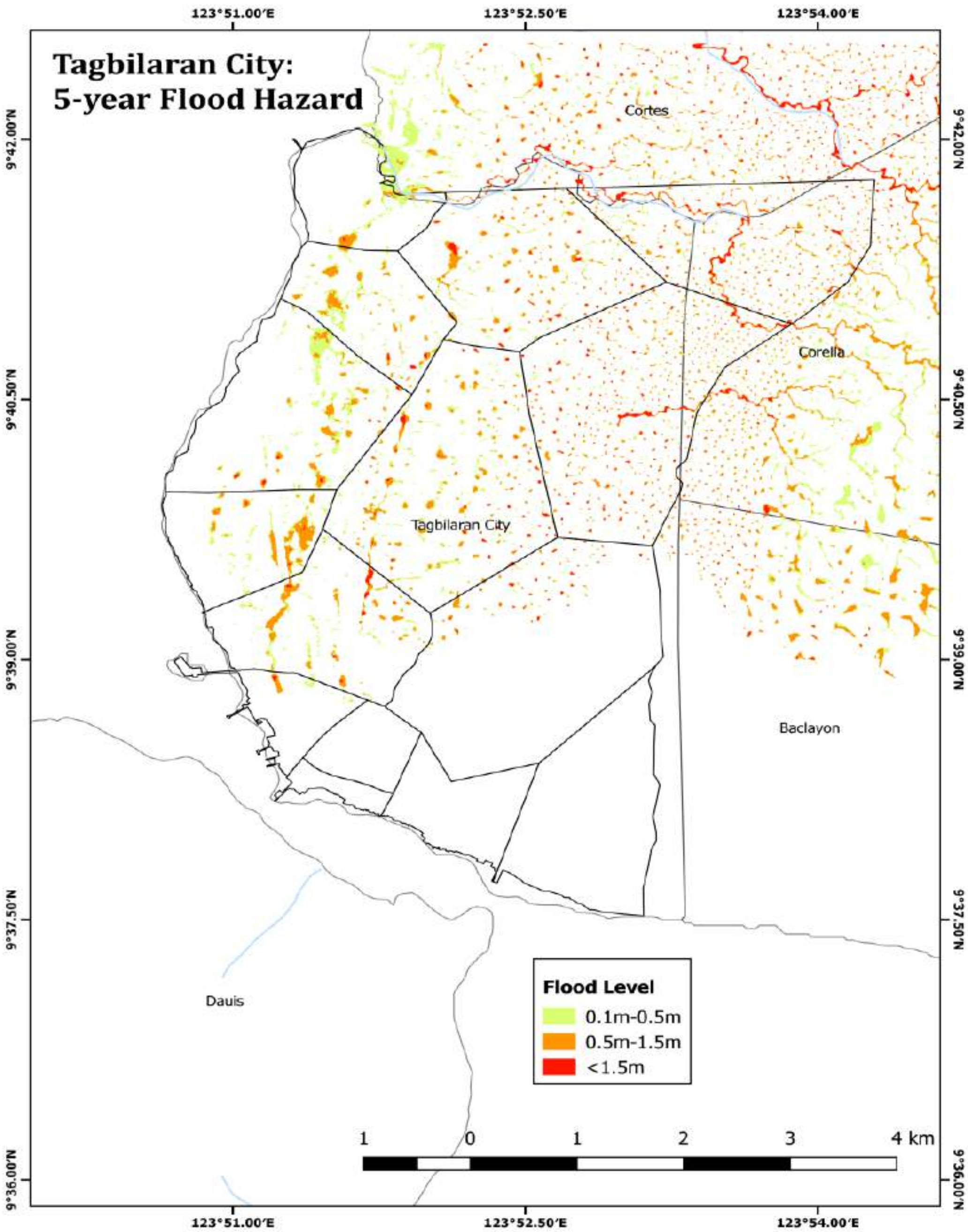
### *Flood Hazard*

The city is only traversed by a single river to the north and is rarely affected by typhoons (Tagbilaran Environmental Profile 2006). It is because of this that in terms of flooding the city is mostly affected by surface run-off. Flooding usually occurs in the northern *barangays* of Dao, Isidro, Cogon, Booy, Taloto, Ubujan, Manga, Tiptip, Cabawan, and San Isidro. Small portions of the *barangays* of Poblacion II and Dampas are also affected, but the remaining portions of the *barangays* and the southern *barangays* are unaffected due to their elevation ***(Map 3.5.7)***.

In particular, the *barangays* of Cogon, Buoy, Taloto, Ubujan, and Manga have the largest areas of flood. But, it is worth noting that even in one in 100 year floods the area of floods that exceed 1.5 meters are relatively small.

### *Five (5) Year Return Period*

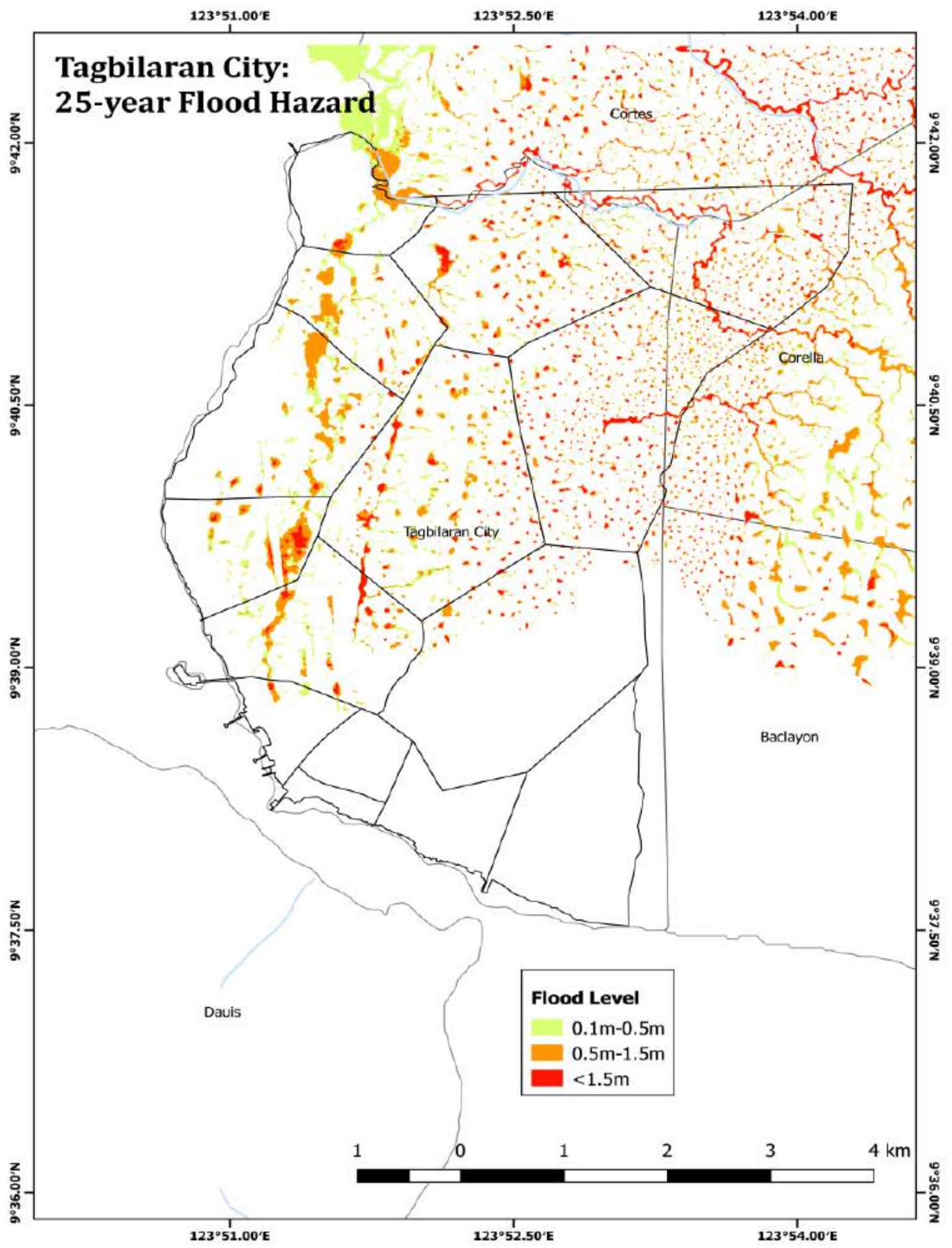
There is a 1/5 (20%) probability of a flood with 5 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 121.200mm.




***Map 3.5.7.*** *5-Year Flood Hazard Map (source: DREAM Project)*

*25 -Year Return Period*

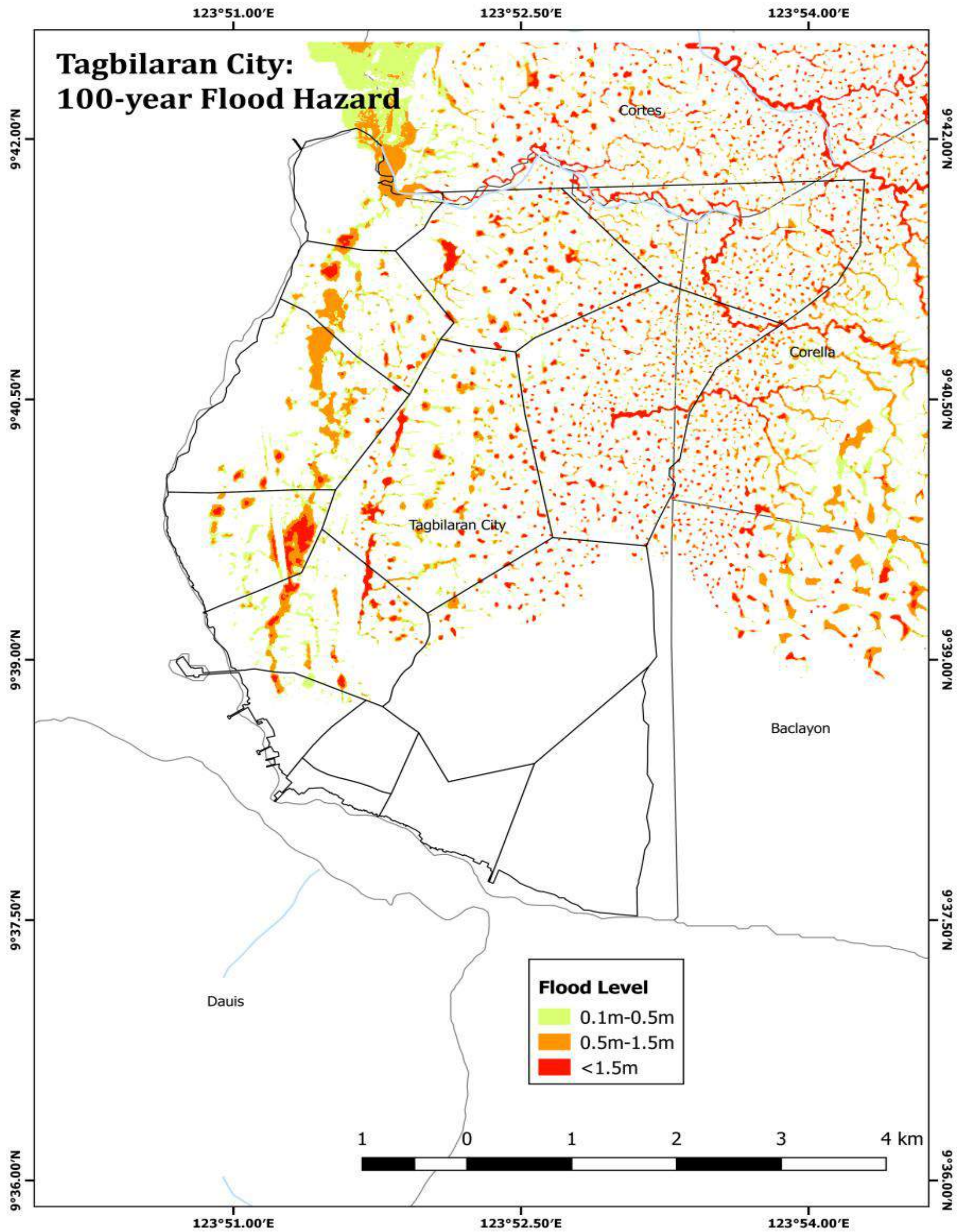
There is a 1/25 (4%) probability of a flood with 25 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 176.700 mm.




***Map 3.5.8.*** *25-Year Flood Hazard Map (Source: DREAM Project)*

## 100-Year Return Period

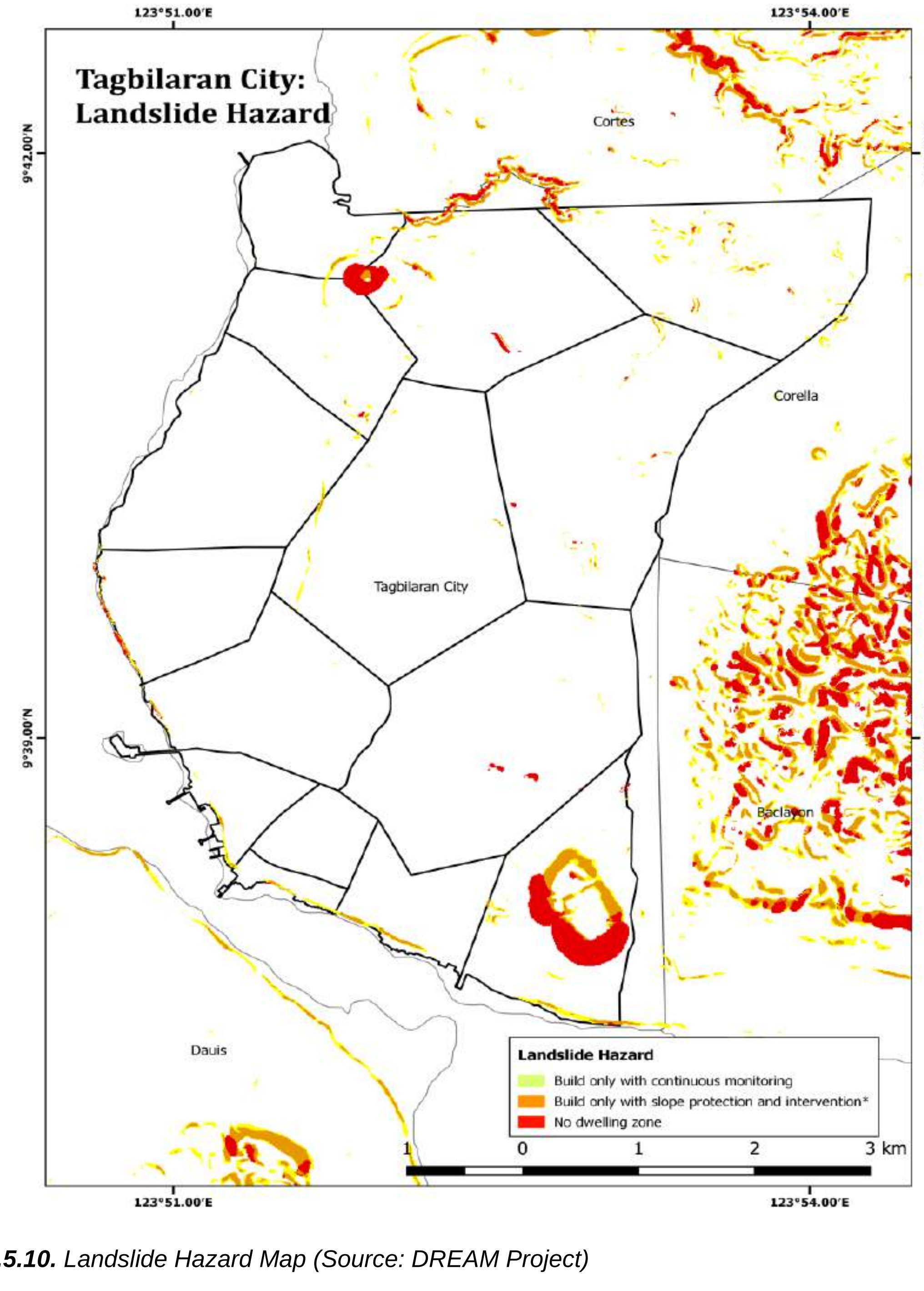
There is a 1/100 (1%) probability of a flood with 100 year return period occurring in a single year. The Rainfall Intensity Duration Frequency is 222.600 mm.




***Map 3.5.9.*** *100-Year Flood Hazard Map (Source: DREAM Project)*

### Landslide Hazard

The landslide hazards of the city are relatively contained to the two peaks of Elley Hill and Banat-I hill found at the northern and southern areas of the city ***(Map 3.5.10)***. Hence, this particular hazard is not prevalent in the rest of the city because of its level terrain.

