Climate Risk Vulnerability Assessment in Occidental Mindoro and Palawan

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I. *Introduction*

A. Background of the study

Climate Change is considered as a major global environmental problem and a great concern of developing countries. Most of the population in the Philippines is largely dependent on the agriculture sector, followed by forests and fisheries for their livelihood. Agriculture, on the other hand, is not only sensitive to climate change but it is also one of the major drivers of climate change. Climate sensitivity in agriculture is uncertain because there is regional variation in rainfall, temperature, crops and cropping systems, soils, and management practices (Ranganathan, et. al., 2010).

The Philippines, because of its geographic location, is frequently hit by natural disasters and challenged by several climatic phenomenon. Prolonged dry or wet seasons, flooding and drought and the abrupt change in temperature and precipitation patterns are some climate hazards which may affect human and livelihood. A significant loss in agricultural production caused by these hazards poses a critical economic situation and food security. As part of the sustainable development goal established by the United Nations, impacts of climate change towards food security and life on earth will be addressed through appropriate adaptation and mitigation strategies (DILG, 2011).

Region IV B, also known as the MIMAROPA region. It lies along the Southern Tagalog region in Luzon. It is comprised of five island provinces namely; Oriental Mindoro, Occidental Mindoro, Marinduque, Romblon, and Palawan.

MIMAROPA has a total land area of 2,962,087 hectares and 542,218 hectares is designated to agriculture. Although palay and corn are its primary produce, the region is known for its calamansi and seaweed production. Other yields include coffee, mango, coconut, banana, root crops, and rambutan among others (PSA, 2016). Characterized by types I and II climate condition, the region experiences nearly wet season throughout the year (PSA, 2016). Having the Philippines as one of the most vulnerable countries in the world, MIMAROPA is not spared when it comes to extreme natural events. With this, the region initiated efforts in addressing climate change. One of the initiatives made in the region aimed to enhance the capacities of the local communities in preparing them for the adverse effects of climate change alongside with the conservation of the region's natural resources (PIA MIMAROPA,2016).

Two of the provinces in MIMAROPA are Occidental Mindoro and Palawan. Occidental Mindoro is in the western part of the Mindoro island. It is bounded by Verde Island Passage in the north, Batangas province in the south, Mindoro Strait in the west and south and Oriental Mindoro on the east. Its topography is generally rugged with narrow strips of coastal lowlands. The province has two seasons which the dry season from November to April, and the wet season during the rest of the year. Average annual rainfall is 2,000mm and the temperature ranges from 30.7 to 16.4 degrees Celcius (NEDA, 2021).

Figure 1. Location map of Occidental Mindoro.

While Palawan is located in the west part of the Philippines. The island is bounded by the South China Sea in the northwest and Sulu Sea in the south. In the south is island of Borneo and in the west is Vietnam.

The northern and southern extremities along with its northwestern coast of Palawan has wet season for six months and dry season for the rest of the year (Type I Climate). While the other areas in the province has dry season from one to three months with no pronounced wet season for the rest of the year (Type III climate). Palawan is relatively dry from December to April. The mean annual average temperature is 26.67 degrees Celcius. The warmest months are March to May with an average of 27.5 degrees Celcius. The coolest months are December to February with an average of 25.72 degrees Celcius.

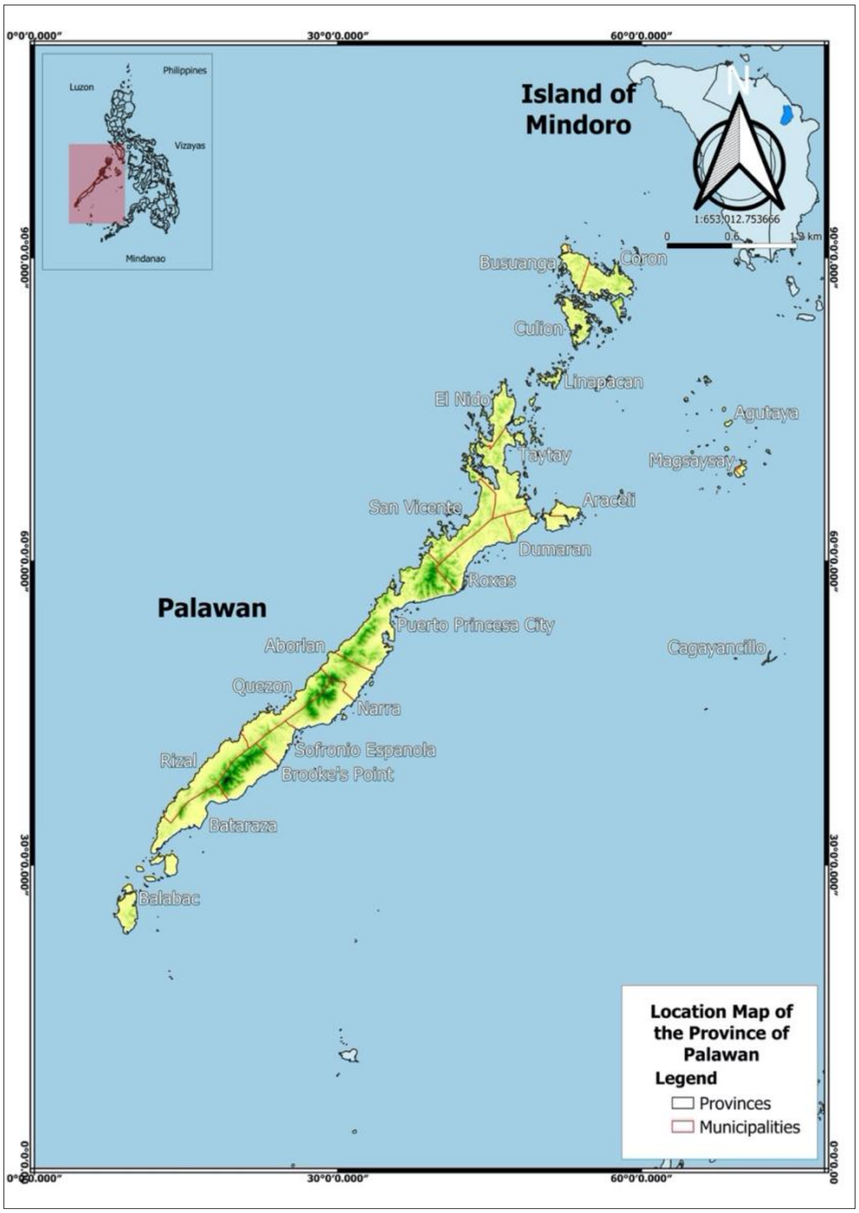

Figure 2. Location map of Palawan.

B. Framework of CRVA

The framework for this project is adapted from the previous Adaptation and Mitigation Initiative for Agriculture (AMIA) 2 project. The following presents an assessment of the three key dimensions of vulnerability for the agricultural sector:

1. **Exposure:** The nature and degree to which a system is exposed to significant climate variations (IPCC, 2014).
2. **Sensitivity:** The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation.
3. **Adaptive Capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2014).

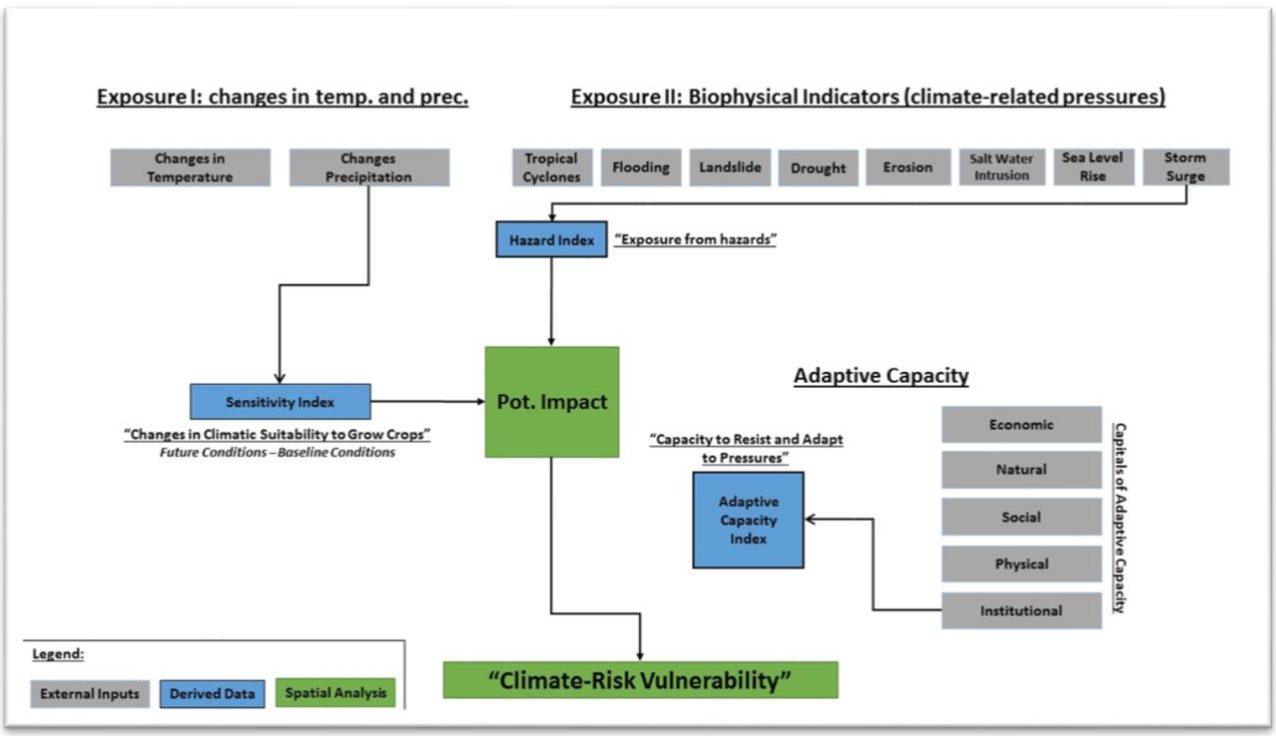

Figure 3. Climate Risk Vulnerability Assessment Framework.

II. Methodologies of CRVA

A. Hazards

In general, there are eight (8) identified natural hazards in the Philippines. These are the following: typhoon, flooding, drought, erosion, landslide, storm surge, sea level rise and saltwater intrusion. The hazard dataset used in this study was from the output of the previous Adaptation and Mitigation Initiative in Agriculture (AMIA) project of the Department of Agriculture. Table 1 summarizes the hazard data, its source and resolution.

Table 1. Overview of hazard dataset used for exposure component.

Parameter	Source	Unit of Measurement, spatial and temporal resolution
Typhoon	UNEP/UNISDR, 2013 (http://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng)	1 kilometer pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simpson scale category 5 (> 252 km/h) from year 1970 to 2009.
Flooding	AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR)	1:10,000 scale. Susceptibility of flood risk for Philippines from the past 10 years
Drought	AMIA multi-hazard map / baseline data from National Water Resources Board	Groundwater potential for the Philippines
Erosion	AMIA multi-hazard map / baseline data from Bureau of Soils and Water Management	1:10,000 scale. Soil erosion classified from low to high susceptibility
Landslide	AMIA multi-hazard maps / baseline data from MGB, DENR	1:10,000 scale. Landslide classified from low to high susceptibility
Storm Surge	AMIA multi-hazard maps / baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST)	
Sea level rise	AMIA multi-hazard map	Assumption based on 5m sea level rise
Saltwater intrusion	AMIA multi-hazard map / baseline data from the NWRB	Groundwater potential for the Philippines

The hazard scores used in this study was given by the partner agency of the AMIA 2 project which is CIAT. It was adopted in the previous Adaptation and Mitigation Initiative in Agriculture project.

Table 2.Hazard scores per Island group based from the previous Adaptation and Mitigation Initiative in Agriculture (AMIA) project.

Hazards	**Island Group**		
	Luzon (%)	Visayas (%)	Mindanao (%)
Typhoon	**20.00**	18.21	16.95
Flood	**19.05**	16.40	15.25
Drought	**14.25**	16.17	16.95
Erosion	**11.43**	12.57	12.71
Landslide	**8.57**	10.72	14.41
Storm Surge	**9.52**	10.39	8.47
Sea Level Rise	**5.71**	8.33	5.08
Saltwater Intrusion	**11.43**	7.21	10.17

B. Sensitivity

For the crop selection and collection of occurrence datasets, the Provincial Agriculture's Office and DA-Field Regional Offices identified the crops that would be consider for analysis. The priority crops for Occidental Mindoro are as follows: rice, cassava, onion, mango and yellow corn. While priority crops for Palawan are as follows: rice, cashew, mango, banana, and coffee.

Agricultural technicians and representatives from the provincial and municipal agriculture's office were asked to give the estimate the location of crops. A map was provided with features such as road networks, river network, digital elevation model of the province, municipal and barangay boundaries and satellite imagery. A fishnet with 1 x 1 km grid size was also included in the map which the grid represents the climate resolution. The key informants identifies the different crops that occur for each grid of the fishnet. A procedure was followed that for each crop, aside from the personal knowledge, it should be based on the current reports. Only one occurrence record was allowed for the same crop, but multiple occurrences from different crops for each grid was allowed.

Sensitivity of crop to climate change was determined using the Maximum entropy (MaxEnt). MaxEnt program determined the best location on the present climatic condition and future climatic projections. Only the province of Occidental Mindoro was assessed in MaxEnt Program. Twenty bioclimatic variables (Table 3) were used in assessing the crop suitability of selected crops of the province. The described bioclimatic factors are relevant to understand species responses to climate change (O'Donnell and Ignizio, 2012). Eleven of the bioclimatic variables are temperature related and nine are precipitation related.

Crop distribution were modeled for the present and future conditions to assess the degree of changes in crop suitability. Representative concentration pathway (RCP) 8.5 scenario based from IPCC Assessment Report 5 was used as basis for future projection of climate change by year 2050. RCP 8.5 is characterized as increasing greenhouse gas emissions over time. As ensemble of 32 global circulation models (GCMs) based from was used for this assessment to assess the impact of climate change to crops. All the data came from CIAT. They also processed the GMCs to generate 1km resolution climate database that can be used for ecological niche modeling. The climate database that was used in this project is available online: http://www/ccafs-climate.org/data_spatial_downscaling/.

Table 3.Bioclimatic variables used in crop distribution modeling

Parameters	Description (O'Donnell, M and Ignizio, D. 2012)
Temperature Related	
Bio_1-Annual mean temperature	Annual mean temperature derived from the average monthly temperature
Bio_2-Mean diurnal range	The mean of the monthly temperature ranges (monthly maximum minus monthly minimum)
Bio_3-Isothermality	Oscillation in day-to-night temperatures
Bio_4- Temperature seasonality	The amount of temperature variation over a given year based on standard deviation of monthly temperature averages
Bio_5- Maximum temperature of warmest month	The maximum monthly temperature occurrence over a given year (time series) or averaged span of years (normal)
Bio_6- Minimum temperature of coldest month	The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal)
Bio_7-Temperature annual range	A measure of temperature variation over a given period.
Bio_8-Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio_9-Mean temperature of driest quarter	This quarterly index approximates mean temperatures that prevail during the driest quarter
Bio_10- Mean temperature of warmest quarter	This quarterly index approximates mean temperatures that prevail during the warmest quarter

Bio_11-Mean temperature of coldest quarter	This quarterly index approximates mean temperatures that prevail during the coldest quarter
Precipitation Related	
Bio_12- Annual precipitation	This is the sum of all total monthly precipitation values
Bio_13-Precipitation of wettest month	This index identifies the total precipitation that prevails during the wettest month.
Bio_14- Precipitation of driest month	This index identifies the total precipitation that prevails during the driest month
Bio_15-Precipitation seasonality	This is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation and is expressed as percentage
Bio_16-Precipitation of wettest quarter	This quarterly index approximates total precipitation that prevails during the wettest quarter
Bio_17-Precipitation of driest quarter	This quarterly index approximates total precipitation prevails during the wettest quarter
Bio_18-Precipitation of warmest quarter	This quarterly index approximates total precipitation that prevails during the warmest quarter
Bio_19-Precipitation of coldest quarter	This quarterly index approximates total precipitation that prevails during the coldest quarter
Bio_20-Number of consecutive dry days	Consistent number considered as dry days

To determine the sensitivity of each crop for the different municipalities, the equation in the previous AMIA 2 project was used in this study and this was shown below:

$$\frac{Projected\ Conditions - \ Current\ Conditions}{Current\ conditions}\ X\ 100$$

An index was developed from -1.0 to 1.0 for the sensitivity of crops where the range from 0.25 to 1.0 indicates a loss in suitability, while -0.25 to -1.0 indicates a gain suitability to climate change (Table 4).

Table 4. Percent change in suitability and its description

Percent Change in Suitability (Range in %)	Index	Description
<=-50 (Very high loss)	1.0	Loss
>-50 & <=-25 (High loss)	0.5	
>-25 & <=5 (Moderate loss)	0.25	
>-5 & <=5 (No change)	0	No Change
>5 & <=25 (Moderate gain)	-0.25	
>25 & <=50 (High gain)	-0.5	
>50 (Very high gain)	-1.0	Gain

Source: Palao et al., 2017

On the other hand, only the crop occurrence was done for Palawan. Crop location maps of Palawan were assessed based on the actual data from the field and on the available climate scenarios in the Philippines for rice, coffee, banana, and mango. Cashew was further assessed by initially running the available data in MaxEnt. This is to assess if the data gathered on the field was sufficient in doing the sensitivity analysis. On the other hand, the data that will be generated should be again validated with the Municipal Agriculture Office (MAO) and Provincial Agriculture Office (PAO) for the complete and updated assessment of vulnerability of the province.

C. Adaptive Capacity

a. List of indicators used

A wide secondary data collection identified sources that were able to provide some of the needed indicators on municipality level. Foremost the National Competitiveness Council (NCC) provided an extensive up-to-date database, but also the Philippines Statistics Authority and previous DA projects were consulted. Furthermore, the data was derived from the International Water Management Institute and the National Mapping and Resource Information Authority derived to calculate indicators for the natural capital component.

Furthermore, the values of the indicators were integrated in the shapefile municipal boundaries. Each of the indicators were normalized and were treated with equal weights. The sum of the 20 indicators provided the final adaptive capacity index. Five equal breaks were developed to establish the thresholds: 0-0.20 (Very Low), 0.20-0.40 (Low), 0.40-0.60 (Moderate), 0.60-0.80 (High), and 0.80-1.00 (Very High).

Table 5. Indicators used in analyzing adaptive capacity.

