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Philippine Climate Change and Food Security Analysis

Regional Report on Bangsamoro Autonomous Region in Muslim Mindanao

October 2024

Alliance Bioversity & CIAT

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List of Abbreviations

AEZ	Agro-Ecological Zones
AFF	Agriculture, Forestry, and Fishery Sector
AMIA	Adaptation and Mitigation Initiative in Agriculture
CCAFS	Climate Change, Agriculture and Food Security
CCFSA	Climate Change and Food Security Analysis
CIAT	International Center for Tropical Agriculture
CPH	Census of the Population and Housing
CRVA	Climate Risk and Vulnerability Assessment
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DSI	Drought Susceptibility Index
DREAM	Disaster Risk and Exposure Assessment for Mitigation
ENGP	Enhanced National Greening Program
FSI	Flood Susceptibility Index
GCM	Global Climate Model
GIS	Geographic Information System
GRDP	Gross Regional Domestic Product
KII	Key Informant Interview
LGU	Local Government Unit
LHZ	Livelihood Zone
MODIS	Moderate Resolution Imaging Spectroradiometer
NAMRIA	National Mapping and Resource Information Authority
NWRB	National Water Resources Board
OCHA	Office for the Coordination of Humanitarian Affairs
OECD	Organisation for Economic Co-operation and Development
PDSI	Palmer Drought Severity Index
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PSA	Philippine Statistics Authority
PRISM	Philippine Rice Information System
RCP	Representative Concentration Pathway
SDM	Species Distribution Modeling
SLR	Sea Level Rise
SS	Storm Surge
UNEP	United Nations Environment Programme
UNISDR	United Nations Office for Disaster Risk Reduction
WFP	World Food Programme

Foreword

Globally, the impacts of weather extremes, environmental degradation, and economic shocks continue to hamper people's access to nutritious and affordable food. Now, more than ever, strengthening the resilience of food systems is crucial, as this is the path where food travels from the farm to the table.

In 2021, the United Nations World Food Programme (WFP) conducted a robust study entitled Climate Change and Food Security Analysis (CCFSA), which assessed the interconnectedness of climate change and food security. To inform key actors of the Government and the private sector, CCFSA highlighted the trends and potential risks of climate change on food and nutrition security, and how they affect livelihoods in rural and urban areas of the Philippines.

Last year, WFP and the International Center for Tropical Agriculture (CIAT) expanded the CCFSA published in 2021. Five regional reports were produced based on quantitative and qualitative research conducted from May 2022 to October 2023. CIAT and WFP prioritized five areas for the sub-national level analysis, as these regions were not able to participate in the initial validation of the key results of the national-level research three years ago.

To that end, WFP presents the CCFSA regional report for the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM). The report interweaves i) climate change, ii) food and nutrition security, and iii) livelihoods and lays out ramifications and mitigation measures. Individual interviews and group consultations with representatives of key regional and national government institutions were also done to supplement the "ground truth" to the CCFSA findings.

To support policy development and resource management, this report provides government and non-government partners with a better understanding of interplay amongst natural hazards, crop suitability, and economy at the local level in BARMM. It also presents base maps of major livelihood zones at the city and municipal levels, illustrating a visual representation of the main economic activities. These aim to i) enhance existing development and action plans and ii) help determine the most effective way to strengthen the adaptive capacity of the different localities to climate change.

The regional report can easily be updated since the CCFSA database can incorporate new datasets (small-area poverty estimates, agricultural production data, nutrition, etc.) from national and international government agencies and non-government organizations. CCFSA can also complement current government initiatives like the national colour-coded agricultural guide map of the Department of Agriculture and provide valuable information for smallholder farmers and fisherfolks.

WFP would like to extend its gratitude for the unwavering support of the national and regional partners and the analytical work of CIAT, which made possible the success of this research project.

WFP hopes that this analysis will support shaping policies, programmes, and investments at the local level to mitigate the effects of climate change and enhance the resilience of many Filipinos. As demonstrated through the past decades, WFP is committed to achieving food and nutrition security in the Philippines.

Regis Chapman
Representative and Country Director
UN World Food Programme, Philippines

Executive Summary

Following the conduct of the Climate Change and Food Security Analysis (CCFSA) and the development of a country-wide Livelihood Zone (LHZ) map in 2021, a follow-up project was conducted to validate the results at the regional level. Using spatial analysis, modelling, and Key Informant Interviews (KII), the exposure and vulnerability of different livelihoods to climate change and climate-related hazards in the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) were analyzed. Practical applications on the use of the LHZ map for developing strategic adaptation measures on several social issues such as poverty, food security, and undernutrition were also presented in this report.

The following are some of the key findings of the study:

Livelihood Zones

- Of the nine (9) major LHZs nationwide, seven (7) were initially identified in BARMM, namely: Aquaculture/Freshwater Fisheries Zone, Aquaculture/Coastal Fisheries Zone, Irrigated Rice Zone, Rainfed Rice Zone, Annual Crops Zone, Perennial Crops Zone, and Built-up Areas Zone.
- An additional LHZ was created during the validation workshop – the Sugarcane LHZ which includes the municipalities of Bumbaran and Wao in the province of Lanao del Sur.

Climate Hazards

- Drought and flood were identified as the top two hazards that significantly affect the majority of the livelihoods in BARMM.
- Most of the LHZs susceptible to drought and flood are irrigated and rainfed rice in the mainland provinces[1]. Perennial crops in the island provinces, on the other hand, are susceptible to drought alone.
- Presently, municipalities in the island provinces[2] have relatively low susceptibility to sea-based hazards such as sea level rise, storm surge, and saltwater intrusion. However, BARMM's island group will be considerably more exposed to these hazards in the future because of its high population and remoteness.

[1] Mainland provinces include Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur.
[2] Island provinces include Basilan, Sulu, and Tawi-Tawi.

Impacts on Crops

- Future climate scenarios based on RCP 8.5 (year 2050), show less conducive environments for rice production throughout the region. This is particularly true for the rice production areas in Maguindanao provinces, but not for inland pockets in Lanao del Sur.
- The impact of climate change on the future suitability of maize will result in less favorable conditions, especially in the mainland provinces of BARMM.
- For banana, suitability varies across the provinces of Maguindanao del Norte, Maguindanao del Sur, and Lanao del Sur. Areas in the Maguindanao provinces will become less conducive, while Lanao del Sur will have more favorable conditions in the future.
- By 2050, temperature will continue to rise, creating an opportune environment for pests and diseases to spread and proliferate, especially in the areas with temperature greater than 30°C. Rice, maize, and banana will likely be impacted the most by an increased incidence of pests and diseases.

Impacts on Aquaculture

- The projected increase in temperature and amount of rainfall will have direct and indirect impacts on the abundance and distribution of marine and coastal resources, and on aquaculture production. Twelve municipalities in the island provinces of BARMM under the Aquaculture/Coastal Fisheries LHZ are potentially at-risk to these climate change hazards.

Impacts on Livestock

- Increased temperature can negatively affect livestock performance. This includes stunted growth, deficient meat and by-products, decreased reproductive capacity, and diminished feed quality and quantity.
- A total of 12 municipalities – one (1) in Lanao del Sur, and 11 in the Maguindanao provinces, with livestock and poultry as complementary activities, may be at risk to the projected temperature increase. Livestock and poultry production of 29 municipalities in the island provinces of BARMM will also be at risk: four in Basilan; eight (8) in Tawi-Tawi; and 17 in Sulu.

1. Introduction

1.1. Project Background

The World Food Programme (WFP), in collaboration with the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), completed a national-level Climate Change and Food Security Analysis (CCFSA) in May 2021. The project aimed to assist the Philippine government in delivering its priority agenda of 1) Reducing vulnerabilities of food systems and nutrition to long-term shocks and other climate-related hazards; and 2) Improving community resilience by understanding critical impacts of climate change on different aspects of food security.

One of the major accomplishments of the project was the development of a National-level Livelihood Zones (LHZ) Database. This tool can assist planners and policymakers in strategically assessing impacts of climate-related risks to food security and livelihoods through an accurate classification of LHZs at the city/municipal level. This site-specific information is important in crafting tailored recommendations that will support local-level climate change adaptation and promote climate-adaptive food systems.

In July 2022, a follow-up analysis was undertaken by the WFP and Alliance of Bioversity International and CIAT to validate the initial findings in four regions, namely: Region IV-B (MIMAROPA), Region XI (Zamboanga Peninsula), Region XII (SOCCKSARGEN), and the BARMM. Additionally, the CCFSA in the National Capital Region (NCR) was reviewed to further substantiate its urban analysis.

This report focuses on the **regional-level CCFSA for BARMM** which presents the validated livelihood and climate-related profiles of the region. Additionally, this report identifies the specific locations of livelihoods in BARMM that are most susceptible to climate-related hazards. This information can support the development of strategic adaptation plans at the local level that aim at minimizing the adverse climate-related impacts on livelihoods and food security.

In the long-term, the results of the regional CCFSA will be matched with the findings of the Vulnerability and Risk Analysis (VRA) undertaken by the WFP Philippines Country Office and WFP Regional Bureau in Bangkok from 2019 to 2021. The VRA provides an overview of underlying vulnerabilities to climate-related risks to provide geographic priority for shock-responsive social protection interventions in the country. Like the CCFSA, the analysis of the VRA is available at the city and municipal level for the whole country. The complementation of the two studies is expected to provide a better understanding of the interplay of livelihood, natural hazard, and exposure to determine the adaptive capacity of the different cities and municipalities in the Philippines to climate change.

1.2. Initial Livelihood Zones

The initial LHZ database of the Philippines developed during the first phase of the project included a total of nine (9) major categories: **Aquaculture/Freshwater Fisheries Zone**; **Aquaculture/Coastal**

Fisheries Zone; **Irrigated Rice Zone**; **Rainfed Rice Zone**; **Annual Crops Zone**; **Perennial Crops Zone**; **Cool Environment Zone**; **Pasture Zone**; and **Built-up Areas Zone**[3] (**Table 1**).

The database contains 1,646 records of unique cities and municipalities nationwide, following the administrative boundary from the National Mapping and Resource Information Authority (NAMRIA), co-created by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). All of the datasets were stored in Shapefile format which can either be viewed as maps or be exported as tabular data.

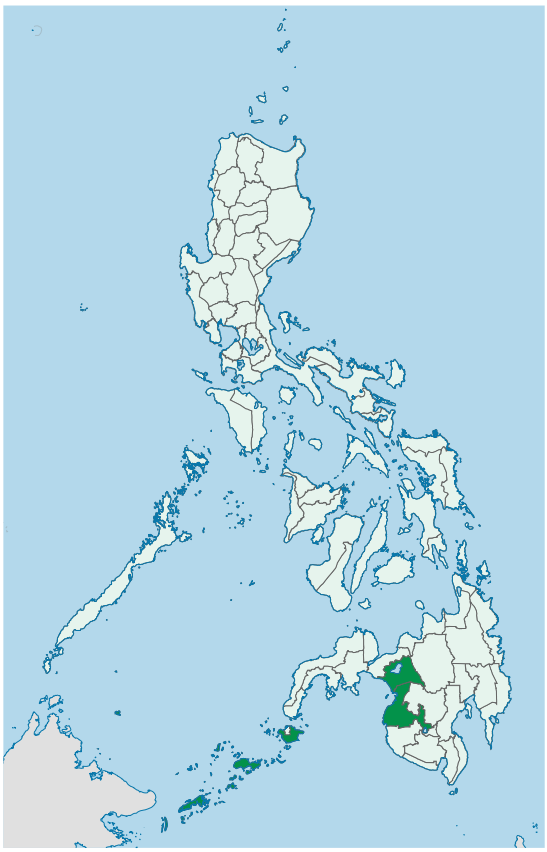
Table 1. Categories of Livelihood Zones developed during the 1st Phase of the CCFSA Project

Major Zones		Descriptions
1	Aquaculture/ Freshwater Zone	Activities related to raising and breeding freshwater aquatic animals and plants for economic purposes with ponds, reservoirs, lakes, rivers, and other inland waterways (brackish water).
2	Aquaculture/ Coastal Zone	Activities related to fisheries and seaweed farming in coastal marine areas.
3	Irrigated Rice Zone	Activities related to rice farming in bunded fields wherein water supply is reliable using irrigation systems. Rice grows once or twice a year and sometimes mixed or intercropped with vegetables.
4	Rainfed Rice Zone	Activities related to growing rice in upland and/or hilly areas wherein water supply is dependent on rainfall. It is usually mixed with maize, cassava, and other vegetables.
5	Annual Crops Zone	Activities related to growing vegetables and root crops that are harvested seasonally and have a life cycle for a year.
6	Perennial Crops Zone	Activities related to growing more permanent plants such as coconut, banana, cacao, coffee, rubber, abaca, calamansi, mango, and other fruit-bearing trees, which requires several growth cycles before its fruit is produced and/or harvested.
7	Cool Environment Zone	Consists of a combination of activities unique in terms of temperature ranges in the area (e.g., highland crops such as broccoli, cauliflower, lettuce, etc., can be grown only in this zone).
8	Pasture Zone	Activities related to raising livestock, swine, poultry, and other domesticated animals, such as goats, cattle, cows, etc., and growing of plants and/or grasses used for feeding animals.
9	Urban Zone	Activities related to commerce, industry, and non-agricultural jobs in urban or built-up areas.

[3] The previously termed "Urban LHZ" was renamed as "Built-up Areas LHZ" to be consistent with the terminology recommended by the Department of Human Settlements and Urban Development (DHSUD) to be used in the development of Comprehensive Land Use Plans (CLUPs) and Zoning Ordinances (ZOs).

2. Methodology

2.1 Study Site and Population



The BARMM[4], located in the island of Mindanao, is the only autonomous region in the Philippines. It is composed of six (6) provinces, namely: Basilan, Lanao del Sur, Sulu, Tawi-Tawi, Maguindanao del Norte and Maguindanao del Sur. It also has 116 municipalities and three (3) component cities (Lamitan City, Marawi City, and Cotabato City).

The region comprises 12.2% (12,535.79 km^2) of the country's total land area. It is composed of 51% Forestland and 49% Alienable and Disposable lands[5].

In terms of economic productivity, most recent data from Philippine Statistics Authority (PSA) shows that the service sector has the highest share (39.2%) of BARMM's Gross Regional Domestic Product (GRDP), followed by the Agriculture, Forestry, and Fishery (AFF) sector (36.2%), and the industry sector (24.6%). According to the Ministry of Agriculture Fisheries and Agrarian Reform (MAFAR, 2020), the lack of modernized technologies and techniques in farming including storage space, and the limited number of skilled laborers, affect the productivity in the region. High production and transportation costs, particularly for the AFF sector, are also major concerns in BARMM. In spite of these concerns, recent PSA reports (PSA, 2022) show a significant increase in economic growth in the region at the rate of 6.6%. This increase is attributed to the improvement of people's purchasing power in 2022, particularly following the lifting of several restrictions due to the COVID-19 pandemic.

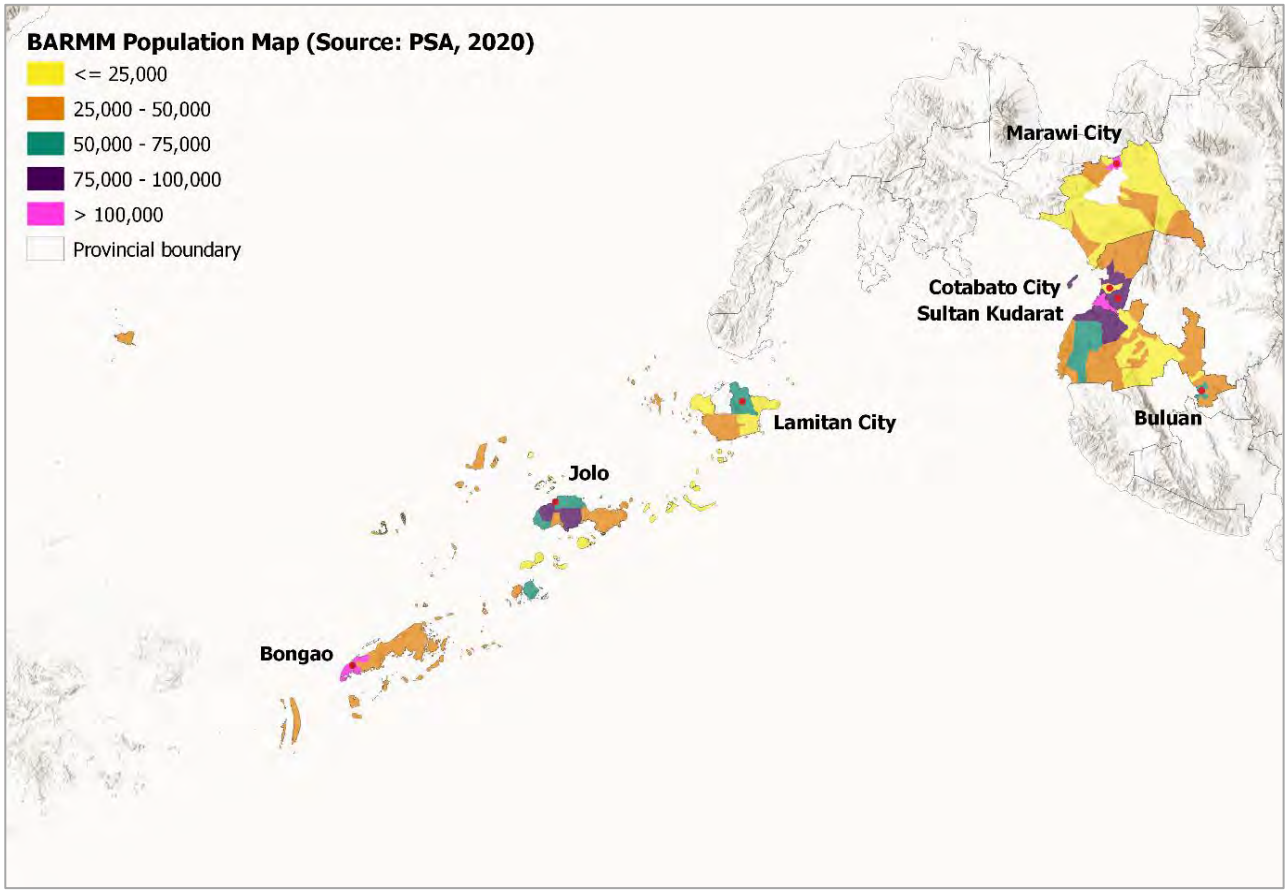
The region has a total population of 4.4 million based on the 2020 Census of the Population and Housing (CPH) by the PSA. This accounts for about 4.04% of the total Philippine population in 2020. Among its provinces, the former Maguindanao province, which was recently divided into del Norte and del Sur, had the biggest population (1.67 million), while Basilan (excluding Isabela City) had the smallest population (0.42 million) in 2020.