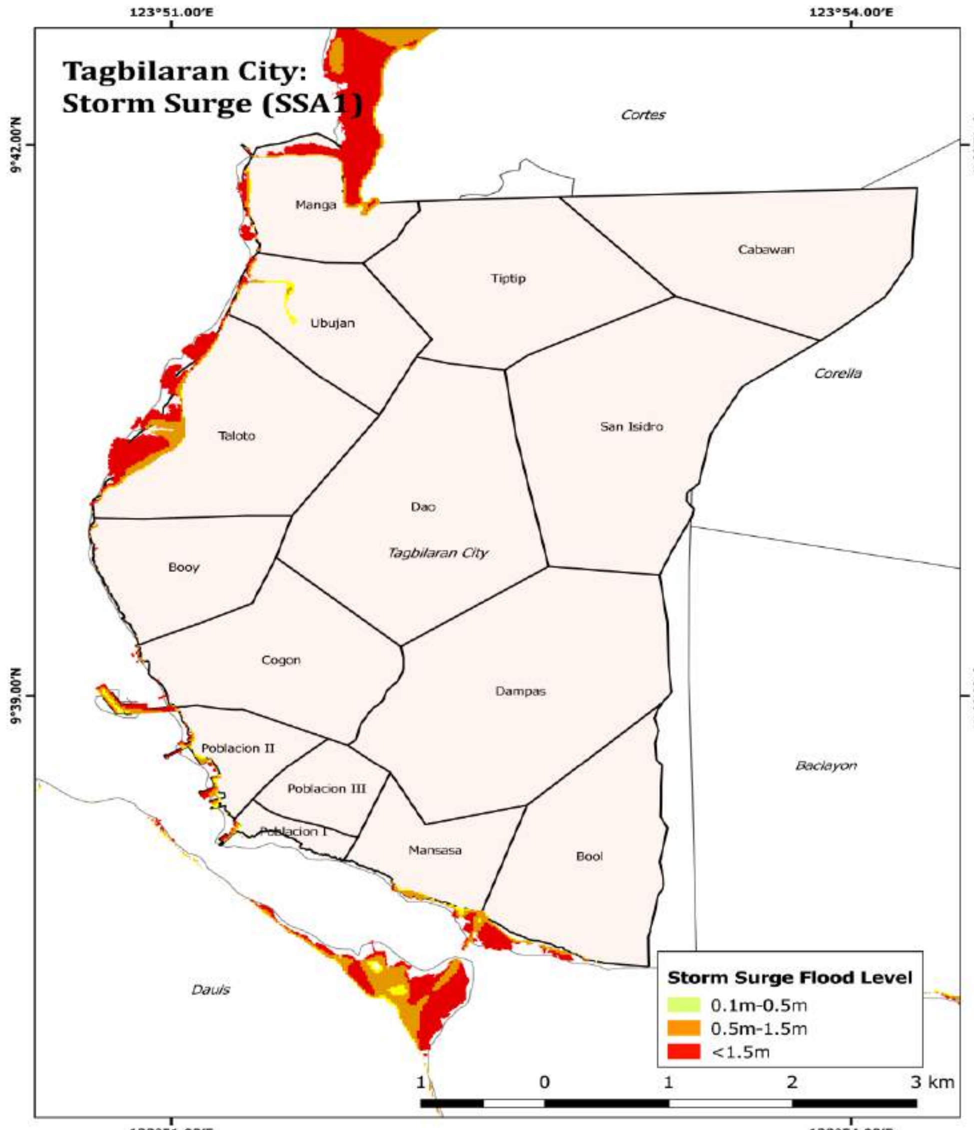



***Map 3.5.10.*** *Landslide Hazard Map (Source: DREAM Project)*

*Storm Surge Hazard (Maps 11-13), (Data from Project NOAH)*

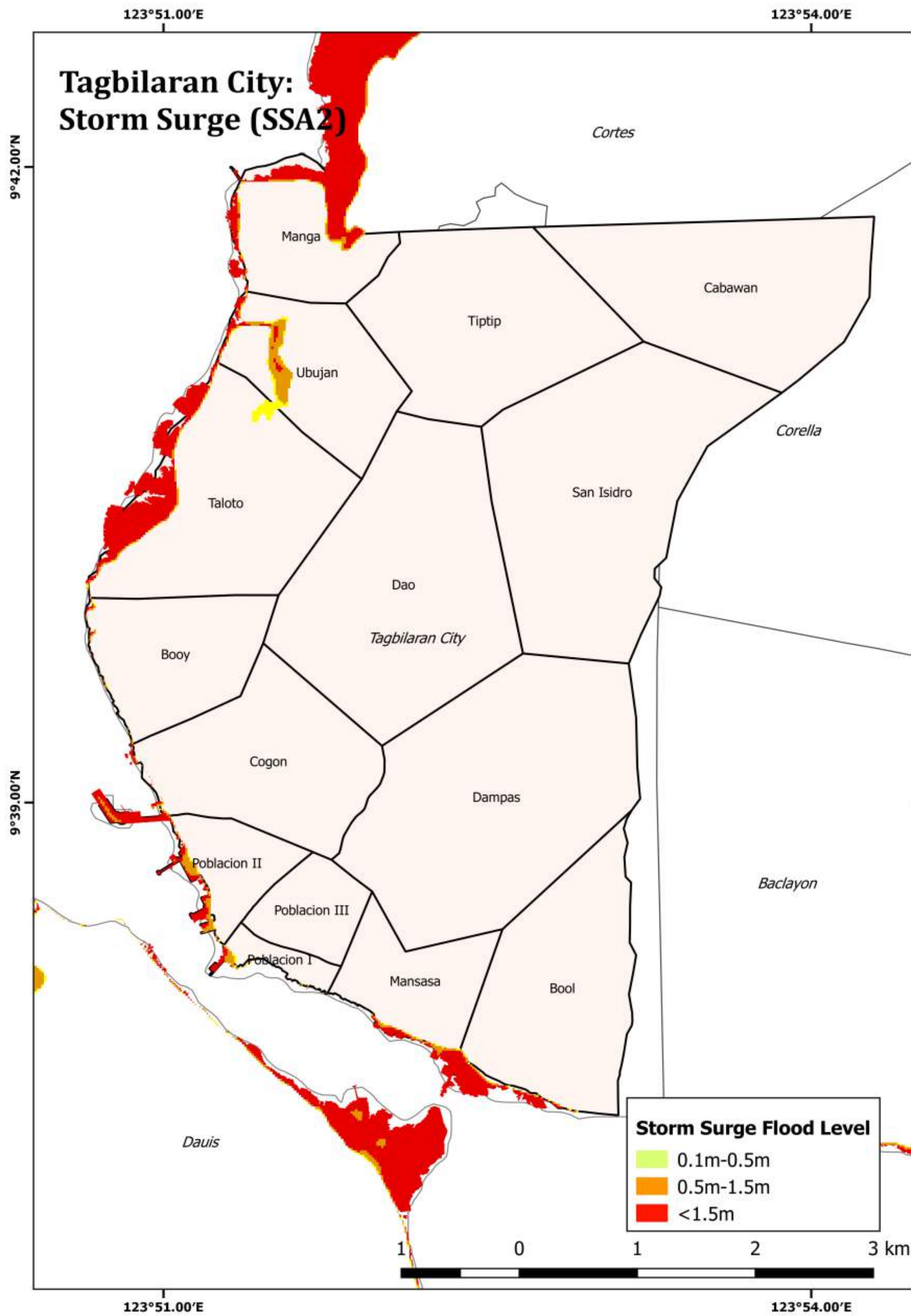
Storm Surge hazards affect most of the *barangays* that are found in the coast of the city. Floods from the storm surge can also affect portions of the city further inland by entering the river located on the north of the city. The *barangays* that are mainly affected by this hazard are Manga, Ubujan, Taloto, Cogo, Poblacion II, Poblacion I, Mansasa, and Bool. The *barangays* of Taloto, Manga, and Ubujan are the most affected. In particular, Taloto has large portions of its area near the coast affected by the storm surge in all scenarios while Manga and Ubujan have larger portions affected in SSA2 and SSA3 due to the intrusion of the flood waters through the river.

SSA 1 Storm Tide Level of 2.01 m to 3.0 m



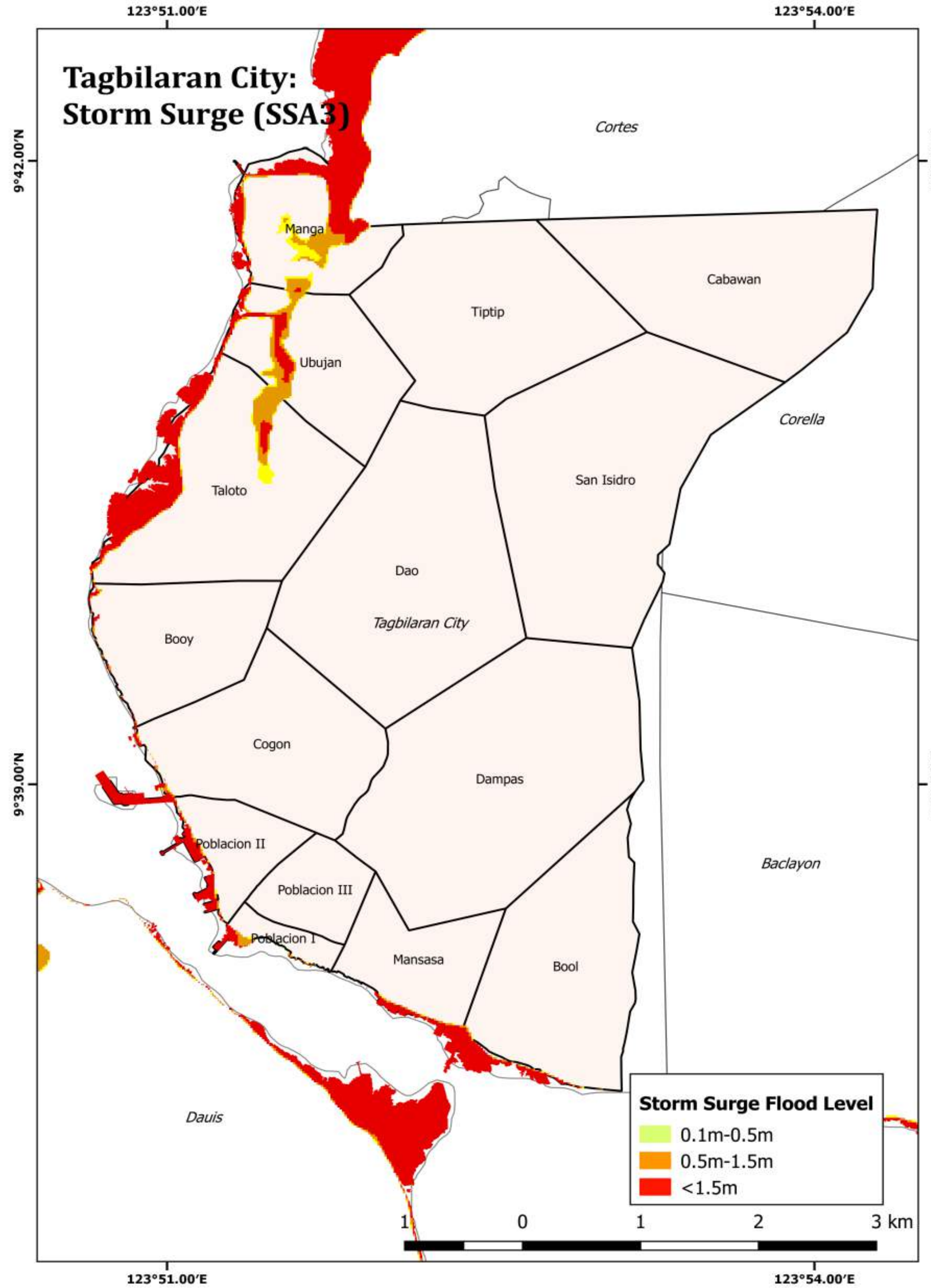

***Map 3.5.11.*** *Storm Surge (SSA 1) Hazard Map (Source: Project NOAH data)*

## SSA 2 Storm tide level of 3.01 m to 4.0 m




***Map 3.5.12.*** *Storm Surge (SSA 2) Hazard Map (Source: Project NOAH data)*

## SSA 3 Storm Tide Level of Greater than 4.0 m




***Map 3.5.13.*** *Storm Surge (SSA 3) Hazard Map (Source: Project NOAH data)*

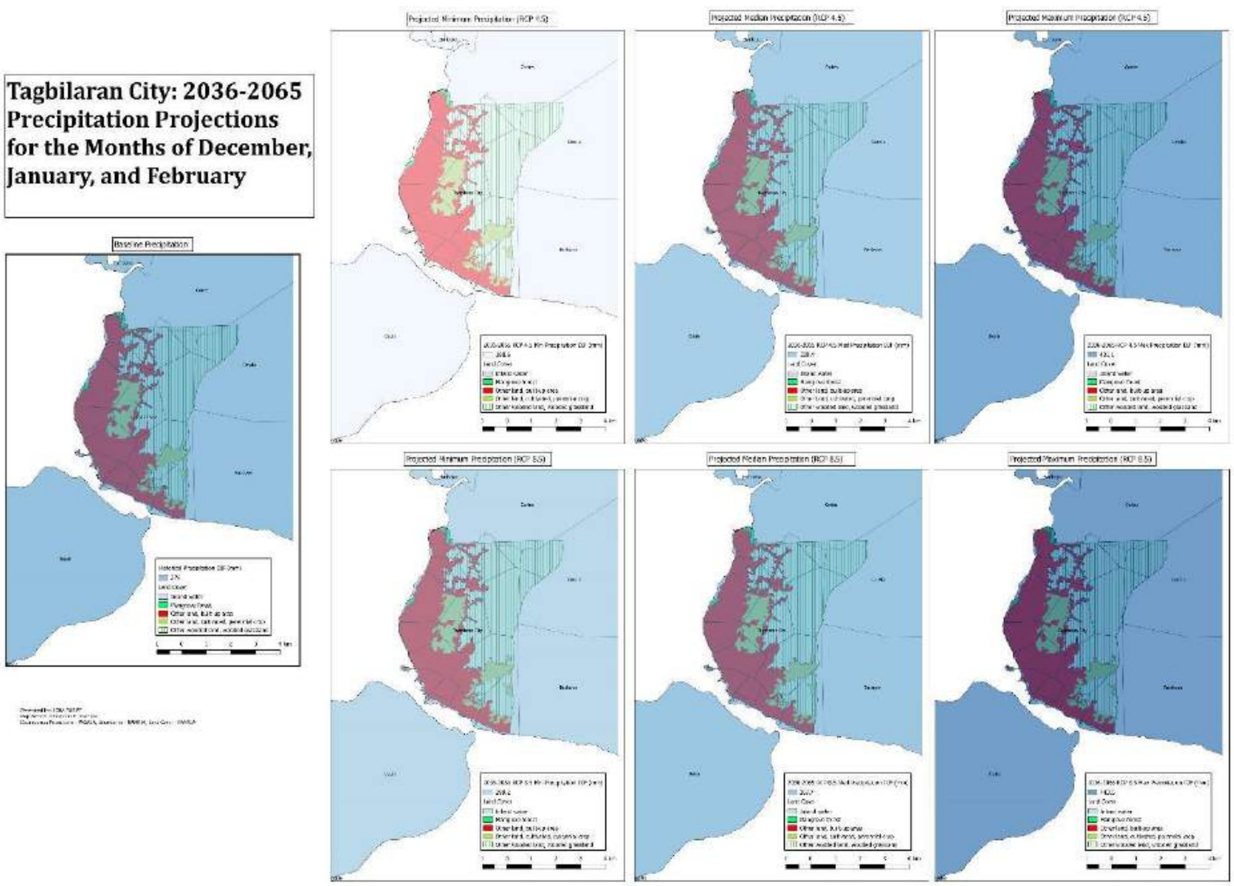
## Projections and Grid Extent (data on Projections come from PAGASA)

### *Change in Precipitation*

### Mid-21st Century Projections (2036-2065), Maps 14-17

The months of December, January and February are projected to have a general decrease in the cumulative rainfall amount relative to the baseline based on the median value of both scenarios ***(Map 3.5.14)***. The RCP 4.5 scenario projects a drier baseline compared to RCP 8.5, the former projected to decrease the baseline precipitation by 9.8% compared to the latter which is projected to decrease by 2.2%. This trend is followed in terms of the maximum and minimum projected possible rainfall amounts.

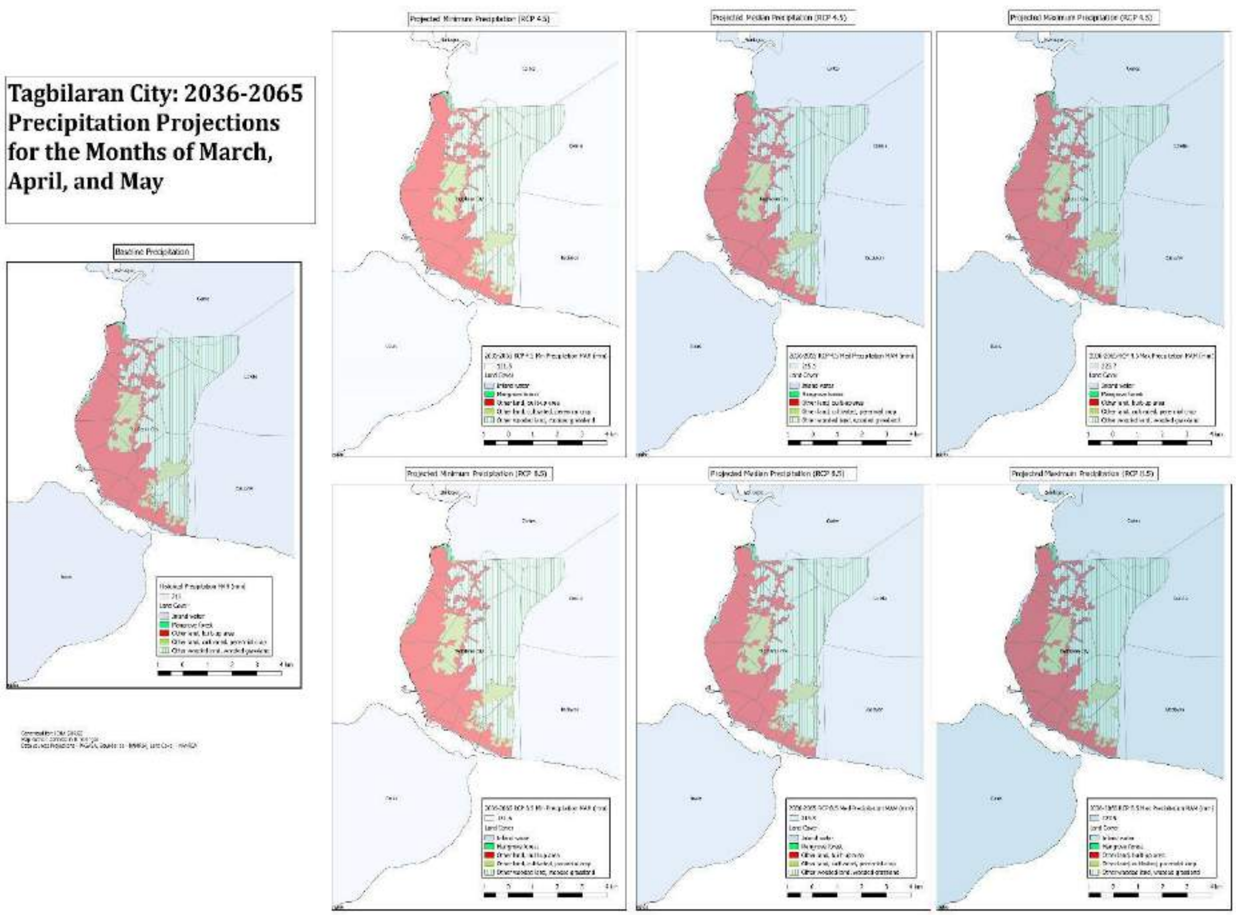
The projected minimum for RCP 4.5 is a decrease of 49.9% from the baseline while the minimum for RCP 8.5 is a decrease of 20.5% from the baseline. The projected maximum on the other hand is an increase of 14.6% from the baseline for RCP 4.5 and an increase of 17.9% for RCP 8.5.




***Map 3.5.14.*** *2036-2065 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be slightly wetter than the historical baseline based from the projected median precipitation of both scenarios ***(Map 3.5.15)***. The scenario under RCP 4.5 will be slightly wetter than RCP 8.5 with a projected increase of 2.6 % from the historical baseline for the former and a projected increase 1.8 % for the latter.