Capital	Indicator	Source
Economic	Cost Electricity Firms and Customers	NCC, 2015
	Diesel Price	NCC, 2015
	Number of Rural Banks	NCC, 2015
	Number of Finance Cooperative	NCC, 2015
	Number of Microfinance Institutions	NCC, 2015
	Total Banks and Finance Institutions	NCC, 2015
Human	Number of Public Doctors	NCC,2015
	Number of Public Health Service	NCC, 2015
	Number of Private Doctors	NCC, 2015
	Number of Private Health Service	NCC, 2015
	Number of Health Service Manpower	NCC, 2015
	Total Public Health Facilities	NCC, 2015
	Total Private Health Facilities	NCC, 2015
	Number of Public Secondary Schools	NCC, 2015
	Number of Private Secondary Schools	NCC, 2015
	Number of Public Tertiary Schools	NCC, 2015
	Public Vocational Schools	NCC, 2015
Physical	Total Road Network	NCC, 2015
	Road Density	NCC, 2015
	Percent of Household with Water Service	NCC, 2015
	Percent of Household with Electricity Service	NCC, 2015
Institutional	Presence of CLUP	NCC, 2015
	Presence of DRRMP	NCC, 2015
	Presence of DRMMO	NCC, 2015
	DRRM Budget Allocation	NCC, 2015

D. Climate risk vulnerability maps

The climate risk vulnerability maps were formed using the following formula:

$$f(Haz, Sens, AC) = \left(\left(Haz_{(w_h)} + Sens_{(w_s)}\right) + 1 - AC_{Wa}\right)$$

where: Haz=hazard index, Sens=sensitivity index ($_i$=crop), and AC=adaptive capacity index. W_h=weight given for hazard, W_s=weight given for sensitivity, and W_a=weight given for adaptive capacity.

III. Results and Discussion

A. Climate Risk Vulnerability Assessment of Occidental Mindoro

a. Hazard maps

The over all hazard map of Occidental Mindoro showed that the municipality Sablayan and Santa Cruz are the most exposed to hazards. These municipalities are found in the central area of the province. While the municipalities of Paluan and Mamburao that are found in the northern part of the province have high exposure to hazards. The eight hazards will be discussed below.

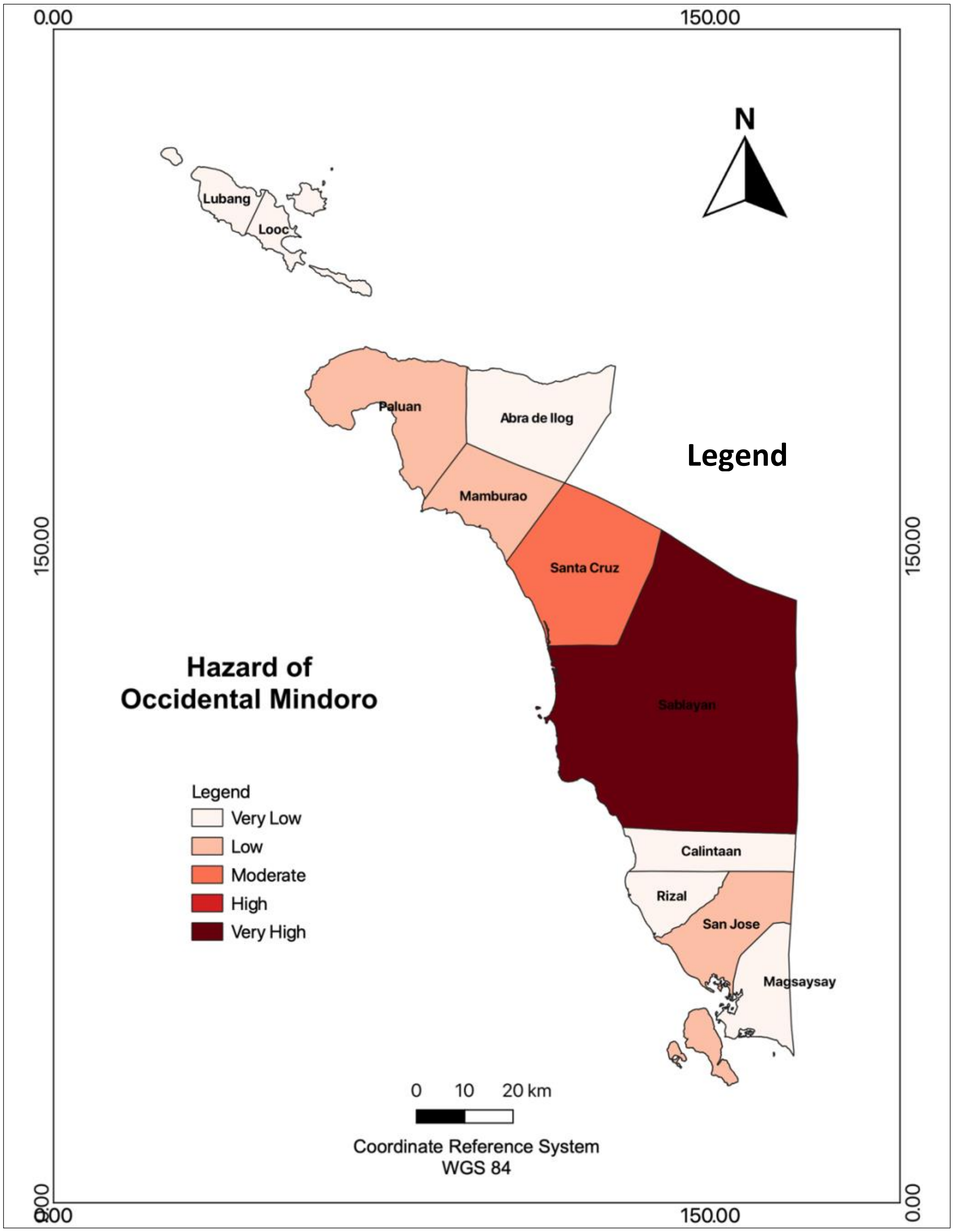

Figure 4. Hazard map of Occidental Mindoro.

a. 1. Flooding

Flooding is one the major problem in the country during the rainy season or monsoon season. Typhoons also causes flooding in most of the areas in the country. The municipalities of Rizal and Magsaysay have high exposure to flooding. These municipalities are found in the southern portion of the province. Adjacent municipality, San Jose, have high exposure to flooding.

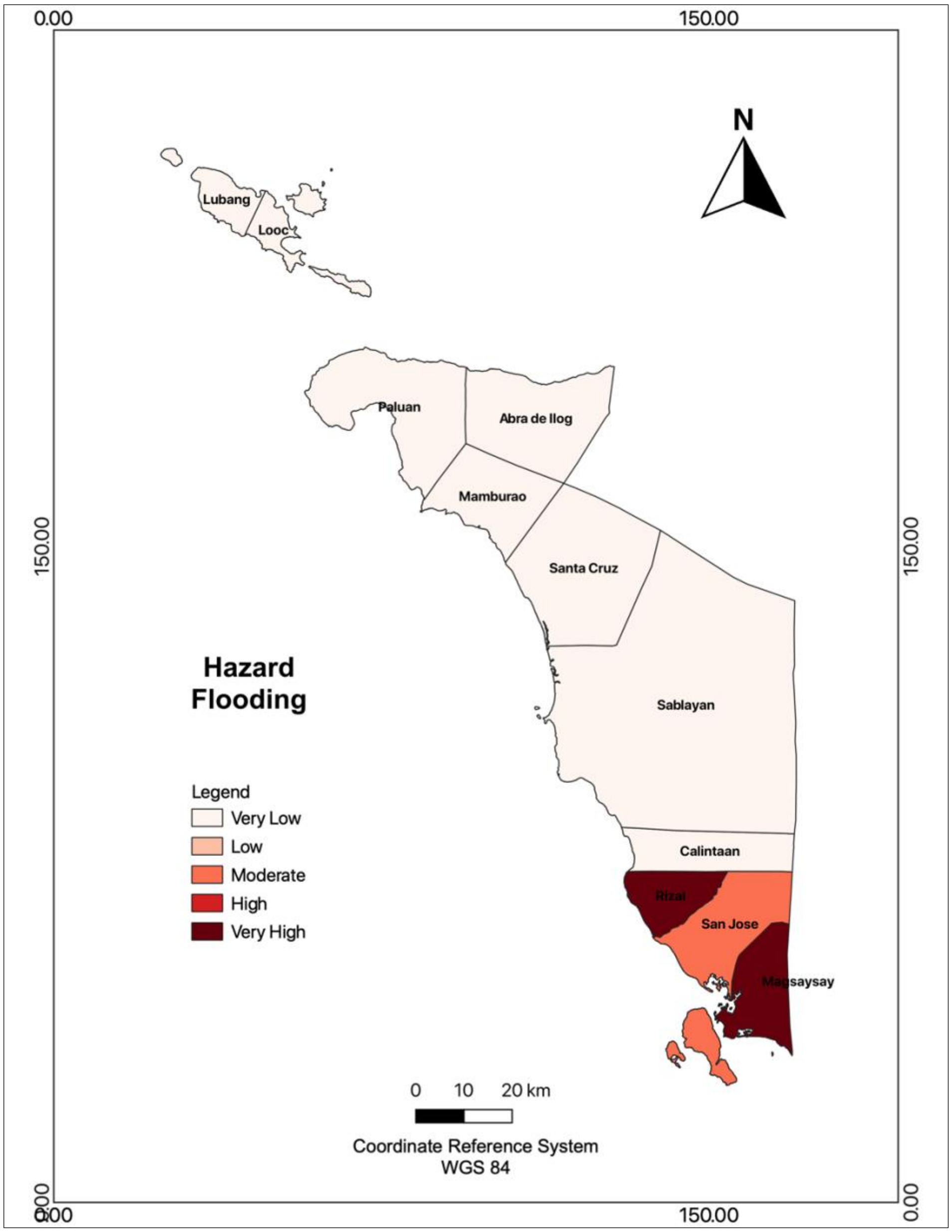

Figure 5. Flooding map of Occidental Mindoro.

a. 2. Landslide

According to the USGS, landslide is the movement of a mass of rock, debris, or earth down a slope. The most exposed municipalities to landslide are Abra de Ilog, Sablayan, Paluan, Santa Cruz.

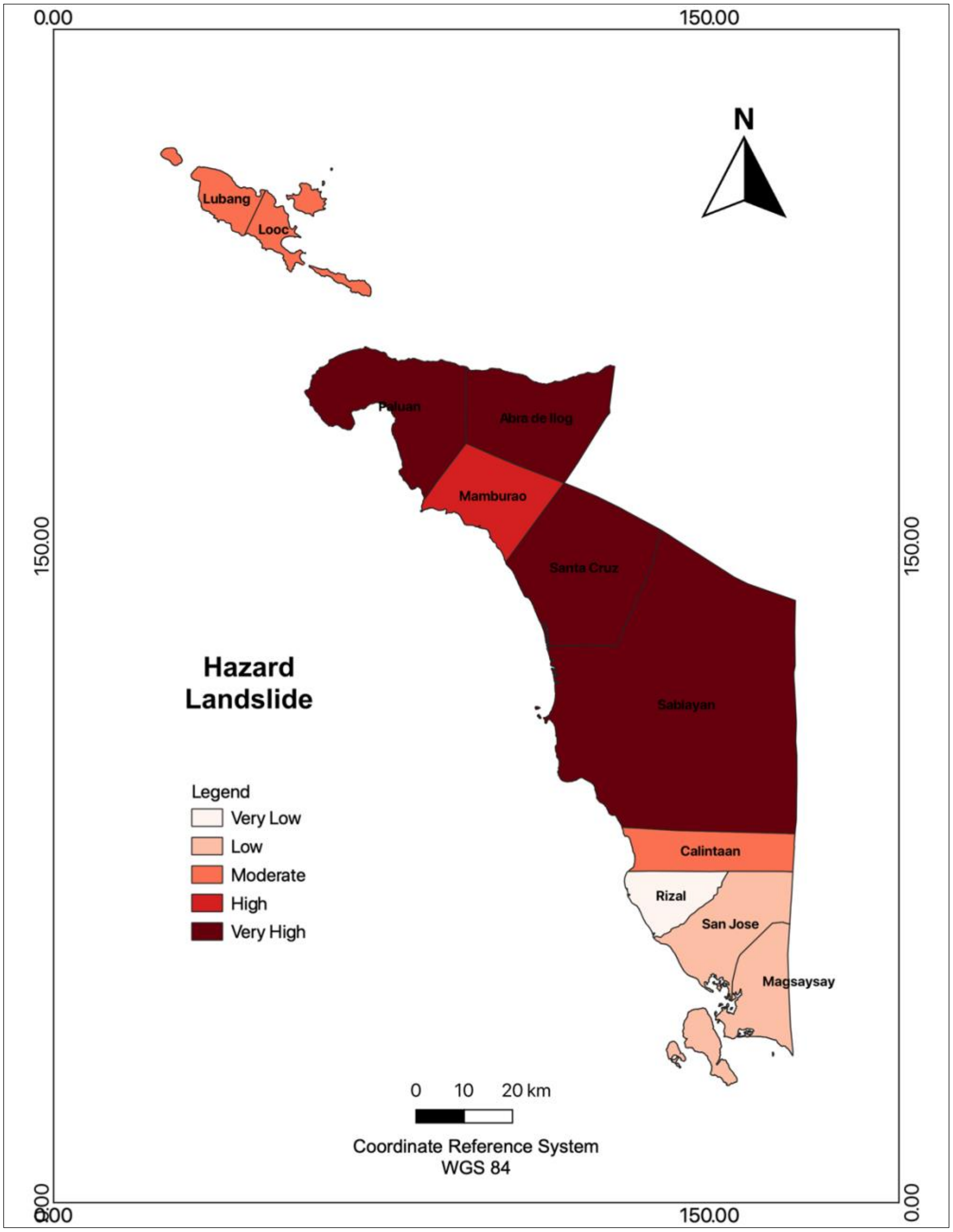

Figure 6. Hazard map of Occidental Mindoro.

a.3. Drought

Drought has a major impact in the agricultural sector. This hazard is also difficult to observe. The municipalities that have high exposure to drought are found in the central portion of the province. These are Santa Cruz and Sablayan.

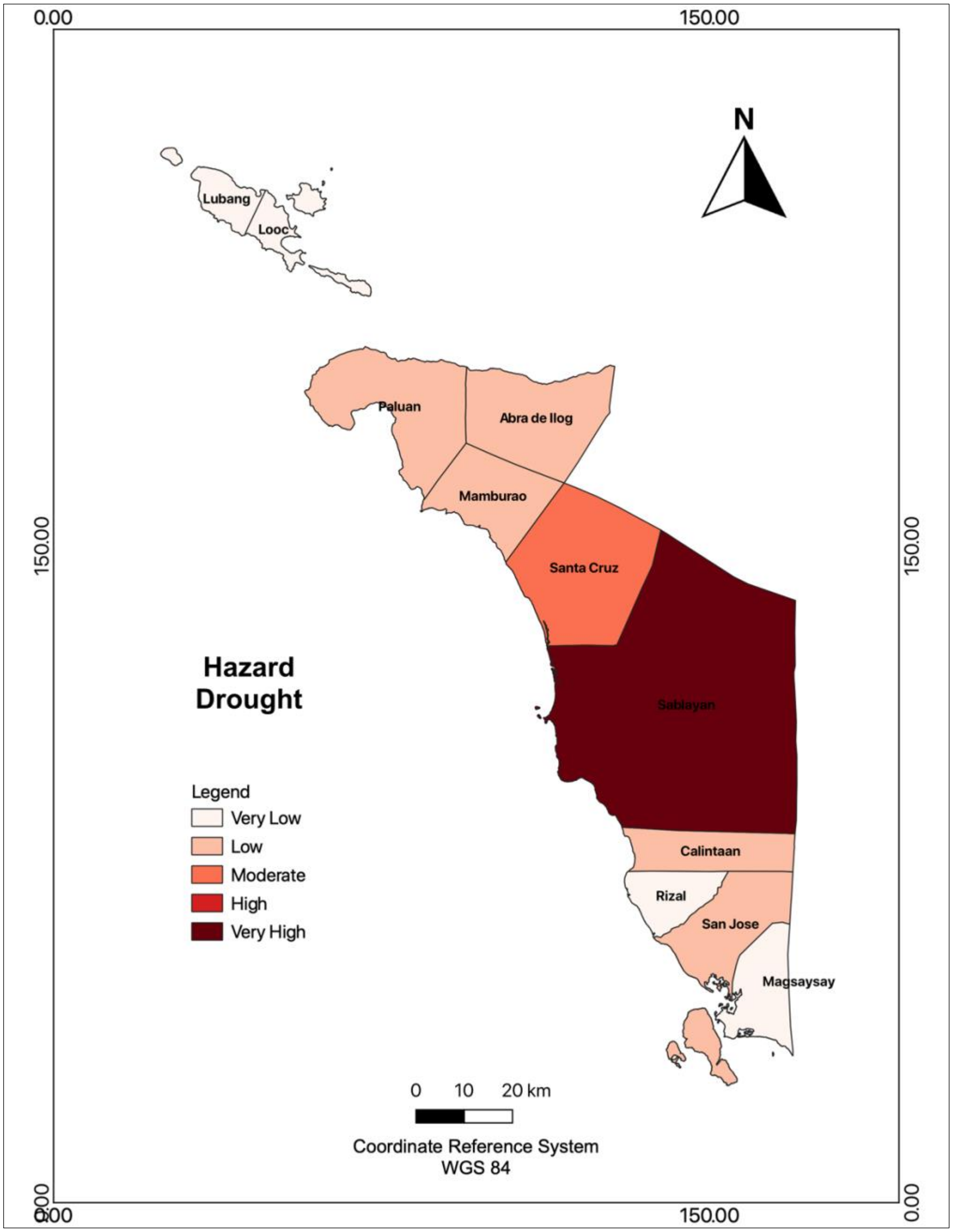

Figure 7. Drought map of Occidental Mindoro.

a. 4. Erosion

Soil erosion is occurring process that affects all landforms. In agricultural sector, soil erosion refers to the wearing away of the topsoil by the natural physical forces of water and wind or through forces associates with farming activities such as tillage (OMAFRA, 2018). Municipalities of Abra de Ilog and Santa Cruz are the ones who have high exposure to erosion.