[4] BARMM also covers 63 barangays in the neighboring province of North Cotabato which voted to become part of BARMM in two plebiscites held in 2019. These barangays are found in 6 municipalities in North Cotabato and are designated as BARMM Special Geographic Area (SGA). For this analysis, the SGA are not included yet under BARMM as the analysis is done at the municipal level where these barangays are originally associated with.

[5] Alienable and disposable lands refer to those lands of the public domain which have been the subject of the present system of classification and declared as not needed for forest, mineral purposes, or national parks (Philippine Senate S. No. 11, 2004).

The top four (4) localities with the highest population in the region in 2020 were Cotabato City (Maguindanao) with about 325,079 persons, Marawi City (Lanao del Sur) with approximately 202,000 persons, Jolo (Sulu) with approximately 126,000 persons, and Bongao (Tawi-tawi) with approximately 101,000 persons (Figure 1).

Figure 1. Population map of BARMM (PSA, 2020)



2.2. Livelihood Zones Mapping

The CCFSA utilized seven (7) different national datasets to build the LHZ (Table 2). These datasets include Land Cover Map, Agro-Ecological Zones (AEZ), MODIS-derived Rice Extent Map, Tourism Areas, Mining Locations, the Land Classification from the Philippine Local Government Units (LGUs), and areas classified as industrial zones.

The datasets were processed using the Geographic Information System (GIS) software. All datasets were converted into a shapefile format for uniformity. Standardizing data allows better processing of statistical information at a more granular level. Furthermore, the use of data at the city/municipal level enables a more comprehensive and up-to-date analysis that is beneficial for socio-economic planning and development.

Table 2. Data sources for the LHZ database

Layer	Source	Data Type	Resolution	Time Period
Land cover	National Mapping and Resources Information Authority (NAMRIA)	Polygon	1:10,000	2015
Agroecological zones	Department of Agriculture	Polygon	1:10,000	2016
Rice extent	International Rice Research Institute	Raster	250m x 250m	2015
Mining locations	Department of Environment and Natural Resources	Point, Tabular	Municipal scale	2015
Tourism areas	Philippine Geoportal	Point	Municipal scale	2015
Local Government Unit Category	Philippine Statistics Authority	Tabular	Municipal scale	2015
Industrial zones	Local Government Units	Tabular	Municipal scale	2015 up to latest year

The Spatial Overlay operation in GIS was employed to identify the spatial relationships among the different thematic maps in Table 2. All of the datasets and attributes were superimposed and analyzed within a polygon[6] which represents a city/municipality. Using this technique, different combinations of data were formed to analyze portions of the various layers within polygons. The resulting layer contains new attribute information which formed the LHZ based on the percent area that an activity/livelihood occupied within the polygon. Duplicates and overlaps among the attributes (i.e., land cover, agro-ecological zones, and rice extent) were eliminated using the erase tool to further refine the output.

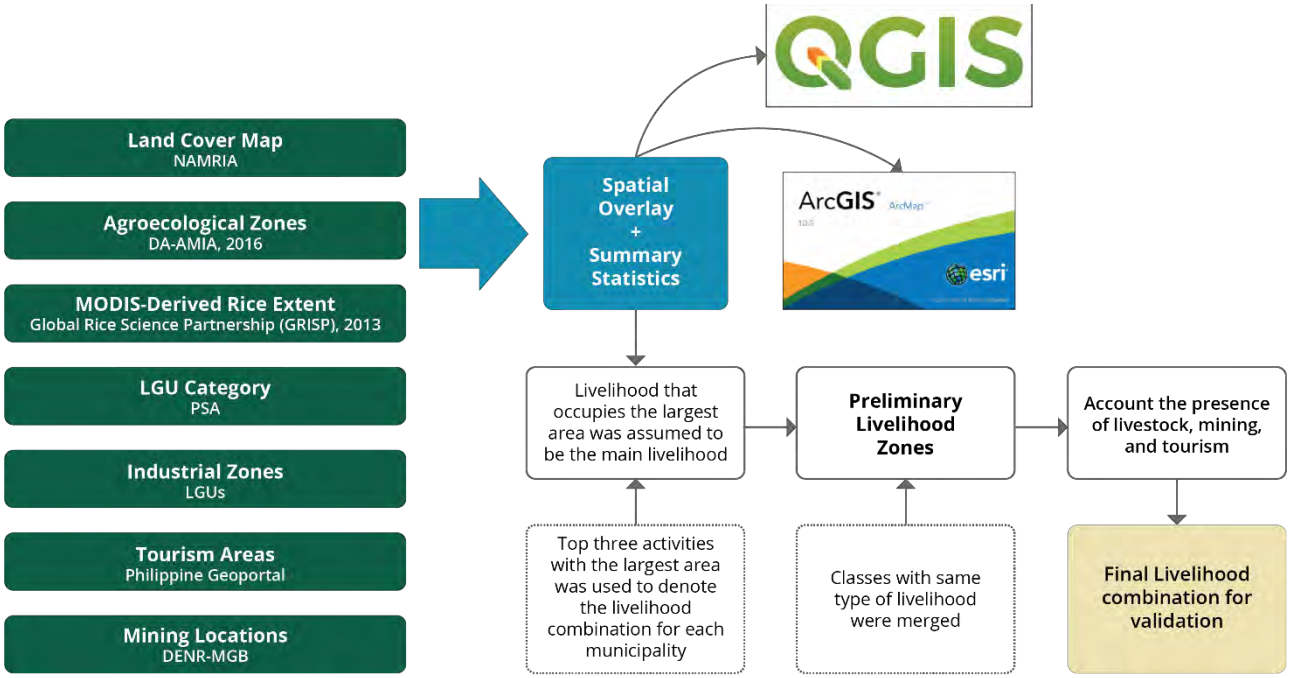
To determine the extent of each type of livelihood, the area in hectares (ha.) being occupied by a specific activity was calculated using the Summary Statistics Tool. The activity that occupied the largest area in each city/municipality was considered as the Major Livelihood. On the other hand, the succeeding activities that occupy the next largest areas were identified as Secondary, Tertiary, or Quaternary Livelihoods, accordingly.

The additional datasets on tourism and mining are all point data[7] which were computed as counts per polygon. Livestock activities were also simply classified as “Yes” (present) or “No” (lacking) so they had no geographical extent. Nevertheless, presence of these activities was still accounted for and included in the analysis whenever identified in a particular city/municipality.

[6] Polygon feature is a closed shape defined by a connected sequence of x and y coordinate pairs. It is a geographic representation of an area and location (ESRI).
[7] Point data does not allow for geographical extent or area calculation. In a map, point data is normally shown as point feature representing location or presence of tourism or mining areas.

Based on the analytical method shown in Figure 2, a livelihood zone unit can be defined as an area that occupies one position on the map with a resolution at a city/municipal level, which contains similar attributes on livelihood activities based on agroecology, land use characteristics, and dominant economic activities within a production system.

Figure 2. Process flow in GIS for the Livelihood Zones development and mapping



2.3. Assessment of Climate-Related Hazards

2.3.1. Hazard Mapping

To identify and qualify the major climate-related hazards prioritized in the initial phase of the project, six (6) datasets on hazards were used to characterize the exposure of the Philippines to climate variability and extreme weather events. These hazards include Typhoon, Flooding, Drought, Storm Surge, Saltwater Intrusion, and Sea Level Rise (Table 3). The selection of these hazards was based on the availability of data at the city/municipal level and the hazard's potential impact on livelihood, food security, and nutrition.

Table 3. Overview of hazard datasets for the Philippines

Parameter	Source	Unit of Measurement, Spatial and Temporal Resolution
Typhoon	United Nations Environment Programme (UNEP)/United Nations Office for Disaster Risk	1-km pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simpson scale category 5. (> 252 km/h) from 1970 to

	Reduction (UNISDR) (2013) (https://preview.grid.unep.ch/) WFP Philippines	2013; typhoon tracks
Flooding	Mines and Geosciences Bureau, Department of Environment and Natural Resources (DENR-MGB)	1:10,000 scale. Susceptibility of flood risk for the Philippines, average of 10 years (2008-2017).
Drought	TerraClimate (Abatzoglou et al., 2018); Palmer Drought Severity Index (PDSI) from 1950 to near present	PDSI, Standard Precipitation Index
Storm surge	Adaptation and Mitigation Initiative in Agriculture (AMIA) multi-hazard maps/baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST)	1:100,000 scale (resampled). Exposure of an area to storm surge
Saltwater intrusion	AMIA multi-hazard map/baseline data from the NWRB	1:100,000 scale (resampled). Risk of saltwater intrusion
Sea level rise	AMIA multi-hazard map	1:100,000 (resampled). 3-meter sea-level rise

2.3.2. Crop Suitability Mapping

For the climate-based suitability assessment of the selected crops, the project employed Species Distribution Modeling (SDM) to estimate which of the current food production regions will turn into no longer viable, less suitable, or suitable for the introduction of a different crop, upon changes in climatic conditions. This analysis was used to identify areas with “high” negative impacts into which shifting to new crops or livelihood source may be feasible and areas with “increased” positive impacts which in turn can be a future investment.

The SDM employed in this project is the EcoCrop model in R, a mechanistic model originally developed by Hijmans (2001) and further developed by Ramirez-Villegas et. al. (2013). EcoCrop was used to predict the baseline and future suitability of the selected crops under different climatic conditions. EcoCrop considers the monthly temperature and rainfall conditions within the crop growing period and assesses crop suitability based on the crop requirements (Table 4), used to run the model.

Table 4. List of parameters used to run the EcoCrop model

Code	Description
GMN	Minimum length of the growing season (days)
GMX	Maximum length of the growing season (days)
TKILL	Absolute temperature that will kill the plant (◦C)
TMN	Minimum average temperature at which the plant will grow (◦C)
TOPMN	Minimum average temperature at which the plant will grow optimally (◦C)
TOPMX	Maximum average temperature at which the plant will grow optimally (◦C)
TMX	Maximum average temperature at which the plant will cease to grow (◦C)
RMN	Minimum rainfall (mm) during the growing season
ROPMN	Optimal minimum rainfall (mm) during the growing season
ROPMX	Optimal maximum rainfall (mm) during the growing season
RMX	Maximum rainfall (mm) during the growing season

A set of climate layers (gridded data) from WorldClim (https://www.worldclim.org/) with a spatial resolution of about 1 km^2 (or 30 arc-seconds) was used to generate the baseline condition. On the other hand, climate data for future conditions were based on Representative Concentration Pathway (RCP) 8.5 scenario using CMIP5 Global Climate Models (GCMs) downloaded from CCAFS (Climate Change, Agriculture and Food Security).

The RCP 8.5 scenario represents potentially very high greenhouse gas emission levels in the atmosphere and the subsequent increase in solar energy that would be absorbed (radiative forcing) (IPCC AR5, 2014). Under RCP 8.5, increase in temperature is at +1.4 – 2.6 degree Celsius (°C) for the mid-century[8] and +2.6 – 4.8°C for the end of the century[9] (IPCC, 2013). The RCP 8.5 scenario was used in the analysis because climate risks tend to rise in extremely high emission scenario and temperature conditions (Katzfey, 2015).

Compared to other scenarios which are more optimistic emission pathways such as RCP 4.5, the RCP 8.5 provides emphasis on risk assessment by providing understanding of the upper limits of potential climate change impacts to inform policy and decision-making. RCP 8.5 scenario is also a valuable tool for assessing vulnerabilities and preparing for potential extreme outcomes which highlights the urgency to address climate change by demonstrating the potential consequences of business-as-usual and inaction. Using this scenario can help motivate actions from policymakers, the public, and other stakeholders through a combined efforts to mitigate climate change.

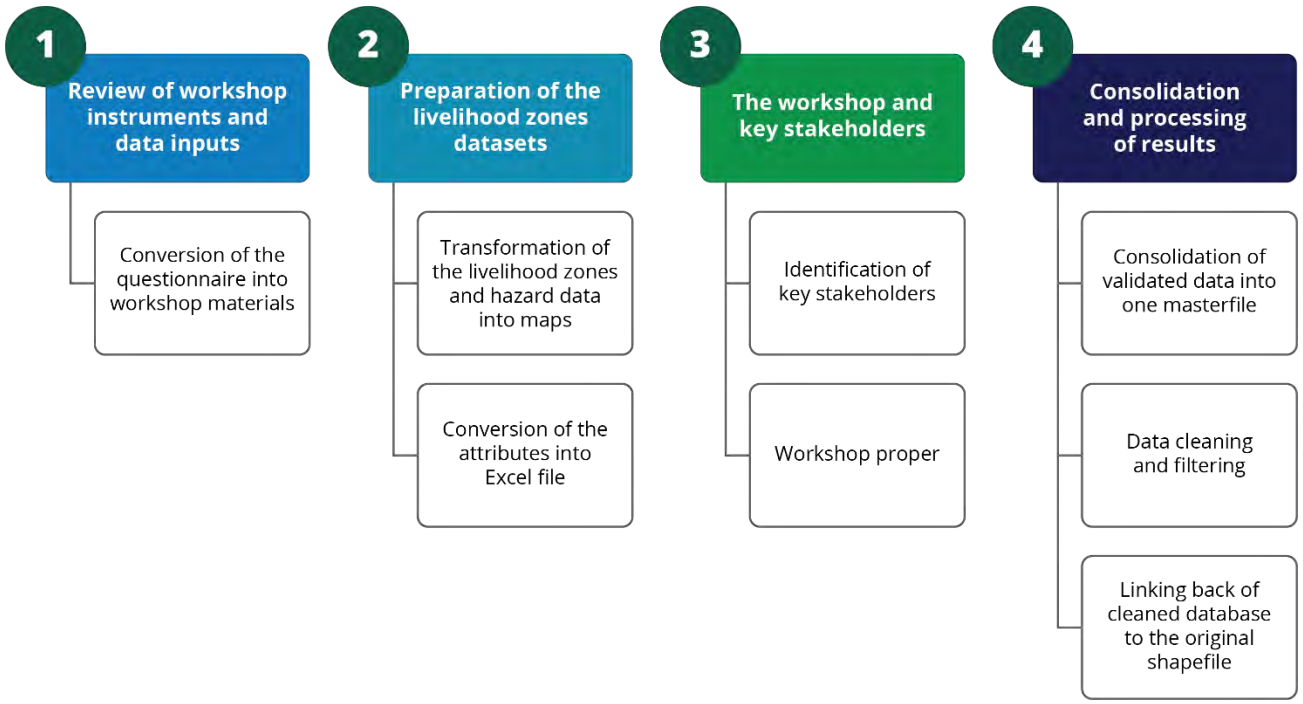
2.4. Regional Validation Workshop

A virtual validation workshop was conducted on 6-8 September 2022 in General Santos City. It was attended by several experts from different Regional Ministries who are familiar with the local agricultural systems and livelihoods in BARMM. The list of experts is attached as Annex 1.

[8] Mid-century represents the 20 years from 2046 to 2065.
[9] End of century represents the 20 years from 2081 to 2100.

The step-by-step process in conducting the face-to-face validation workshop is shown in Figure 3.

Figure 3. Step-by-step process of the livelihood zones validation



1

Review of workshop instruments and data inputs

The team reviewed available datasets and identified relevant materials that are useful for the conduct of a face-to-face workshop such as printed/interactive maps, questionnaires, and other presentation materials. Data inputs such as the LHZ data and the climate-related hazard maps (typhoon, drought, flood, saltwater intrusion, sea level rise, storm surge) were consolidated accordingly.