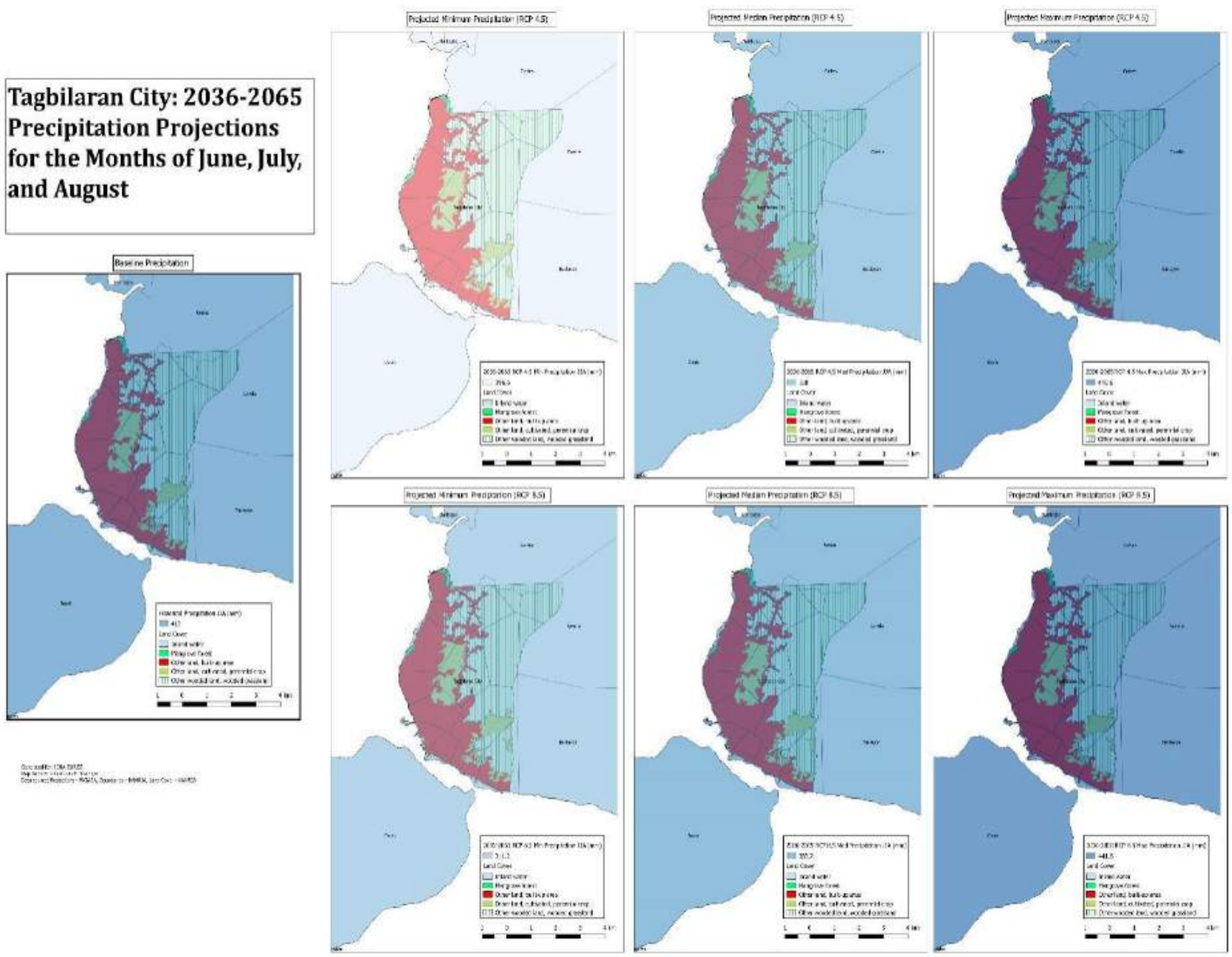
In terms of the maximum and minimum projected rainfall for the scenarios, RCP 4.5 is projected to be drier while RCP 8.5 is projected to be wetter following the same trend as the previous quarter. The minimum cumulative rainfall amount for RCP 4.5 is a projected decrease of 42.1% from the historical baseline while a projected decrease of 27.7% for RCP 8.5. The maximum cumulative rainfall amount on the other hand is a projected increase of 6.7% for RCP 4.5 and an increase of 8.5% for RCP 8.5.




***Map 3.5.15.*** *2036-2065 Precipitation Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August are projected to be drier than the historical baseline based from the projected median precipitation of both scenarios ***(Map 3.5.16)***. The scenario under RCP 4.5 is drier than that of RCP 8.5 with a projected decrease of 13.3 % from the historical baseline for the median rainfall of the former while a projected decrease of 7.2% from the historical baseline for the median rainfall of the latter.

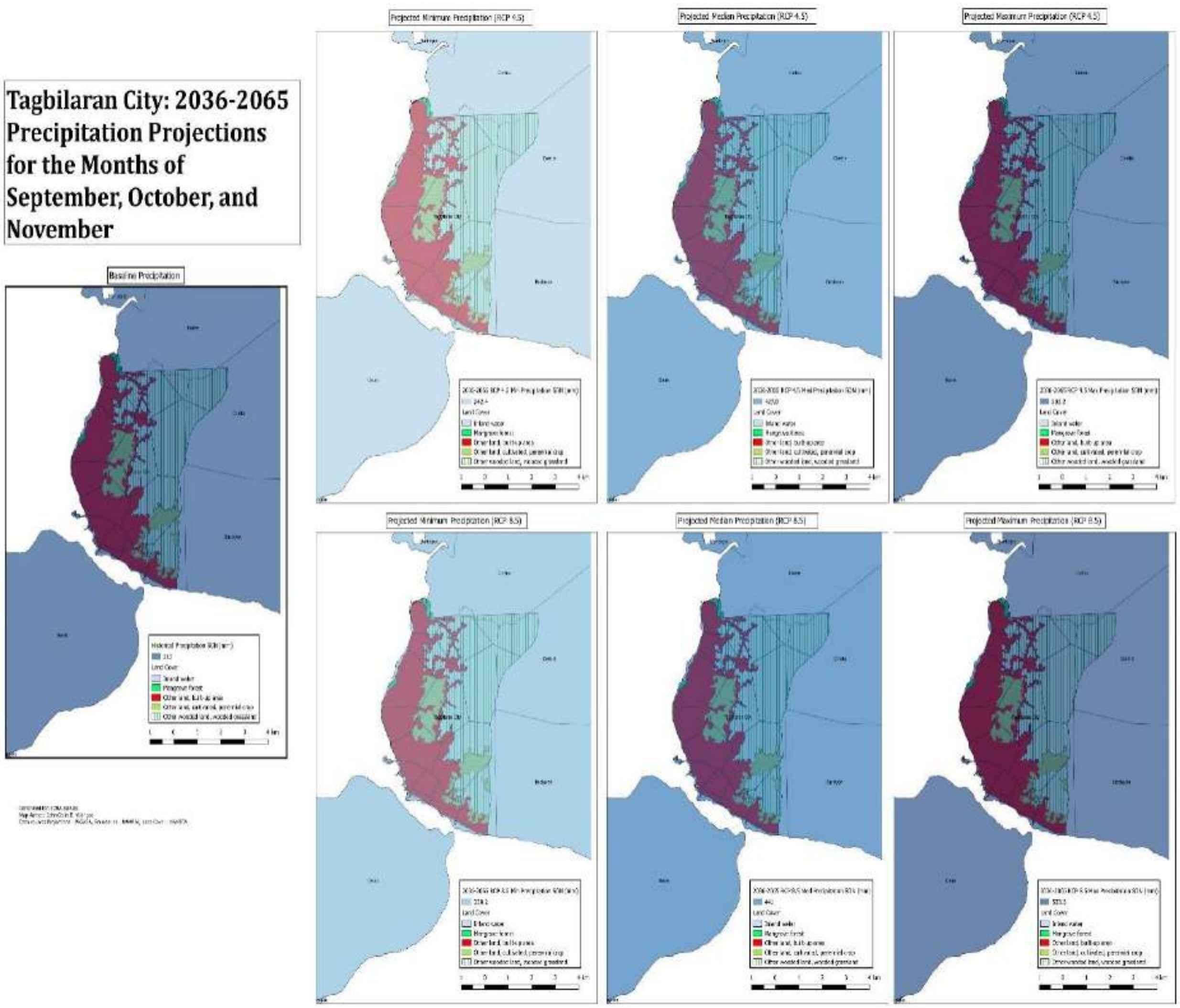
The same can be said for the maximum and minimum projected rainfall amounts. The projected minimum cumulative rainfall amount for RCP 4.5 is a decrease of 52.4% from the historical baseline while for RCP 8.5 the projected minimum rainfall amount is a decrease of 24.6%. The projected maximum cumulative rainfall for RCP 4.5 is an increase of 6.7% from the historical baseline while the maximum cumulative rainfall for RCP 8.5 is an increase of 7% from the historical baseline.




***Map 3.5.16.*** *2036-2065 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to be drier than the historical baseline based on the median values for both scenarios ***(Map 3.5.17)***.

Similar to the trend of the previous quarters, RCP 4.5 is projected to be drier than RCP 8.5. It is also worth noting that in RCP 4.5 even the projected maximum is drier than the historical baseline. The projected median for RCP 4.5 is a projected decrease of 16.8% from the historical baseline while for RCP 8.5 there is a projected decrease of 14.3% from the historical baseline. The projected minimum for RCP 4.5 is a projected decrease of 52.9% from the historical baseline while for RCP 8.5 there is a projected decrease of 34.1% from the historical baseline. Lastly, the projected maximum for RCP 4.5 is a projected decrease of 2.2% from the historical baseline while for RCP 8.5 there is a projected increase of 3.7% from the historical baseline.

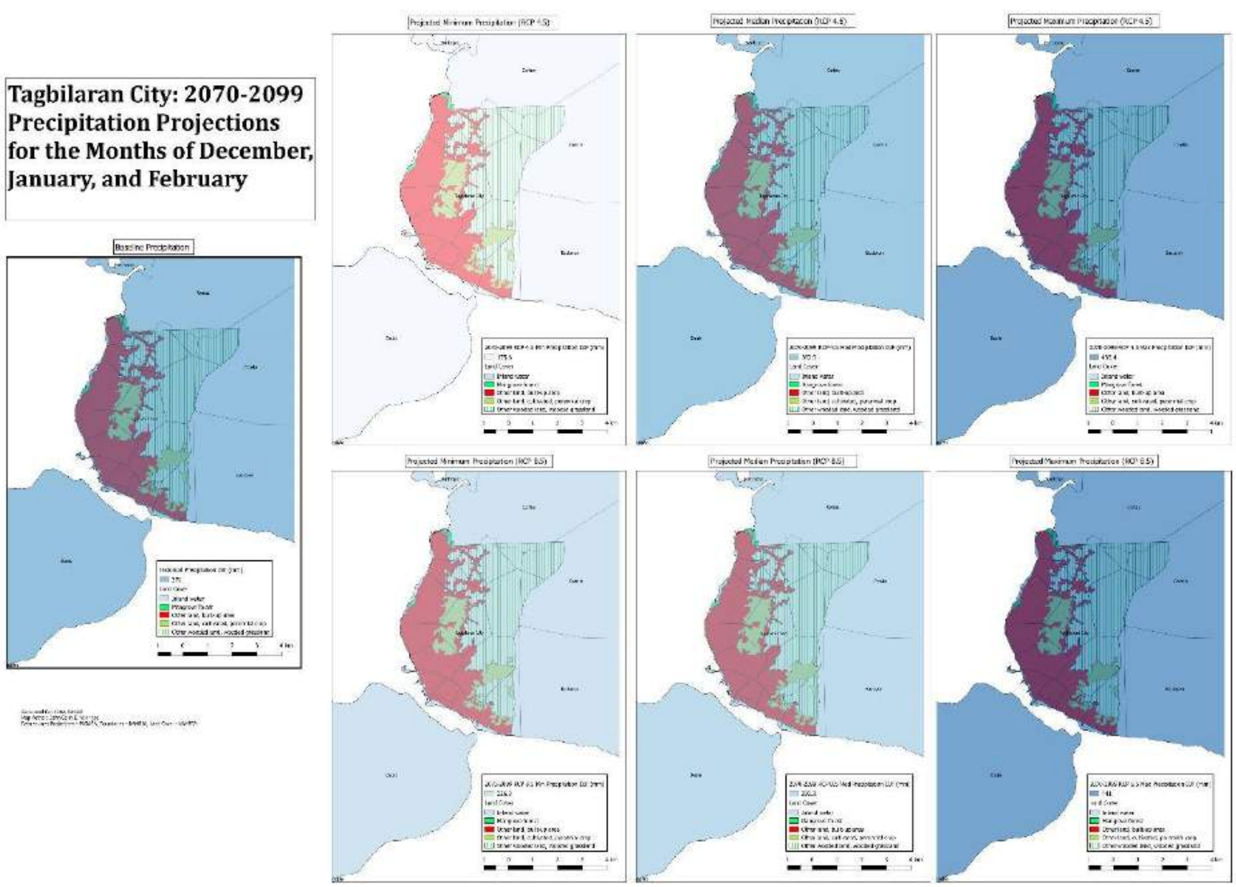



***Map 3.5.17.*** *2036-2065 Precipitation Projections for September October and November (Source: PAGASA data)*

### Late 21st Century Projection (2070-2099), (Maps 18-21)

For the late century the general trend for all quarters for both scenarios is projected to be drier than the historical baseline. Also, there is a bit of an inversion from the mid-century in that for the late century the median is drier in RCP 8.5 than on RCP 4.5. However, the trend for the projected minimum remains the same in that RCP 4.5 is drier than RCP 8.5

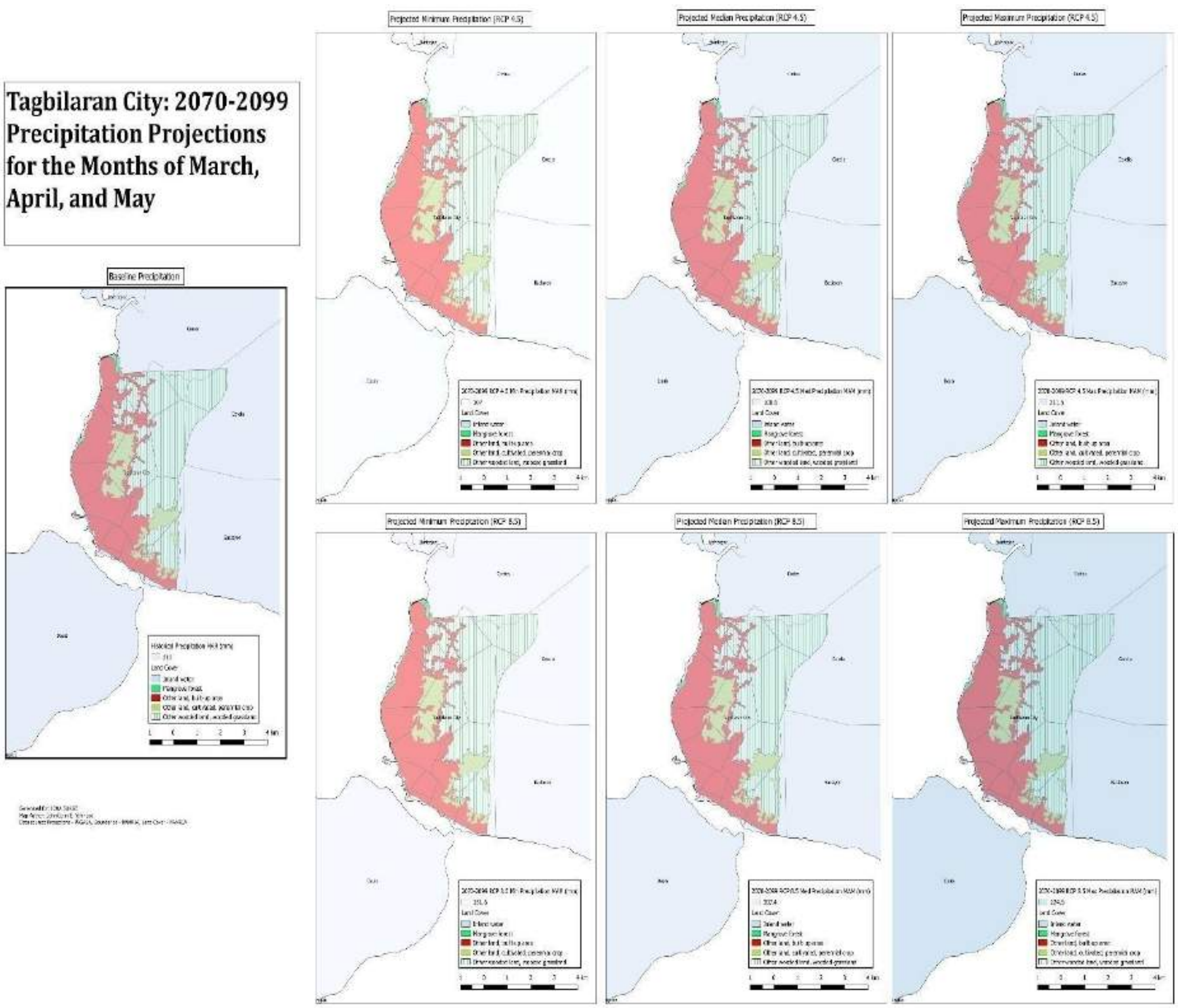
The months of December, January and February will be drier than the historical baseline based on the median values for both scenarios ***(Map 3.5.18)***. This is especially notable in RCP 8.5 where the median is projected to have a decrease of 22.8% from the historical baseline. This is compared to RCP 4.5 which is projected to have a median which is a decrease of 3.5% from the historic baseline; this decrease is less than what is projected for the mid-century for the same scenario. In terms of the projected maximum and minimum cumulative rainfall RCP 4.5 is projected to be drier than RCP 8.5. The projected minimum for RCP 4.5 is a projected decrease of 53.3% from the historical baseline while for RCP 8.5 there is a projected decrease of 39.8% from the historical baseline. Lastly, the projected maximum for RCP 4.5 is a projected increase of 15.8% from the historical baseline while for RCP 8.5 there is a projected increase of 17.3% from the historical baseline.




***Map 3.5.18.*** *2070-2099 Precipitation Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to be slightly drier than the historical baseline based on the median values for both scenarios with RCP 4.5 being drier than RCP 8.5 ***(Map 3.5.19)***.

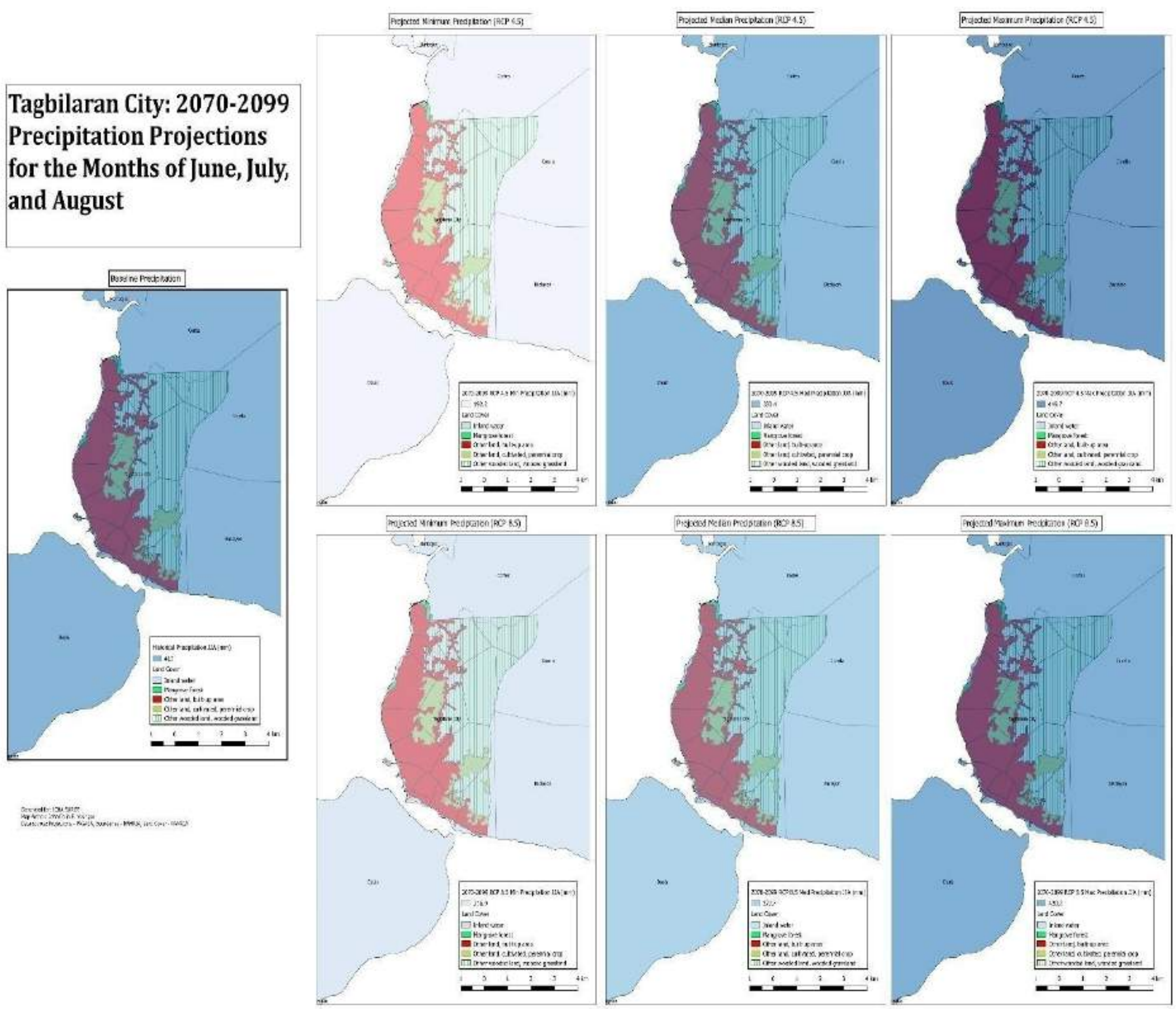
The median projected cumulative rainfall amount for RCP 4.5 is a decrease of 4.3% from the historical baseline while for RCP 8.5 there is a projected decrease of 1.0%. In terms of the projected maximum and minimum cumulative rainfall RCP 4.5 is projected to be drier than RCP 8.5. The projected minimum for RCP 4.5 is a projected decrease of 49% from the historical baseline while for RCP 8.5 there is a projected decrease of 27.7% from the historical baseline. Lastly, the projected maximum for RCP 4.5 is a projected increase of 0.9% from the historical baseline while for RCP 8.5 there is a projected increase of 7.2% from the historical baseline.