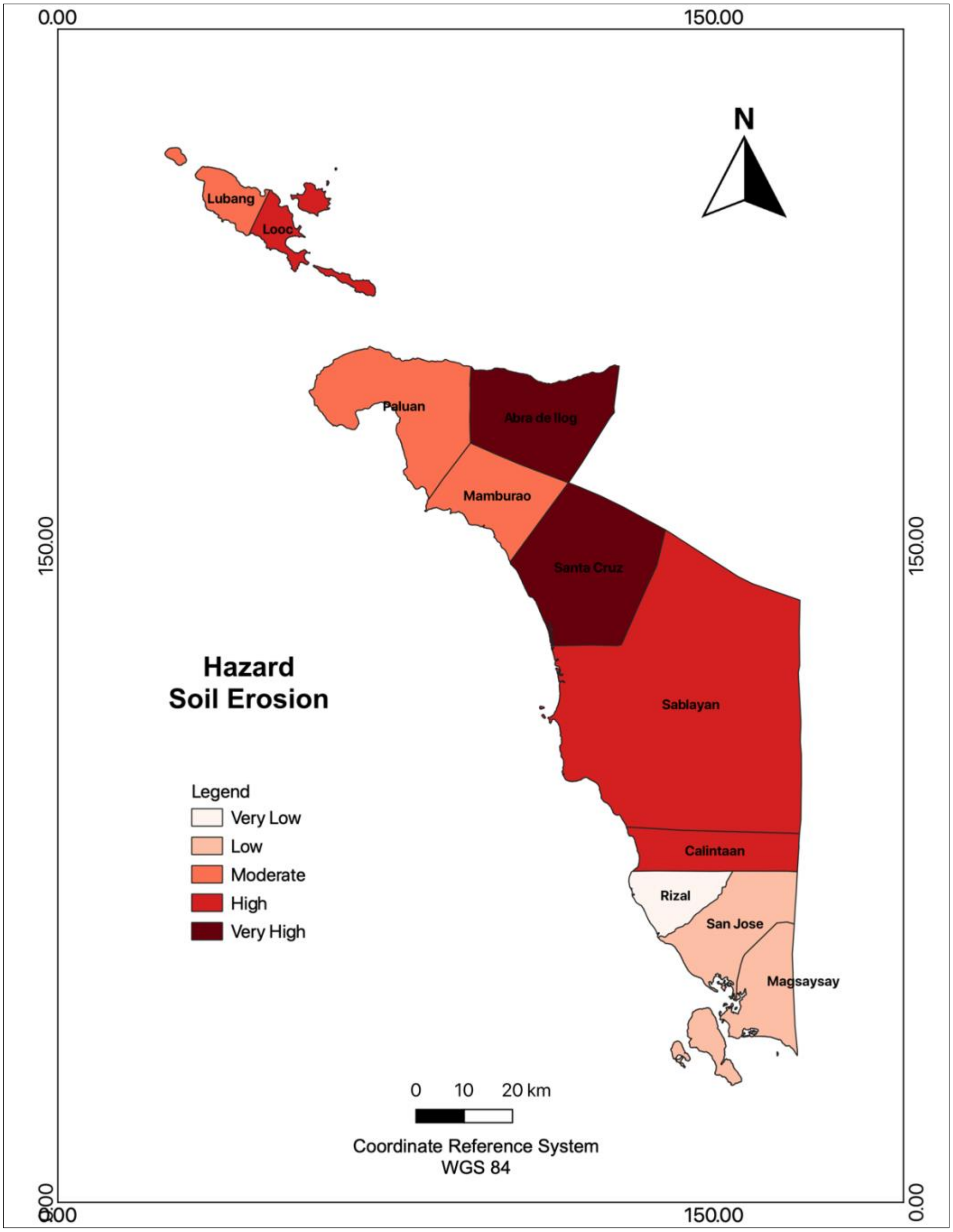

Figure 8. Soil erosion map of Occidental Mindoro.

a. 5. Saltwater Intrusion

Saltwater intrusion decreases the freshwater storage in the aquifers, and can result in the abandonment of supply wells. Furthermore, saltwater intrusion occurs by many mechanisms, including lateral encroachment from coastal waters and vertical upcoming near discharging wells (USGS, 2018). Based on the data available, the whole province is not exposed to saltwater intrusion. It is still considered in the analysis of the over all hazard map of Occidental Mindoro.

a. 6. Sea Level Rise

Sea level rise is caused primarily by the two factors related to global warming: the added water from melting ice sheets and glaciers and the expansion of seawater as it warms (NASA). The municipalities that have high exposure to sea level rise are Mamburao and Santa Cruz.

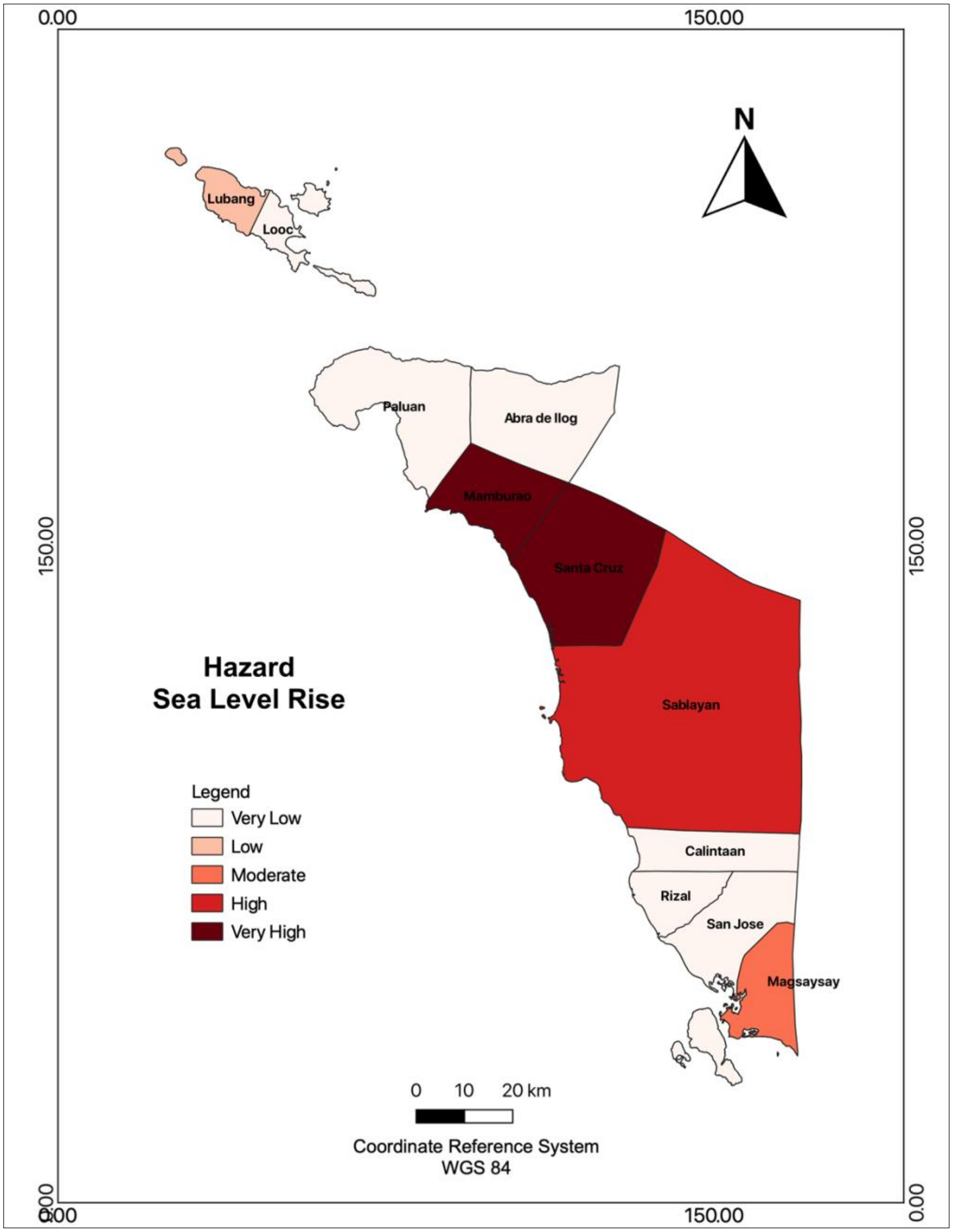

Figure 9. Sea Level Rise map of Occidental Mindoro.

a. 7. Storm Surge

According to NOAA, storm surge is the abnormal rise in seawater level during a storm. It is measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing onshore. The amplitude of the storm surge at any given location depends on the orientation of the coast line with the storm track, intensity, size and speed of storm. The municipalities of Santa Cruz and Sablayan are the ones with high exposure to storm surge.

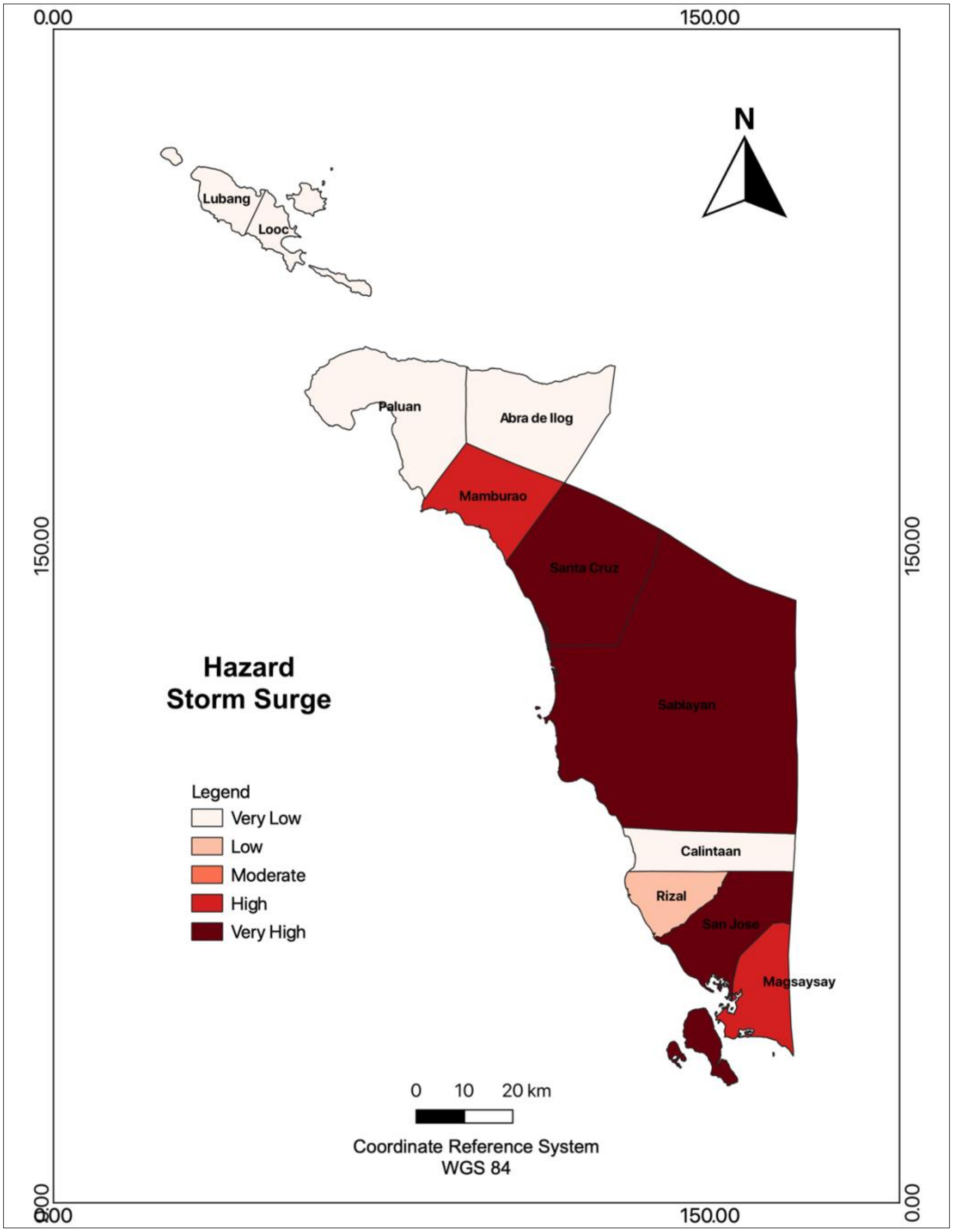

Figure 10. Storm Surge map of Occidental Mindoro.

a. 8. Tropical Cyclone

On the average, there are about twenty (20) typhoons that enter the Philippine Area of Responsibility every year (PAG-ASA, 2011). The municipalities of Lubang and Looc have high exposure to tropical cyclone. These are island municipalities in the northern part of the province.

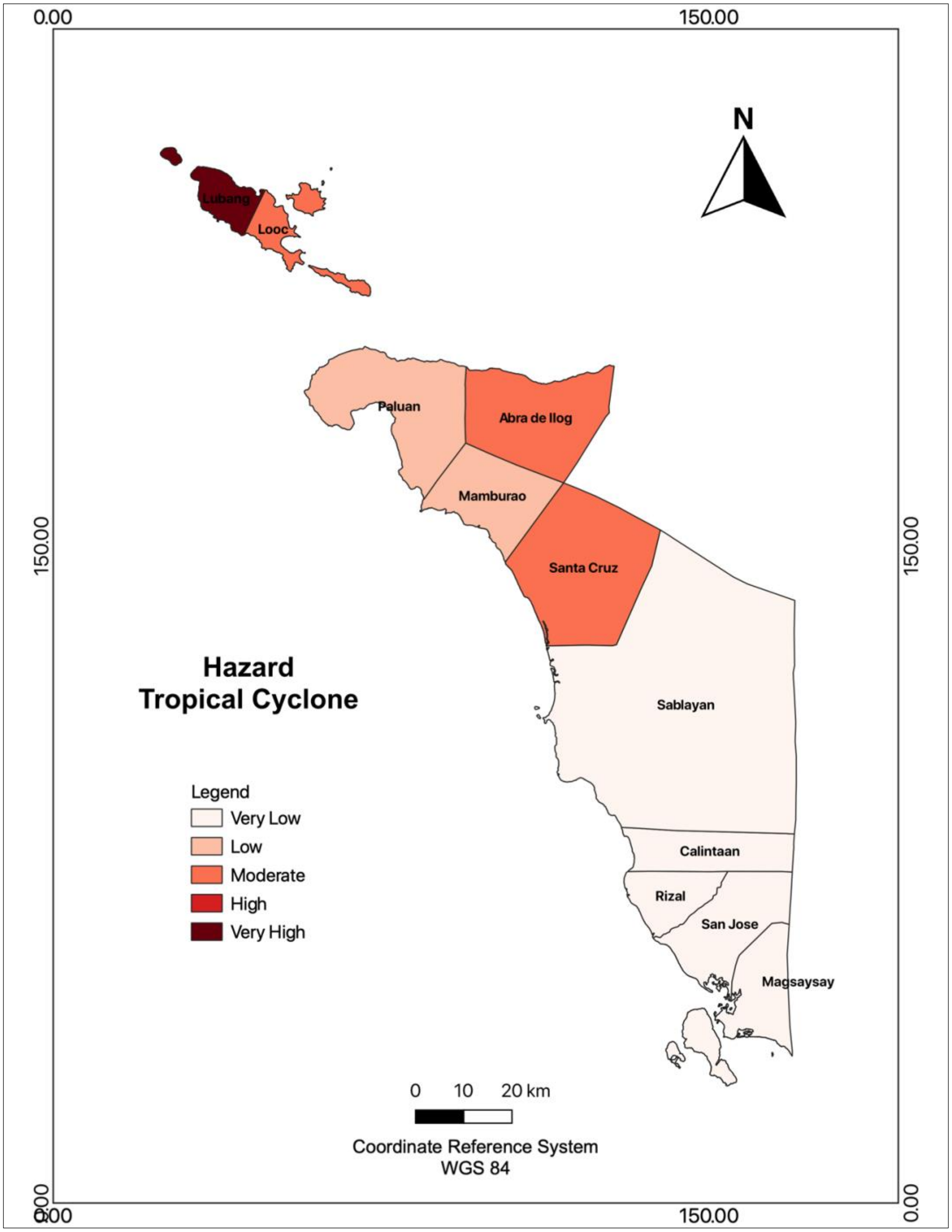

Figure 11. Tropical cyclone map of Occidental Mindoro.

b. Sensitivity

The results showed the changes in climatic suitability for cassava, rice, corn, onion and mango. Paluan, Abra de Ilog and Mamburao are the most sensitive to climate change for cassava. For rice, majority of the municipalities are sensitive to climate change. These includes: Abra de Ilog, Mamburao, Santa Cruz, Sablayan, Calintaan, Rizal and Magsaysay. For corn, it showed that Abra de Ilog, Mamburao, Santa Cruz, Sablayan, Calintaan and Rizal are the most sensitive. It also showed that in onion production, Palauan, Mamburao, Santa Cruz, Rizal, San Jose and Magsaysay are the most sensitive. While in mango, the most sensitive municipalities are Looc, Palauan, Abra de Ilog, Mamburao, and Rizal.

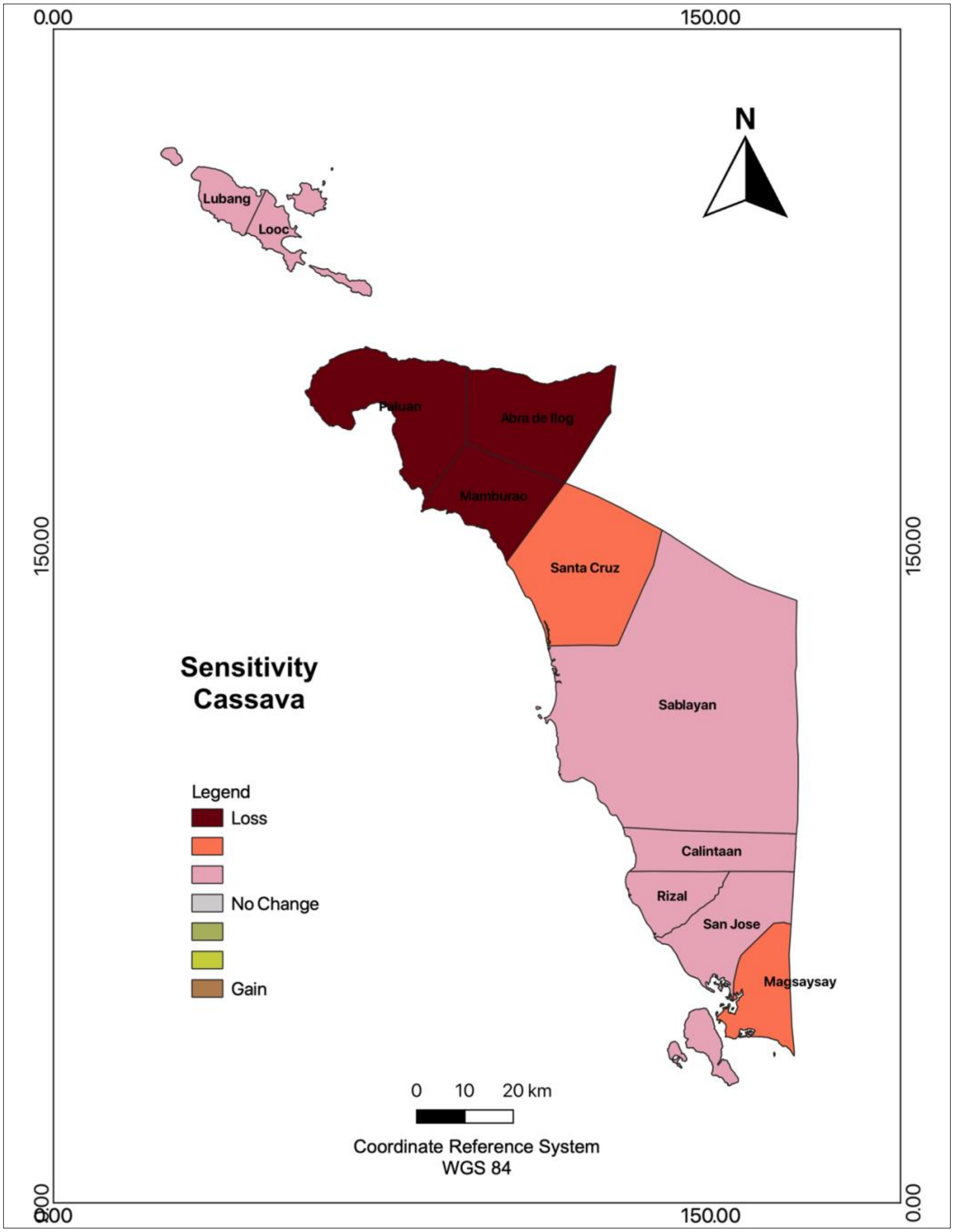

Figure 12. Sensitivity map of cassava in Occidental Mindoro.