2

Preparation of the livelihood zones datasets (shapefile and excel file)

Considering that not all of the participants were familiar with using GIS format (i.e., shapefiles, KML), the team reviewed the data inputs and transformed these into more user-friendly forms. All of the LHZ data were presented as image maps while the corresponding spatial attributes were converted into Excel files. This allowed the participants to freely revise the data as needed using an interactive map uploaded on the AMIA-CIAT[10] website.

3

Conduct of the workshop

A total of eight (8) representatives from seven (7) different ministries in BARMM participated in the workshop (Figure 4). They were composed of experts who are knowledgeable with the local agricultural systems and livelihoods in the region. Of the total number of participants, five (62.5%) were male and three (37.5%) were female (see Annex 1 for more details).

[10] AMIA (Adaptation and Mitigation Initiative in Agriculture) was a project of CIAT in partnership with the Department of Agriculture.

Figure 4. The participants during the Regional CCFSA Validation Workshop

During the workshop, classification of the identified zones was further refined and validated. As mentioned earlier, a zone was determined based on the extent of the area that it occupies in a city/municipality which was classified as either a major or secondary/tertiary/quaternary livelihood. However, since data on the extent of the area of the identified other zones were lacking, the term **Secondary/Tertiary Livelihood** was used to capture activities, aside from the major livelihood, that also exist in the city/municipality. These zones pertain to the activities that provide alternative resources and work opportunities in a city/municipality, following the concept of "alternative livelihood" by Wright et. al. (2015). It is recommended, however, that these "secondary/tertiary livelihoods" be further ranked based on their area, once data is already available.

On the other hand, livestock, mining, and tourism activities were termed as **Complementary Activities** since these are point data which do not have numerical values and cannot be computed and classified. CCFSA defines the term "complementary activities" as economic activities that provide an added value to a livelihood zone without altering the original use of the land.

Aside from the validation of the LHZs, the workshop participants also validated the occurrence and level or degree of the impact (ranging from "Very Low" to "Very High") of the six (6) climate-related hazards. The validation was based on the hazard maps being used by the Rapid Emergency Action on Disaster Incidence (READi) and the Comprehensive Land Use Plan (CLUP) developed by the Bangsamoro Planning and Development Authority (BPDA).

4

Consolidation and processing of results

All of the validated data were consolidated into a Masterfile. These data were further cleaned and filtered to check for consistency and to remove any duplication. After standardizing, the Masterfile was transformed back into a shapefile format. The shapefiles were then used to update the current LHZ geospatial database of BARMM.

3. Results

3.1. Analysis of the Initial Livelihood Zones

The LHZ database of BARMM had a total of 119 records corresponding to the three (3) component cities and 116 municipalities in the region. BARMM initially had seven (7) major LHZs, namely: **Annual Crops Zone, Aquaculture/Coastal Fisheries Zone, Aquaculture/Freshwater Fisheries Zone, Built-up Areas Zone, Irrigated Rice Zone, Perennial Crop Zone,** and **Rainfed Rice Zone.** After the regional validation, Sugarcane Zone was added as an additional LHZ. This zone constitutes the areas where sugarcane farming is the major livelihood activity.

The previously identified "Aquaculture" and "Built-up Areas" LHZs were also validated during the workshop. Ten additional areas were classified under the Aquaculture Fisheries LHZ increasing its number to 11 municipalities. Meanwhile, the Built-up Areas LHZ in BARMM was reduced from 14 areas to one (1) city and two (2) municipalities. It was also further categorized into Commercial, Manufacturing, and Industrial-related work zones.

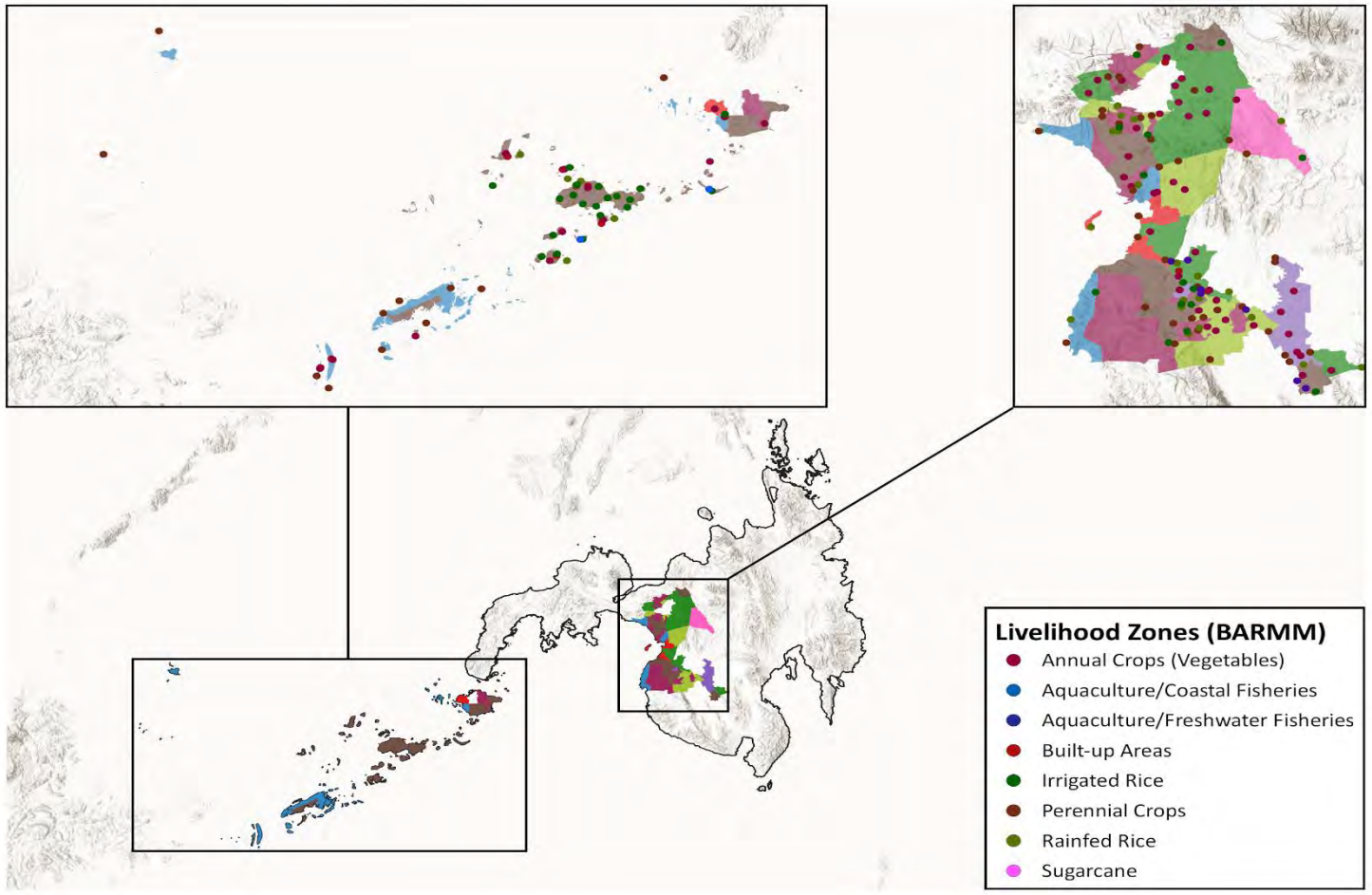
WFP staff conduct a community site visit in Piagapo, Lanao del Sur where annual crops are a major LHZ. © WFP

3.2. Validation Workshop Findings

3.2.1. Major LHZs in BARMM

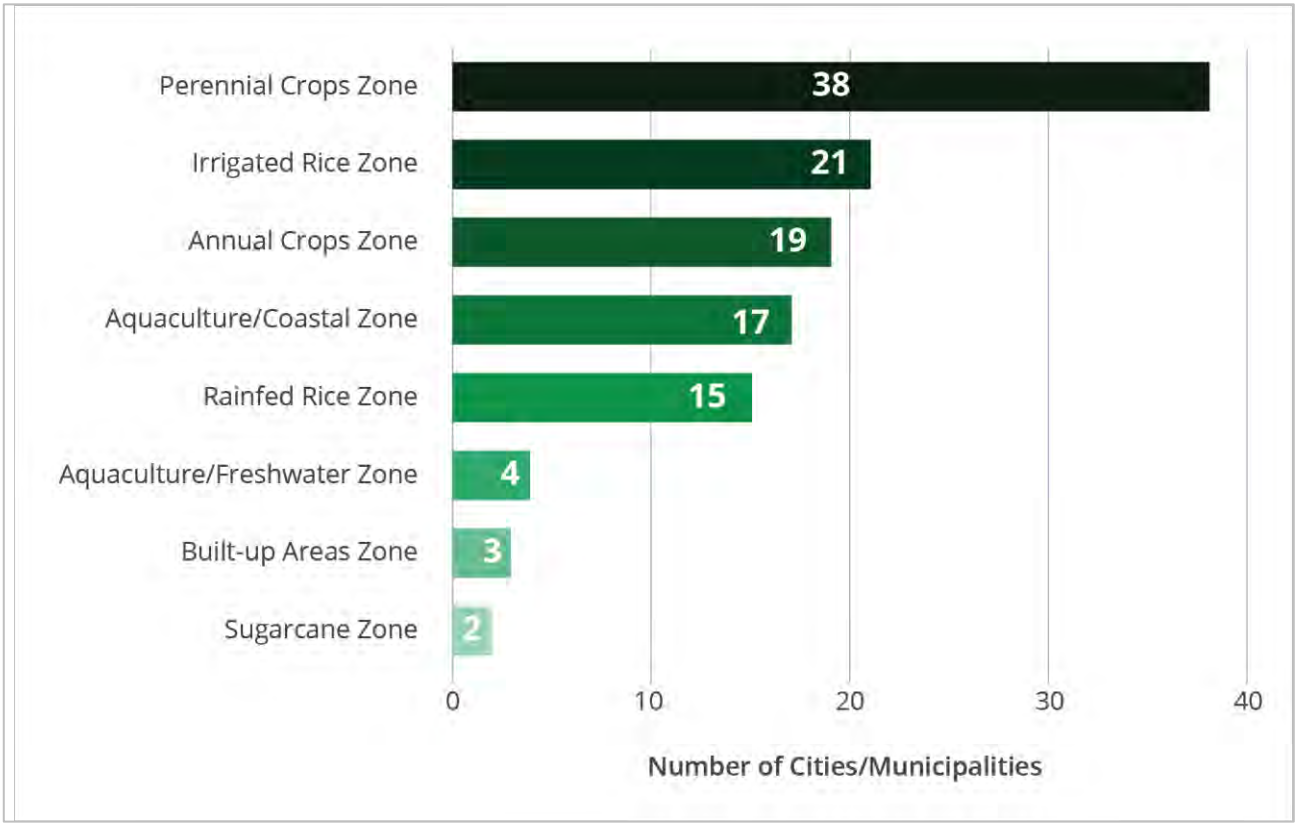
The validated LHZ map of BARMM is presented in Figure 5, showing the eight (8) major LHZs in the region.

Figure 5. Validated LHZs in BARMM



Results of the validation workshop revealed that majority of the livelihoods in BARMM are still agriculture-based (Figure 6). A total of two (2) cities and 91 municipalities were found to be highly dependent on agriculture, specifically on perennial crops (38), irrigated rice (21), annual crops (19), and rainfed rice (15).

Figure 6. Major LHZs in BARMM



On the other hand, aquaculture-based livelihoods were the second most dominant major LHZ in the region, comprising 21 municipalities. Among these municipalities, 17 were classified under the Aquaculture/Coastal Fisheries LHZ, and three (4) were identified as Aquaculture/Freshwater LHZ.

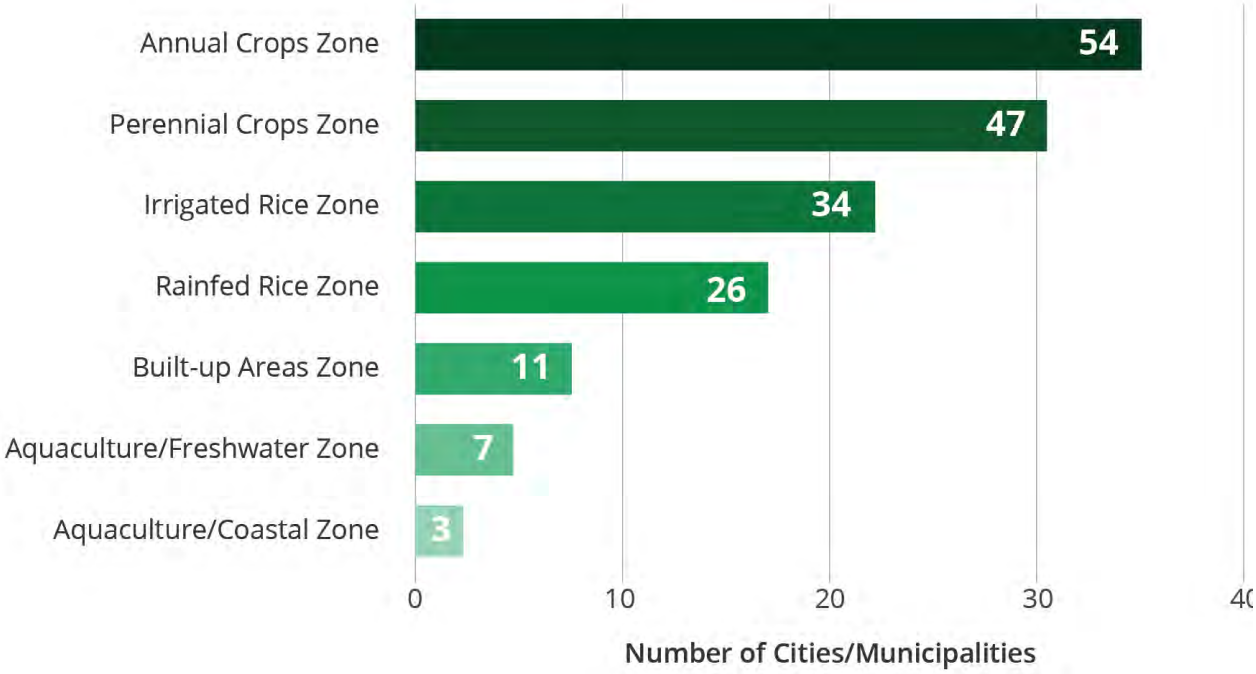
Moreover, one (1) city and two (2) municipalities were classified under the Built-up Areas LHZ, with Commercial Work Zone as the most dominant activity. These areas include Cotabato City, Basilan, and the Maguindanao provinces, which also function as free ports and special economic zones in the region.

Meanwhile, the municipalities of Bumbaran and Wao in the province of Lanao del Sur were both classified under the newly created Sugarcane Zone.

3.2.2. Secondary/Tertiary LHZs in BARMM

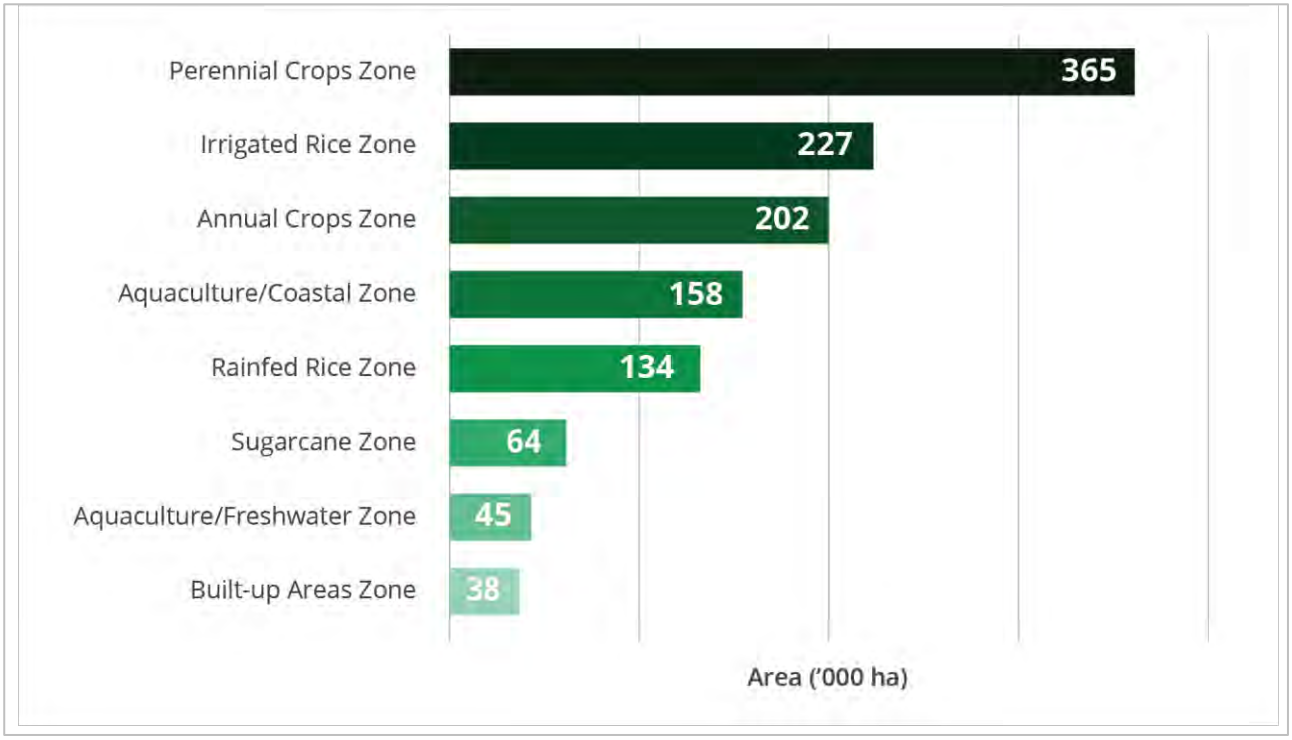
The workshop findings also showed that vegetable farming (annual crops) was the most dominant Secondary/Tertiary Livelihood in the region as it is practiced in two (2) cities and 52 municipalities. It was followed by perennial crops farming within 47 municipalities, and irrigated rice farming within 34 municipalities (Figure 7).