***Map 3.5.19.*** *2070-2099 Precipitation Projections for March, April and May (Source: PAGASA data)*

Trend for the months of June, July, and August is similar to that of the months of December, January and February in that the projected cumulative median rainfall is notably drier for RCP 8.5 than that of RCP 4.5 ***(Map 3.5.20)***.

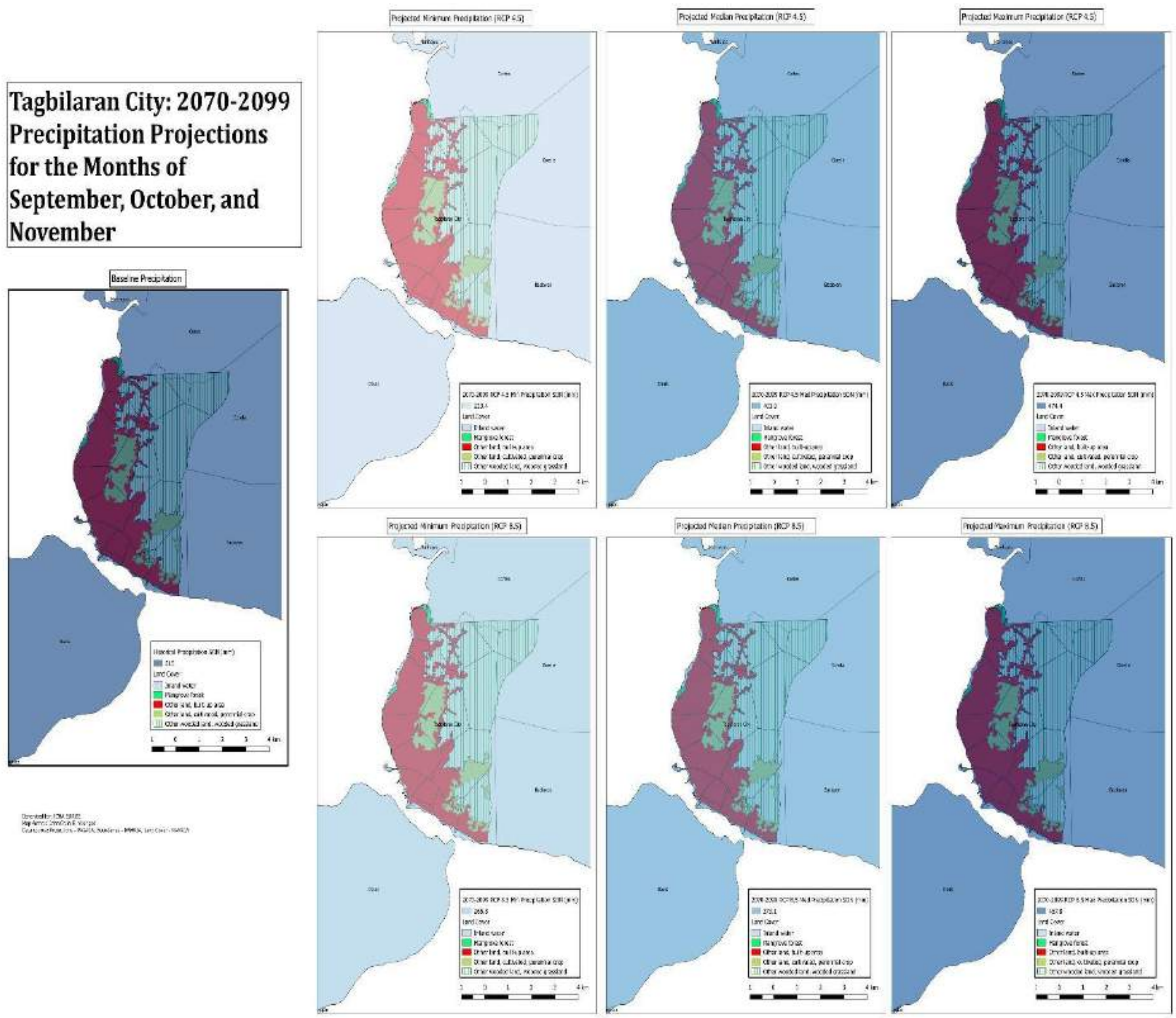
The projected median for RCP 4.5 is a projected decrease of 7.2% from the historical baseline while for RCP 8.5 there is a projected decrease of 20.6% from the historical baseline. In term of the maximum and minimum rainfall amounts, RCP 4.5 has a wider range of projected possible amounts compared to RCP 8.5. The projected minimum for RCP 4.5 is a projected decrease of 53.4% from the historical baseline while for RCP 8.5 there is a projected decrease of 47.5% from the historical baseline. Lastly, the projected maximum for RCP 4.5 is a projected increase of 8.9% from the historical baseline while for RCP 8.5 there is a projected increase of 4.2% from the historical baseline.




***Map 3.5.20.*** *2070-2099 Precipitation Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November are projected to be notably drier in both scenarios based not only on the median values, but also on the maximum values ***(Map 3.5.21)***.

The maximum possible projected cumulative rainfall amounts for both scenarios are lower than the historical baseline. The values for RCP 8.5 for this quarter are drier than that of RCP 4.5. The projected median for RCP 4.5 is a projected decrease of 21.9% from the historical baseline while for RCP 8.5 there is a projected decrease of 27.5% from the historical baseline. The projected minimum for RCP 4.5 is a projected decrease of 56.6% from the historical baseline while for RCP 8.5 there is a projected decrease of 48.3% from the historical baseline. Lastly, the projected maximum for RCP 4.5 is a projected decrease of 7.8% from the historical baseline while for RCP 8.5 there is a projected decrease of 11% from the historical baseline.



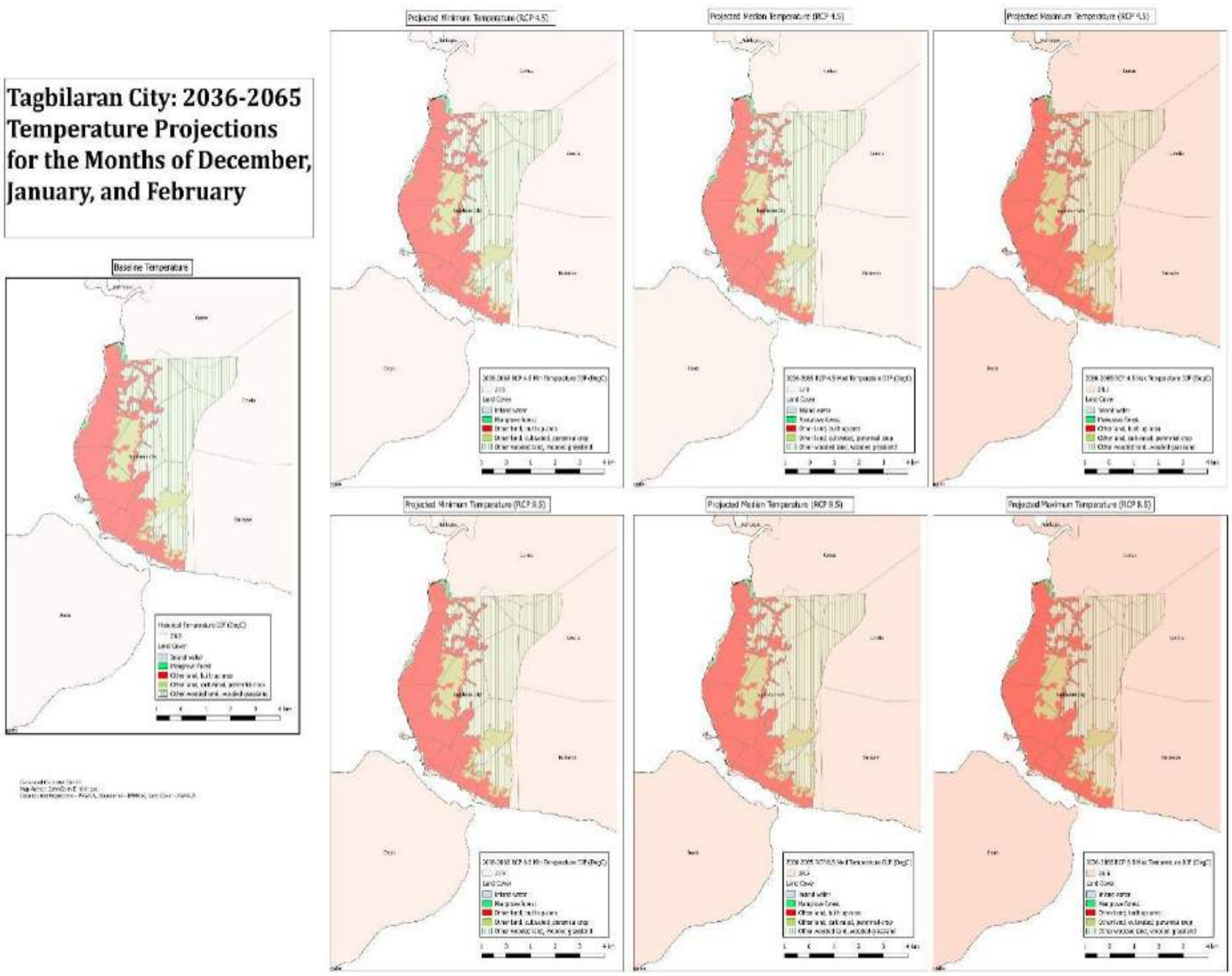

***Map 3.5.21.*** *2070-2099 Precipitation Projections for September, October and November (Source: PAGASA data)*

### *Change in Temperature*

The general trend for all scenarios and throughout the mid and late century is an increase from the baseline temperature differing only for each quarter. The details are specified below.

#### Mid-21st Century Projections (2036-2065), Maps 22-25

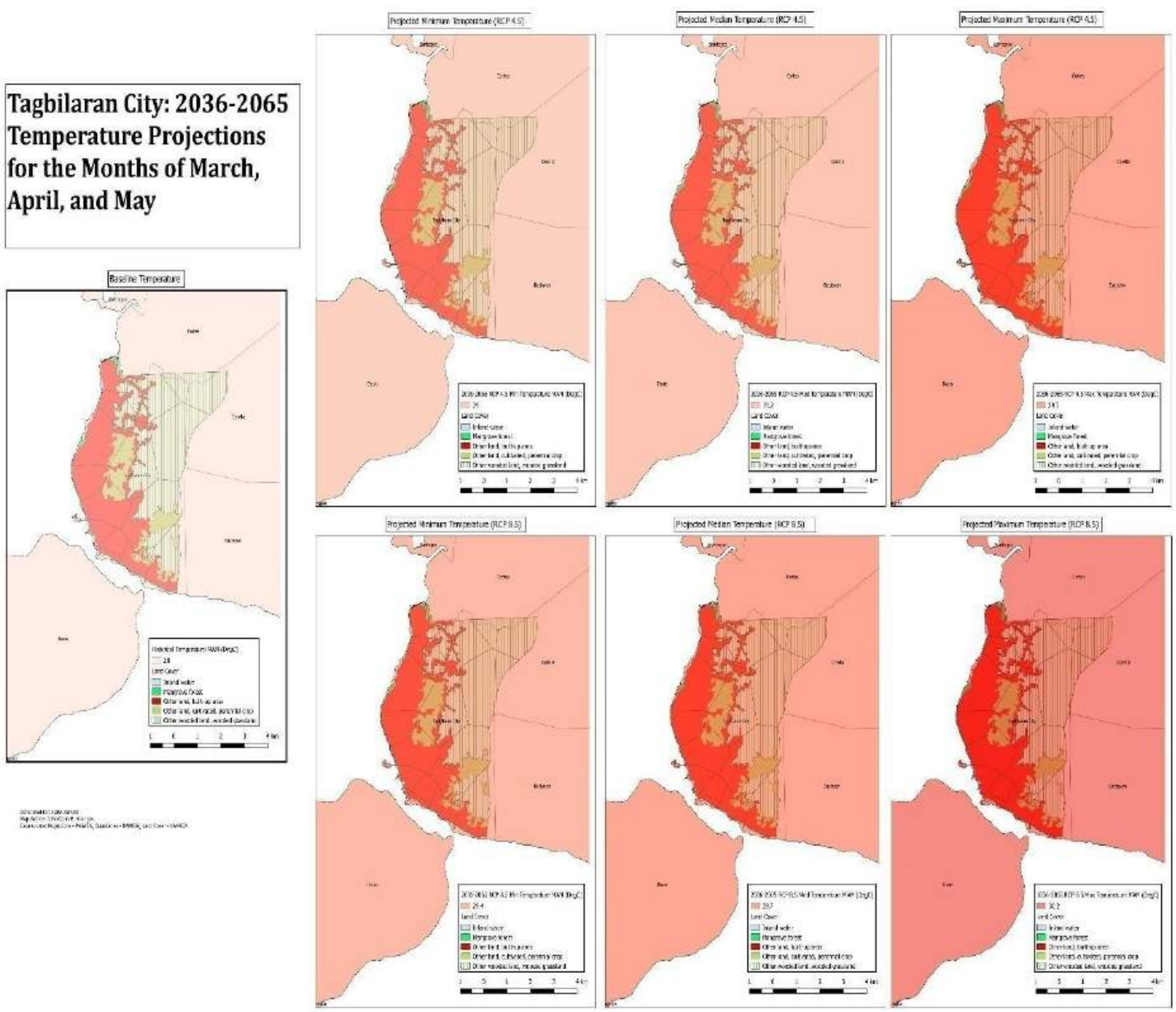
The months of December, February and January are projected to have temperatures increase with RCP 8.5 being hotter than RCP 4.5***(Map 3.5.22)***. The projected median temperature for RCP 8.5 is 28.2 degrees Celsius while for RCP 4.5 it is 27.7 degrees Celsius. The projected median temperature for RCP 8.5 is the same temperature as that of the historically hottest. The projected minimum temperature for RCP 8.5 is a 1.3 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperatures for both scenarios are hotter than the historical hottest. The maximum projected temperature of RCP 8.5 is an increase 2.0 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.7 degrees.




***Map 3.5.22.*** *2036-2065 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May will see an increase that is estimated to be hotter than the historical hottest temperatures for both scenarios and for all possible values ***(Map 3.5.23)***.

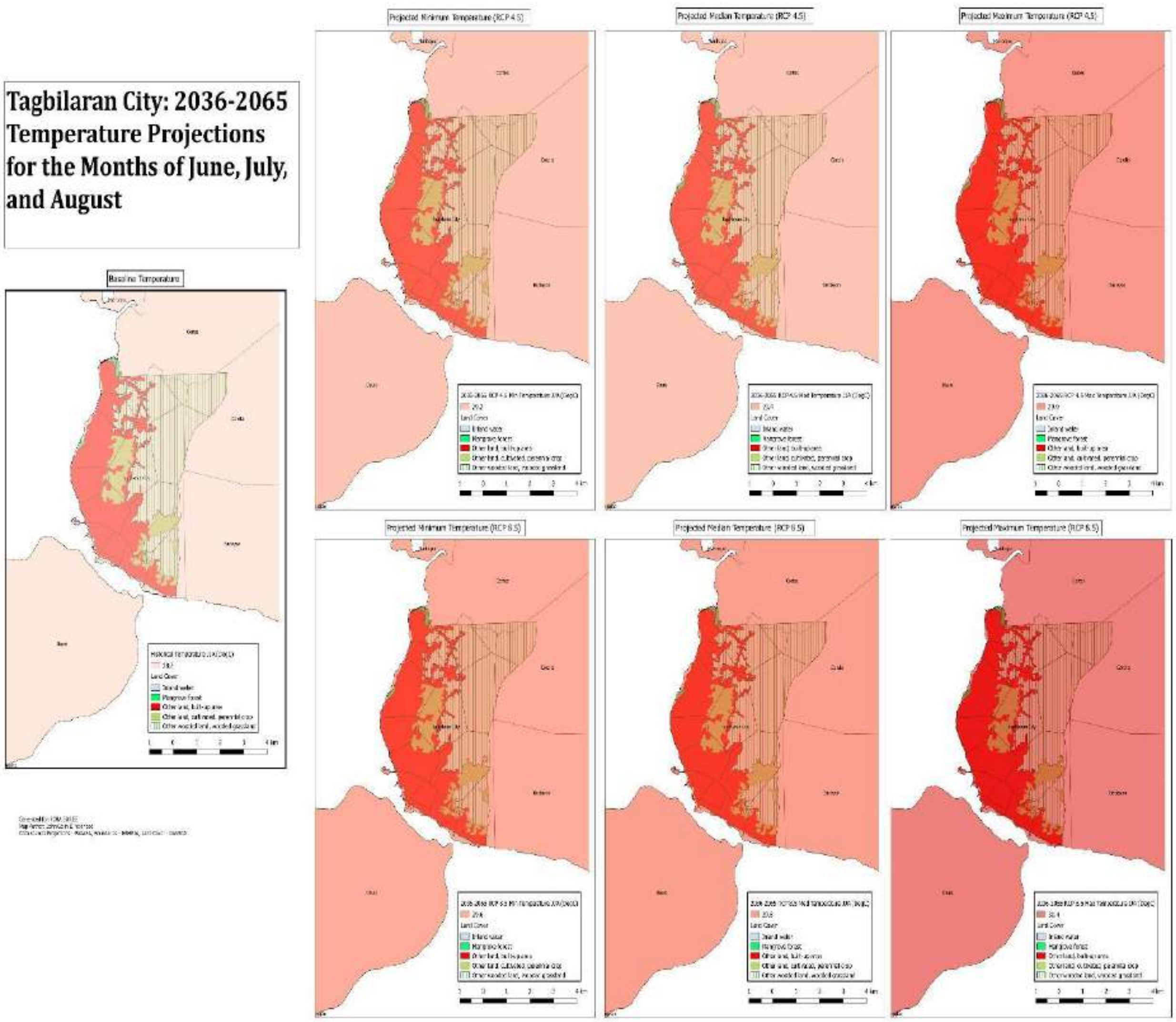
The projected median temperature for RCP 8.5 will be an increase of 1.7 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase 2.2 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.7 degrees.