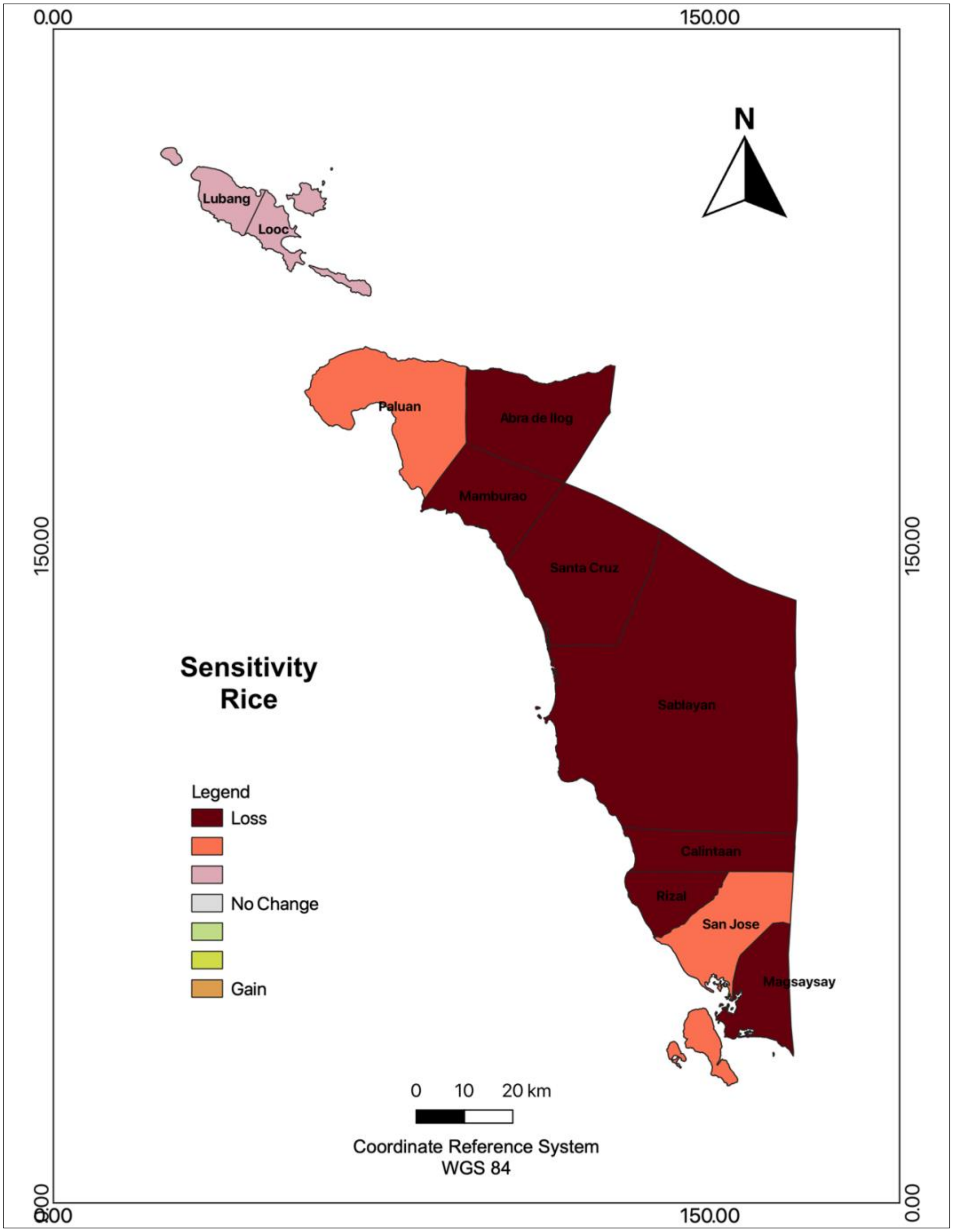

Figure 13. Sensitivity map of rice in Occidental Mindoro.

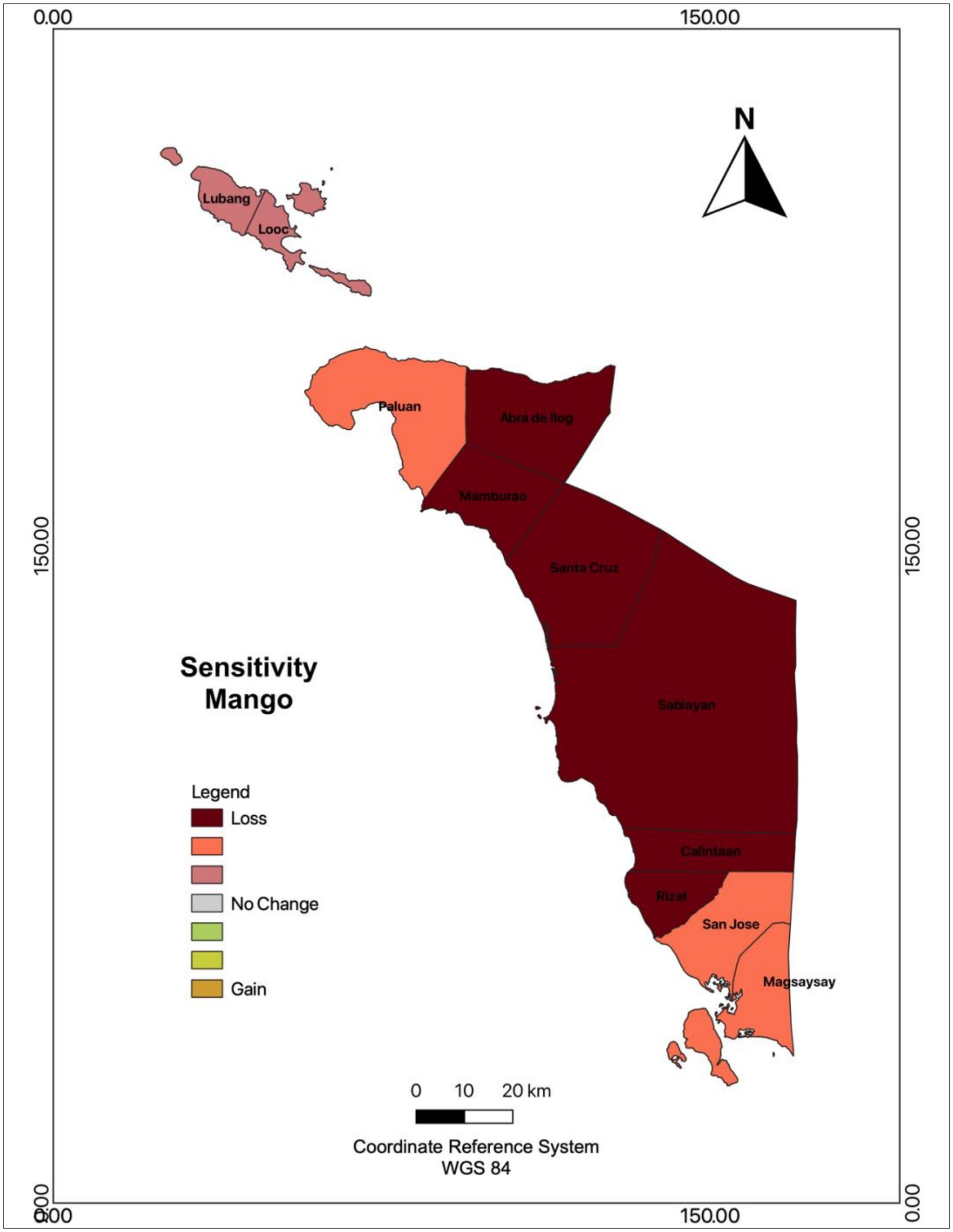

Figure 14. Sensitivity map of corn in Occidental Mindoro.

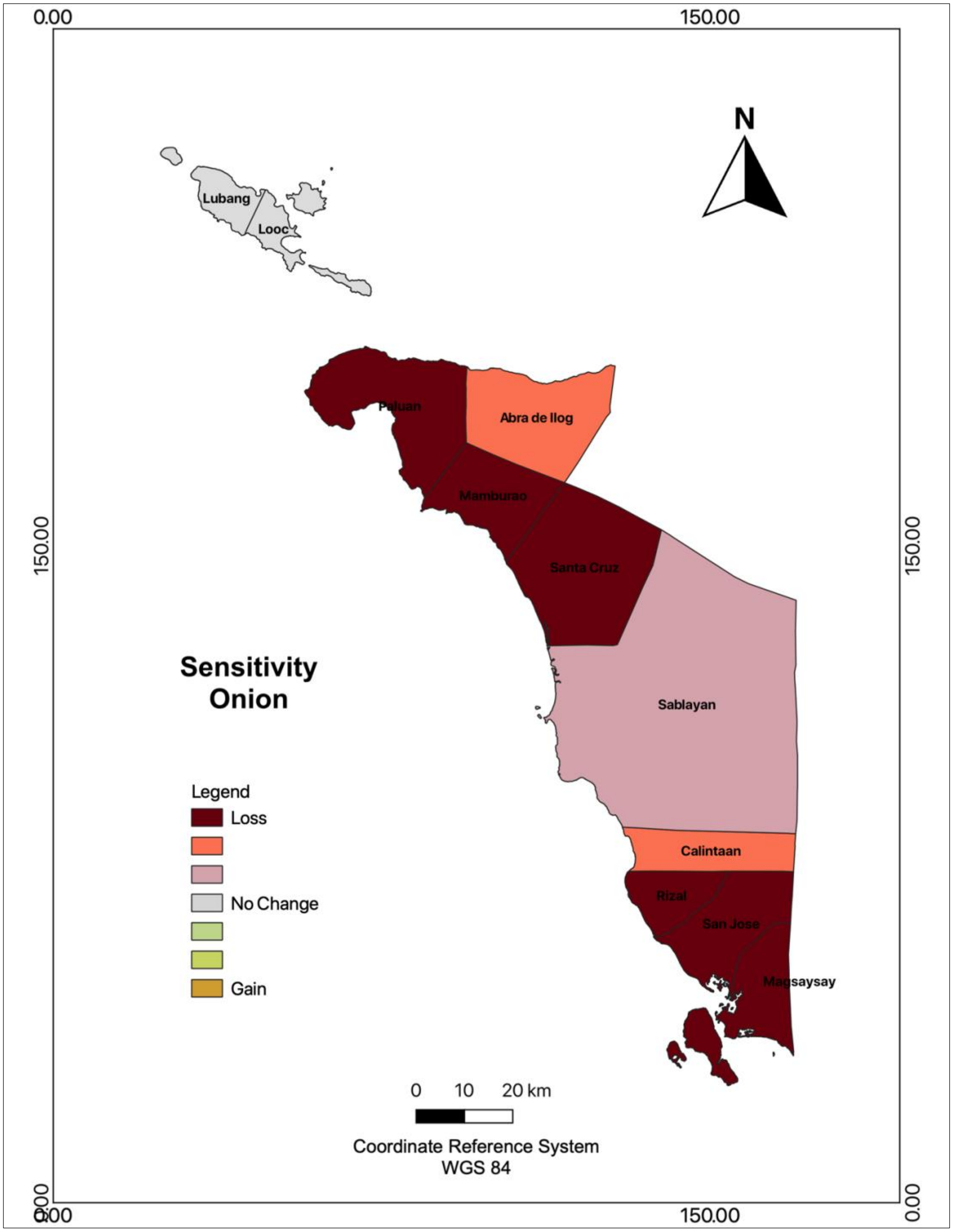

Figure 15. Sensitivity map of onion in Occidental Mindoro.

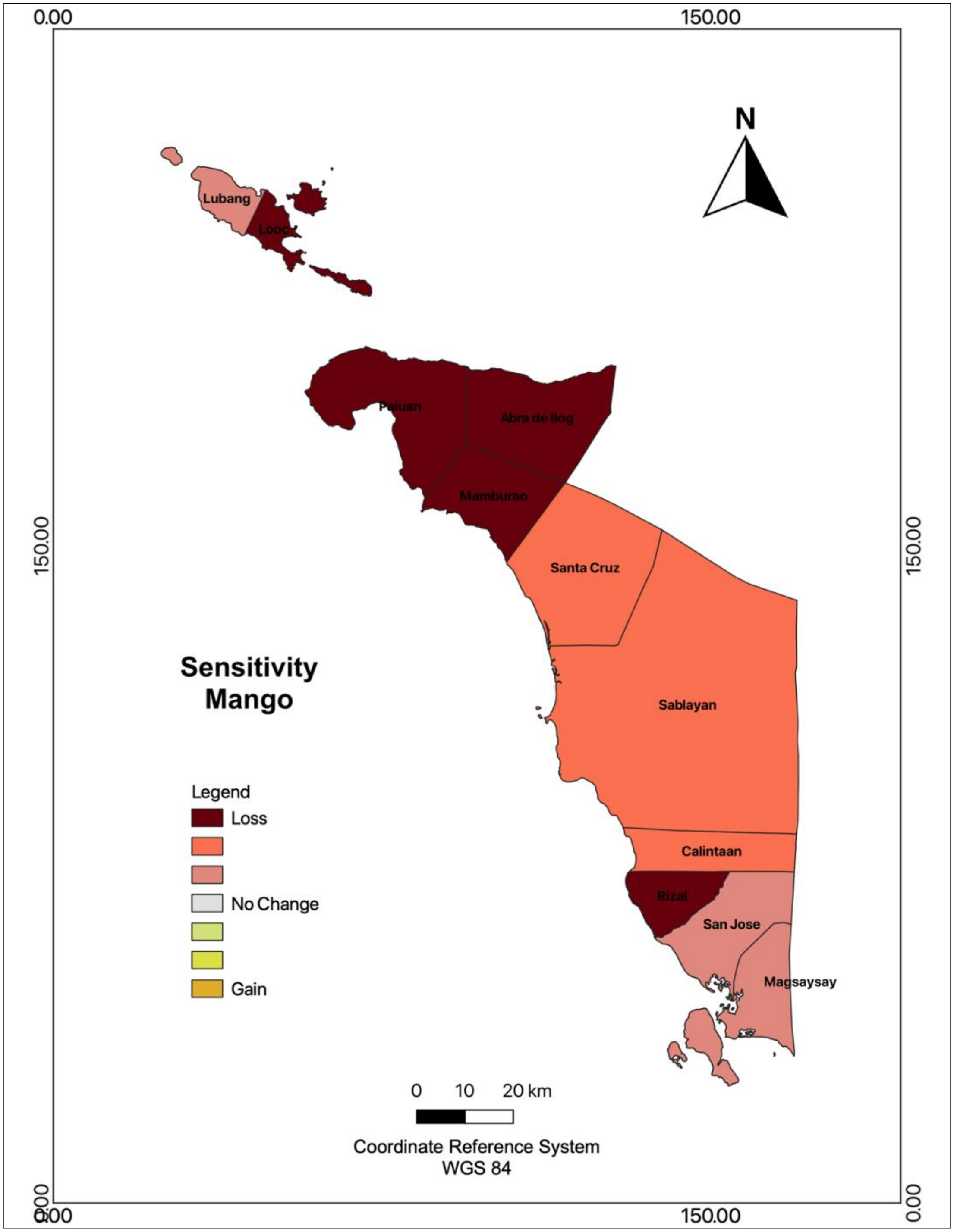

Figure 16. Sensitivity map of Mango in Occidental Mindoro.

c. Adaptive Capacity

The indicators used for adaptive capacity were categorized into four (4) capitals. By this, it can be seen the municipalities which has a high capacity to adapt and what are the municipalities need assistance. The following figure presents spatial It shows that San Jose has the highest capacity to

adapt. In this case, San Jose is the center of economic activity and have higher access to basic services such as health and education.
The municipality that has a high economic capital is San Jose. This is followed by Santa Cruz and Sablayan. While the municipalities that has a very low economic capital are Lubang and Looc. These two municipalities are found in the northern part of the province and an island municipalities.

For the human capital, San Jose has the classification of very high followed by Mamburao. The municipalities that have very low classification are Looc, Paluan, Abra de Ilog, Calintaan, Rizal and Magsaysay.

Lubang has a very high classification in physical capital followed by Looc. The municipalities that has a classification of very low are Abra de Ilog, Santa Cruz, and Calintaan.

Majority of the municipalities have a very high classification in institutional capital. Only the municipality of Paluan is considered to have a very low institutional capital.

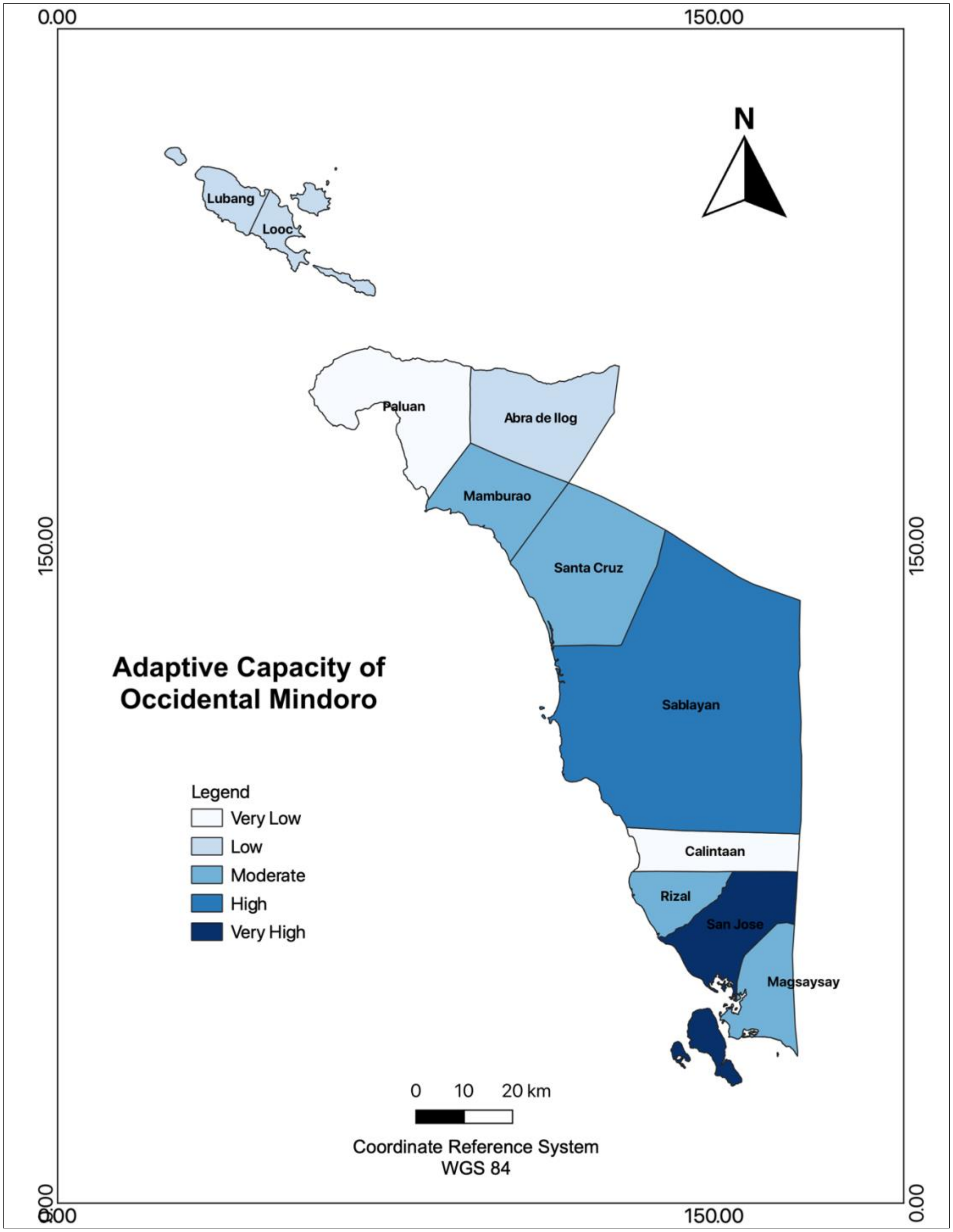

Figure 17. Over all adaptive capacity of Occidental Mindoro.