Figure 7. Type and number of Secondary/Tertiary LHZs in BARMM



In terms of land area, perennial crops occupied the largest size with approximately 365,000 ha. which constitutes 29.60% of the total land area of BARMM. It was followed by irrigated rice and annual crops with approximate land areas of 227,000 ha. (18.42%) and 202,000 ha. (16.34%), respectively (Figure 8).

Figure 8. Land area occupied by the major LHZs in BARMM



The municipalities of Datu Piang in Maguindanao del Sur and Kabuntalan in Maguindanao del Norte (Irrigated Rice LHZ) had the most diverse composition of Secondary/Tertiary Livelihoods including aquaculture/freshwater fisheries, rainfed rice, perennial crops, annual crops, and built-up areas zones.

On the other hand, four (4) secondary/tertiary livelihoods, were identified in six (6) municipalities in the province of Sulu, namely: Jolo, Hadji Panglima Tahil, Pangutaran, Pata, Patikul, and Siasi (Perennial Crops LHZ). These include irrigated rice, rainfed rice, annual crops, and built-up area zones.

Moreover, one (1) city and nine (9) municipalities have identified the Built-up Areas Zone as their Secondary/Tertiary Livelihood. The municipalities of Jolo, Hadji Panglima Tahil, Pangutaran, Pata, Patikul, Siasi in the province of Sulu and Marawi City in the province of Lanao del Sur were classified as Commercial Work Zones. Meanwhile, the municipalities of Sitangkai and Sibutu in the province of Tawi-tawi.

3.2.3. Complementary Activities in BARMM

Livestock raising emerged as the most common complementary activity in BARMM with 56 municipalities covered, followed by tourism in one (1) city and 33 municipalities, and mining in one (1) municipality.

3.3. Susceptibility to Climate-Related Hazards

Several longitudinal studies have identified significant changes in temperature and in rainfall patterns across the country from the 1950s to 1990s. A study from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) revealed that observed temperature in the Philippines over the past 65 years (1951 – 2015) is warming at an average rate of 0.1°C/decade. Moreover, evidence showed that the intensity and frequency of rainfall events in most parts in the Philippines are increasing which result to higher rainfall volumes in more recent decades (Thomas et al., 2012; Pajuelas, 2000). Additionally, future projections also indicate that seasonal rainfall volumes will exceed historical averages by approximately 40% across the Philippines, however with some decreases over central sections of Mindanao (CCC, n.d.).

The aforementioned data support the validation workshop results which revealed that flood and drought are the climate-related hazards with the greatest impact on the region. To illustrate the impact of these hazards, a Flood Susceptibility Index (FSI) and a Drought Susceptibility Index (DSI) were developed using the Spatial Overlay operation in GIS. The FSI and DSI were derived by computing the aggregated areas within the municipality with medium to very high flood and drought hazards (Table 3) over the total land area per municipality. FSI value of 0 indicates no flooding, while the value of 1 indicates total submergence of the geographic unit in the event of flooding. On the other hand, DSI value of 0 indicates abnormally dry condition defined as lingering water deficits and short-term dryness slowing plant growth, while the value of 1 indicates extreme drought with no rainfall on the scale of one to three months which may result to crop losses.

The derived FSI and DSI value of 0 to 1 were further categorized into five classes: Very Low (0.0 – 0.2), Low (0.2 – 0.4), Moderate (0.4 – 0.6), High (0.6 – 0.8), and Very High (0.8 – 1.0). The categories were developed to easily compare the degree of hazards experienced by one municipality versus the other municipalities (Table 5).

Table 5. List of LHZs in BARMM that are susceptible to flood and drought

Province	City/Municipality	Livelihood Zone
Mainland BARMM		
Flood (High Susceptibility)		
Maguindanao Del Sur	Buluan	Perennial Crops Zone
	Mangudadatu	Perennial Crops Zone
	Datu Abdullah Sangki	Rainfed Rice Zone
	Shariff Saydona Mustapha	Rainfed Rice Zone
	Datu Saudi-Ampatuan	Rainfed Rice Zone
Maguindanao Del Norte	Talitay	Aquaculture/Freshwater Zone
	Sultan Mastura	Irrigated Rice Zone
	Cotabato City	Built-up Areas Zone
Flood (Very High Susceptibility)		
Maguindanao Del Norte	Northern Kabuntalan	Irrigated Rice Zone
	Kabuntalan	Irrigated Rice Zone
Maguindanao Del Sur	Datu Piang	Irrigated Rice Zone
	Mamasapano	Rainfed Rice Zone
	Sultan Sa Barongis	Rainfed Rice Zone
	Rajah Buayan	Annual Crops Zone

Province	City/Municipality	Livelihood Zone
	Pagagawan	Aquaculture/Freshwater Zone
	Pagalungan	Aquaculture/Freshwater Zone
	Gen. Salipada K. Pendatun	Aquaculture/Freshwater Zone
	Paglat	Aquaculture/Freshwater Zone
	Pandag	Aquaculture/Freshwater Zone
Drought (Moderate Susceptibility)		
Maguindanao Del Sur	Ampatuan	Rainfed Rice Zone
	Datu Abdullah Sangki	Rainfed Rice Zone
	Sultan Sa Barongis	Rainfed Rice Zone
	Rajah Buayan	Annual Crops Zone
	Pagagawan	Aquaculture/Freshwater Zone
	Pagalungan	Aquaculture/Freshwater Zone
	Gen. Salipada K. Pendatun	Aquaculture/Freshwater Zone
	Paglat	Aquaculture/Freshwater Zone
	Pandag	Aquaculture/Freshwater Zone
	Datu Paglas	Irrigated Rice Zone
	Buluan	Perennial Crops Zone
	Mangudadatu	Perennial Crops Zone
Island Group BARMM		
Drought (Moderate Susceptibility)		
Basilan	Akbar	Perennial Crops Zone

Province	City/Municipality	Livelihood Zone
	Tuburan	Perennial Crops Zone
	Hadji Mohammad Ajul	Perennial Crops Zone
	Al-Barka	Perennial Crops Zone
	Ungkaya Pukan	Perennial Crops Zone
	Sumisip	Perennial Crops Zone
	Lamitan City	Annual Crops Zone
	Tipo-Tipo	Annual Crops Zone
	Hadji Muhtamad	Aquaculture/Freshwater Zone
	Maluso	Aquaculture/Freshwater Zone
	Lantawan	Built-up Areas Zone
Sulu	Lugus	Perennial Crops Zone
	Pandami	Perennial Crops Zone
	Siasi	Perennial Crops Zone
Tawi-Tawi	Panglima Sugala	Perennial Crops Zone
	Turtle Islands	Perennial Crops Zone
	South Ubian	Aquaculture/Freshwater Zone
	Languyan	Aquaculture/Freshwater Zone
	Tandubas	Aquaculture/Freshwater Zone
	Sapa-Sapa	Aquaculture/Freshwater Zone
	Bongao	Aquaculture/Freshwater Zone
Drought (High Susceptibility)		
Basilan	Tabuan-Lasa	Perennial Crops Zone
Sulu	Tongkil	Perennial Crops Zone

Province	City/Municipality	Livelihood Zone
	Omar	Perennial Crops Zone
	Luuk	Perennial Crops Zone
	Kalingalan Caluang	Perennial Crops Zone
	Pata	Perennial Crops Zone
	Old Panamao	Perennial Crops Zone
	Patikul	Perennial Crops Zone
	Talipao	Perennial Crops Zone
	Jolo	Perennial Crops Zone
	Indanan	Perennial Crops Zone
	Maimbung	Perennial Crops Zone
	Parang	Perennial Crops Zone
	Tapul	Perennial Crops Zone
	Hadji Panglima Tahil	Perennial Crops Zone
	Pangutaran	Perennial Crops Zone

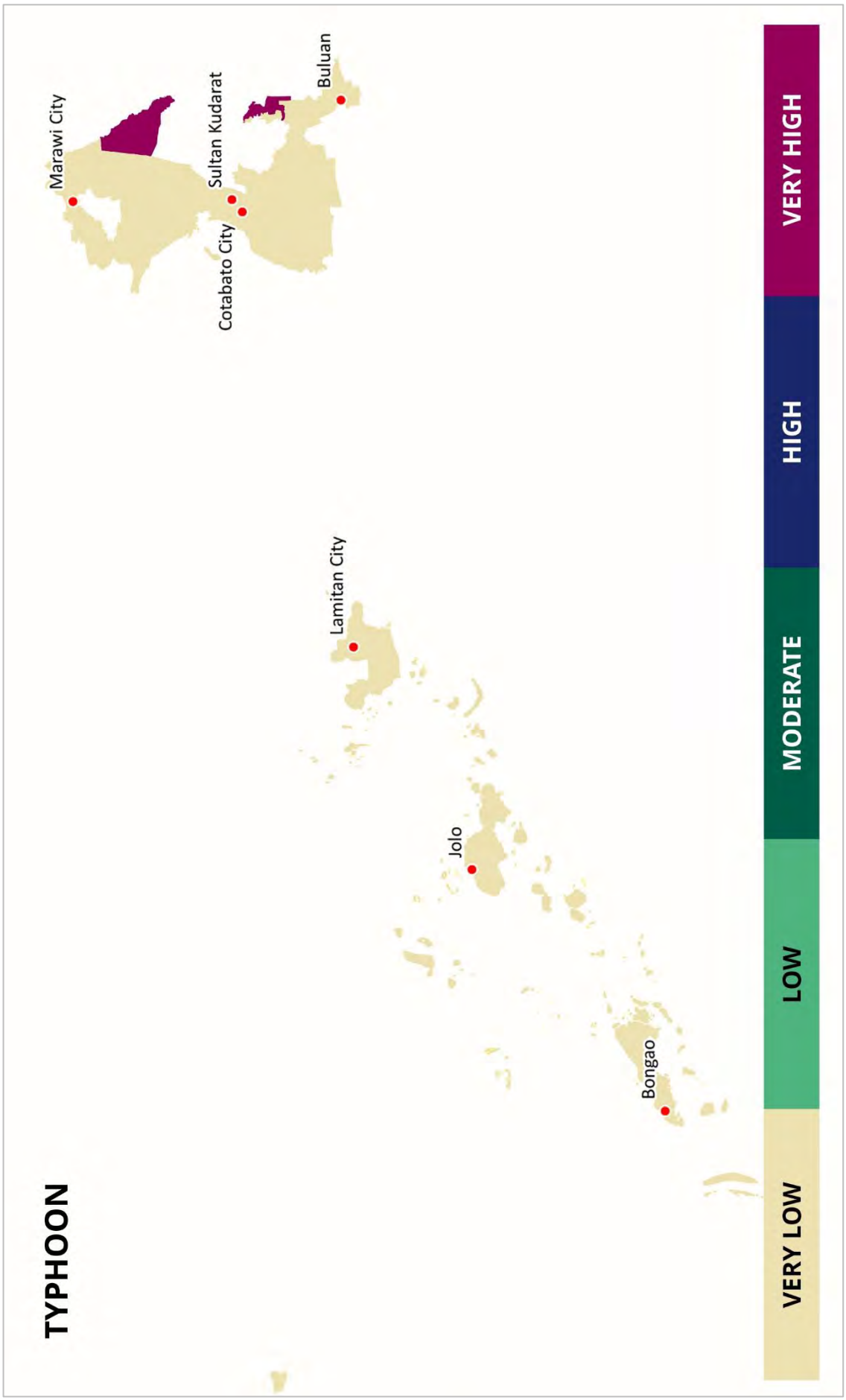
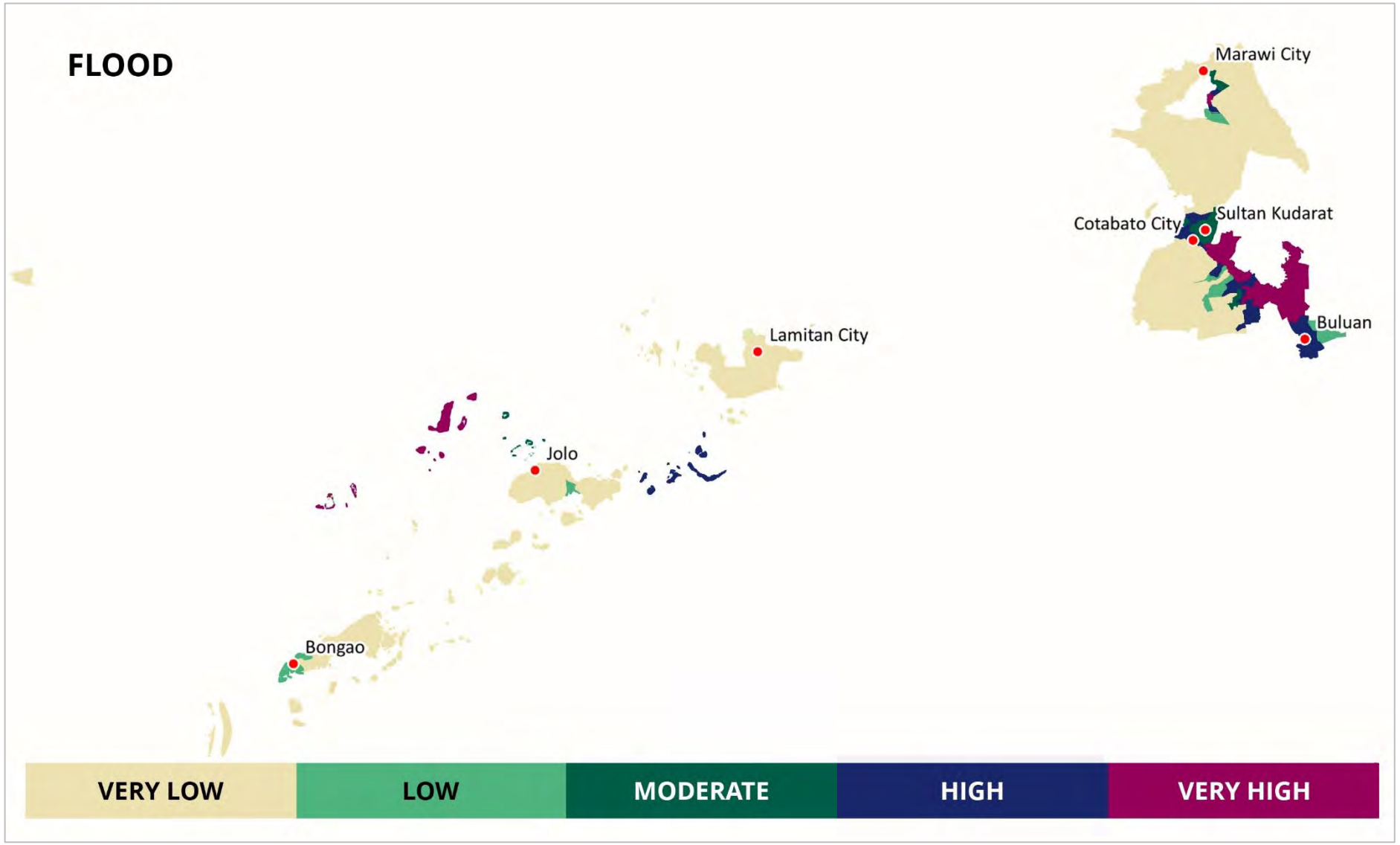