***Map 3.5.23.*** *2036-2065 Temperature Projections for March, April and May (Source: PAGASA data)*

The months of June, July and August continue the trend from the previous quarter in that all temperatures are hotter than the hottest historical temperature for the year and that the increase for all values is higher in RCP 8.5 than in RCP 4.5 ***(Map 3.5.24)***.

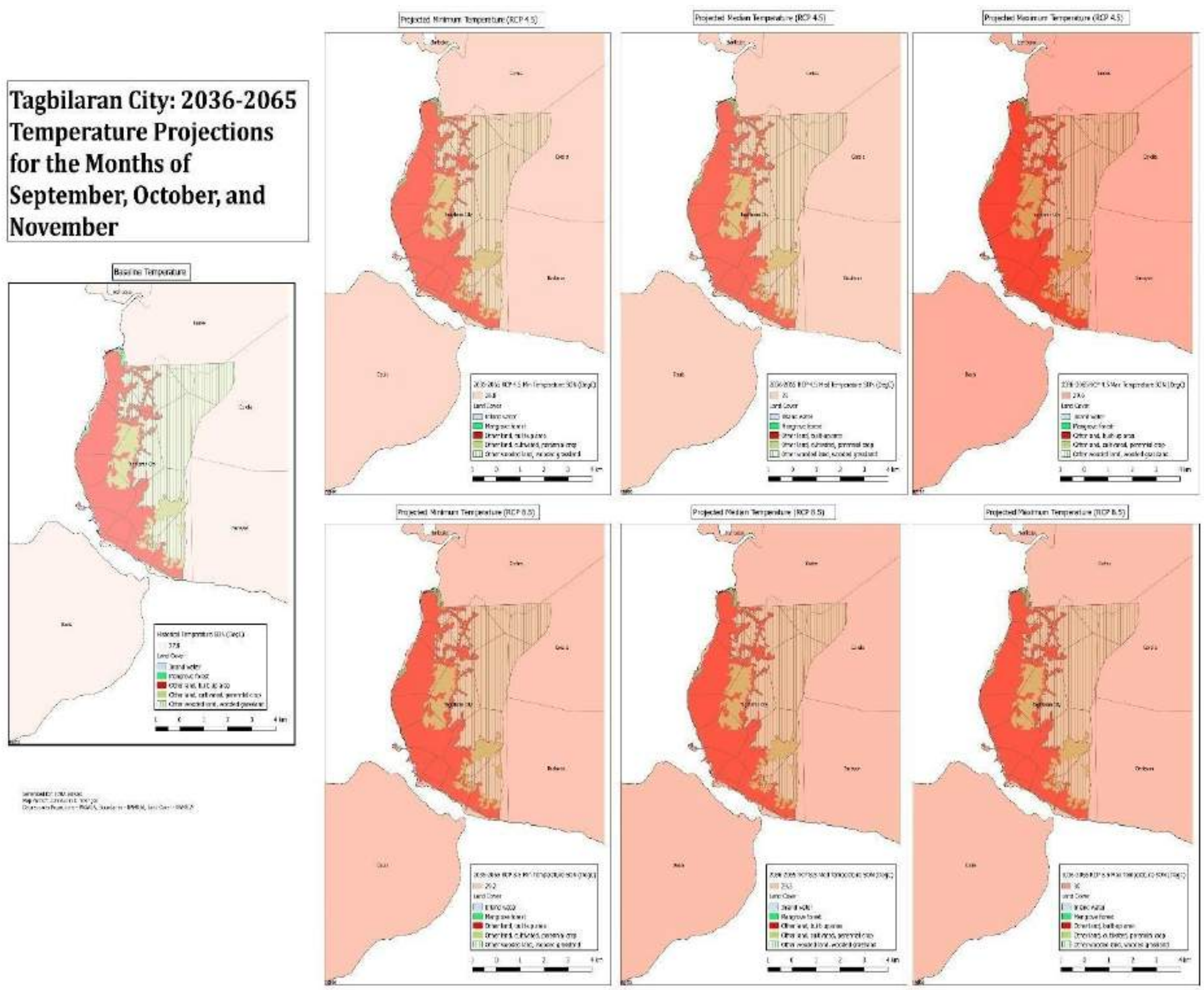
The projected median temperature for RCP 8.5 will be an increase of 1.6 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase 2.2 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.7 degrees. This quarter is projected to be the hottest of the year.




***Map 3.5.24.*** *2036-2065 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November continue the trend from the previous quarters in that all temperatures are hotter than the hottest historical temperature for the year and that the increase for all values is higher in RCP 8.5 than in RCP 4.5 ***(Map 3.5.25)***.

The projected median temperature for RCP 8.5 will be an increase of 1.5 degrees from the historical baseline while for RCP 4.5 there is a projected 1.2 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 1.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.0 degrees. The maximum projected temperature of RCP 8.5 is an increase 2.2 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 1.8 degrees.

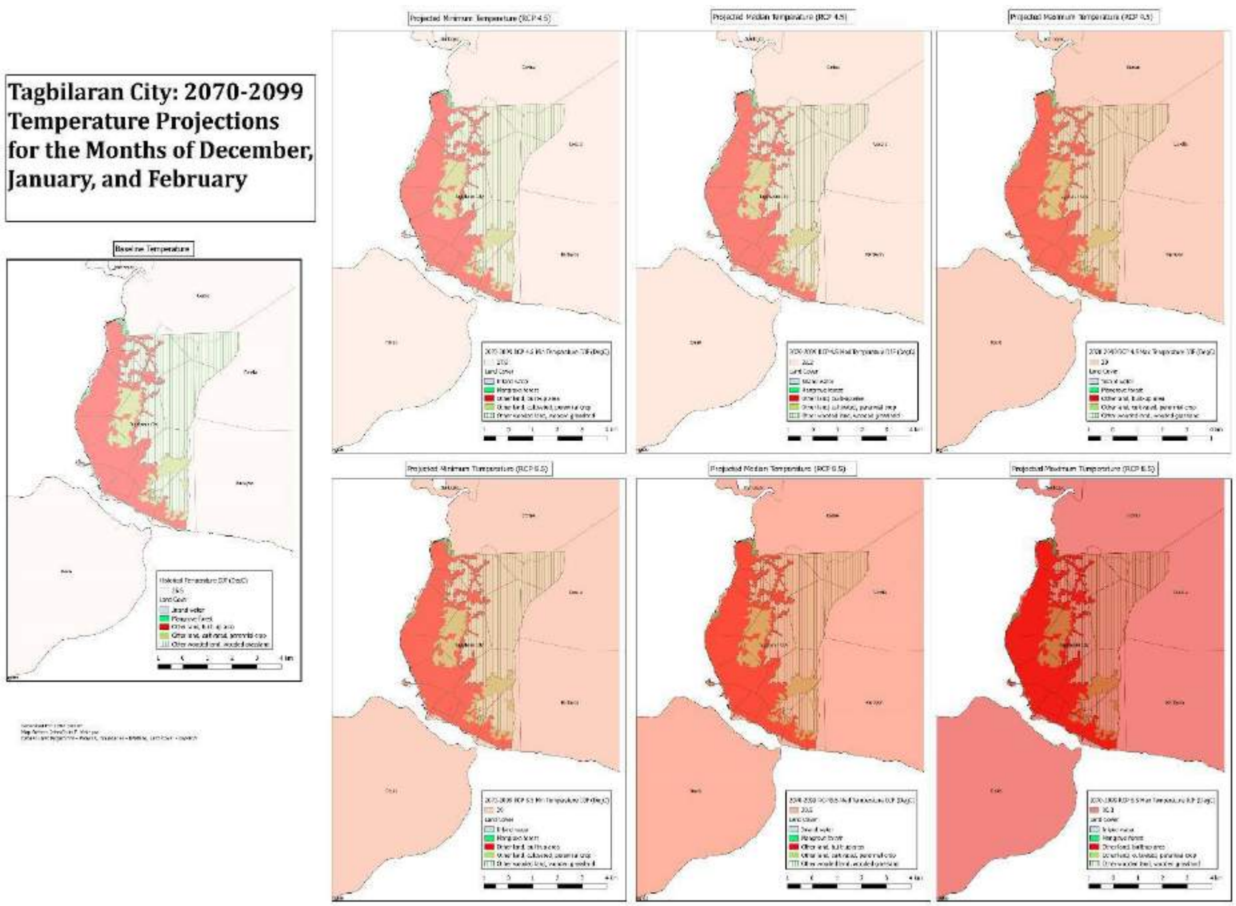



***Map 3.5.25.*** *2036-2065 Temperature Projections for September, October and November (Source: PAGASA data)*

### Late 21st Century Projections (2070-2099), Maps 26-29

The late century continues the trend of the mid-century except that RCP 8.5 will have a noticeably higher increase in temperature compared to RCP 4.5. The increases for RCP 8.5 in several instances were twice that of RCP 4.5. Also worth noting is that the increase in temperature of RCP 4.5 is also higher than the increase in temperature of RCP 8.5 in the mid-century.

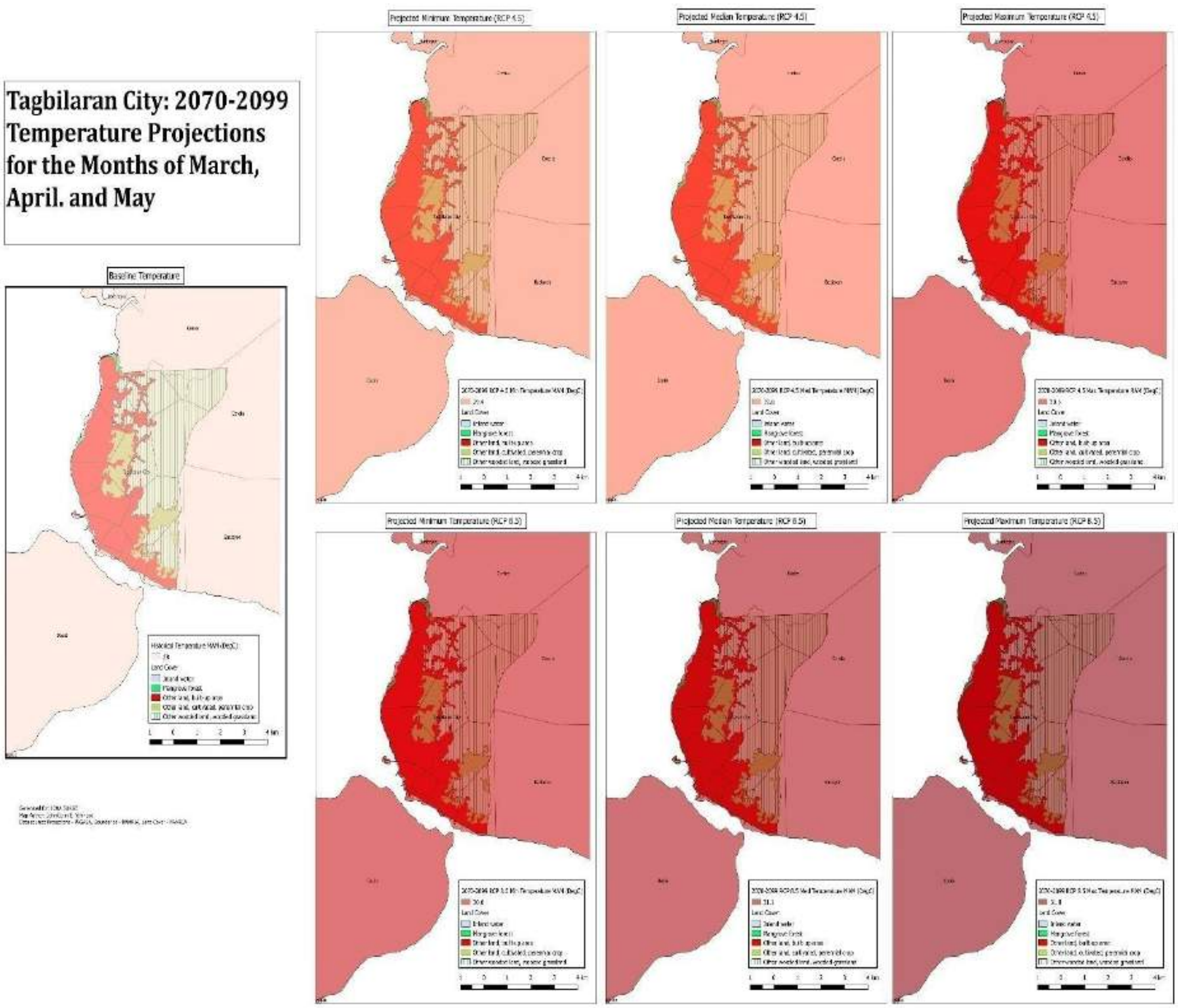
The months of December, January and February were historically the coolest and are projected to be so but the temperatures will exceed that of the hottest historical temperature in RCP 8.5 ***(Map 3.5.26)***. In RCP 4.5 the temperatures are projected to reach that of the hottest temperature in terms of the median temperatures and will exceed it in the maximum temperature. The projected median temperature for RCP 8.5 will be an increase of 2.9 degrees from the historical baseline while for RCP 4.5 there is a projected 1.6 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.4 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase 3.7 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 2.4 degrees.




***Map 3.5.26.*** *2070-2099 Temperature Projections for December, January and February (Source: PAGASA data)*

The months of March, April and May are projected to have temperatures hotter than the hottest historical temperatures in both scenarios with RCP 8.5 being hotter than RCP 4.5 ***(Map 3.5.27)***.

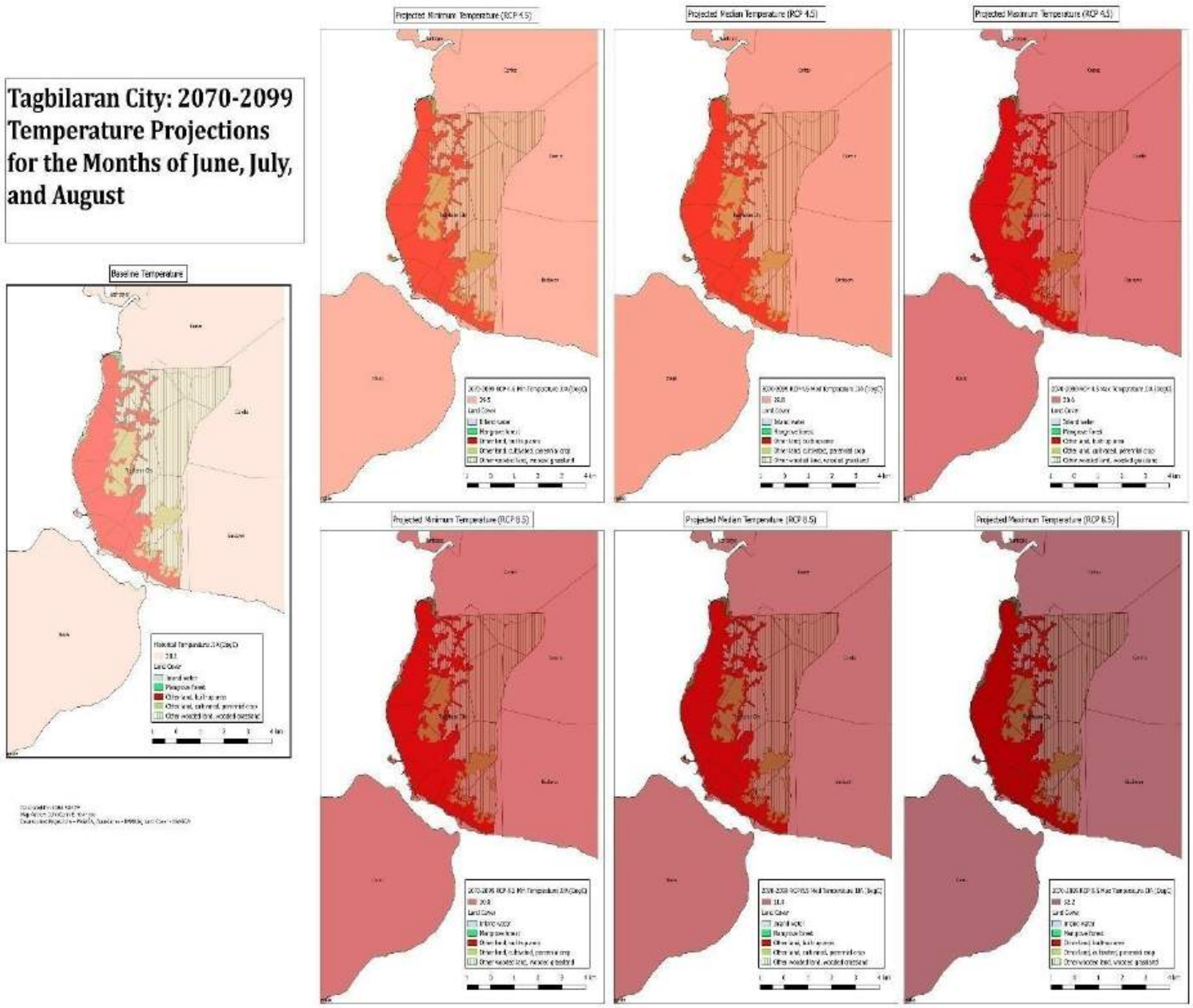
The projected median temperature for RCP 8.5 will be an increase of 3.1 degrees from the historical baseline while for RCP 4.5 there is a projected 1.6 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.6 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.4 degrees. The maximum projected temperature of RCP 8.5 is an increase 3.8 degrees from the historical baseline for the quarter while for RCP 4.5 there is a projected increase of 2.5 degrees.




***Map 3.5.27.*** *2070-2099 Temperature Projections for March, April, and May (Source: PAGASA data)*

The months of June, July and August are projected to continue to have the hottest temperatures of the year. The temperatures in both scenarios exceed that of the historical hottest ***(Map 3.5.28)***.