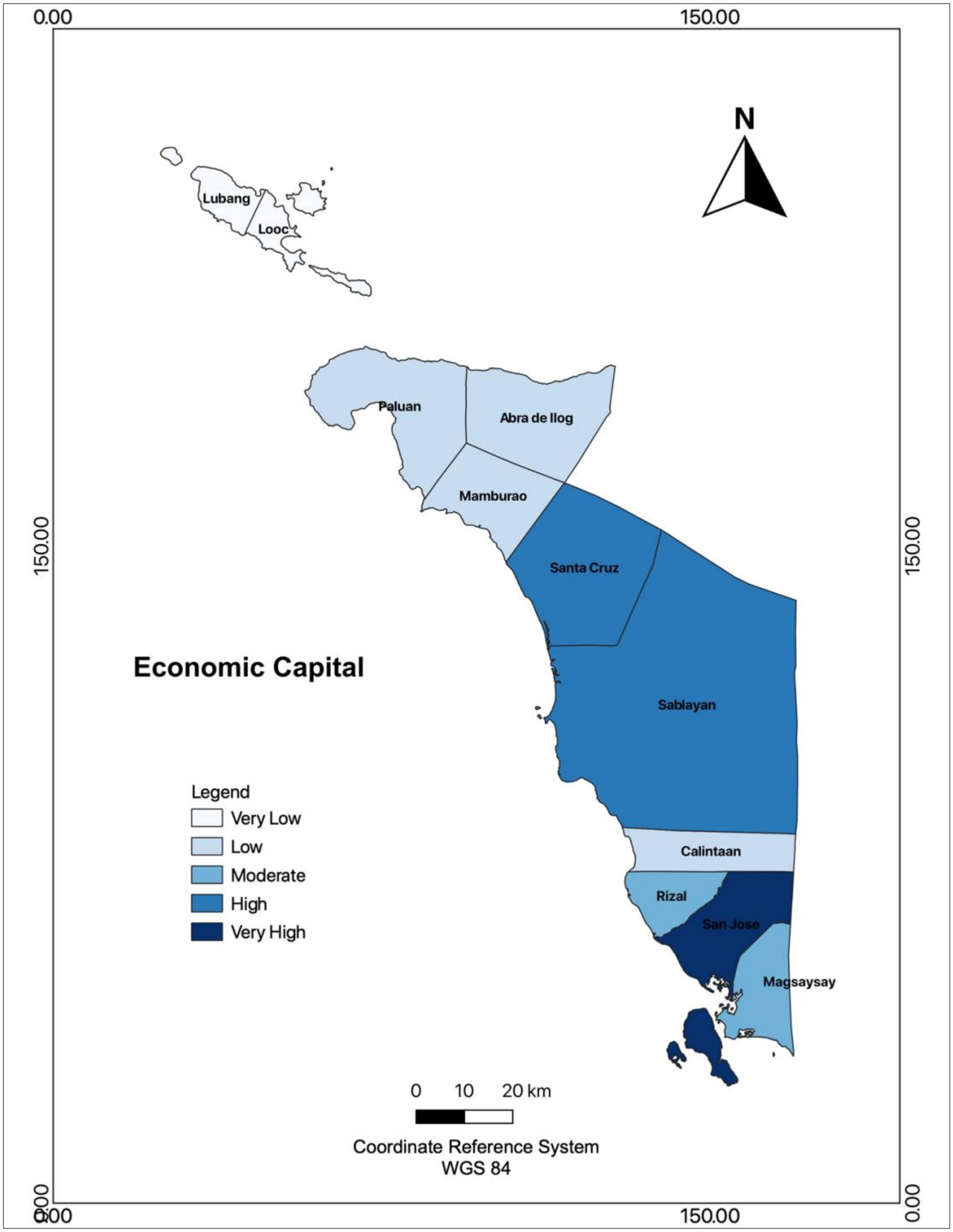

Figure 18. Economic capital of Occidental Mindoro.

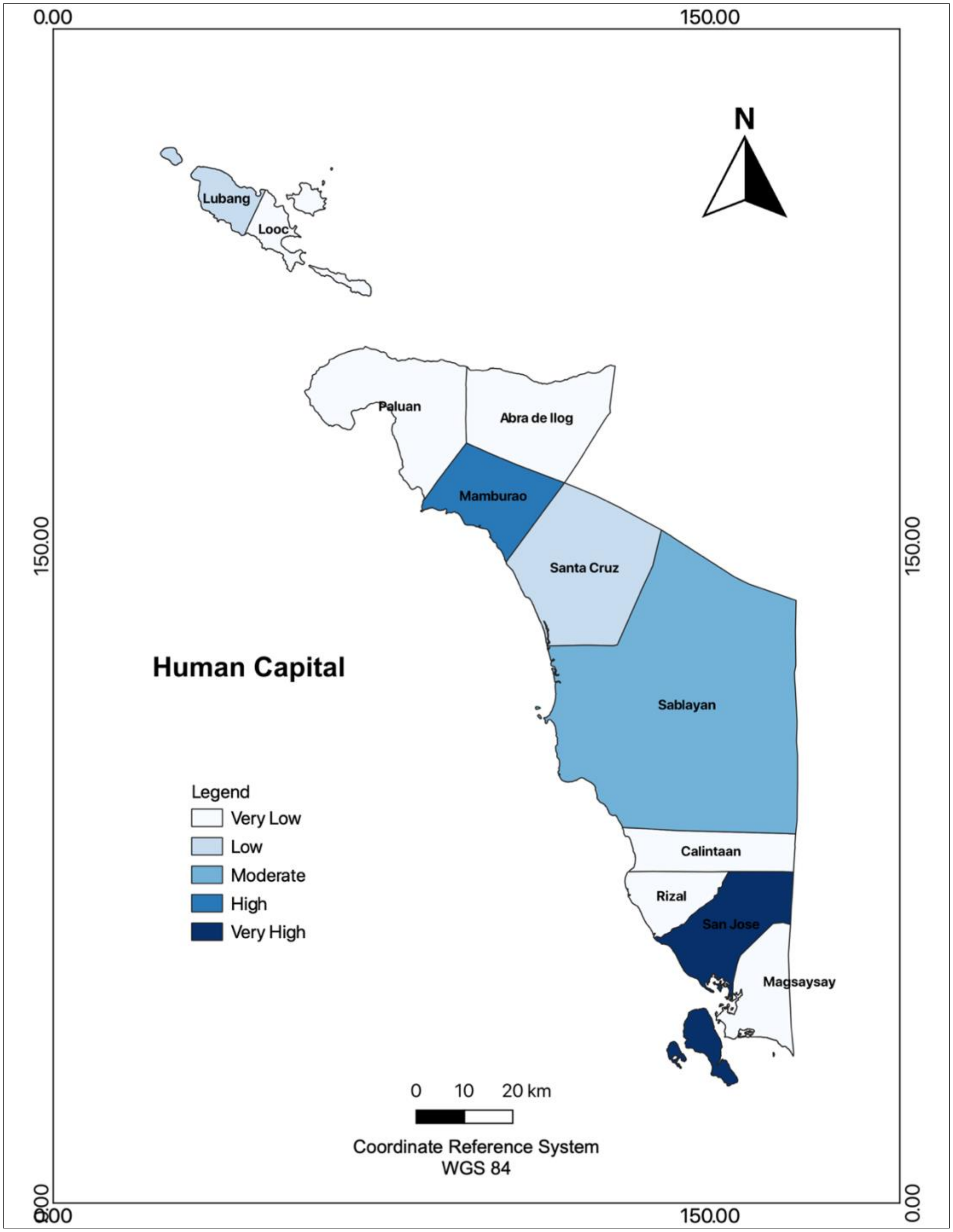

Figure 19. Human capital of Occidental Mindoro.

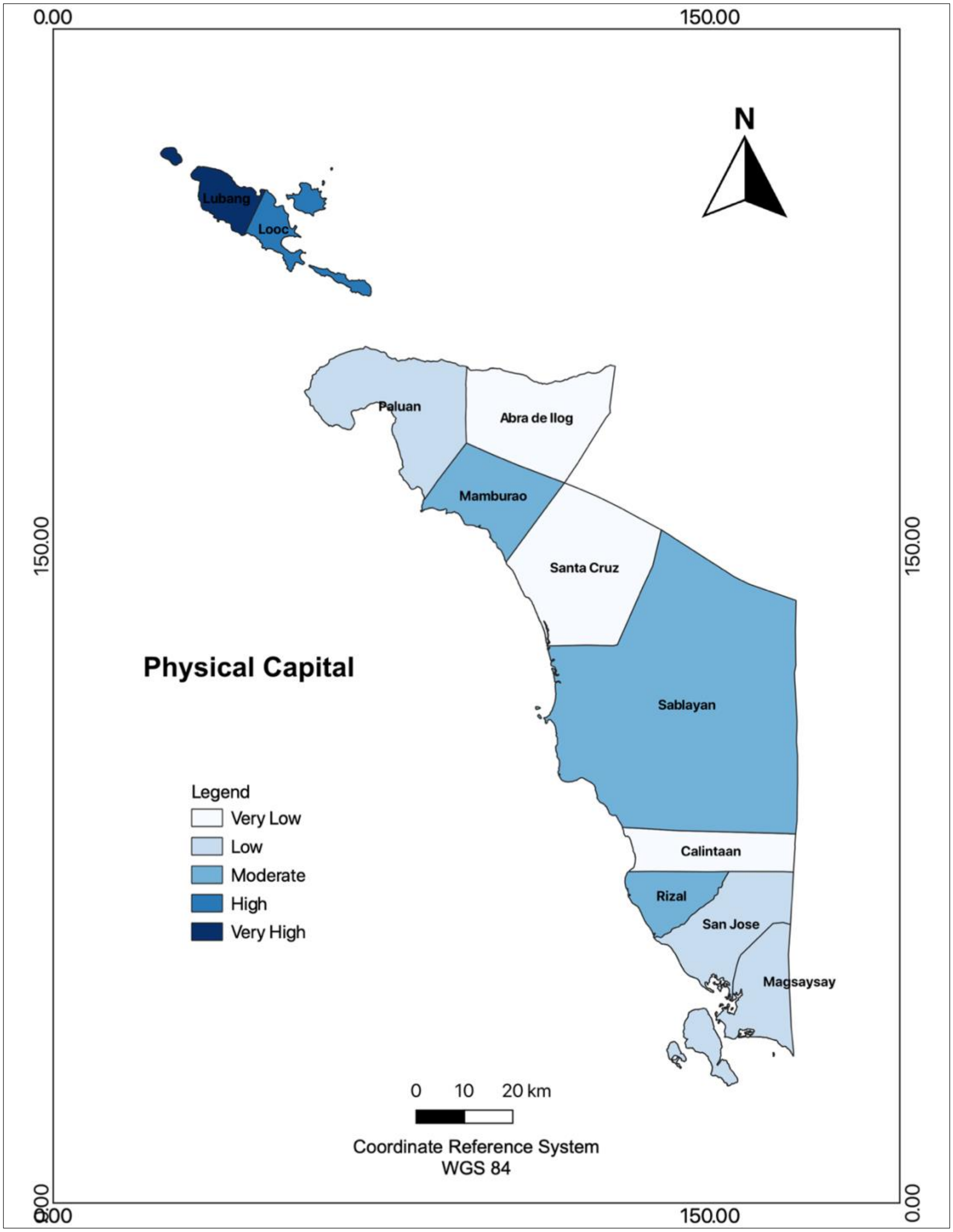

Figure 20. Physical capital of Occidental Mindoro.

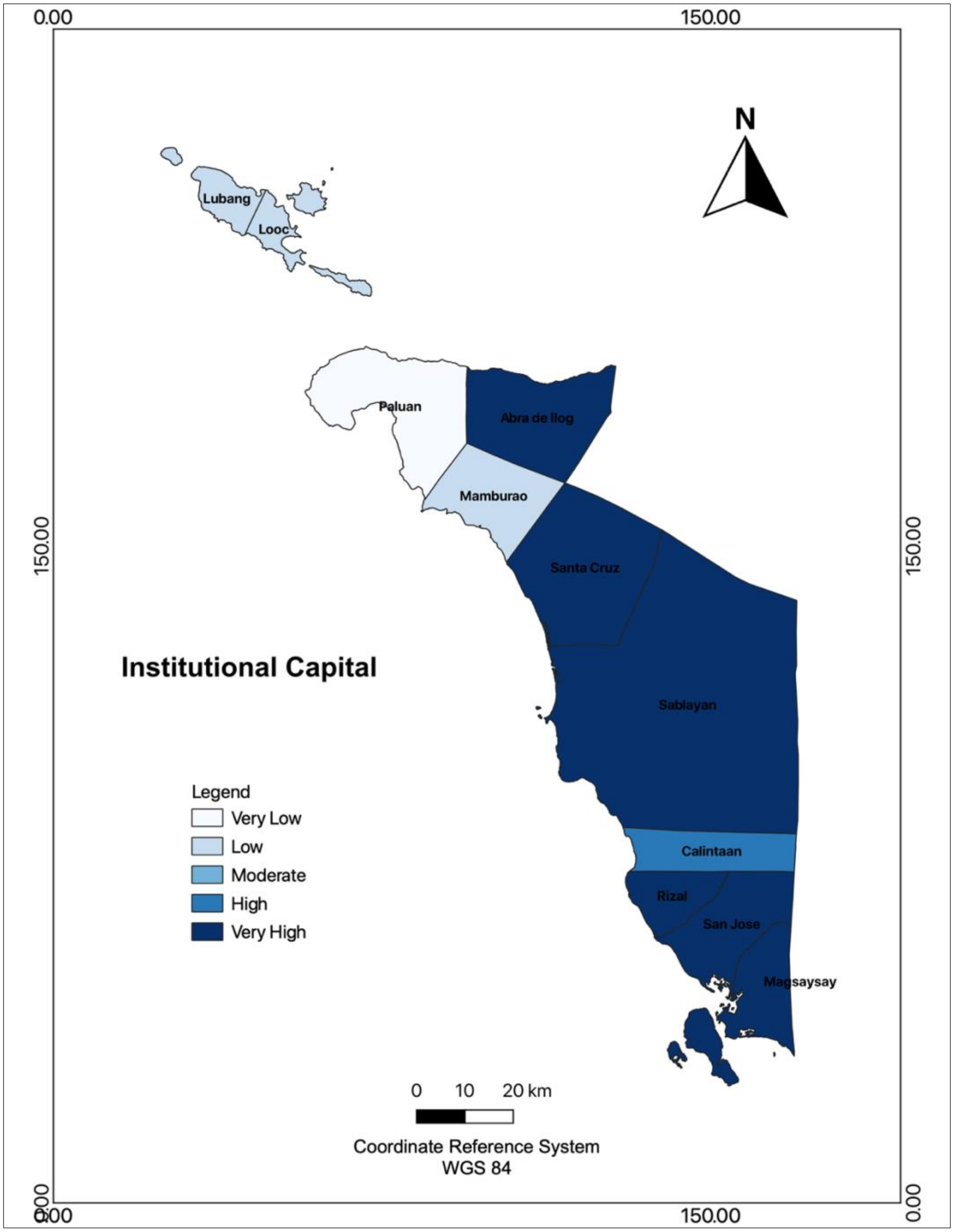

Figure 21. Institutional capital of Occidental Mindoro.

d. Vulnerability Assessment of crops

Three key dimensions of vulnerability which are hazard (15%), adaptive capacity (70%) and sensitivity (15%) were combined together with different weights to determine the overall vulnerability of the different municipalities in Occidental Mindoro for the various major crops.

a. Cassava

Paluan is the most vulnerable to climate change. It is being followed by Abra de Ilog, Mamburao, and Calintaan. While San Jose is the least vulnerable in the province.

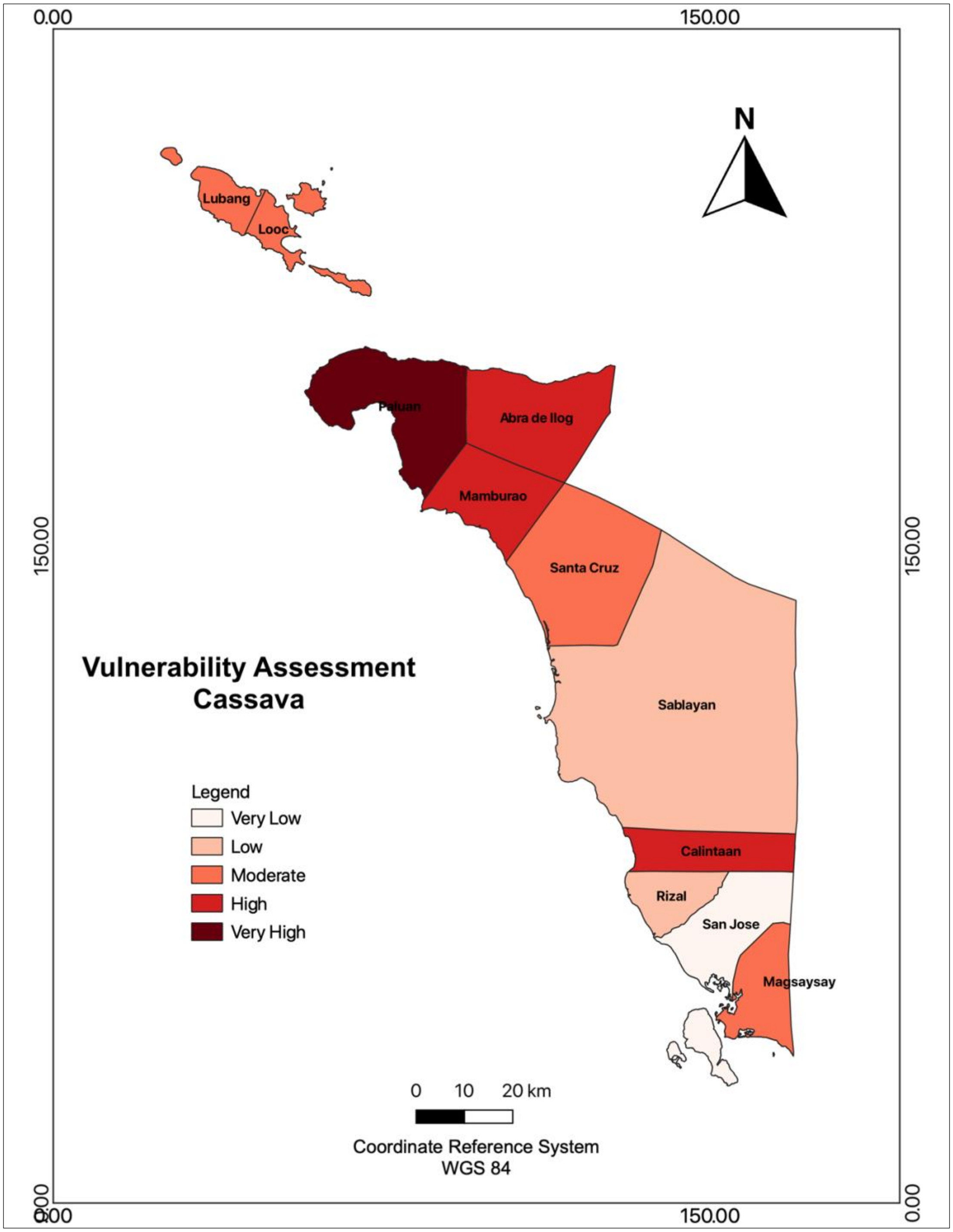

Figure 22. Vulnerability map of cassava in Occidental Mindoro.

b. Rice

Majority of the municipalities have moderate to very high vulnerability to climate change except for San Jose that has a very low classification of vulnerability. The most vulnerable municipalities are Paluan and Calintaan.