Figure 9. Validated typhoon incidence map of BARMM

Figure 10. Validated flood incidence map of BARMM



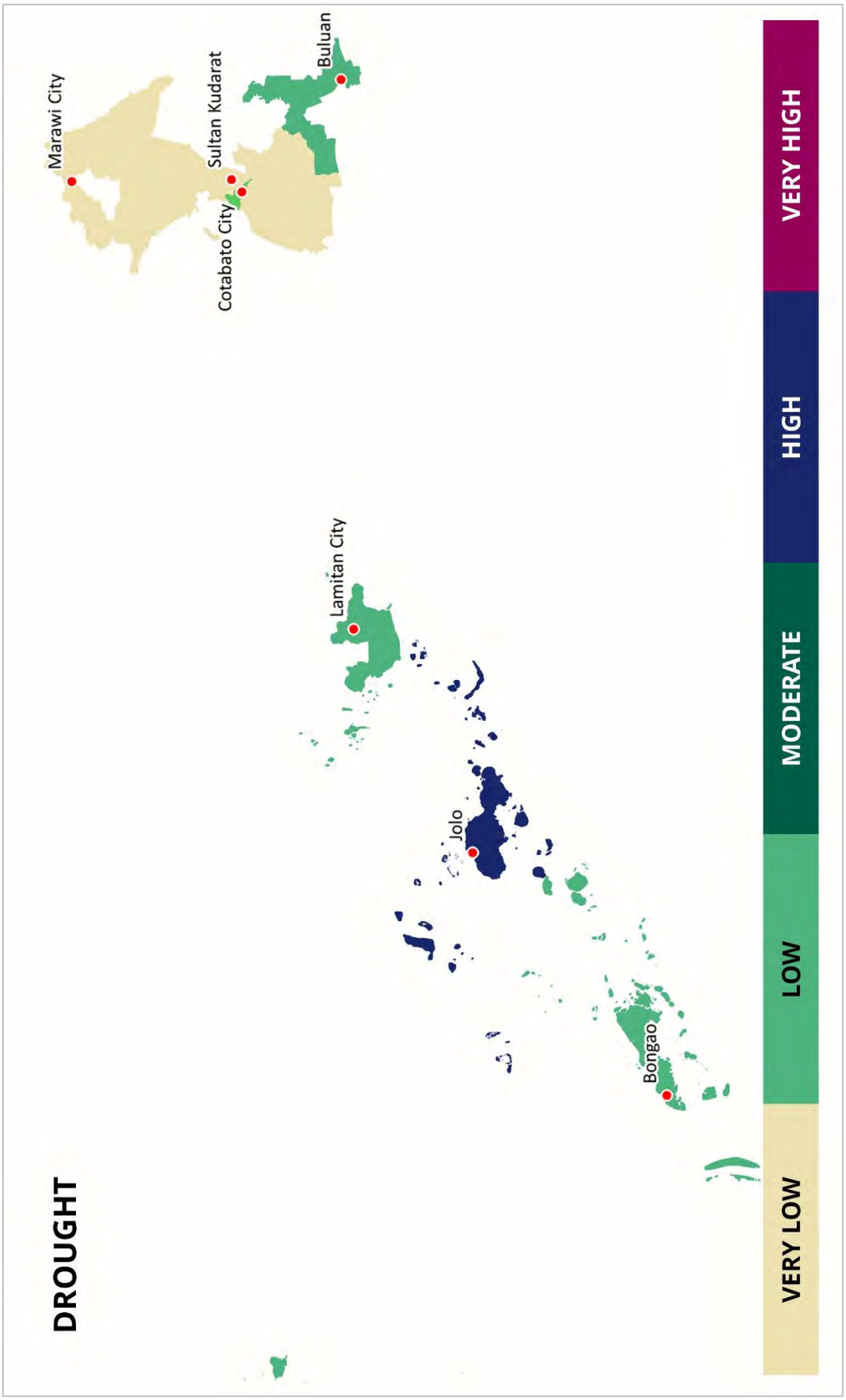


Figure 11. Validated drought incidence map of BARMM

Figure 12. Validated storm surge hazard map of BARMM

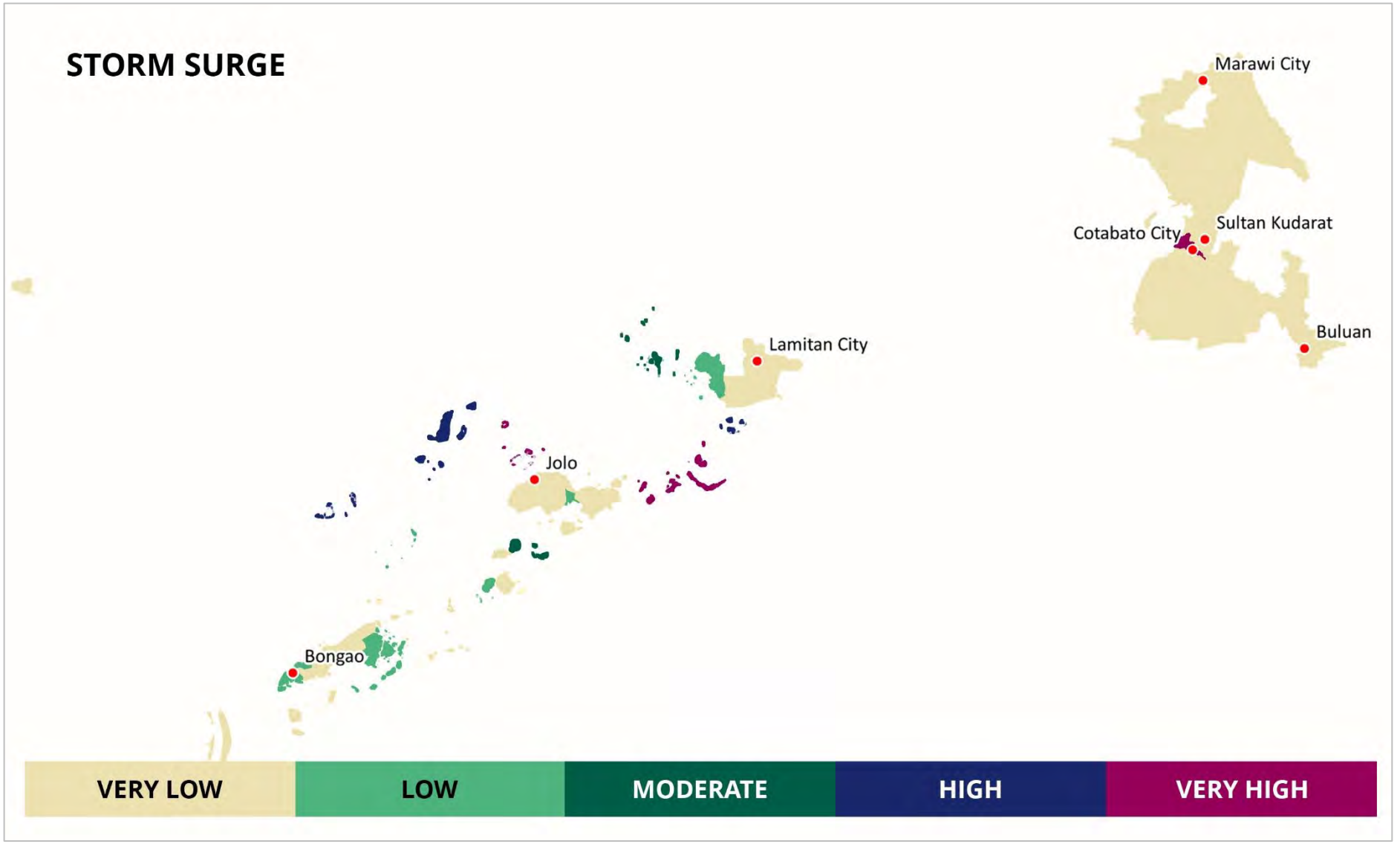


Figure 13. Validated sea level rise hazard map of BARMM

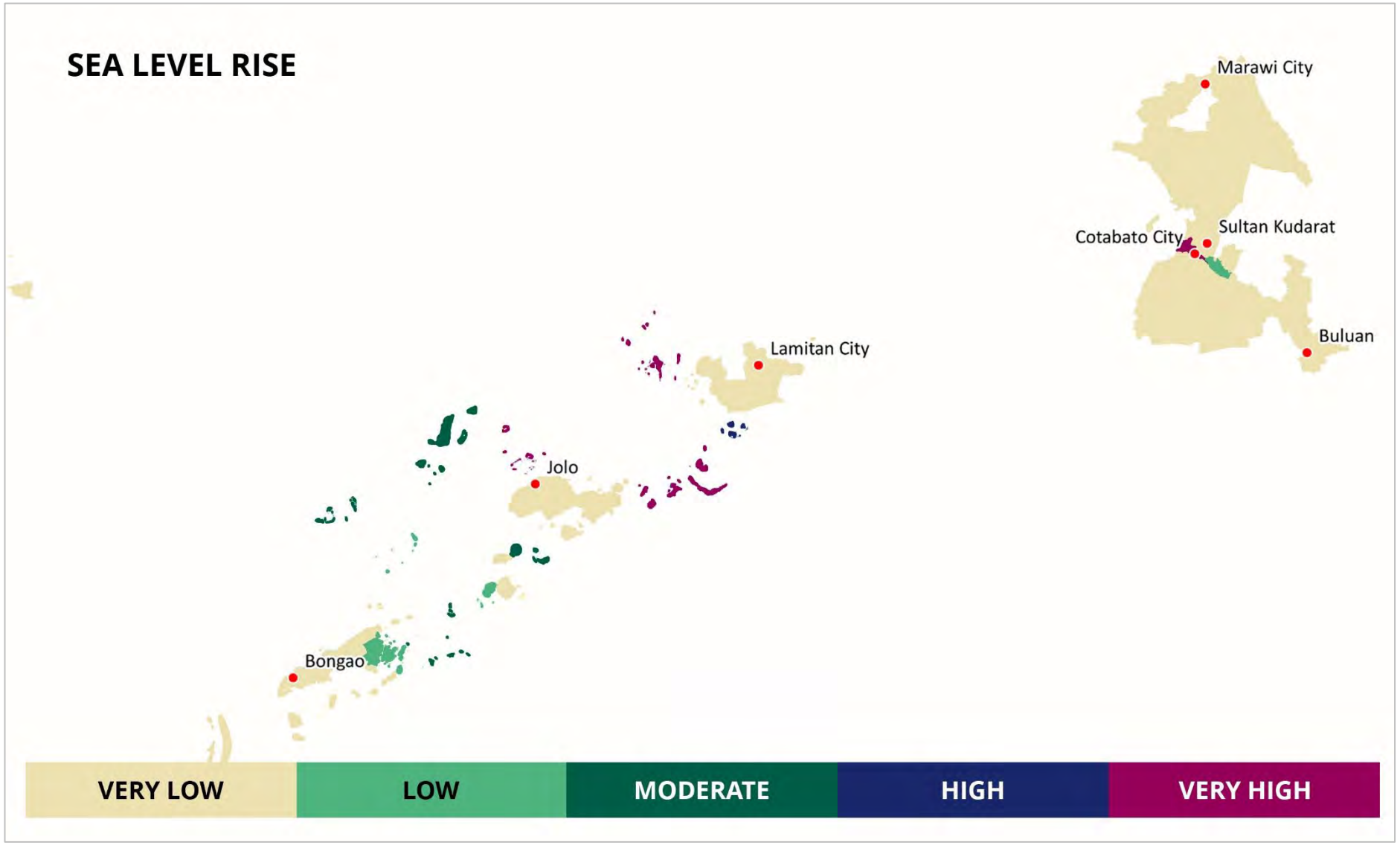
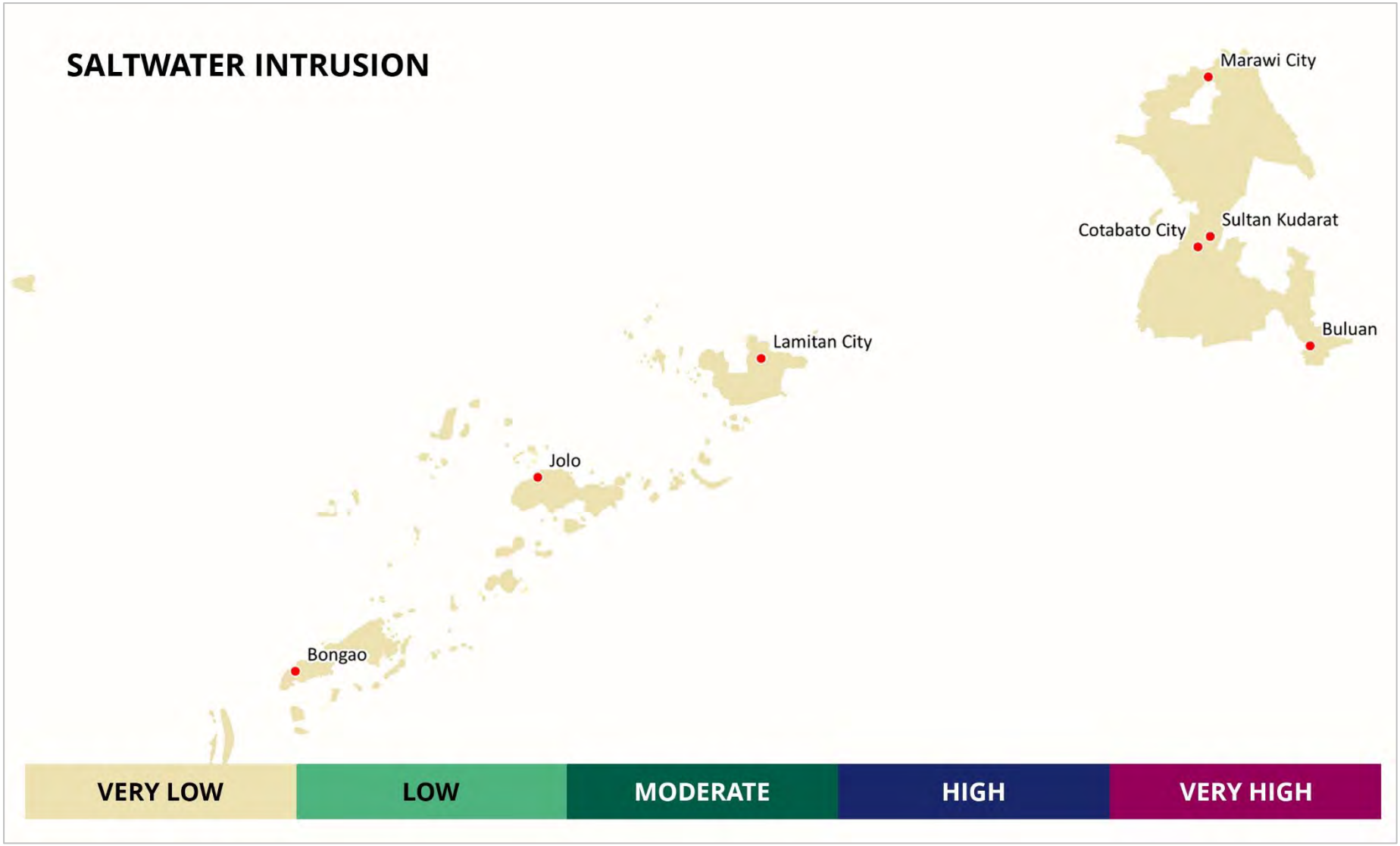


Figure 14. Validated saltwater intrusion hazard map of BARMM



3.4. Projected Impacts of Climate-Related Hazards on Livelihoods

3.4.1. Projected Impacts on LHZs on Mainland Provinces

As seen in Figure 15, the areas under the Irrigated Rice LHZ affected by both increase in temperature and amount of rainfall (mm) are: the municipalities of Mulondo, Tamparan, and Taraka (Lanao del Sur), Kabuntalan, Northern Kabuntalan, Sultan Kudarat, and Sultan Mastura (Maguindanao del Norte), and Datu Piang (Maguindanao del Sur). These municipalities have low susceptibility to drought but have moderate to very high susceptibility to flood based on the validation done by the regional experts. Vegetable farming and aquaculture were also identified as the Secondary/Tertiary Livelihood in all of the aforementioned municipalities in the provinces of Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur, respectively. Additionally, Commercial Built-up Areas zones were present in the municipalities of Datu Piang and Kabuntalan (Annex 2).

For the Rainfed Rice LHZ, two (2) municipalities in the province of Lanao del Sur, one (1) municipality in Maguindanao del Norte, and six (6) municipalities in Maguindanao del Sur will be affected by both the increase in temperature and amount of rainfall (mm). These municipalities include Lumbatan and Lumbayanague (Lanao del Sur), Barira (Maguindanao del Norte, and Datu Salibo, Datu Abdullah Sangki, Shariff Aguak, Mamasapano, Datu Saudi-Ampatuan, and Shariff Saydona Mustapha (Maguindanao del Sur). Both municipalities in Lanao del Sur have very low to low susceptibility to drought and flood. In terms of drought, the municipality of Datu Abdullah Sangki has moderate susceptibility while the rest of the municipalities have low susceptibility.

In terms of the planting schedule of rice in BARMM, Figure 16 illustrates the most recent data from the Philippine Rice Information System (PRISM) which shows the peak of planting rice in the region based on the area planted in 2022-2023. From the graph, it can be seen that most areas in the region plant rice from the months of September to November, with October as the peak of planting during the first semester. On the other hand, planting during the second semester peaks in the month of December and starts to decline until March of the succeeding year. On the other hand, Table 6 shows availability of rainfall and its effects on planting activities per month. Based on the data, the impact of low amount of rainfall in 2019 shows that no farming activity is possible for both rainfed and irrigated rice from December extending to January until April which covers the second semester of rice in BARMM. It was followed by a minimal amount of rainfall in the following months of May and June, but still, farming activities are hampered due to insufficient volume of rain. This information, together with the data from Figure 16, can give valuable insights on the right timing to perform farming activities, and the proper management strategies to minimize potential impacts on crop growth and production.