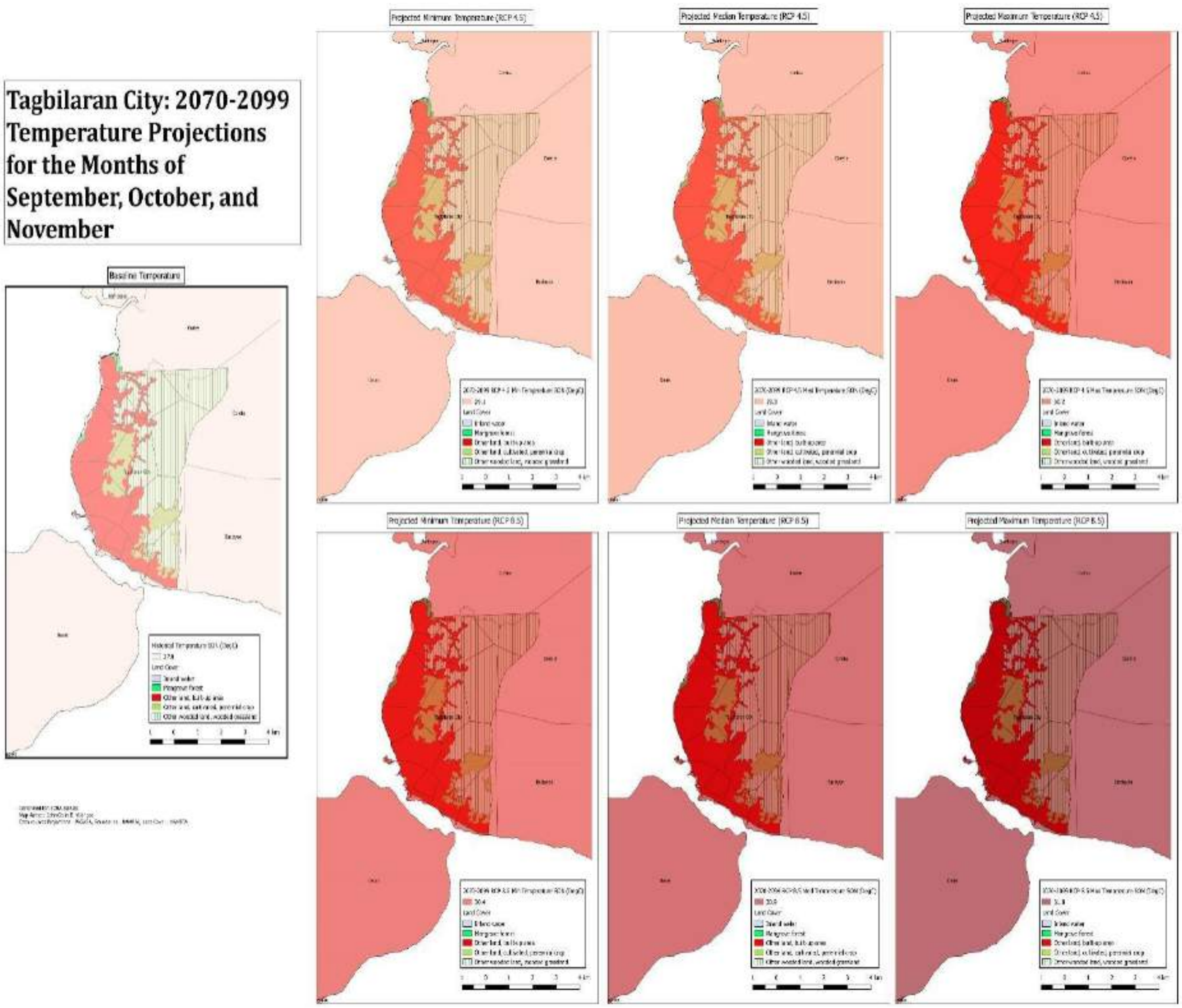
The projected median temperature for RCP 8.5 will be an increase of 3.2 degrees from the historical baseline while for RCP 4.5 there is a projected 1.6 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.6 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase of 4.0 degrees from the historical baseline for the quarter while for RCP 2.4 there is a projected increase of 2.4 degrees.




***Map 3.5.28.*** *2070-2099 Temperature Projections for June, July and August (Source: PAGASA data)*

The months of September, October and November continue the trend of the previous quarter, having temperatures higher than the historical hottest and the temperatures for RCP 8.5 being higher then RCP 4.5 ***(Map 3.5.29)***.

The projected median temperature for RCP 8.5 will be an increase of 3.1 degrees from the historical baseline while for RCP 4.5 there is a projected 1.5 degrees increase from the historical baseline. The projected minimum temperature for RCP 8.5 is a 2.6 degrees increase from the historical baseline while for RCP 4.5 there is a projected increase of 1.3 degrees. The maximum projected temperature of RCP 8.5 is an increase of 4.0 degrees from the historical baseline for the quarter while for RCP 2.4 there is a projected increase of 2.4 degrees.




***Map 3.5.29.*** *2070-2099 Temperature Projections for September, October and November (Source: PAGASA data)*

## Impacts and Adaptation Options

Tagbilaran city is a relatively small city characterized by a high level of urbanization with small areas for agriculture and wooded grassland. One of the key features of the city is that a number of its barangays and the majority of its settlements are located along the coasts. In terms of the projections the general trend for all scenarios projects that in either scenario the climate will both be drier and hotter than the historical baseline. The relatively uniform projected trend in turn indicates similar impacts differing in degrees of intensity from each scenario and from mid to late centuries. The projected impacts of the said trends for each of the sectors are as follows.

### *A. Demography*

Because of the largely urban characteristic of the city one of the main effects to its population are the urban heat effects which lead to health problems such as heat stroke and dehydration. The increased temperature has adverse effects on the prevalent primary economic activities in the city which can lead to loss of livelihood (IPCC 2014). The increase in temperature and the projected drier climate also leads to larger demand for water which at the current state of system, depending largely on groundwater (Tagbilaran Environmental Profile 2006), cannot sustain. The loss of livelihood and the potential health effects can lead to a possible out migration trend (Black et al. 2008).

The city currently has plans that aid in educating in the effects of climate change and possible alternative livelihoods for the at risk sectors of fisheries and agriculture, but largely focus on flood based risks. One of the adaptation options that are suggested by literature in the urban setting is the creation of policies that change behaviour and custom. In terms of a hotter and drier climate this may take the form of policy regarding attire, possibly opting for cooler types of clothing materials for institutions. This can also cover changes in working and class hours opting for cooler hours of the day (Sabbag 2013).

### *B. Social*

The social effects of the projected climate are partly embraced in the section above. Health and educational institutions will be largely affected given the possible health risks to the citizens, staff, faculty, and students that frequent the said institutions. There is also a higher risk for the urban poor who lack access to facilities that can help mitigate the dangers of the drier and hotter climate.

The city has plans that adapt to this sector such as socialized housing for the urban poor, alternative livelihoods for at risk sectors, and information campaigns on effects of climate change. The city has also required business to build sidewalk canopies for pedestrians and the adoption of the green building code.

Possible additional adaptation options are policies such as those proposed in the above section regarding behaviour, but also investments on health facilities and equipment that can handle heat based diseases. Moreover, smart design and technology can be adopted in houses and government facilities that make use of better indoor ventilation (Sabbag 2013). The addition of green spaces and vegetation may also mitigate the increase in temperature in the urban setting (Sabbag 2013).

### C. Economic

In terms of the economic sector the most affected industries to the projected increase in temperature and decrease in precipitation are the fisheries and agricultural sectors. The projected climate will negatively affect the needed water supply for the agricultural sector effectively reducing yield (IPCC 2014). In particular, the projected rise in temperature has a negative effect on crops of corn, rice, and potatoes (Eitzinger et al. 2016), all of which are cultivated in the city. The coral reefs that attract fish species and lend to the nutrient content of the waters near the city will be lessened due to the projected increase in water and may even induce coral bleaching (IPCC 2014). This in turn decreases fish catch. Furthermore, due to the possible reduction in yield, fish catch, increased consumption of energy, and increased water demand the prices of commodities will tend to increase.

The city has adopted plans to mitigate the possible impacts of climate change to the sector such as the introduction of alternative livelihoods to fisher folk and farmers and incentives for the use of alternative energy sources. For crops, it is suggested that aside from alternative livelihoods alternating crops and adoption of climate tolerant varieties are possible ways to adapt to the climate (Howden et al. 2007 & Toda et al. 2016). Development of more efficient water storage systems and better water usage management practices are suggested to further augment this (Howden et al. 2007). Fisheries are also suggested to monitor and manage fishing patterns through alternating seasons of fishing so the ecosystem can replenish both the fish and nutrients in the region (Howden et al. 2007)

### D. Infrastructure

In terms of infrastructure the projected increase in temperature has a consequential increase in energy consumption due to its higher demand. The increase temperatures can also cause cracks and unevenness in roads which can increase costs of maintenance (Sabbag 2013 & Schweikert et al. 2014) and has consequent impacts on economy and the price of goods. The city has provided incentives for the use of renewable energy to help address the energy aspect of this sector, but it has yet to address the possible impacts to the road infrastructure. Possible solutions are adoption of infrastructure planning methods that help monitor and maintain roads (Schweikert et al. 2014) also adoption of climate appropriate infrastructure materials may prove more resilient roads (Sabbag 2013).

### E. Environment

The impacts to the environment due to the estimated increase in temperature and decrease in precipitation are mainly the lowering of the groundwater table, deforestation, and coral bleaching, (IPCC 2014). The consequences of the lowering of the water table are significant to the city since its main source of water is groundwater (Tagbilaran City Environmental Profile 2006). Hence, the increase in temperature and decrease in precipitation lowers the groundwater recharge and thus lowers the overall fresh water supply of the city. In terms of coral bleaching the impacts and adaptation options to such have been enumerated above. The city has adopted the green building code to aid in mitigating the said impacts and also the implementation of the waste management plan to aid in keeping the water supply clean and usable. Other adaptation options are the development of water storage systems to aid in augmenting water supply (Howden et al. 2007)

### *F. Hazards*

In terms of hazards the increase in temperature and decrease in precipitation will increase the probability of droughts and wildfires (IPCC 2014). The said reduction in precipitation also reduces the probability of high height floods in the city. The possible adaptation options to the increase in droughts have been enumerated above. In terms of adaptation options for wildfires investment in more firefighting measures throughout the city are suggested along with identification of fire hazard zones (Four Twenty-seven Climate Solutions 2017).

## Adaptation Options

***Table 3.5.2.*** *Summary of Impacts and Adaptation Options for Tagbilaran City*

| **Summary of Impacts and Adaptation Options** | | | |
|---|---|---|---|
| **Climate Variable** | **Sector Characteristic** | **Impacts** | **Adaptation Options** |
| Increase in Temperature and decrease in precipitation (Year-round and for all scenarios) | Demography | Increased heat related health risk to population, possibility of out migration, loss of livelihood | Education campaign, introduction of alternate livelihoods, policies that adapt attire to higher temperatures and adjustment of working and class hours |
| | Social | Increased heat related health risk to population, possibility of out migration, loss of livelihood, increased health risk to urban poor, | Education campaign, introduction of alternate livelihoods, policies that adapt attire to higher temperatures and adjustment of working and class hours, adoption of smart designs for residential and government facilities, establishment of green spaces |
| | Economic | Reduced yield of crops and fish catch, reduction of water supply, increased demand for water, projected increase of price of commodities, | Introduction of alternate livelihoods, climate tolerant crop varieties, alternating crops, development of water storage systems and water usage management practise, monitoring and management of fishing patterns |
| | Infrastructure | Higher consumption and demand for energy, cracks and unevenness of roads consequent increase in costs of maintenance. | Incentives for the use of renewable energy, adoption of infrastructure planning methods, adoption of climate appropriate infrastructure materials |
| | Environment | Lowering of groundwater table, deforestation, coral bleaching | Adoption of a green building code, implementation of waste management plan, development of water storage systems |
| | Hazards | Increase of probability of droughts and wildfires | Development of water storage systems, firefighting measures, identification of fire hazard zones. |

## References

Black, R.; Kniveton, D.; Skeldon, R.; Coppard, D.; Murata, A.; & Schmidt-Verkerk, K. (2008). Demographics and Climate Change: Future Trends and their Policy Implications for Migration. Working Paper, Development Research Center on Migration, Globalisation, and Poverty.

Eitzinger, A.; Laderach, P.; Giang Tuan, L.; Ramaraj, A.; Ng'ang'a, K.; Parker, L.; Learning and Coping with Change: Case Stories of Climate Change Adaptation in Southeast Asia. Case Story Book Vol. 1. Pp 83-97

Four Twenty-seven Climate Solutions (2017). Fremont Climate Hazard Assessment and Adaptation Options.

Howden, S.M.; Soussana, J.; Tubiello, F.; Chhetri, N.; Dunlop, M.; & Meinke, H. (2007) Adaptingagriculture to climate change.Proceedings of the National Acadamy of Sciences of the United States of America. Vol 104 no. 50

IPCC, 2014: Climate Change 2014: Synthesis Report. Working Groups II Fifth Assessment Report of the Intergovernmental Panel on Climate Change.IPCC, Geneva, Switzerland, 151 pp.

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Sabbag, L. (2013). Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation.From Sheltering from a Gathering Storm working paper No. 4. Institute for Social and Environmental Transition-International.

Schweikert, A.; Chinowsky, P.; Espinet, X.; & Tarbert, M. (2014). Climate Change and infrastructure impacts: comparing the impact on roads in ten countries through 2100. Procedia Engineering 78. pp 306-316.

Toda.L.L., Yokingco, J.C.E., Paringit, E.C., Lasco, R.D.L. (2017) A LiDAR based flood modelling approach for mapping rice cultivation areas in Apalit, Pampanga.Journal of Applied Geography.Vol. 80. Pp 34-47.

## IV. CONCLUSION AND DISCUSSIONS

The study was able to show that available data as well as literature can be used in assessing climate change impacts and proposing possible adaptation options for cities. The methodology used is simple and make use of readily available open sourced data that can be subjected to minimal geo-processing to generate maps. During the validation workshop with the city staff wherein the process, the framework used in developing the maps and the tables were presented, the viability of the application of the method was confirmed.

During the workshop the members of the participating cities were tasked to construct an impact chain *(Annex 2)* to make the users familiar with the use of the results of the study and to validate adaptation options that were proposed by the study. The end outputs of the workshop showed similar impacts and adaptation options similar to the results generated by the synthetic assessment. Not only did it validated the results of the study, it validated the use of open data. The process was sufficient to produce the same assessment as those by the city which are more knowledgeable about the characteristics of their respective cities. Furthermore, the impact chains were able to display the ease of use and sustainability of the framework which was designed to adapt to changing data, literature, and models on climate change.

One of the notable feedbacks from the workshop was the observations on map comparisons. The use of the comparative visualization of the differing values for each scenario was appreciated by the participants of the workshop commenting that these provided a better illustration of the different temperature and precipitation values with reference to the baseline. It is also worth noting that the participating cities all used QGIS as their GIS platform which makes the transfer of the process more viable. Once the data is turned over to the cities, they can already use, open and manipulate the shapefiles generated by the study.

As elaborated earlier, one key objective of the study is to provide a method that would make climate change projections easier to use and integrate into the local plans of the cities. The emphasis on available data and open access techniques were driven by the need to provide a sustainable method wherein updated data can easily be accommodated. The validation and interaction with the cities during the workshop was able to showcase this ability of the framework to address that concern. Moreover, in the advent of new data, cities can easily make adjustments by just replacing the primary data used in the generation of the results hence, update the impacts and adaptation options following the same framework.

Despite the plausibility of the approach, there remains some challenges that still need to be addressed in order for the framework to fully function, and this was raised during the workshop – the ease in obtaining the data and weaknesses in the actual policy contexts. The climate change projections were readily available from PAGASA, but their availability was not widely made known to the cities. The CLIRAM tool which was created PAGASA was available only upon request, but in spite of this the participating cities have not yet acquired a copy of such until the actual workshop.

Cross-border impacts were also not yet integrated into the study for the given projections were limited into provincial boundaries. This was pointed out by one of the participants wherein they stated that they wished to know the projections of a neighboring city which belonged to a different province.

For such a concern, the framework of the study can still be applied as it dealt mostly with the physical aspects of the impacts to the cities which are not bound nor affected by the political boundaries. In this case, should data be made available, this could still be used, although with considerations on the need to create a more holistic ecosystem approach to the assessment of climate change impacts. The current policy context is the only limiting factor as guidelines such as those provided for by HLURB do not require an analysis of the city with respect to a larger ecosystem that goes beyond its political boundaries. More commonly, the city is treated as an isolated system.

Taking all of these into account, the study can be regarded as a good step to practically use available data in assessing the impacts of climate change to the cities that may allow the development of viable adaptation options. The sustainability of the framework was validated leaving only challenges that are inherent to the weaknesses in the policy context for cities to overcome in the future.

As a recommendation, the method can be enhanced using projections that have a higher spatial resolution than the provincial scale projections that were used in this study. Projections that have a resolution that can take into account more spatially based conditions such as topography. By using higher resolutions, more localized and detailed impacts and adaptation options can be provided up to smaller government units such as barangays. This may be probable in the near future using the Coupled Model Intercomparison Project 5 (CMIP5) projections that PAGASA is currently using to update its data, which unfortunately was still not available in time for this study.

Also, in the future, it is suggested to make use of more localized literature or case studies to ensure that the results matched with the conditions more accurately reflects the reality. For this study, most of the impacts and adaptation options were referenced from literature available from open sourced journals and online reports due to the difficulty of collation or lack of local studies. The availability of local studies or within similarly situated areas such as those within the province can provide inputs for more localized information. Lastly, supplemental assessments to the synthetic framework may be beneficial. The synthetic framework provides a broad qualitative overview of possible impacts and adaptation options for the LGUs. Assessments that make use of methodologies involving indices or models will then provide a more detailed or quantitative view of these impacts and adaptation options.

# RERERENCES

Benson, C. (2009). Mainstreaming Disaster Risk Reduction into Development: Challenges and Experiences in the Philippines. Geneva: Provention Consortium.

Beuavais, N., Ghosh, I., & Dickson, L. (2015).Translating the Science of Climate Change into Built Solutions. Michigan Journal of Sustainability .

Boaz, A., & Hayden, C. (2002). Pro-active Evaluators: Enabling Research to be Useful, Usable, and Used. Evaluation , 440-453.

Boureima, M.; Abasse, T.; Montes, C.S.; Weber, H.; Katkore, B.; Mounkoro, B.; Dakouo, J.M.;

Samake, O.; Sigue, H.; Bationo, B.A.; & Diallo, B.O. (2013). Participatory analysis of vulnerability and adaptation to climate change: a methodological guide for working with rural communities. World Agroforestry Center (ICRAF)

Burdeos, K., & Lansigan, F. (2017).Statistical Downscaling of Future Precipitation Scenarios. Climate, Disaster and Development Journal .

Carter, J., Cavan, G., Connelly, A., Guy, S., Handley, J., & Kazmierczak, A. (2015). Climate Change and the City: Building Capacity for Urban Adaptation. Progress in Planning .

Cuevas, S., Peterson, A., Robinson, C., & Morrison, T. (2015). Challenges in Mainstreaming Climate Change Adaptation into Local Land Use Planning: Evidence from Albay, Philippines. The International Journal of Climate Change: Impacts and Responses .

Duante, C., Cuarteros, C., Gironella, G., Ferrer, E., Acuin, C., & Capanzana, M. (2015).Impacts of Climate Shocks on Caloric Intake of Filipinos. Food and Nutrition Research Institute – Department of Science and Technology .

Gil, S. (2004). Literature Review: Impacts of Climate Change on Urban Environments. Center for Urban and Regional Ecology.The University of Manchester.

Harrison, P.; Holman, I.; Cojocaru, G.; Kok, K.; Kontogianni, A.; Metzger, M.; & Gramberger, M. (2013) Combining qualitative and quantitative understanding for exploring cross-sectoral climate change impacts, adaptation and vulnerability in Europe. Regional Environment Change 13. pp 761-780

Lorenz, S., Dessai, S., Forster, P., & Paavola, J. (2015). Adaptation planning and the use of climate change projections in local government in England and Germany. Sustainability Research Institute No. 86 .

Masser, V., et al. (2014).Adapting Cities to Climate Change: A systemic modelling approach.Journal of Urban Climate.

National Institute of Geological Sciences, University of the Philippines-Diliman, Geosience Foundation Incorporated. (2014). Analysis of Climate Change Impacts on Stream Discharge using STREAM.FAO-AMICAF.

Perez, R. (2002). Assessment of Vulnerability and Adaptation to Climate Change in the Philippines Coastal Resource Sector.PAGASA.

Puyallup Tribe of Indians and Cascadia Consulting Group.(2016). Climate Change Impact and Adaptation Options. Puyallup: Cascadia Consulting Group.

Ranasinghe, R (2016) Assessing climate change impacts on open sandy coasts: A review. Earth Science Reviews 160 (2016). pp 320-332

Santos, T., Toda, L., Orduña, J., Santos, F., & Ferrão, J. (2016). The impacts of Typhoon Haiyan in the Philippines: Implications to land use planning. Climate, Disaster and Development Journal .