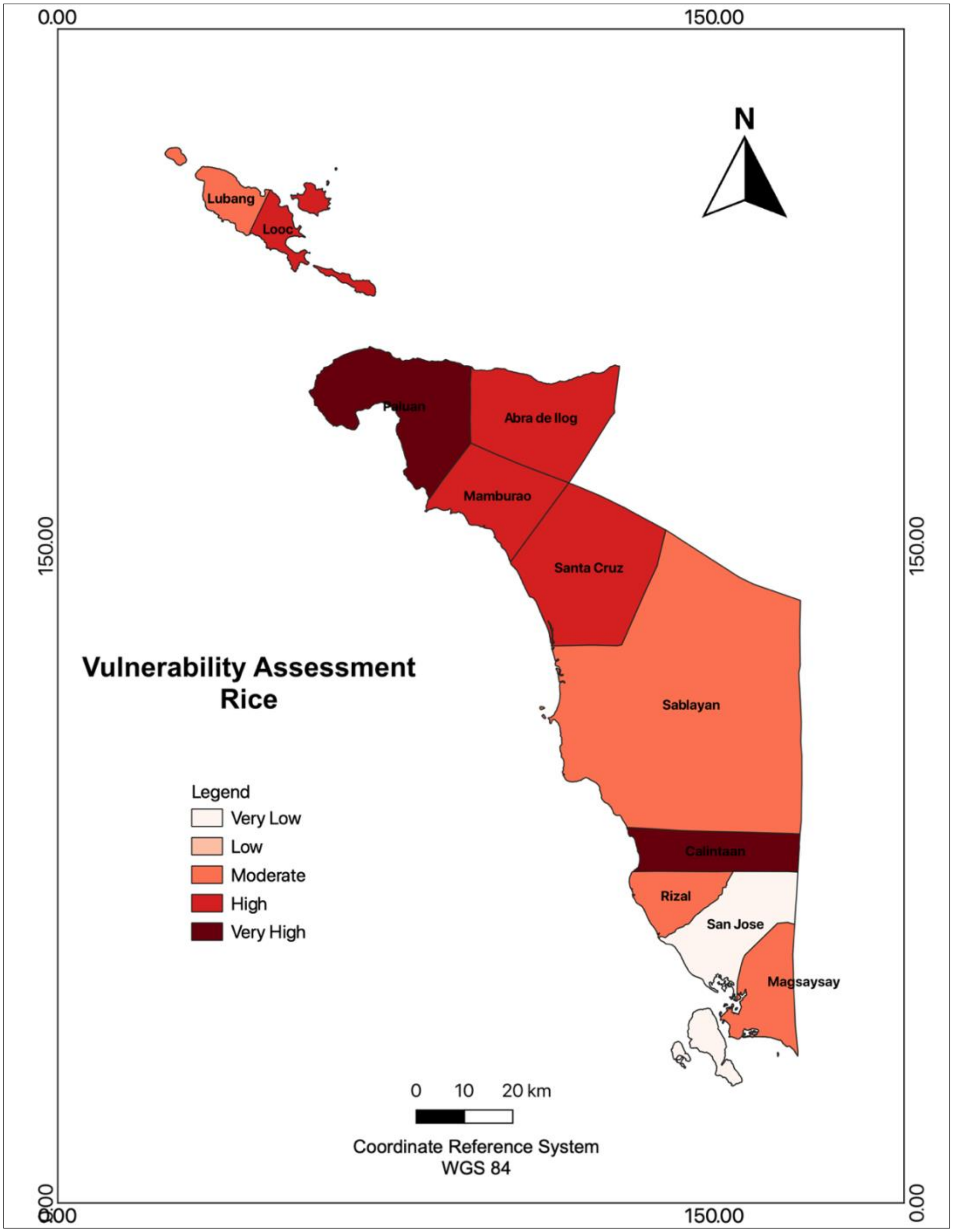

Figure 23. Vulnerability map of rice in Occidental Mindoro.

c. **Corn**

Majority of the municipalities have moderate to very high classification of vulnerability except for San Jose with a very low classification. Paluan and Calintaan are the most vulnerable and is being followed by Abra de Ilog, Mamburao and Santa Cruz.

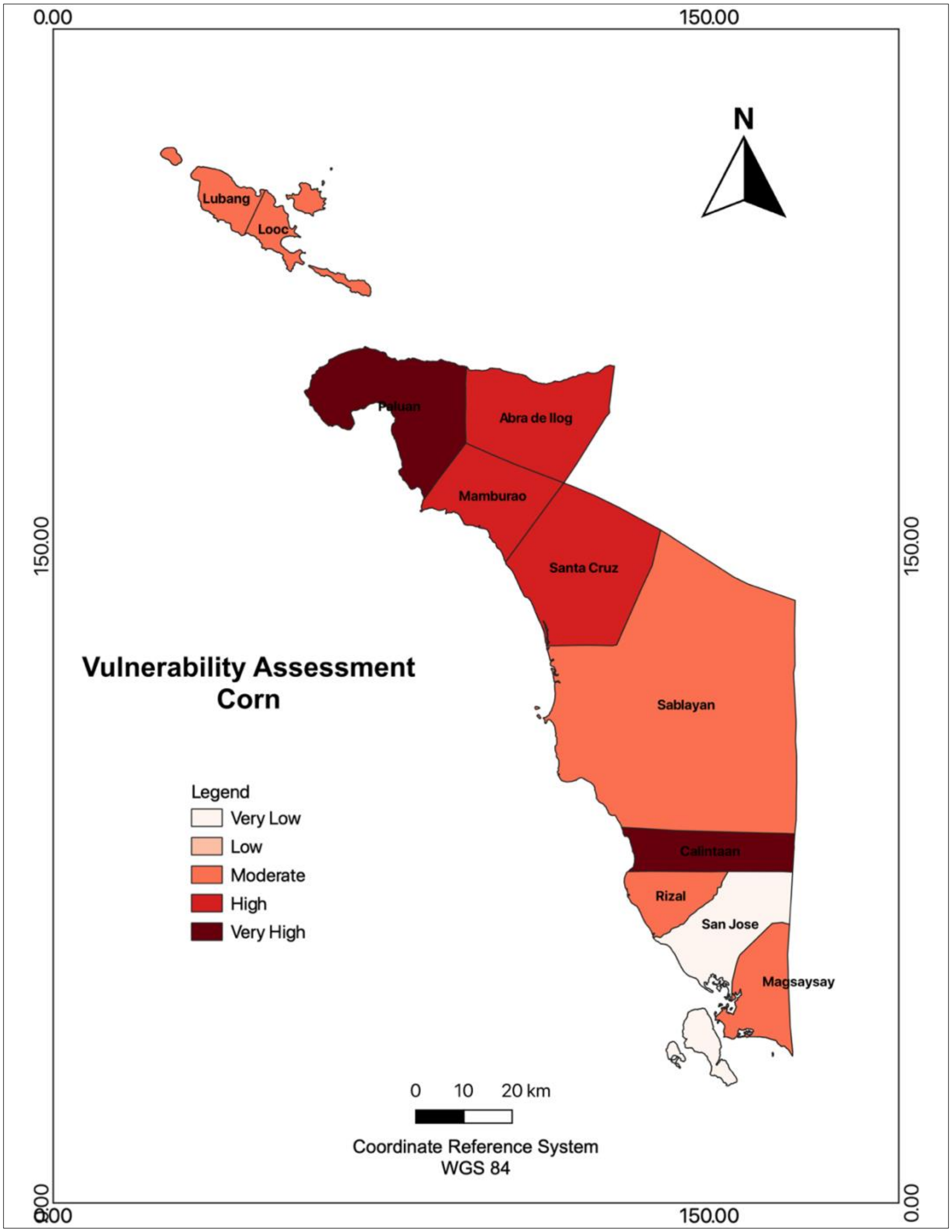

Figure 24. Vulnerability map of corn in Occidental Mindoro.

d. Onion

Palauan is the most vulnerable municipality while Mamburao, Calintaan and Magsaysay have high classification of vulnerability. San Jose is the least vulnerable municipality.

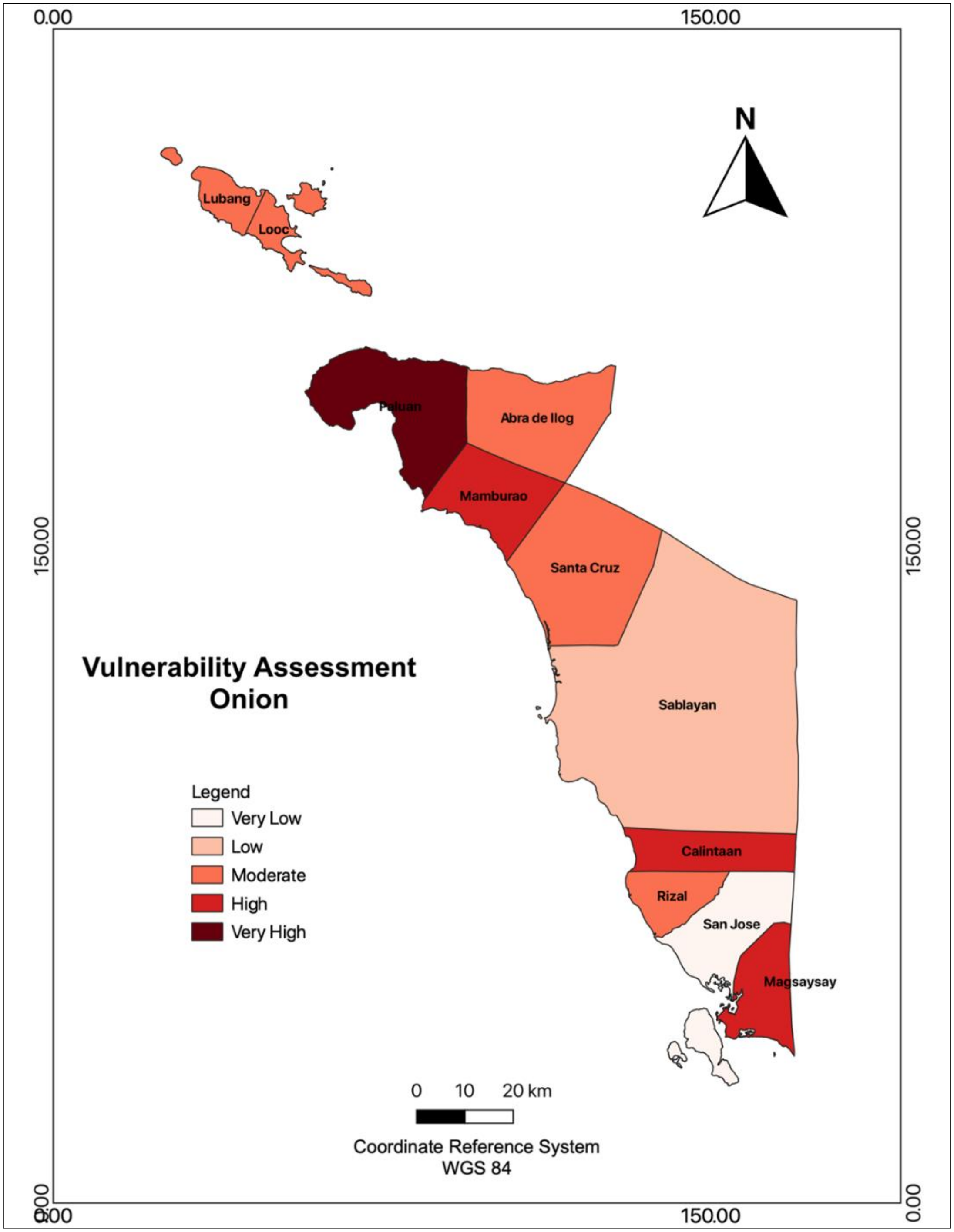

Figure 25. Vulnerability map of onion in Occidental Mindoro.

e. Mango

Palaun is the most vulnerable municipality while Looc, Abra de Ilog, Mamburao, and Calintaan have high classification of vulnerability. San Jose is the least vulnerable.

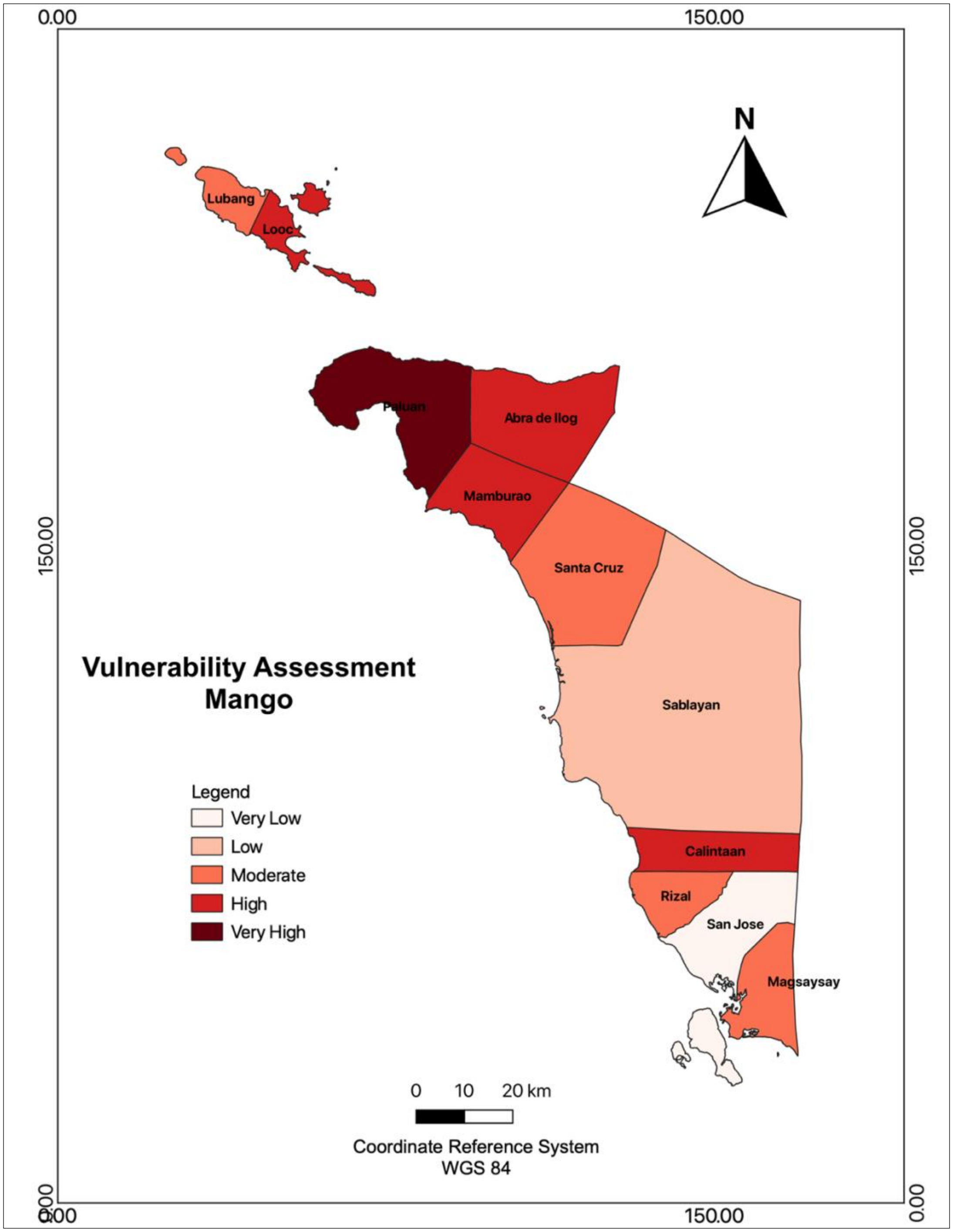

Figure 26. Vulnerability map of mango in Occidental Mindoro.

B. Initial Assessment of Climate Risk Vulnerability of Palawan

The following maps are the initial assessment for the climate scenarios of rice, banana, coffee, mango and cashew. Climate scenarios consist of baseline and future climate suitability scenarios. These two scenarios are essential in the sensitivity analysis. It showed that the available actual and secondary data was sufficient for the sensitivity analysis.