Moreover, according to PAGASA, mainland provinces in BARMM belong to Type 3 climate which is relatively dry in the months of November to April, and wet during the rest of the year. Moreover, island provinces belong to Type 4 climate wherein rainfall is evenly distributed throughout the year. Knowing the current seasonality of rice and the climate type in the region that can trigger flood or drought can help policymakers and local government units in strategizing solutions that can protect the livelihoods that mostly depend on rice.

Women engage in vegetable farming, one of the main sources of livelihood in BARMM. © WFP/Dale Rivera

Additionally, the Secondary/Tertiary livelihoods identified in the municipalities from Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur were classified under perennial and annual crops, except for the municipality of Datu Salibo which also included aquaculture on their list (Annex 2). In summary, 17 out of the 77 mainland municipalities of BARMM under the irrigated and rainfed rice LHZ will be affected both by the increase in temperature and amount of rainfall (mm) by the year 2050. These 17 municipalities comprise a total land area of 33.09 ha., covering approximately 38% of the total land area of the mainland provinces of BARMM.

For the Perennial Crops LHZ, only three (3) municipalities will be affected both by the increase in temperature and amount of rainfall (mm) in the future. These are the municipalities of Balabagan, Lumbaca-Unayan (Lanao del Sur), and Guindulungan (Maguindanao del Sur). All of these municipalities were also identified to have a decrease in climate suitability by the year 2050. Even though they are expected to have unfavorable conditions in the future, these municipalities were also identified to have very low to low susceptibility to drought and flood based on the experts' validation.

Moreover, the identified Secondary/Tertiary livelihoods vary among these three municipalities: Guindulungan (Maguindanao del Sur) – rice and vegetable farming; Balabagan (Lanao del Sur) – aquaculture; and Lumbaca-Unayan (Lanao del Sur) - vegetable farming (Annex 2).

Figure 15. The map represents LHZ affected by the (a) projected temperature greater than 30°C; (b) projected increase in annual rainfall (mm) greater than 5% and (c) LHZ affected by both projected increase in temperature and annual rainfall (mm) in year 2050 in the mainland province of BARMM.

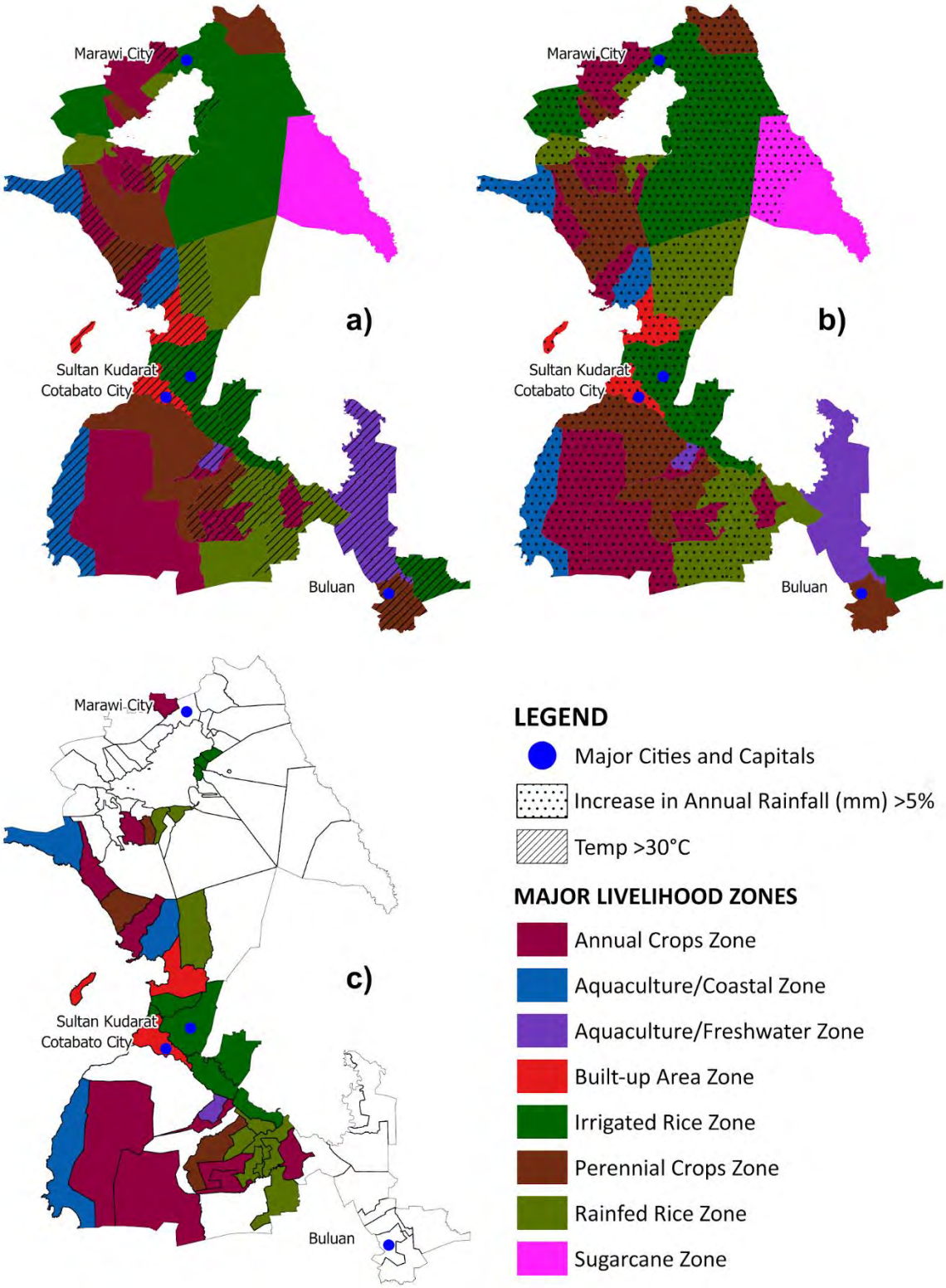
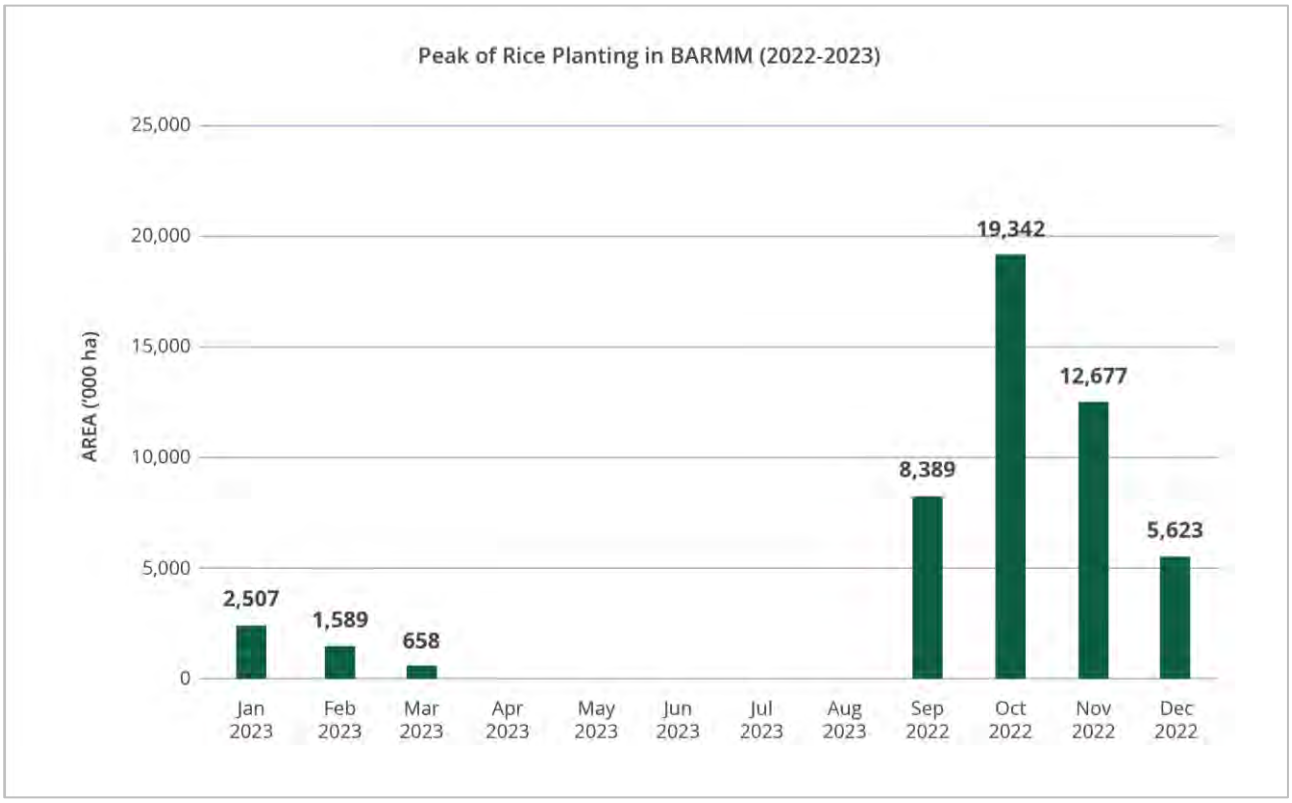


Figure 16. Data from the Philippine Rice Information System (PRISM) showing the peak of planting for rice in BARMM based on the total area planted in 2022-2023



Rice farming is a primary source of income and livelihood in the region. © WFP

Table 6. Cropping calendar of rice and maize in BARMM showing how rainfall affects the planting date of the crops. (Data from PAGASA Agroclimatic Assessment in 2019)

Months	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAINS	Insufficient moisture				Minimal rainfall	Sufficient moisture	Sufficient rainfall	Scarcity of moisture			Good weather	Very low rainfall
Rainfed Rice												
Irrigated Rice												
Maize												

LEGEND	
	No farming activity related to planting (rice and maize) is possible.
	Any farming activities related to planting (rice and maize) were hampered due to insufficient amount of rainfall.
	Rice and Maize crops were not planted all over the region because of the inadequate rainfall received in the preceding month.
	Land preparation, planting, and transplanting activities has started across the region.
	The newly planted and late planted crops across the region experienced moisture stress.
	Harvesting and post-harvest activities (sun drying, stocking, etc.) has started across the region.

3.4.2. Projected Impacts on LHZs on Island Provinces

Basilan, Sulu, and Tawi-Tawi comprise the island provinces in BARMM. These provinces have 42 municipalities in total – 12 in Basilan, 19 in Sulu, and 11 in Tawi-Tawi.

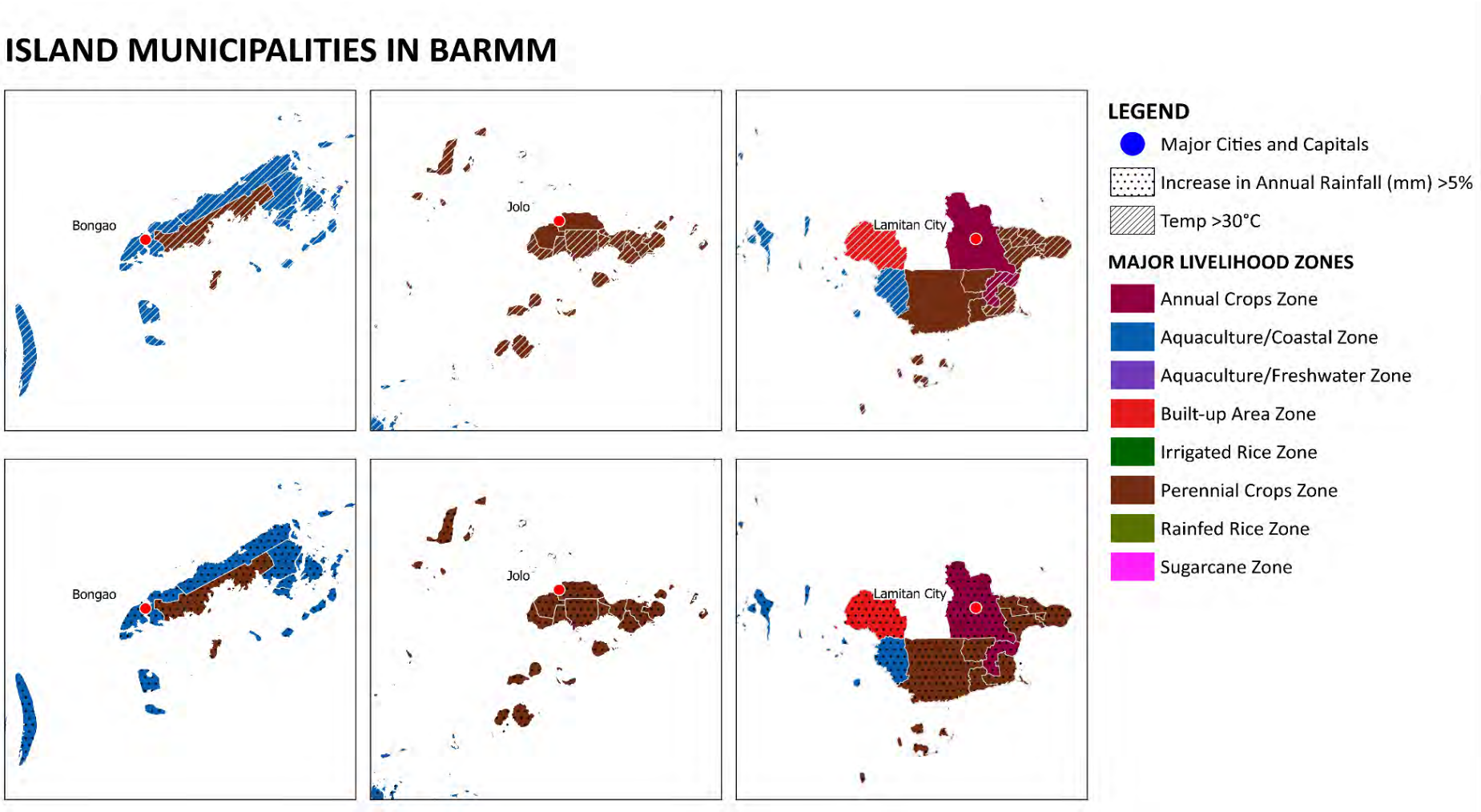
Based on the results of the validation workshop, regional experts have classified these island provinces as generally "low susceptibility" to Typhoons, Flood, Storm Surge, Sea Level Rise, and Saltwater Intrusion. On the other hand, these areas were classified as "low" to "moderate susceptibility" for drought. Such results can be attributed to the low availability of freshwater resources in these localities (Asadi, 2018). Related to this, reports and bulletins from PAGASA frequently list Basilan, Sulu, and Tawi-Tawi as areas experiencing dry conditions due to periods of no rain, often leading to drought.

Results of the climate projection using the RCP 8.5 scenario also showed that in 2050, all of the municipalities in these island provinces will experience more than a 5% increase in the amount of annual rainfall (Figure 17). At the same time, 36 municipalities or approximately 86% of the three (3) island provinces will experience an increase in temperature to greater than 30^{o}C.

Twenty-seven of the municipalities in these island provinces were classified under the Perennial Crops LHZ which are planted with banana, coffee, coconut, and other fruit bearing trees such as mango, durian, and mangosteen. Moreover, 23 banana-growing municipalities or approximately 85% of the Perennial Crops LHZ in these island provinces are projected to have an increase in temperature to greater than 30^{o}C in 2050. In relation to pests and diseases, this suggests that these areas with banana may suffer from Fusarium wilt and Black Sigatoka given that the fungi that cause these diseases thrive in environments with high humidity and temperature.

Aside from perennial crops, these island provinces also have a significant number of aquaculture sites which contribute to the fisheries production in the region. The province of Tawi-Tawi, in particular, recorded the highest aquaculture production in the region, contributing 52.44% of the total regional production in BARMM in 2020 (PSA-BARMM, n.d.). The province of Sulu, on the other hand, had a total of 30.56% share in the same year. Twelve or approximately 29% of the total municipalities in these island provinces are classified under the Aquaculture/Coastal Fisheries LHZ. Meanwhile, two (2) municipalities were classified under Annual Crops LHZ, and Lantawan in the province of Basilan was the lone municipality included in the Built-up Areas LHZ.

Figure 17. The map represents LHZ affected by the (a) projected temperature greater than 30°C; (b) projected increase in annual rainfall (mm) greater than 5% and (c) LHZ affected by both projected increase in temperature and annual rainfall (mm) in year 2050 in the island provinces of BARMM.



3.4.3. Projected Impacts on Crops

Agricultural production in the Philippines is projected to be significantly affected by climate change. Consistent to the projected increase in temperature and annual rainfall (mm) by the year 2050 using the RCP 8.5 scenario, results of the future crop suitability showed that majority of the areas in BARMM will be unfavorable for growing crops. The provinces of Lanao del Sur, Maguindano del Norte, and Maguindanao del Sur, particularly, showed both decreasing suitability. These provinces will also exhibit and increase[11] in temperature greater than 30^{o}C, and amount of rainfall (mm) greater than 5% by the year 2050 (Figure 15).

Exposure to temperature extremes has effects on plant growth and development and has major impact on vegetative and reproductive stages of crops (Hatfield and Prueger, 2015) as well as in the storage of harvested crops. Moreover, studies show that proliferation of pests and diseases is highly correlated with hotter temperatures of 26°C or higher.