Sajise, A.J.; Sombilla, M.; & Ancog, R. (2012) Socioeconomics of Climate Change in the Philippines: A Literature Synthesis (1990-2010). Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) and Philippine Council for Agriculture Aquatic, Forestry and Natural Resources Research and Development.Los Banos, Laguna.

Toda, L., Yokingco, J., Lasco, R., & Gabriel, A. (2014). Linking Climate and Disaster Science and Policy for Effective Decision-Making.The Oscar M. Lopez Center Science-Policy Brief Vol. 2(3).

Tolentino, P., Geronia, M., Clutario, M., & David, C. (2015).Potential long-term impact of Typhoon Haiyan on the water resources of Tacloban City and its vicinity.Climate, Disaster and Development Journal.

Tongson, E., Alejo, L., & Balderama, O. (2017). Simulating impacts of El Niño and climate change on corn yield in Isabela, Philippines. Climate, Disaster and Development Journal.

UN HABITAT (2010) CLIMATE CHANGE ASSESSMENT FOR SORSOGON, PHILIPPINES: A SUMMARY. Union, Publishing Services Section, Nairobi.

United Nations Food and Agriculture Organization in collaboration with PAGASA. (2014). Assessment of Climate Change Impacts on Agriculture. Manila: PAGASA.

van Oort, B. (2014). Climate projections for local adaptation in the Hindu-Kush Himalayas.CICERO Report. Oslo, Norway.

Warren, R.; Arnell, N.; Brown, S.; Kjellstrom, T.; Kopp, R.; Nicholls. R.; & Price, J. (2014) Post-IPCC assessment of climate impacts using existing scenarios – advances in understanding. Avoid 2 Programme.

# ANNEXES

## *Annex 1. Questionnaire*

**Overview Tool and Description of the Purpose of the Assessment**

Questions:

**1. Climate Change Adaptation Inventory.** In this section we take stock of what is currently being done in the LGU in terms of climate change adaptation. **This is to create a baseline for the adaptation options.** This will help determine the different plans, and the adaptation activities in each sector (what, where and when these were set in place) see the gaps in the plans and what may be added or improved upon. The table is arranged in this manner in order to see which of the five sectors in the HLURB guidelines have had any integration of adaptation or disaster risk management. (The plans are not limited to the number of slots in the table. Please ask the respondent to briefly discuss these plans).

| | Plan | Activities (Soft/ Hard) | Location (Urban/ Rural) | Time Horizon (Short/ Mid/ Long Term) |
|---|---|---|---|---|
| Demography | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Economic | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Social | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Infrastructure | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Environment | | | | |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

**2. Ranking and prioritization of sectors for planning.** This section seeks to assess the concerns in each sectoral plans the local government unit is currently prioritizing. HLURB has provided guidelines to aid local government planners in generating their comprehensive land use plans. Within the guidelines, the five major sectors are Demography, Economic, Social, Infrastructure, and Environment. The following are the questions to be asked:

a. The next part is to elaborate on the specific aspectsof the sectors the key informants think should be prioritized for adaptation (e.g., women and children, livelihood, structural development, housing, health systems, natural resources such as forests, mangroves and coral reefs). The KIs should list down aspects of each sector which they think should be prioritized (See sample).This section will feed into the next section. (The aspects are not limited to the number of slots in the table).

| | **Aspect/ Concern** | **Location (Urban/ Rural)** |
|---|---|---|
| **Demography** | | |
| | | |
| | | |
| **Economic** | | |
| | | |
| | | |
| **Social** | | |
| | | |
| | | |
| **Infrastructure** | | |
| | | |
| | | |
| **Environment** | | |
| | | |
| | | |

Sample:

| | **Aspect** |
|---|---|
| **Demography** | Population of Women |
| | Population of Children |
| | Population of Elderly |
| **Economic** | Agriculture-Rice Harvest |
| | Agriculture-Corn Harvest |
| | Agriculture-Irrigation |
| **Social** | Education (e.g. Location of Schools, number of school days, etc.) |
| | Health-Number of Hospitals |
| | Housing-flood exposed housing |
| **Infrastructure** | Bridges-Flood exposed bridges |
| | |
| | |

| | |
|---|---|
| **Environment** | Forest Preservation |
| | Species Conservation |
| | |

3. **Climate Change Impacts.** Based on the selected aspect of the sectors, create a matrix to assess the foreseen impacts of the given aspect to climate change. Fill the blank below the specific climate variability if the planners foresee an effect in the given sector for the variability. (ICRAF FRAMEWORK)

Sample:

| **Economic** | Increase in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| Agriculture-Rice harvest | Increase/decline in yield due to increased supply of water (Decline due to prolonged flooding) | Decline in yield due to lack of water | Drought | |
| Agriculture-Corn Harvest | Increase/decline in yield due to increased supply of water (Decline due to prolonged flooding) | Decline in yield due to lack of water | | |
| Agriculture-Irrigation | Larger supply of water | Larger need for supply of water | | |

| **DEMOGRAPHIC ASPECTS (IDENTIFY IF RURAL OR URBAN)** | Increased in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| **ECONOMIC** | Increased in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| **SOCIAL** | Increased in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| **INFRASTRUCTURE** | Increased in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |

| **ENVIRONMENT** | Increased in precipitation | Decrease in Precipitation | Increase in Temperature | Decrease in Temperature |
|---|---|---|---|---|
| 1 | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

4. **Climate Change Projection Validation and Impact Valuation** (UN-HABITAT FRAMEWORK)

The aim of this section is to validate the climate change projections of PAGASA and to also gain inputs of the possible costs of the projected impacts to the City. On the observed impacts column, the respondent is to give examples of past events or years with the same characteristics as displayed in the projected impacts. The respondent is not required to answer if there have been no observed trends. As to the Monetary Cost Column, the respondent fills up the cost of the said events or characteristic year. The respondent should classify the costs per the prescribed sectors provided by HLURB and indicating what specific aspect of that sector was affected.

| **Climate Variable** | **Time Scale** | **Projected impact** | **Observed Impacts (examples of past events or characteristic years (TEMPORAL); affected rural or urban areas (SPATIAL)** | **Monetary cost of Observed impacts to the LGU per past event or characteristic year** |
|---|---|---|---|---|
| Temperature | 2036-2065 | **DJF** 1.2-2.1 degree increase in temperature- General increase in temperature with effects of temperature extremes higher than the hottest months.<br>**MAM** 1.4-2.3 degree increase in temperature- General increase in temperature with effects of temperature extremes higher than the hottest months. Has the most increase in the lowest possible temperature and has the most increase in the highest possible temperature.<br>**JJA** 1.4-2.2 degree increase in temperature- General increase in temperature with effects of temperature extremes higher than the hottest months. Has the most increase in the lowest possible temperature.<br>**SON** 1.4-2.2 degree increase in temperature- General increase in | | Demography<br>Economic<br>Social<br>Infrastructure<br>Environment |

| | | | | |
|---|---|---|---|---|
| | | temperature with effects of temperature extremes higher than the hottest months. Has the most increase in the lowest possible temperature. | | |
| | 2070-2099 | **DJF** 2.2-3.8 degree increase in temperature - A marked increase in temperature exhibiting temperatures above the historical norm<br>**MAM** 2.5-4.0 degree increase in temperature - A marked increase in temperature exhibiting temperatures above the historical norm<br>**JJA** 2.6-4.0 degree increase in temperature - A marked increase in temperature exhibiting temperatures above the historical norm<br>**SON** 2.6-4.0 degree increase in temperature - A marked increase in temperature exhibiting temperatures above the historical norm | | Demography<br>Economic<br>Social<br>Infrastructure<br>Environment |
| Precipitation | 2036-2065 | **DJF** Marked decrease in lowest possible precipitation with an increase in highest possible precipitation - increased intensity of extreme wet or dry weather events and an increase in precipitation in general<br>**MAM** Marked decrease in lowest possible precipitation and increase in highest possible precipitation - increased intensity of extreme dry or wet weather events<br>**JJA** Marked decrease in precipitation - increased intensity of extreme dry events and decrease in precipitation in general<br>**SON** Decrease in lowest possible precipitation - increased intensity of dry weather events | | Demography<br>Economic<br>Social<br>Infrastructure<br>Environment |

| | | | | |
|---|---|---|---|---|
| | 2070-2099 | **DJF** Marked increase and decrease in precipitation - increased intensity of either wet or dry extreme weather events<br>**MAM** Marked decrease in lowest possible precipitation and increase in highest possible precipitation - increased intensity of extreme dry or wet weather events<br>**JJA** Marked decrease in precipitation - increased intensity of extreme dry weather events and decrease in precipitation in general<br>**SON** Marked decrease in precipitation - increased intensity of extreme dry weather events and decrease in precipitation general | | Demography<br>Economic<br>Social<br>Infrastructure<br>Environment |

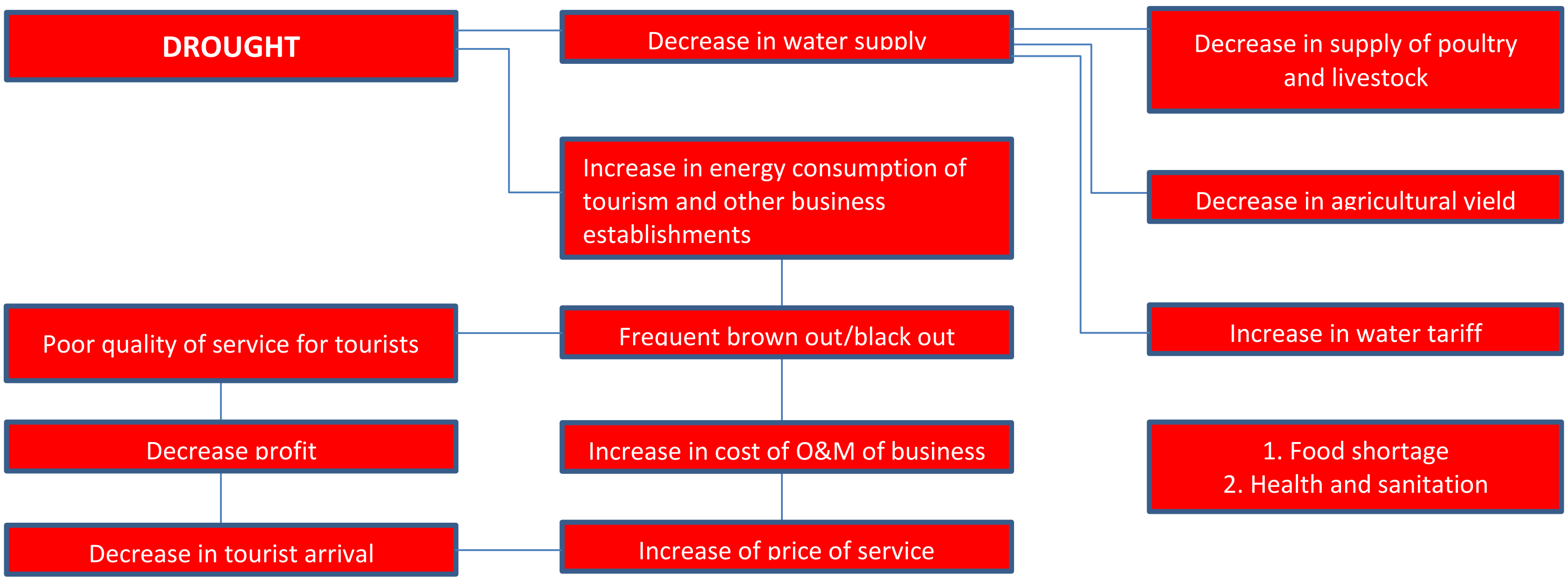
## *Annex 2. Validation Workshop Program and Outputs*

| CITY | MOST IMPORTANT SECTOR IN CITY | JUSTIFICATION | IMPACT CHAIN | | ADAPTATION |
|---|---|---|---|---|---|
| | | | **Temperature** | **Precipitation** | |
| **Batangas City** | **Environment (Water)** | Water is a basic need of the people and the existence of many heavy industries and growing population demands more water supply. Batangas City experiences several geologic and meteorological hazards every year. On a regular basis, minor floods affect coastal and riverbank communities during the monsoon seasons or passage of typhoons. Barangays in the lowlands can easily be flooded especially those traversed by Calumpang River | *Increase in temperature*<br>Hotter temperatures can result to decrease in water supply coming from springs, deep wells, and shallow wells.<br><br>*Extreme weather events*<br>Extreme weather events can damage water supply sources (pipelines)<br><br>*Sea Level Rise*<br>SLR coupled with over-extraction of groundwater puts a lot of water sources at risk to salt water intrusion, resulting to poor water quality | *Changes in Rainfall*<br>Lack of rainfall can dry up wells and springs, causing shortage of water supply<br><br>Increased rainfall can cause seepage to groundwater leading to contamination and poor water quality | *Rooftop water harvesting*<br>• To deal with water stress due to anticipated increasing temperatures and decreasing precipitation<br>• To be made mandatory<br>• *Sewerage system, water sanitation, and waste water treatment*<br>• Pollution control at the source through natural techniques<br>• Improvement of drainage system and waterways (sustainable) drainage design<br><br>*Construction of sea walls/breakwater/retaining wall* |
| **General Santos City** | **Environment (Water)** | | *Increased temperature*<br>Increased temperature leads to coastal flooding, sea level rise and storm surge. | *Increased precipitation*<br>Flooding in low areas | *Sustainable water resources management* through watershed management, excess water management and water sanitation augmentation and conservation |

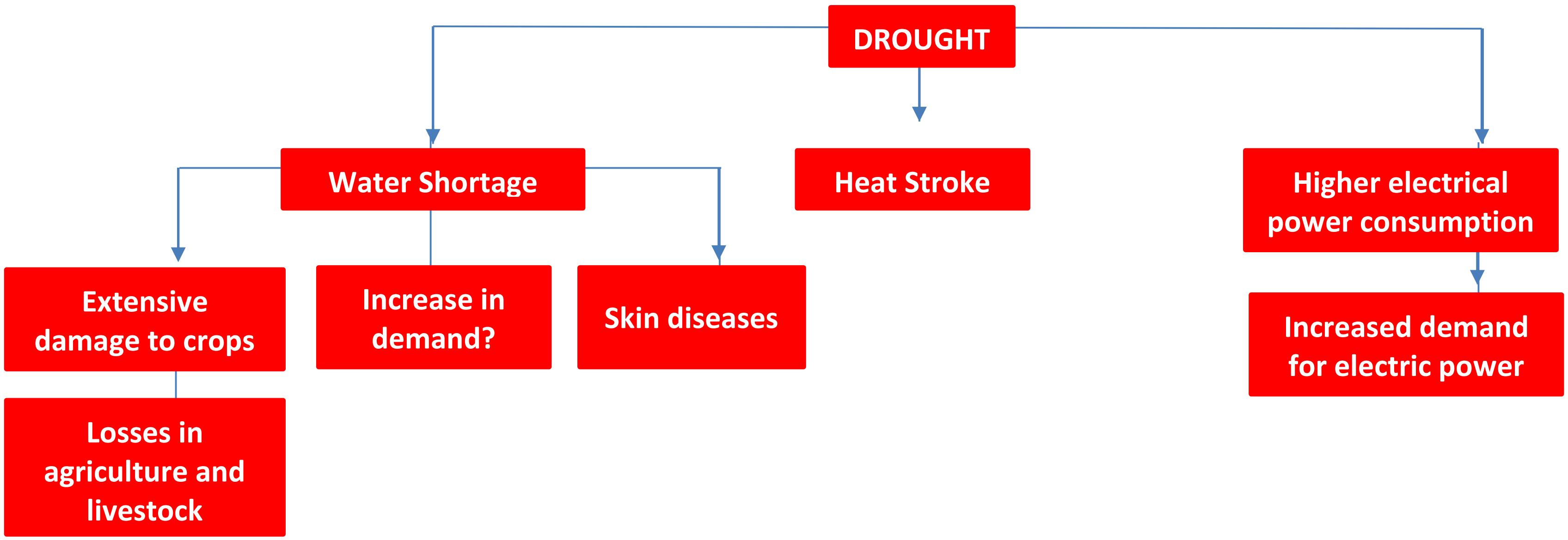
| | | | | | |
|---|---|---|---|---|---|
| | **Environment (Agriculture)** | | *Increased temperature and decreased precipitation*<br>The combination of both leads to decrease in water table levels, drought, and storm surge.<br><br>*Refer to General Santos slides | | *Human Welfare, Productivity and Environmental Sustainability on Agricultural Resources* through water resources development and management, varietal improvement, soil fertility enhancement, and crop diversification |
| **Legazpi City** | **Social** | Affected population is the majority of the urban area<br>- Households<br>- Business Establishments<br>- Institutions<br>- Tourists | | Flooding as most eminent hazard due to increase in rainfall/precipitation | *Improvement of drainage system*<br><br>*Increase of permanent evacuation centers* |
| **Puerto Princesa City** | | | *Increase in temperature and decrease in precipitation*<br>Drought – affecting different sectors of the city Directly affecting water supply (decrease) and energy consumption (increase) thus causing repercussions to economic performance (decrease in supply of livestock and poultry, agricultural yield, profit (due to poor service to tourists)).<br><br>*Refer to Puerto Princesa Diagram | | |
| **Tagbilaran City** | **Infrastructure** | Fast development growth without considering the geophysical characteristics and environment | *Increased temperature*<br>Drought – leading to heat stroke, higher electrical consumption and water shortage (refer to Tagbilaran Diagram 1) | *Increased precipitation*<br>Increase in incidences of flooding causing saturated drainage and damaged roads, affecting the access to facilities and causing heavy traffic that leads to hampered services (work and school) and economic loss, as well as water borne diseases and sanitary issues | Incentives for the use of renewable energy<br><br>Adoption of infra planning methods, climate appropriate infra materials, and green building design<br><br>Formulation of road and drainage development plan<br><br>Strict implementation of National Building Code |

| | | | | | |
|---|---|---|---|---|---|
| | | | | (refer to Tagbilaran Diagram 2) | Tree Planting Program<br><br>Regulation of open sink hole as water catchment<br><br>Establishment of wastewater treatment facility, and pocket forest in every barangay |