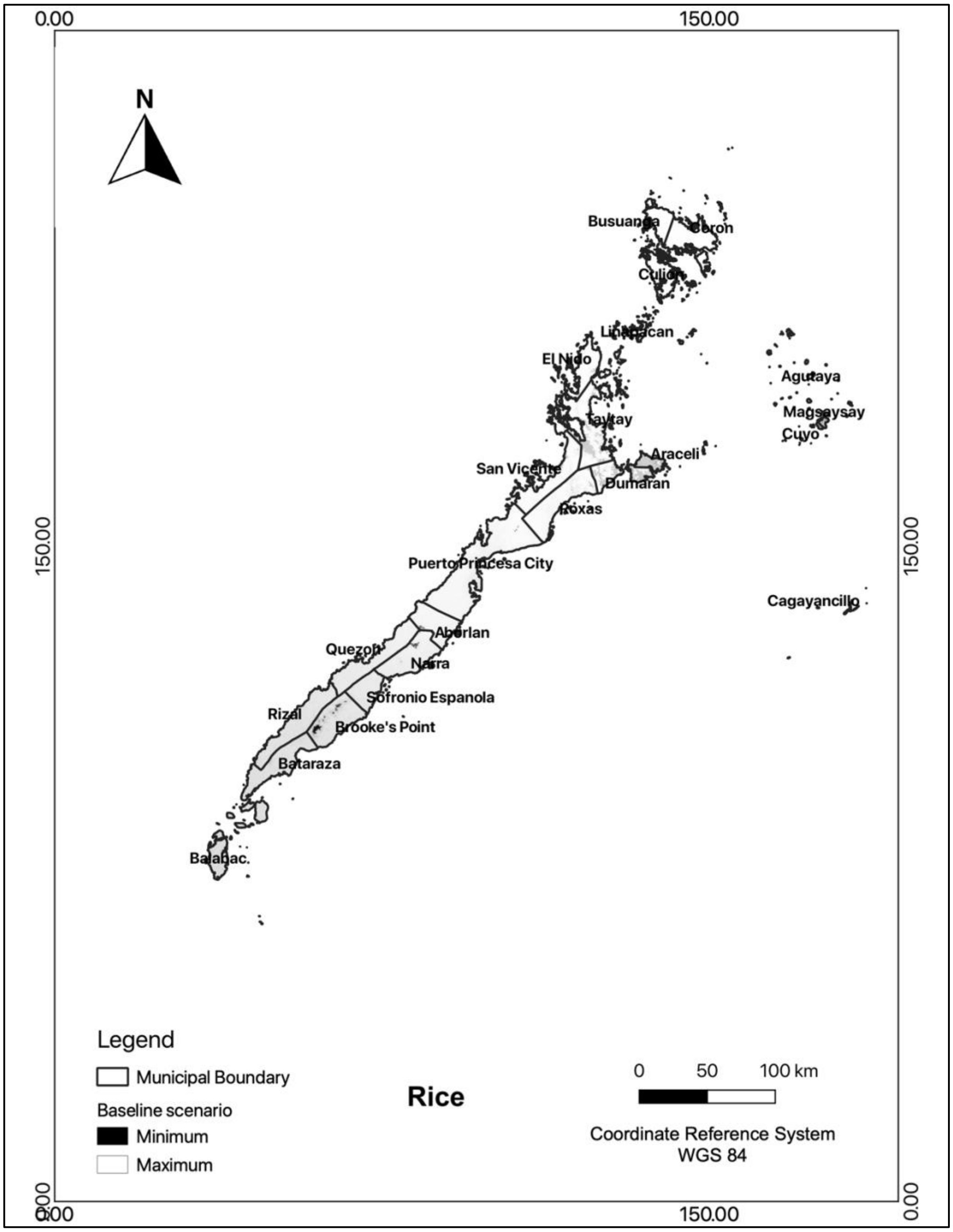

Figure 27. Baseline scenario for rice

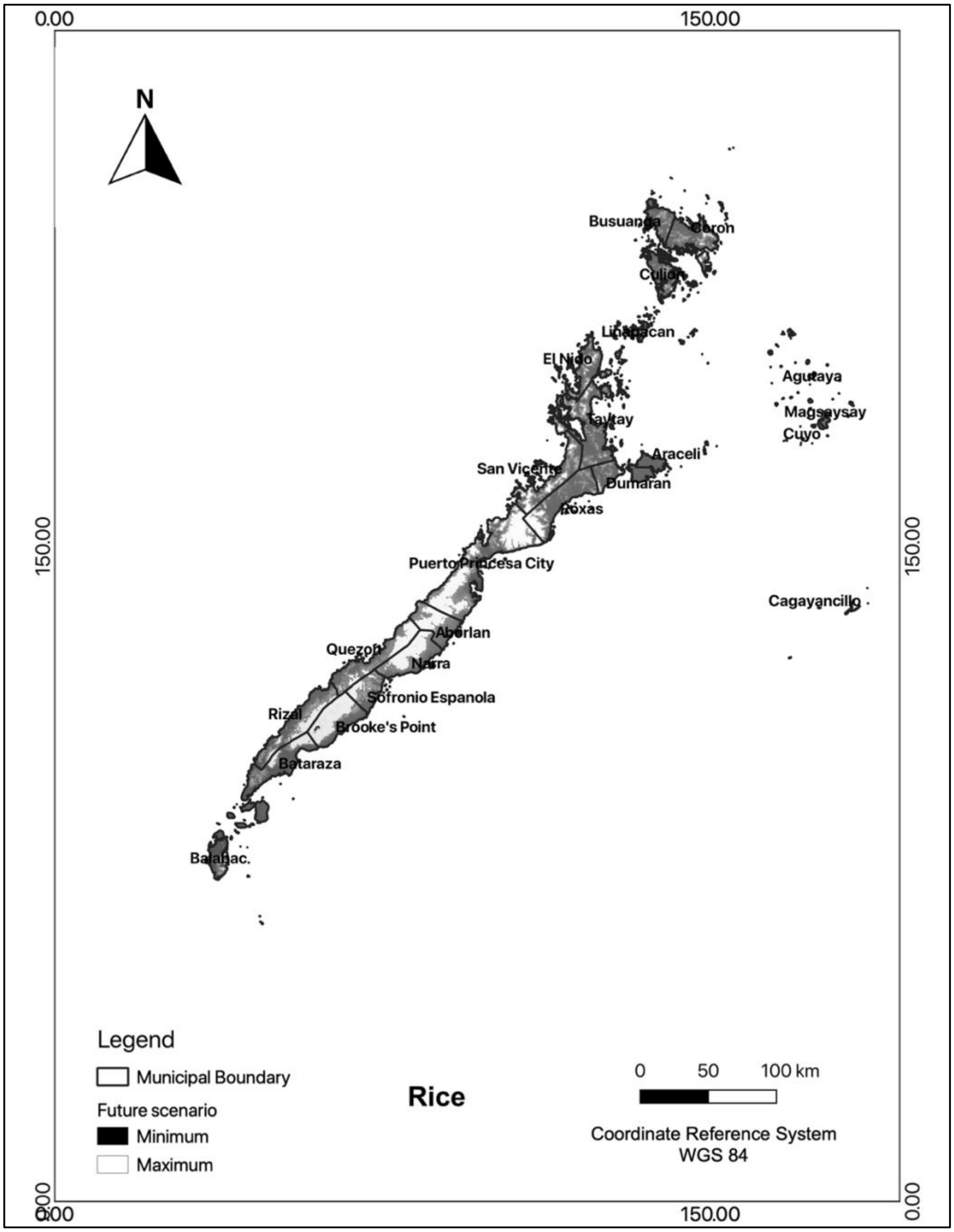

Figure 28. Future scenario for rice.

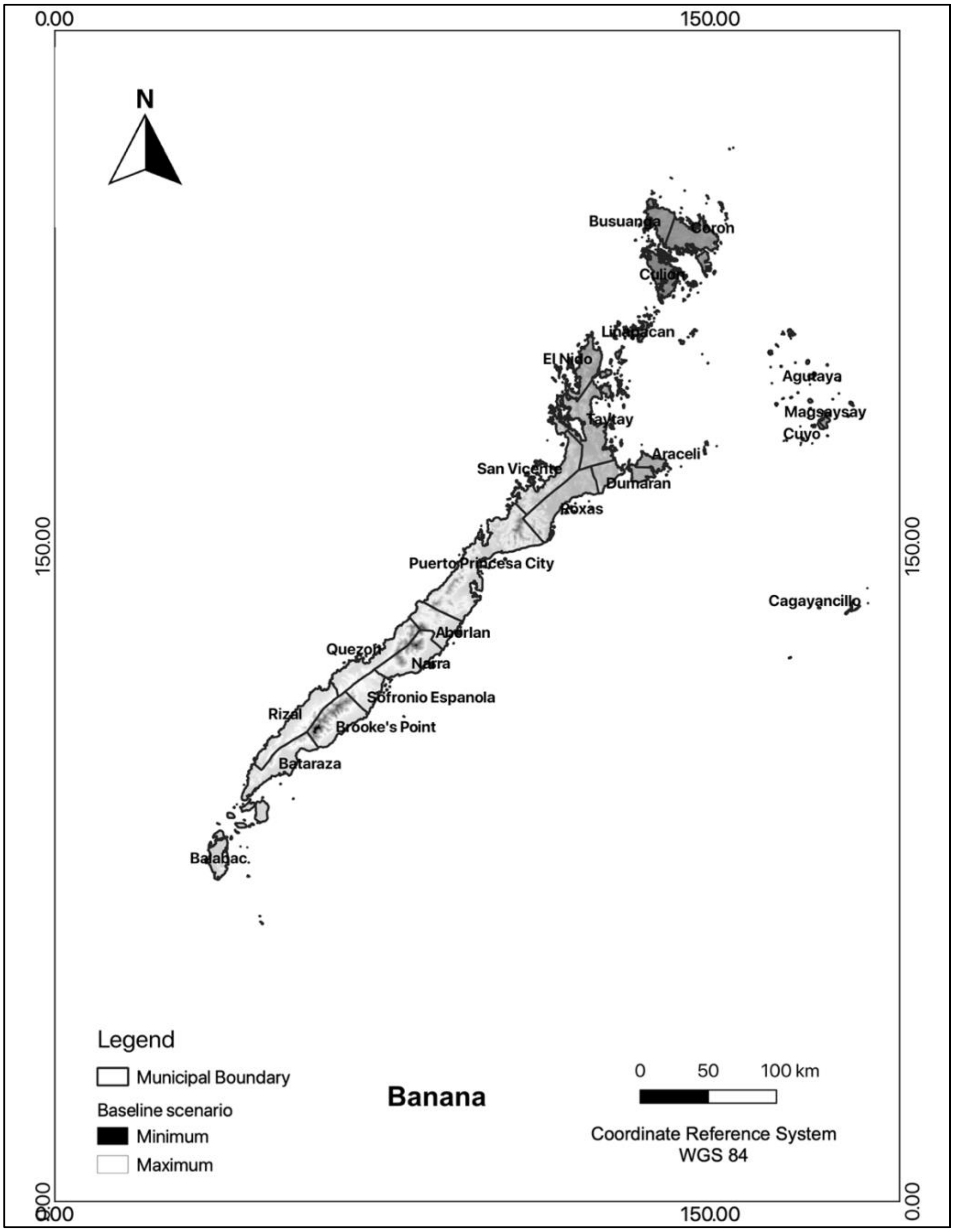

Figure 29. Baseline scenario for banana.

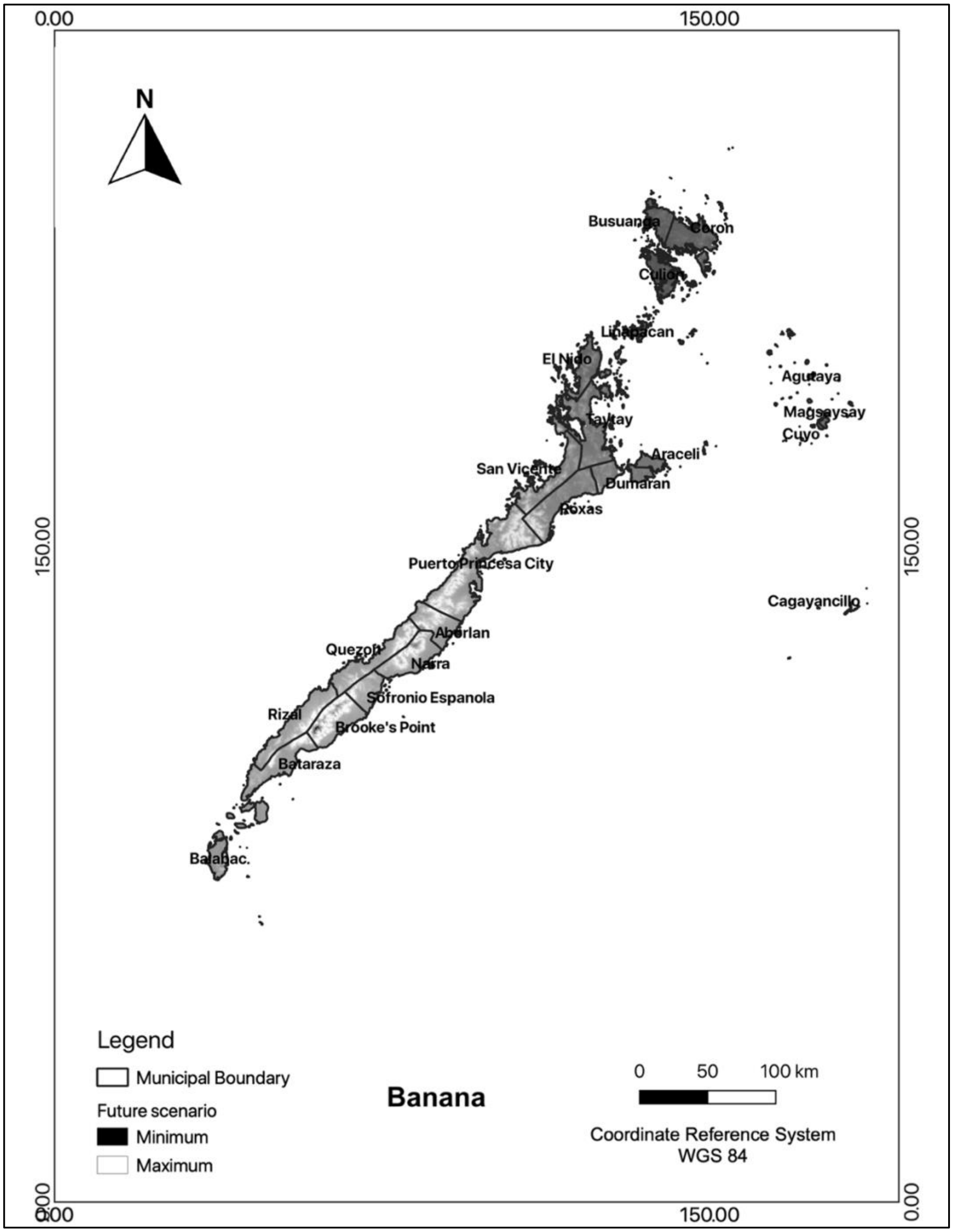

Figure 30. Future scenario for banana.

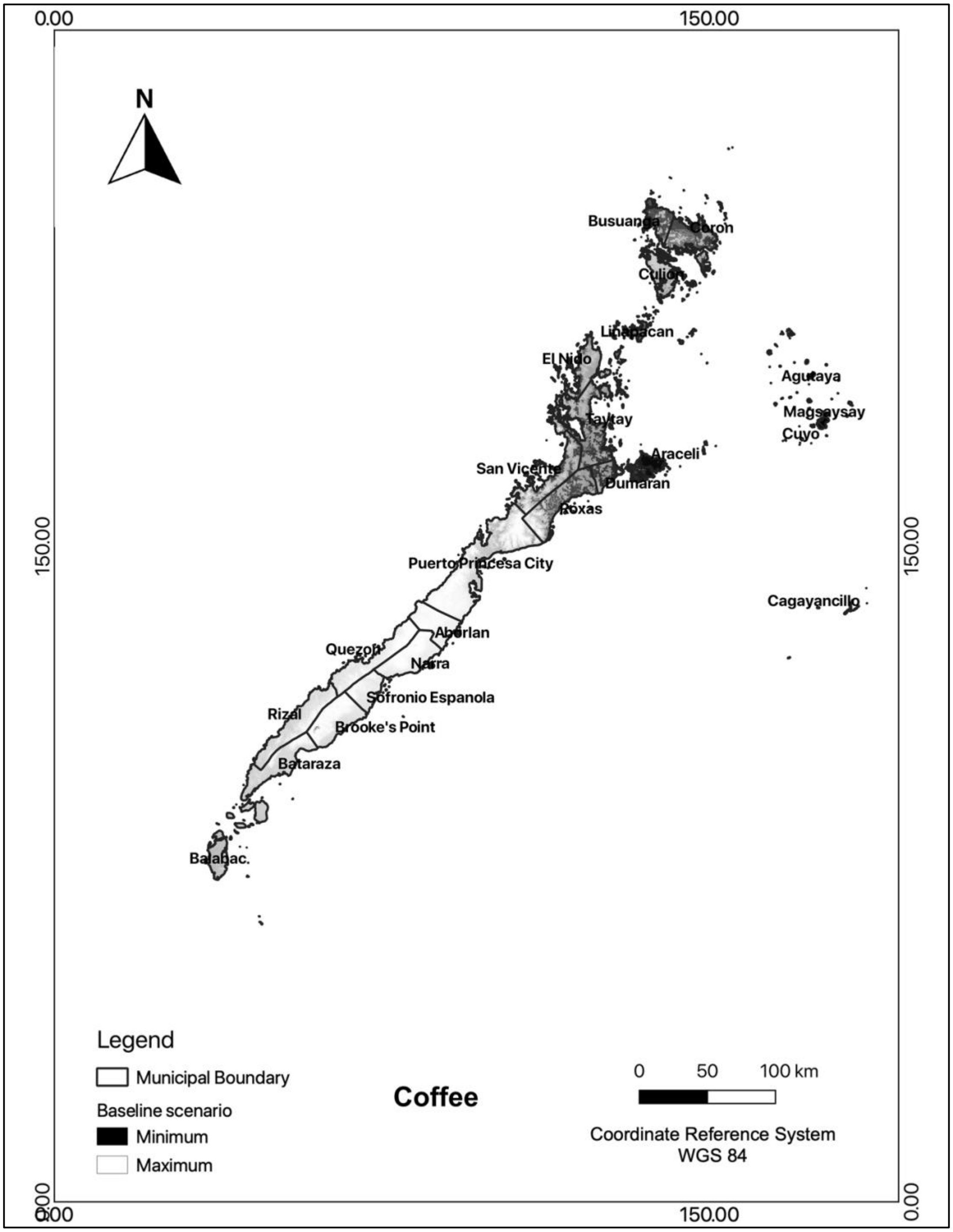

Figure 31. Baseline scenario for coffee.

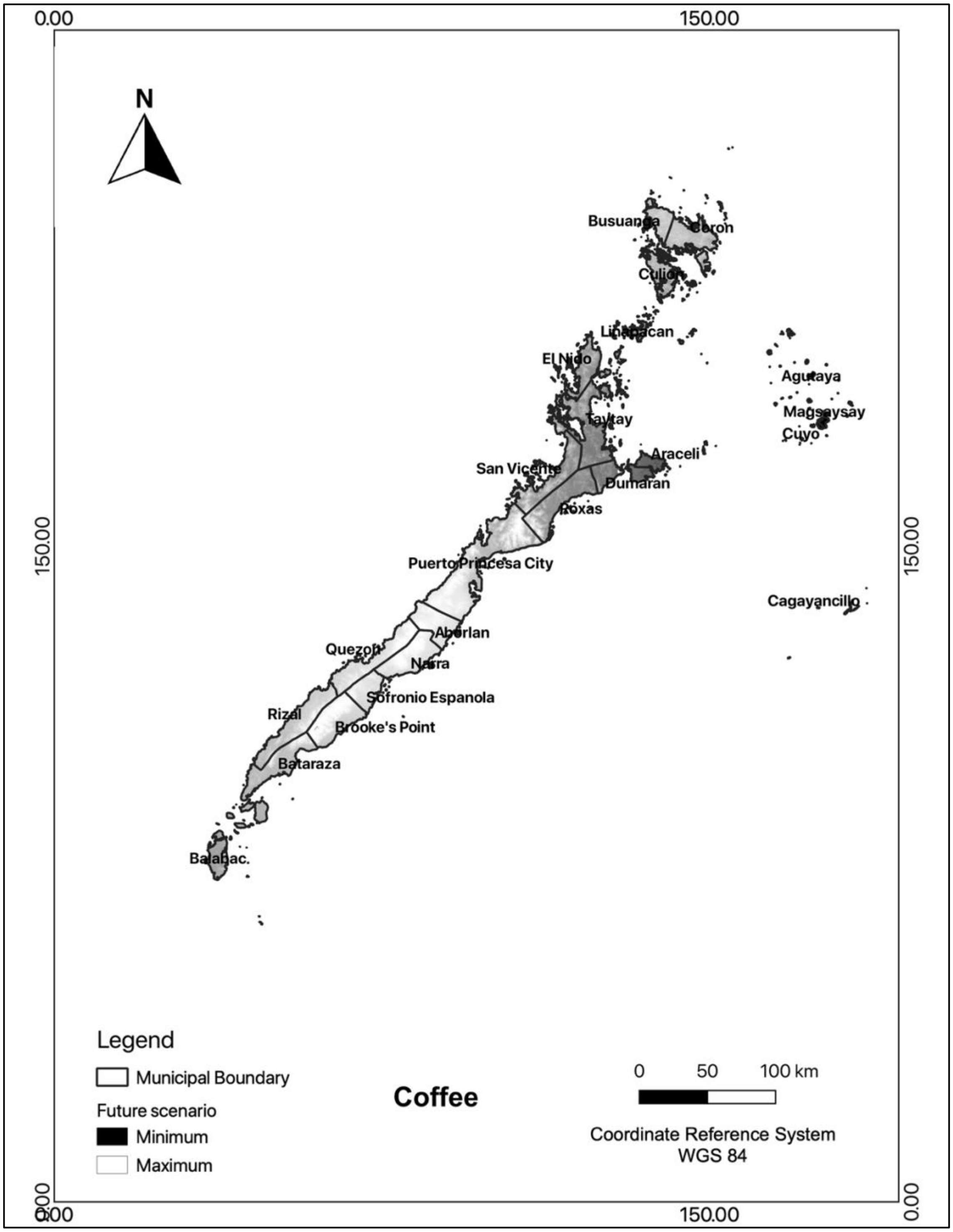

Figure 32. Future scenario for coffee.