In terms of increase in the amount of rainfall (mm), PAGASA data shows that an increase of 5% in the annual rainfall by year 2050 is roughly equivalent to 48.9 mm or an additional 10 days or more in the number of rainy days in Mindanao. This has a significant impact on crop production because of its effects on soil structure. Water logging and flooding as caused by heavy rainfall may result in soil erosion which can wash away the topsoil along with important soil nutrients. This affects crop suitability which can potentially decrease crop production and yield.

3.4.3.1. Projected Impacts on Crop Suitability

To assess the potential impacts of climate change on the productivity of key crops in BARMM, outputs of the crop suitability modeling were used to understand the geospatial components of crop production, while the results of the validation served as bases to contextualize the analysis through the lens of the LHZs.

Based on the validation workshop, rice was ranked as the top priority crop because of its economic importance as a primary source of income and livelihood in the region. Additionally, rice constitutes a large part of the diet of many Filipinos. Not only is it a staple food in BARMM, but also for the whole country. Aside from rice, the workshop participants also identified maize, banana, coconut, and coffee as other important crops.

For this study, rice, maize, and banana were included in the analysis being the top priority crops in the region and because of availability of data. These crops represent the Irrigated/Rainfed Rice, Annual Crops and Perennial Crops LHZs, respectively.

Using the prioritized crops, models were developed following the RCP 8.5 scenario, which is more closely related to our current trajectory, with inadequate mitigation measures implemented by the years 2030 and 2050. The locations of rice, maize, and banana production areas were mapped over the selected future scenarios to determine how crop suitability will likely be affected by climate change.

[11] The increase in temperature and annual rainfall were calculated from the baseline historical climate data downloaded from the WorldClim and future climate data from CMIP5 Global Climate Models (GCMs) downloaded from CCAFS.

For rice, the resulting model (Figure 18) showed that in the years 2030 and 2050, future climate scenarios will provide environments that are generally less conducive for rice production in BARMM. These areas include majority of the municipalities in the mainland provinces, particularly the 14 municipalities in the province of Maguindanao del Norte and Maguindanao del Sur – eight (8) under Rainfed Rice LHZ and six (6) under Irrigated Rice LHZ. However, positive gains may also be achieved in some inland pockets in the municipalities of Butig, Lumba-Bayabao, Madalum, and Madamba in the provinces of Lanao del Sur (under Irrigated Rice LHZ), and in the municipality of Buldon in the province of Maguindanao del Norte (under Rainfed Rice LHZ). But generally, the growing conditions of the irrigated and rainfed rice areas in most of the municipalities in the province of Lanao del Sur will show no change by 2030 and 2050. The results of the analysis were consistent with the study of Gowda et. al., (2018) which concludes that impacts of climate change can be less favorable or more conducive for growing different types of crops in different regions (Gowda, P., et al. (2018)).

For maize, some areas within the mainland provinces in BARMM will also be less conducive for its production (Figure 19). However, for other annual crops, changes will generally be less dramatic in the rest of the region. Decrease in suitability was seen in the municipalities of Malabang and Kapatagan in the province of Lanao del Sur, and in Rajah Buayan, Datu Hoffer Ampatuan, Datu Unsay, and Datu Anggal Midtimbang in the province of Maguindanao del Sur.

For banana and other perennial crops (Figure 20), the resulting suitability in the years 2030 and 2050 will vary across the mainland provinces. Southern portions such as the municipalities of Balabagan in the province of Lanao del Sur; Sinsuat, Datu Odin in the province of Maguindanao del Norte; and Buluan, Guindulungan, and Mangundadatu in the province of Maguindanao del Sur will be less conducive for banana production while the northern portions including the municipalities of Calanogas, Lumbaca-Unayan, Marogong, Tagoloan II, and Tugaya (Lanao del Sur) will be otherwise more suitable.

Lands planted with bananas represent the perennial crop livelihood zone in the region. © WFP/Jacob Maentz

These observed trends are related to extreme weather hazards, particularly extreme rainfall events and droughts, which have affected the agricultural sector in the country including Mindanao. In terms of rainfall (mm), data from 2001 to 2010 shows a positive deviation of 8 mm per month, which could result to an approximately 35% increase in the frequency of extreme rainfall events in the Philippines, adding one every three years (Thomas et al., 2012). On the other hand, being known as a drought-prone area, Mindanao recorded its most severe drought incidents during the El Niño phenomenon in the years 2015 and 2016 which affected an estimated 224,834 ha. of agricultural lands (IFRC, 2016), and in 2018-2019 which hit nine (9) provinces: Bukidnon, Lanao del Norte, Lanao del Sur, Maguindanao (presently Maguindanao del Norte and Maguindanao del Sur), Misamis Occidental, Misamis Oriental, Sulu, Zamboanga del Sur and Zamboanga Sibugay (PAGASA, 2019).

Figure 18. Future crop climate suitability model focuses only on rice under the Irrigated Rice LHZ and Rainfed Rice LHZ for RCP 8.5 by year 2030 and year 2050 in the mainland provinces of BARMM.

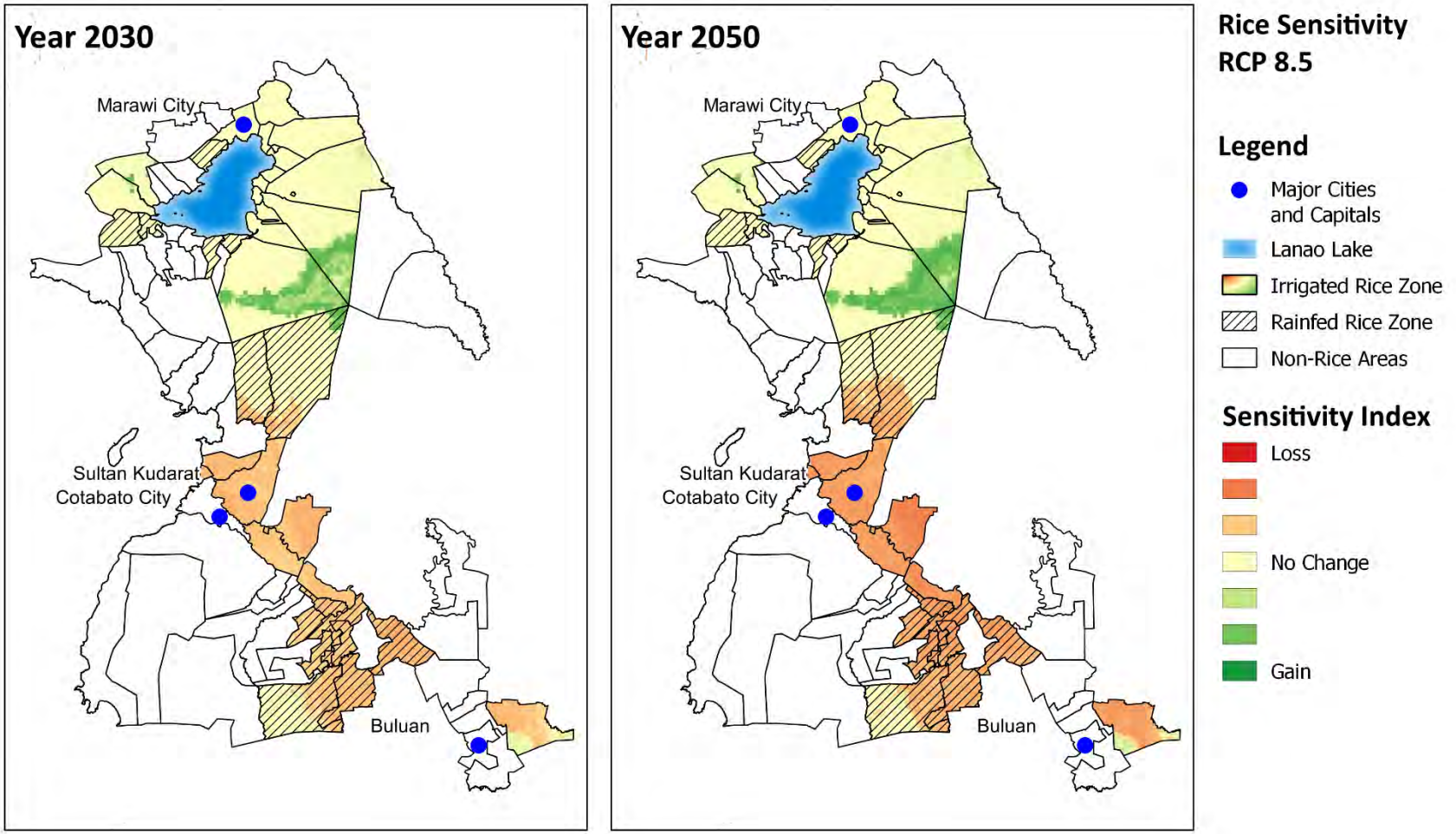


Figure 19. Future crop climate suitability model focuses only on maize under the Annual Crop LHZ for RCP 8.5 by year 2030 and year 2050 in the mainland provinces of BARMM.

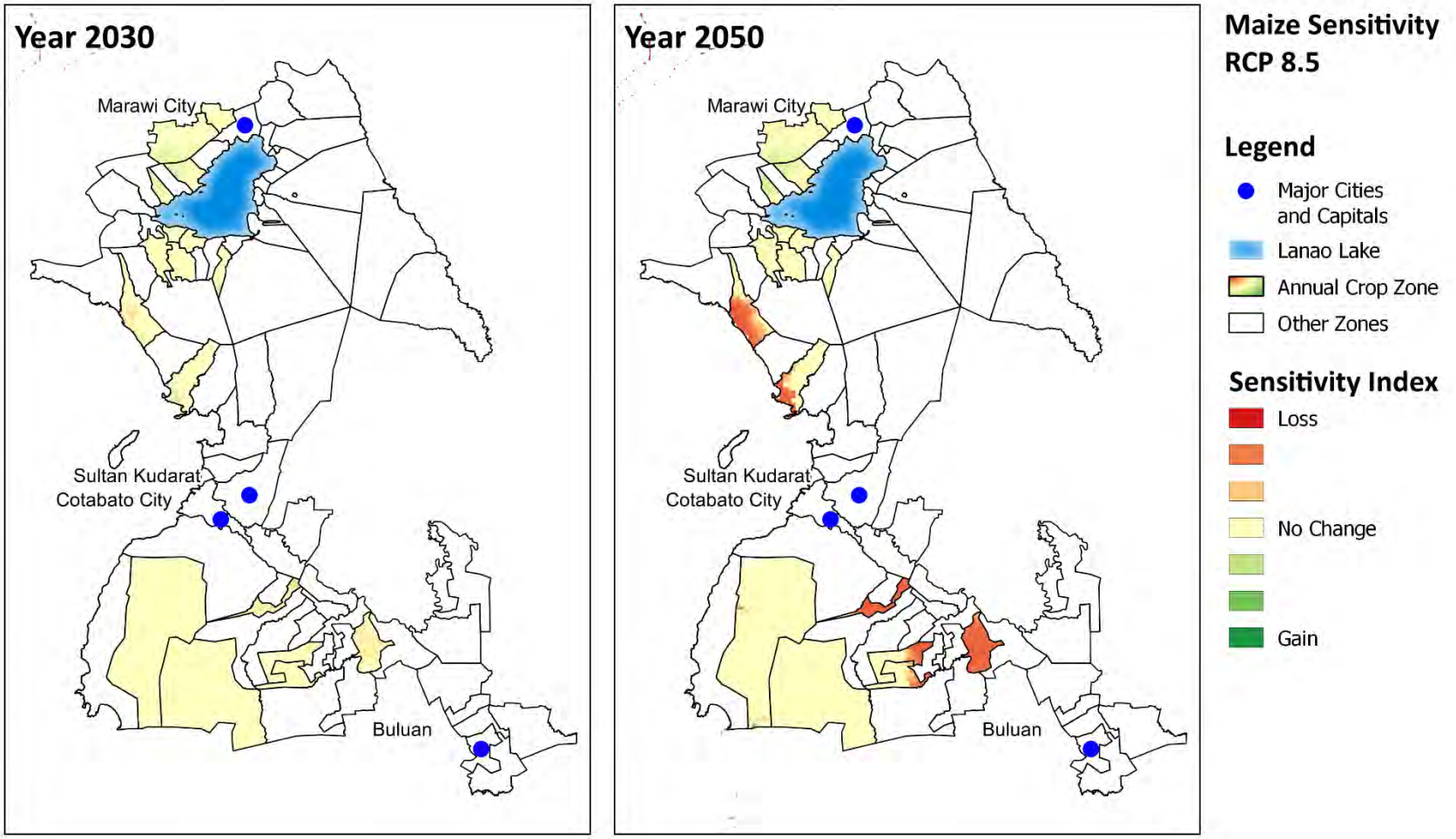
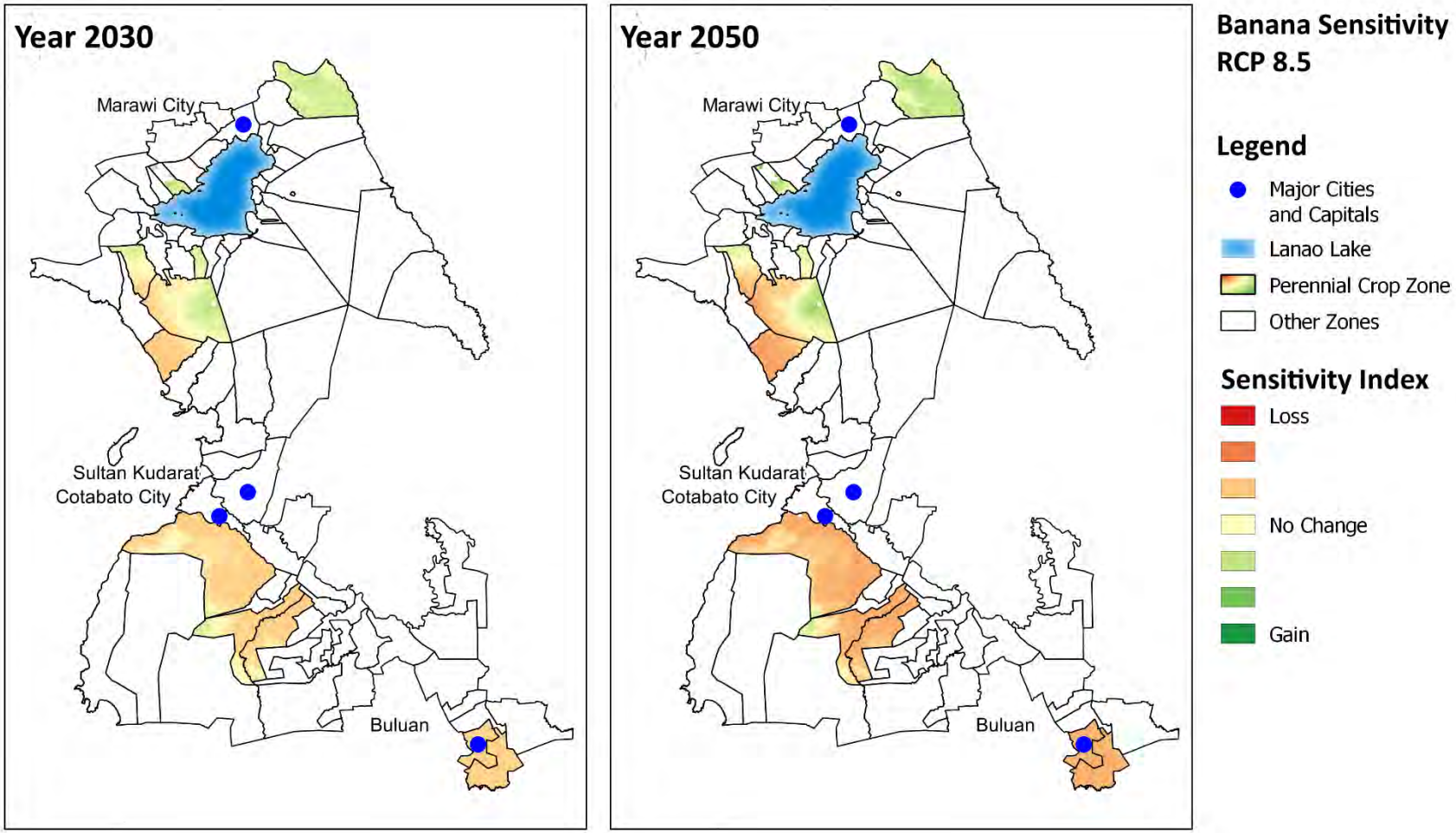


Figure 20. Future crop climate suitability model focuses only on banana under the Perennial Crop LHZ for RCP 8.5 by year 2030 and year 2050 in the mainland provinces of BARMM.



3.4.3.2. Projected Exposure to Pest and Diseases

Future climate conditions are also expected to lead to the proliferation of pests and diseases. This is mainly driven by the changing temperature and rainfall patterns caused by climate change (Doody, 2020). According to FAO (2021), the dispersal and intensity of climate change-induced pests and diseases may result in crop failure, decreasing yield and ultimately, threatening food security. Such conditions increase the demand for pesticides and other pest and disease controls, adding up to the already high cost of agricultural production.