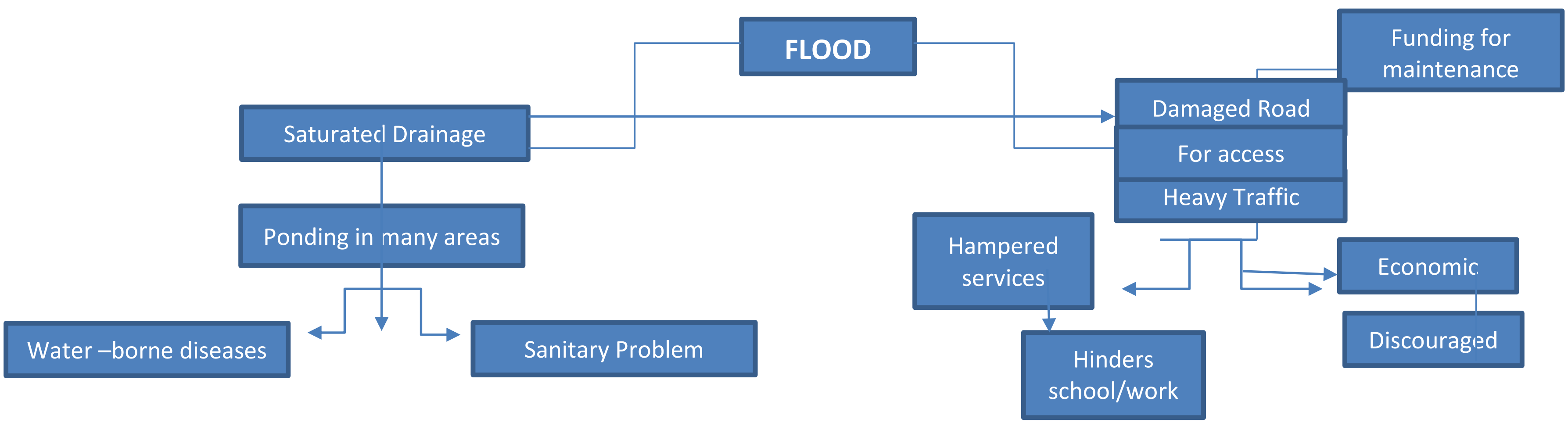
## CITIES IMPACT CHAIN DIAGRAMS



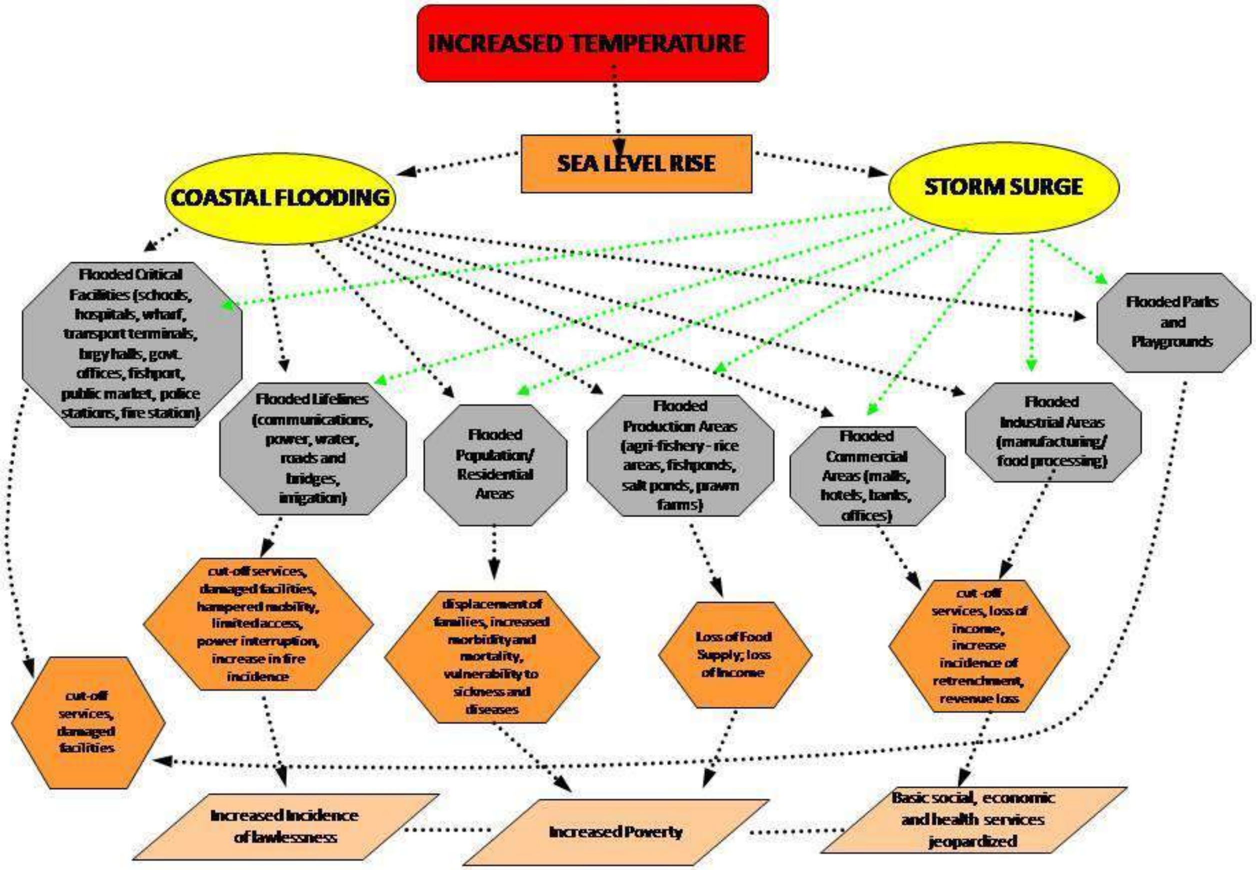

**Puerto Princesa: Increased Temperature Impact Chain**



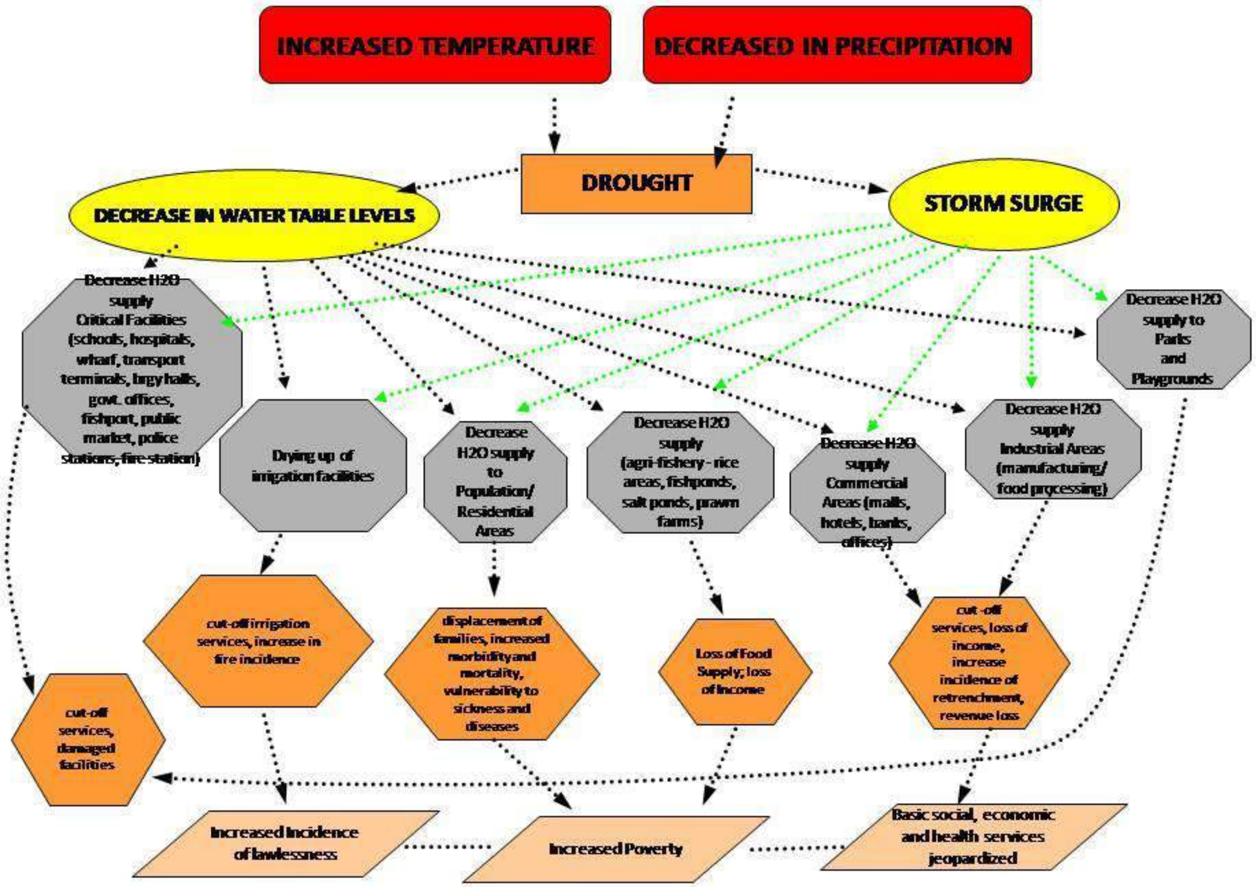

**Tagbilaran City: Increased Temperature Impact Chain**



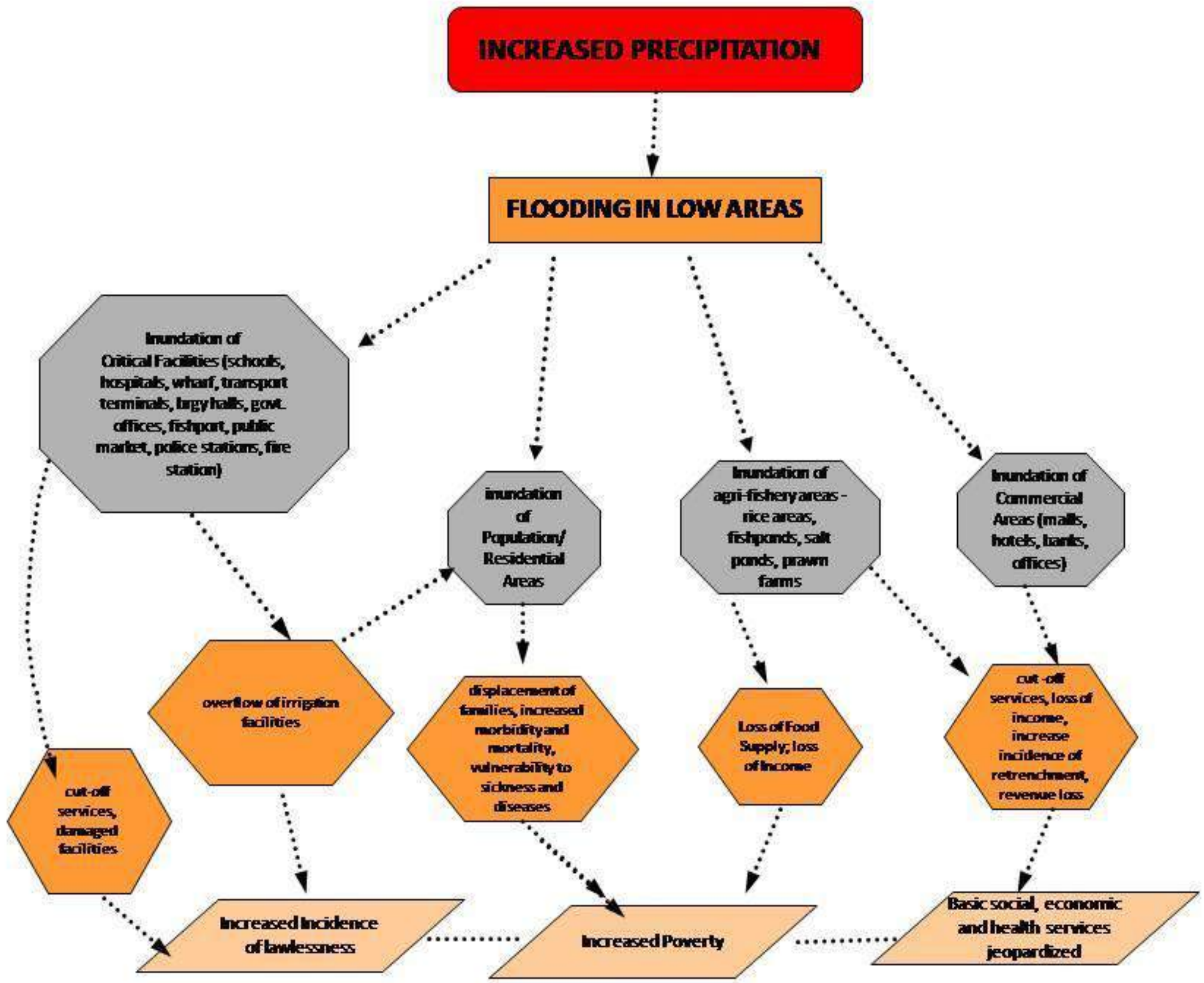

**Tagbilaran City: High Precipitation Impact Chain**



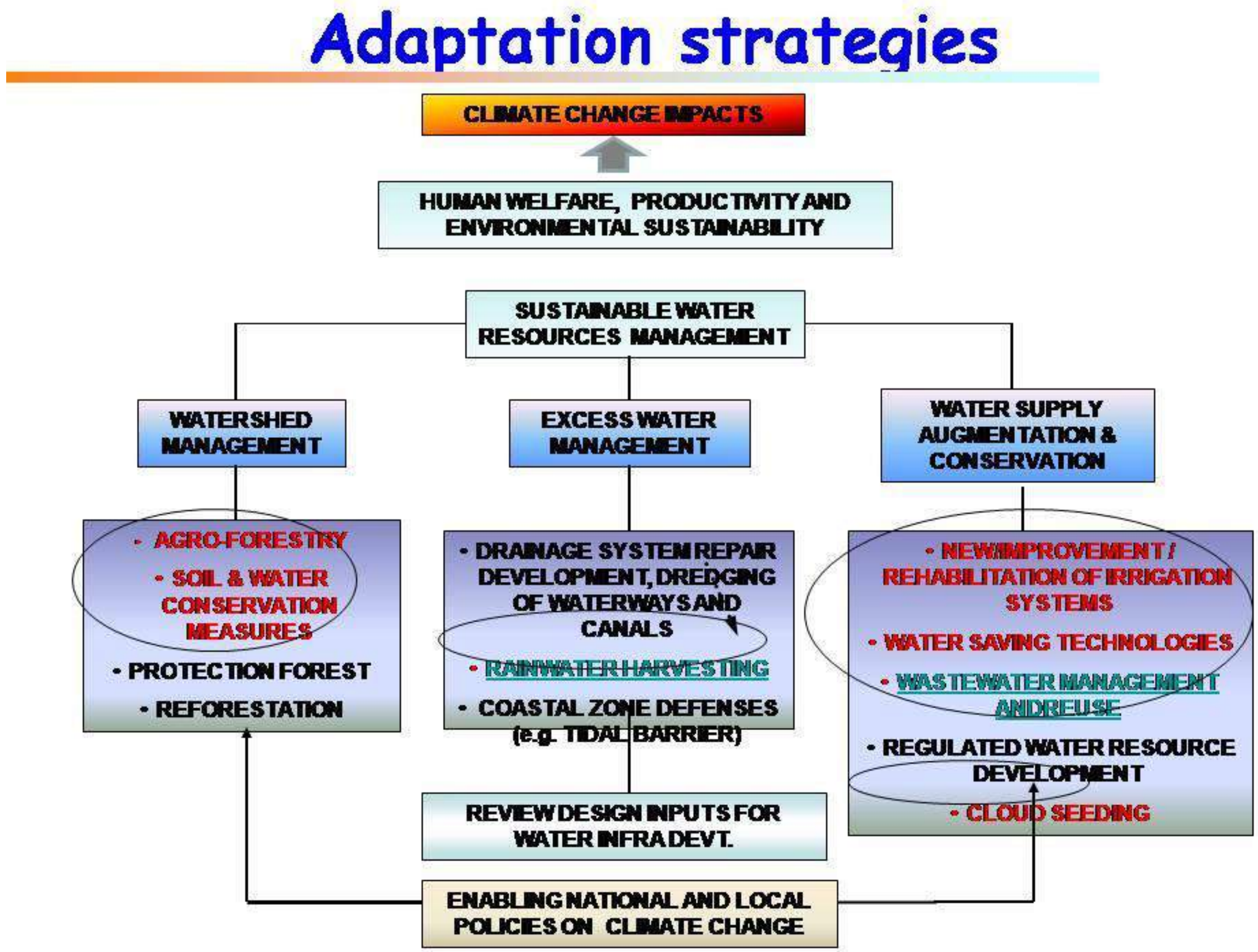

**General Santos City: High Temperature Impact Chain**



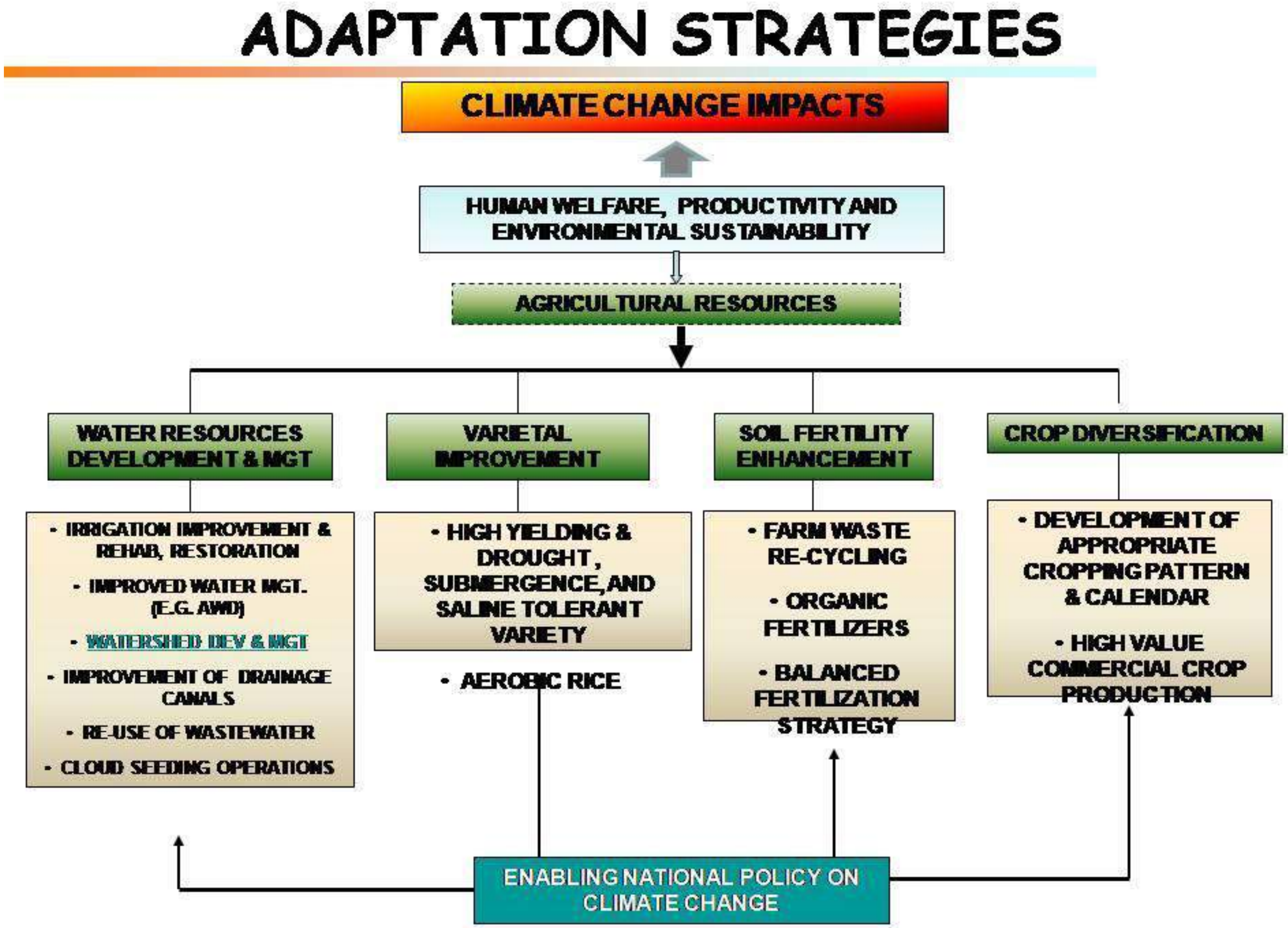

**General Santos City: High Temperature and Decrease in Precipitation Impact Chain**




**General Santos City: High Precipitation Impact Chain**




**General Santos City: Adaptation Strategies Chain 1**




**General Santos City: Adaptation Strategies Chain 2**