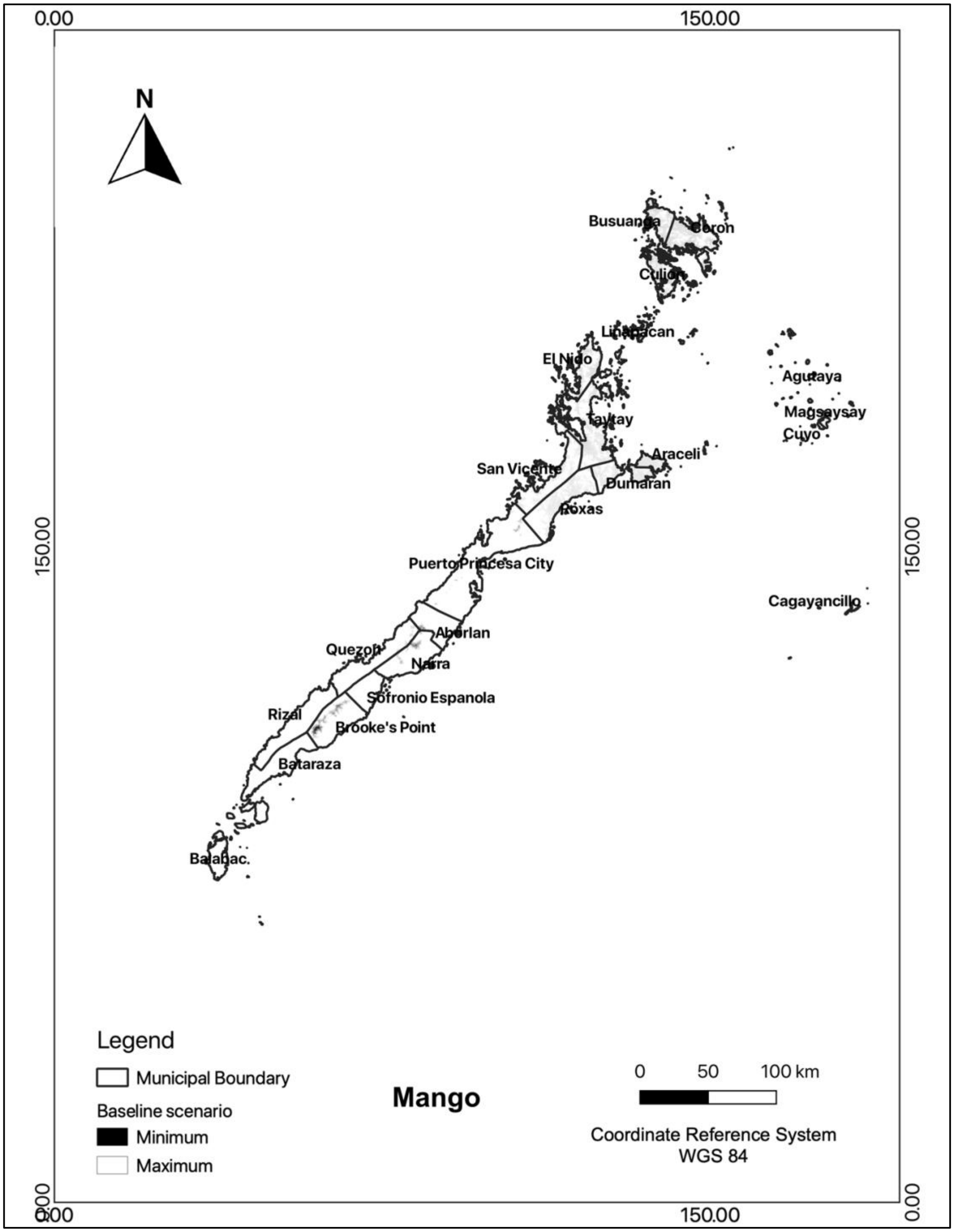

Figure 33. Baseline scenario for mango.

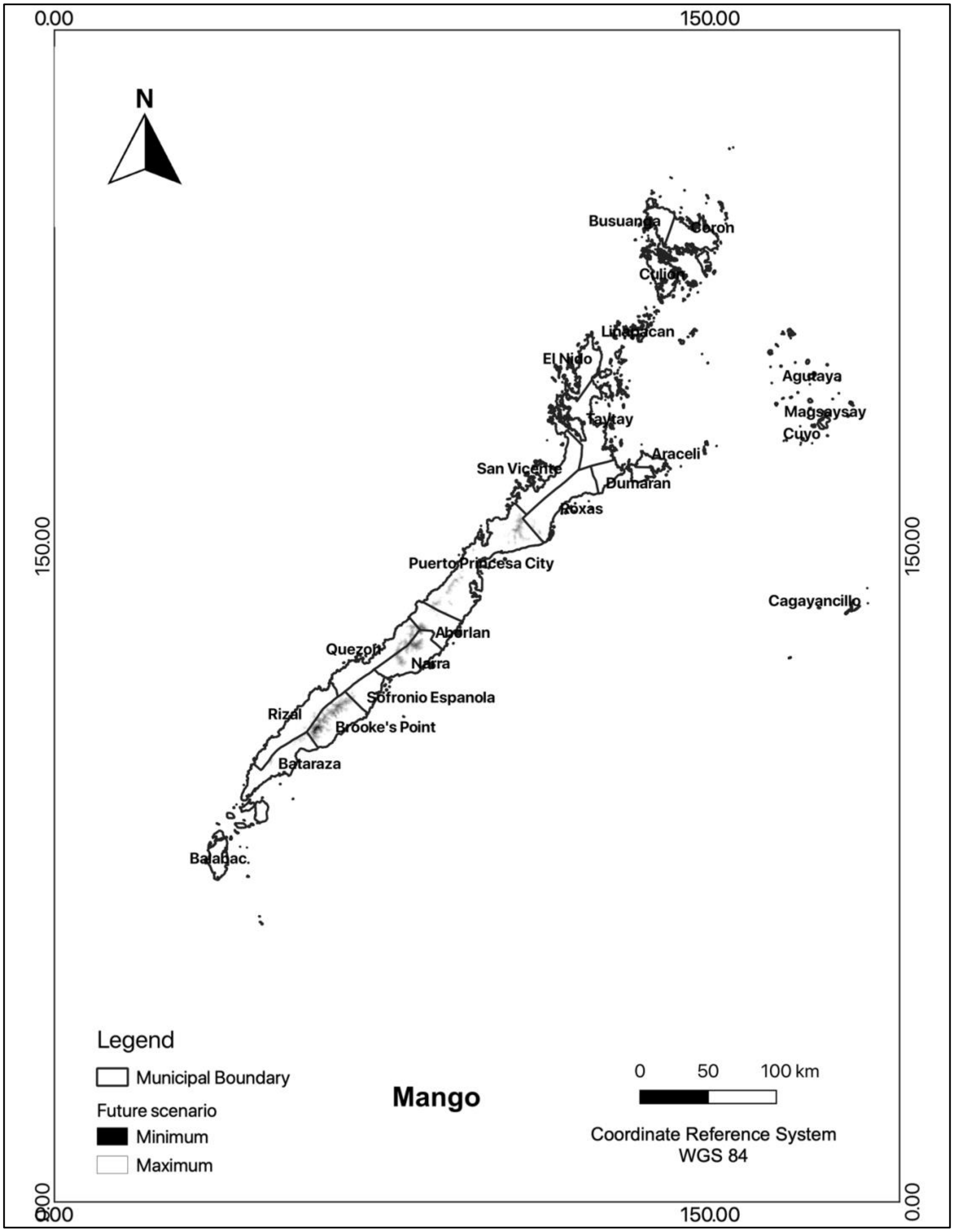

Figure 34. Future scenario for mango.

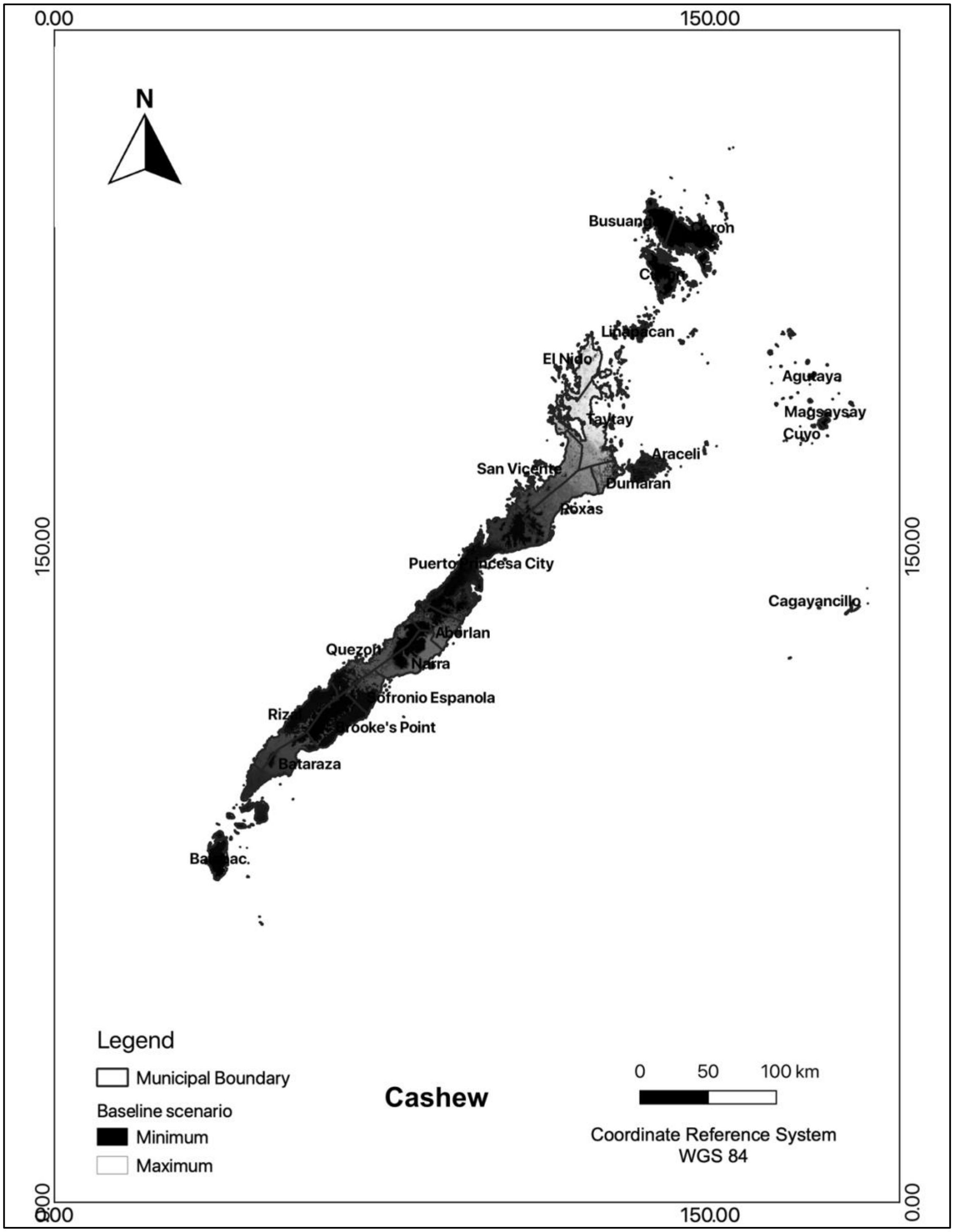

Figure 35. Baseline scenario for cashew.

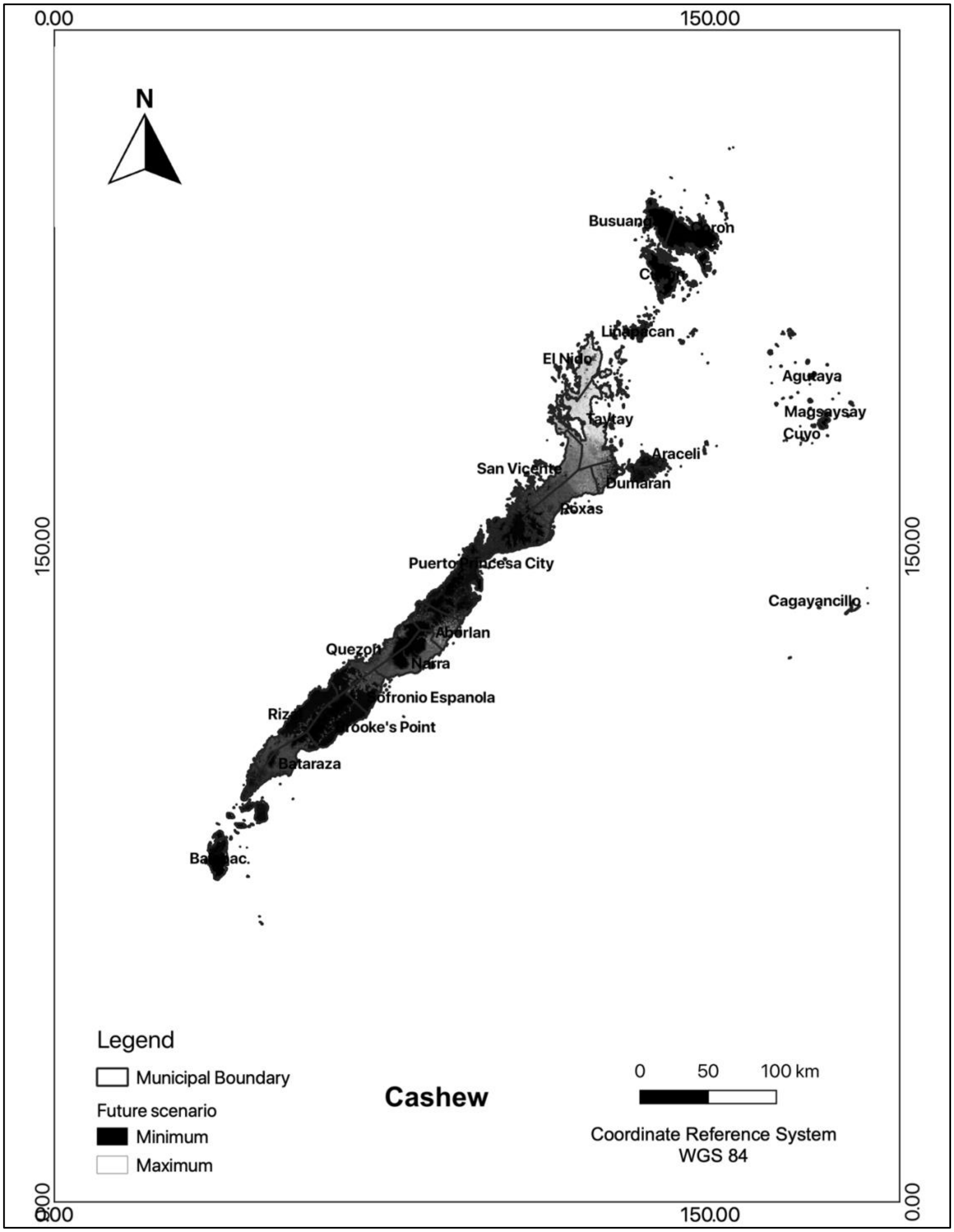

Figure 36. Future scenario for cashew.

IV. Conclusion

Crop vulnerability to climate change was assessed and mapped in 10 municipalities Occidental Mindoro using modelling, climate variability, and socio-economic variables. The analyses focuses on the top five commodities of Occidental Mindoro. Even that the location of crops in the municipality of Lubang was not mapped, it is included in the assessment since this study is based on modelling. It is important to note that there may have uncertainties. However, the assessment is based on a municipal resolution. This is where the planning takes place. The municipality of Paluan is the most vulnerable municipality. While San Jose is the least vulnerable. San Jose is the capital of the province.

V. References:

1. Department of Interior and Local Government. 2014. Climate change in the Philippines.

2. IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC.

3. IPCC. 2014 Jha S, Bacon CM, Philpott SM, Ernesto Mendez V, Läderach P, Rice RA (2014) Shade coffee: update on a disappearing refuge for biodiversity. Bioscience 64:416–428.

4. NASA Global Climate Change. Available online: https://climate.nasa.gov/vital-signs/sea-level/

5. NEDA. 2021. MIMAROPA Region. Available online: http://mimaropa.neda.gov.ph/occidental-mindoro/

6. O'Donnell, M and Ignizio, D., 2012. USGS Data Series 691: Bioclimatic Predictors for Supporting Ecological Applications in the Conterminous United States. Available online: https://pubs.usgs.gov/ds/691/ds691.pdf

7. Ontario Minisitry of Agriculture, Food, and Rural Affairs. Soil Erosion:Causes and Effects. Available online: http://www.omafra.gov.on.ca/english/engineer/facts/12-053.htm

8. PAG-ASA. 2011. Tropical Cyclone. Available online: http://bagong.pagasa.dost.gov.ph/information/about-tropical-cyclone

9. Philippine Information Agency. MIMAROPA. Available online: http://pia.gov.ph/news/regions/mimaropa?p=2

10. Palao, L. K., N. Guerten, A. Martinez, L. Parker, J. G. Balanza, J. Leyte, R. Dikitan, D., and Burra, D.. 2017. A Climate Risk Vulnerability Assessment

for the Adaptation and Mitigation Initiative in Agriculture Program in the Philippines.

11. USGS. 2018. USGS Groundwater Information. Available online: https://water.usgs.gov/ogw/gwrp/saltwater/salt.html

12. Ranganathan, C., K. Palanisami, K. Kakumanu, and A Baulraj. 2010. Mainstreaming the Adaptations and Reducing the Vulnerability of the Poor due to Climate Change. ADBI Working Paper 333. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/working-paper/2011/12/19/4831.adaptations.reducing.vulnerability.poor.climate.change/