Rice

The increase in temperature and rainfall induces the proliferation of several rice diseases such as rice sheath blight and bacterial sheath blight. Studies analyzing the correlation among meteorological parameters and disease incidence find that sheath blight incidence and severity are highly governed by temperature, with disease favoring air temperatures in the range of 26°C to 34 °C (Kaur et al., 2015). In BARMM, high incidence of the disease is projected by year 2050 in the municipalities of Kapatagan and Lala in the province of Lanao Del Norte; Northern Kabuntalan, Kabuntalan in the province of Maguindanao del Norte; Datu Piang in the province of Maguindanao del Sur; and Midsayap in the province of Cotabato.

Maize

On the other hand, mycotoxins, northern corn leaf blight, and southern corn leaf blight were considered as the most threatening diseases for maize.

According to the study of Salvacion et.al. (2015), there were changes associated with climate change noted on the mycotoxin risk of maize production areas in the Philippines. Warm and humid conditions (25 °C to 42 °C) are particularly favorable to the growth of Fusarium mycotoxins in maize. Given the increase in temperature by 2050 (RCP 8.5), maize-growing areas in the Philippines would potentially be at high risk of this disease. For mainland BARMM, seven (7) of the 19 municipalities that grow maize and other annual crops are predicted to experience incidence of mycotoxins in the future. These municipalities include Malabang, Tubaran, and Kapatagan in the province of Lanao del Sur, and Datu Anggal Midtimbang, Datu Hoffer Ampatuan, Datu Unsay, and Rajah Buayan in the province of Maguindanao del Sur.

Consequently, the proliferation of pests and diseases may also result in appreciable yield losses, lowering income among farmers who cultivate maize as their main or complementary crop. Studies have also shown that mycotoxins can affect the health of humans and animals that consume maize and maize-based feeds through acute toxicosis, immune suppression, and several other effects.

Both northern and southern corn leaf blight are fungal infections that initially cause leaves to turn into a tan color and later produce dark gray or black fungus, which can decrease yield by at least 30%. Under highly humid conditions, the fungus will produce new spores at the leaf surface, which are then spread by rain or wind to create secondary infections. Northern corn leaf blight can be found in regions that are relatively wetter and cooler throughout the year. In the context of LHZs in mainland BARMM, all of the 19 municipalities under annual crops which are projected to have more than 5% increase in the annual rainfall (mm) by 2050, may experience widespread of these diseases in the future.

Conversely, southern corn leaf blight spreads widely in regions with high temperatures ranging from 25°C to 42°C. According to the projected temperature by 2050, the maize-producing areas under Annual Crops LHZ that will exhibit ideal temperatures for the proliferation of southern corn leaf blight are the municipalities of Malabang, Tubaran, Kapatagan in the province of Lanao del Sur, and Datu Anggal Midtimbang, Datu Hoffer Ampatuan, Datu Unsay, and Rajah Buayan in the province of Maguindanao del Sur.

Banana

Fusarium Wilt and Black Sigatoka are some of the key diseases expected to challenge banana cultivation in Perennial Crop LHZs in mainland BARMM under changing climate scenarios.

In the Philippines, increased precipitation during the warmest season is predicted to increase fungal activity, including Fusarium wilt, in the coming decades (Salvacion et al., 2019). Based on LHZ maps data, climate change impacts will provide conducive conditions for spore germination and colonization in about 13.97 ha., covering 12 municipalities under Perennial Crop LHZs in Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur, or approximately 89% of the potential banana-growing areas in mainland BARMM.

Another pathogen that may become increasingly threatening to banana production in the Philippines is black sigatoka, a foliar fungal disease caused by Pseudocercospora fijiensis (Busogoro et al., 2004). The climatic characteristics that favor the occurrence of black sigatoka are high relative humidity greater than 90%, significant precipitation, and temperatures from 25°C to 28°C. (Bebber, 2019).

Considering the LHZ map, five (5) municipalities in mainland BARMM may experience Fusarium wilt and black sigatoka infestations following the increase in temperature to greater than 30°C by 2050. These are the municipalities of Balabagan, Lumbaca-Unayan in the province of Lanao del Sur; and Buluan, Guindulungan, and Mangundadatu in the province of Maguindanao del Sur.

Fishponds are part of the aquaculture/freshwater livelihood zone in BARMM. This fishpond was created by community development partners in Barangay Nunguan, Pikit SGA as part of their livelihood activities under FFA-UNJP.
© WFP/Jane Buenaobra

3.4.4. Projected Impacts on Aquaculture

The aquaculture sub-sector was also identified as a major LHZ in some areas in BARMM. In the LHZ database, aquaculture is classified as either freshwater or coastal. As described in Table 1, the Aquaculture/Freshwater LHZ includes areas with aquaculture sites found in inland water bodies including brackish water. The Aquaculture/Coastal LHZ, meanwhile, refers to the areas practicing marine aquaculture. Same with the other commodity systems, livelihoods related to aquaculture are also expected to be adversely impacted by the projected increase in temperature and annual rainfall (mm).

As mentioned, climate change, along with the changes in temperature and amount of rainfall, may affect the oceanic systems resulting in induced sea-based hazards. These hazards may directly or indirectly affect the abundance and distribution of fisheries resources and the suitability of some areas dedicated to aquaculture production. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR 5) provides evidence on the certainty of global warming leading to climate change and its effects on the oceans, coastal areas, and inland waterbodies (FAO, 2016). The IPCC AR 5 also highlights that there is evidence of modification and change in the distribution of marine and freshwater species. Many marine species are found to migrate to deeper waters which have ideal oxygen levels for their survival, causing a migratory shift and resulting in changes in interaction dynamics among species, trophic linkages, and food web. On the other hand, many freshwater species are likely to experience a change in size, reproductive cycles, and survival rates.

The impacts of climate change to fishery and aquaculture systems may bring both positive and negative effects depending on the location. These impacts can directly affect the livelihood and income of fisherfolk. At the same time, these also threaten food security since coastal and marine areas are critical sources of fish and fishery products.

Air temperature greater than 30^{o}C is within the border of the temperature ranges that are optimal for the growth and survival of both marine and freshwater species. As mentioned above, when water temperature gets warmer than usual, marine species tends to migrate to deeper waters which can affect catch rate. On the other hand, negative impacts on freshwater species are mainly felt in the reduction of yield due to the reduction in fish size and lower survival rates.

In terms of rainfall, section 3.3.2 mentioned that an approximate increase of 5% in the annual rainfall by year 2050 is roughly equivalent to 48.9 mm or an additional 10 days or more in the number of rainy days in Mindanao. Increase in the number of rainy days may result to flooding which can wash away fish stocks and reduce production in aquaculture sites. Water quality can also be negatively affected due to the pollutants, sediments, and excess nutrients carried by excess rainfall, possibly leading to oxygen depletion and increased algal blooms.

In BARMM, the aquaculture livelihoods that are projected to experience an increase in temperature and amount of rainfall (mm) in the future are the island provinces and coastal areas in the mainland provinces (Figures 15 and 16).

These include 12 municipalities in the island provinces classified under Aquaculture/Coastal Fisheries LHZ. The Secondary/Tertiary livelihoods identified in these municipalities were vegetable farming and perennial crops including banana and coconut. Eight (8) of these municipalities were also identified to be raising livestock as a complementary activity to aquaculture, vegetable farming, and growing of perennial crops.

On the other hand, nine (9) municipalities in the mainland provinces consider aquaculture as their major livelihood. Five (5) municipalities are under Aquaculture/Coastal Fisheries LHZ and four (4) municipalities belong to the Aquaculture/Freshwater LHZ. All of these municipalities are also growing rainfed rice, annual crops such as vegetables, corn, and cassava, and perennial crops including banana and coconut. Moreover, six (6) of these municipalities are also raising livestock as a complementary activity.

3.4.5. Projected Impacts on Livestock

The Department of Agriculture (DA) defines livestock as domesticated animals raised in an agricultural setting to produce labor and commodities such as meat, eggs, milk, fur, leather, and wool. Poultry, on the other hand, refers to the domesticated birds kept by humans for their eggs, meat, or feathers.

Changes in climate conditions affect poultry and livestock production in the region. © WFP/Earvin Perias

During the validation workshop, the experts identified livestock production as the top complementary activity in 56 municipalities in BARMM. In BARMM, the latest inventory from PSA-BARMM as of April 2022 shows an estimated total of 2,342,822 heads of livestock and poultry of which 76% is from poultry and only 24% is from livestock. Poultry represents chicken and ducks, while livestock represents goat, cattle, carabao, and hog. Records also show the contribution of each of the provinces in BARMM: Lanao del Sur (36%), Sulu (22%), Basilan (18%), Maguindanao (presently Maguindanao del Norte and Maguindanao del Sur) (14%), and Tawi-Tawi (10%).

Changing climatic conditions such as increases in temperature pose challenges to the livestock and poultry sector, both in terms of animal health and the viability of pasturelands and fodder crops that are used as feeds. The ongoing climatic changes, in temperature and moisture, can have detrimental impacts on livestock's growth and weight, reproductive performance, and susceptibility to pests and diseases.

Direct effects of the changes in microclimatic factors on swine and poultry behavior include increased panting, reduction in voluntary feed intake, and increased water consumption, which could in turn result in depressed growth, lower meat quality, lower immune functions, and lower reproductive performance of both male and female breeders (Lara and Rostagno, 2013).

For example, laying hens' productivity is moderately affected by temperatures that exceed 27 °C, while temperatures surpassing 32 °C can have a severe impact on both laying capacity and quality, such as

shell thickness and breaking strength (Mahmoud et al., 1996; Lin et al., 2006; Kim et al., 2020). With regards to hogs, the thermoneutral zone for rearing and finishing[12] pigs is at a temperature from 21°C to 24°C provided that the relative humidity is 70% or lower (Lass, 2019). For sows (adult female hogs), a temperature not more than 22 °C should be maintained (Hörtenhuber et al., 2020) to not negatively affect conception rate. Overall, all animals in a hot environment tend to diminish feed intake to decrease metabolic heat production, resulting in inferior growth performance (Rauw et al., 2020; Secor, 2009).

Based on the projected change in temperature by year 2050, among the livestock and poultry areas at-risk are the 12 municipalities in the mainland provinces Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur namely: Balabagan (Lanao del Sur), Parang, Sultan Kudarat, Sultan Mastura, and Talitay (Maguindanao del Norte), Datu Abdullah Sangki, Datu Anggal Midtimbang, Datu Salibo, Datu Saudi-Ampatuan, Guindulungan, Mamasapano, Shariff Saydona Mustapha (Maguindanao del Sur) (Figure 21). On the other hand, there are 29 municipalities affected in the island provinces of BARMM: four (4) in Basilan, eight (8) in Tawi-Tawi, and 17 in Sulu (Figure 22).

In addition, livestock production in the Philippines is susceptible to extreme weather events, which are expected to increase in frequency and intensity as a result of climate change. For the past decade (2000 to 2010), one study placed the total value of agricultural damage to crops, fisheries, and livestock due to typhoons, floods, and droughts in the Philippines at approximately US$219 billion (Israel and Briones, 2012). In October 2022, Severe Tropical Storm Paeng caused damage to livestock and poultry. The latest data from DA showed that damage to the sector reached PHP 40.04 million which represents 129,596 heads of chicken, swine, cattle, carabao, goat, sheep, duck, and horse perished.

Finally, since intensive swine and poultry production rely heavily on cereal grains, the implications of climate change on the production and distribution of staple grains used in animal feed across the Philippines can likewise affect the health and nutrition of livestock and poultry. As discussed in the preceding sections, climate change may contribute to higher temperatures and variable rainfall that may weaken or expose crops to pests and diseases, thus decreasing the quantity and quality of important feed crops. In terms of natural fodder and pasture for grazing, climatic changes can contribute to resource competition among plants and weeds and a biodiversity loss that further exacerbates the problem.

[12] Finishing is the phase of pig production where pigs are fed to reach market weight.

Figure 22. The map represents LHZ with livestock as complementary activity affected by the projected temperature greater than 30°C by the year 2050 in the mainland provinces of BARMM.

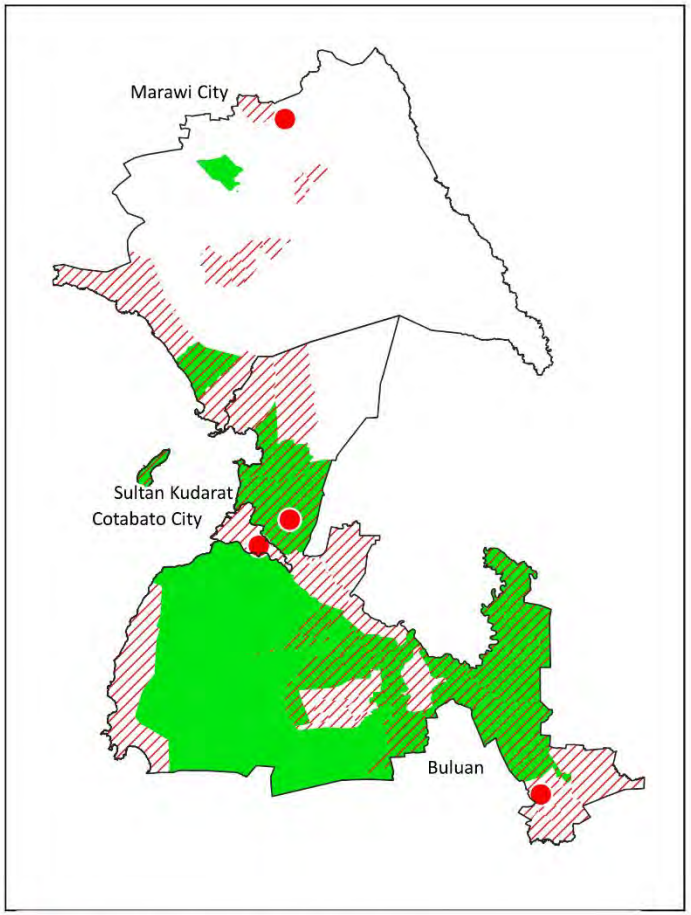
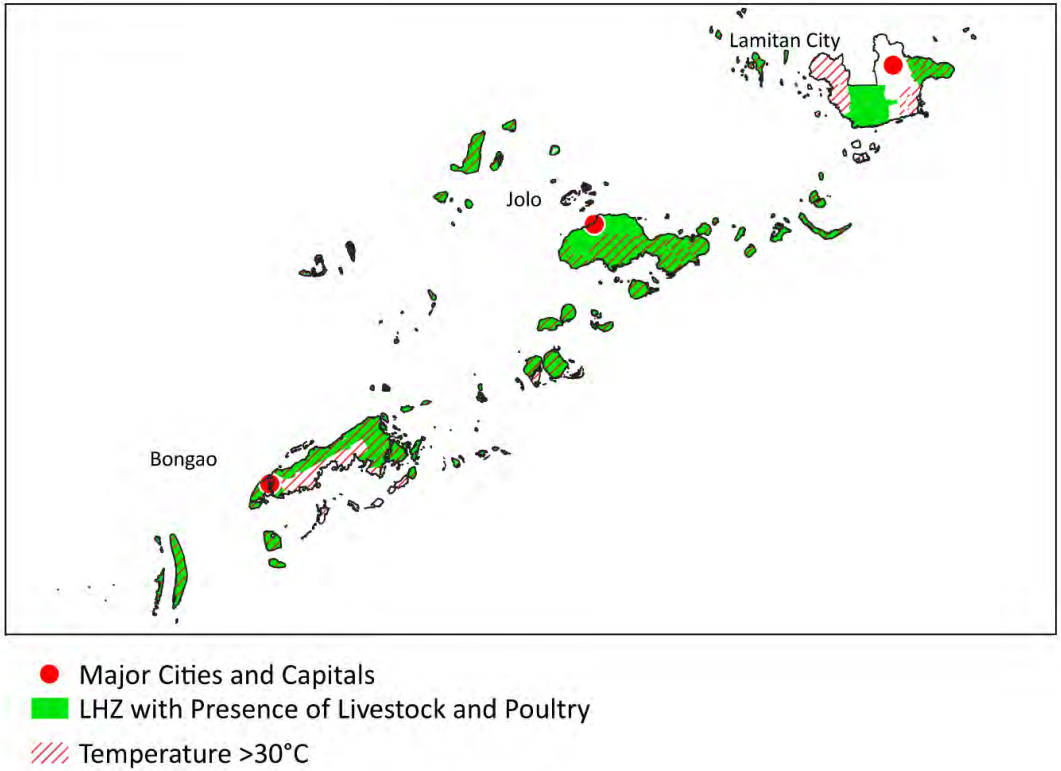


Figure 21. The map represents LHZ with livestock as complementary activity affected by the projected temperature greater than 30°C by the year 2050 in the island provinces of BARMM.



4. Practical Applications of the LHZ Tool

The LHZ map can serve as a guide for planners and decision makers by providing them with geographically disaggregated information that is relevant for food security monitoring, analysis, and decision support (Grillo, 2009). This tool offers a practical, yet strategic process in targeting and prioritizing areas that are most susceptible to potential climate-related hazards. Moreover, the LHZ map can provide more accurate answers about where food security is likely to deteriorate and what alternatives are available at the local level.

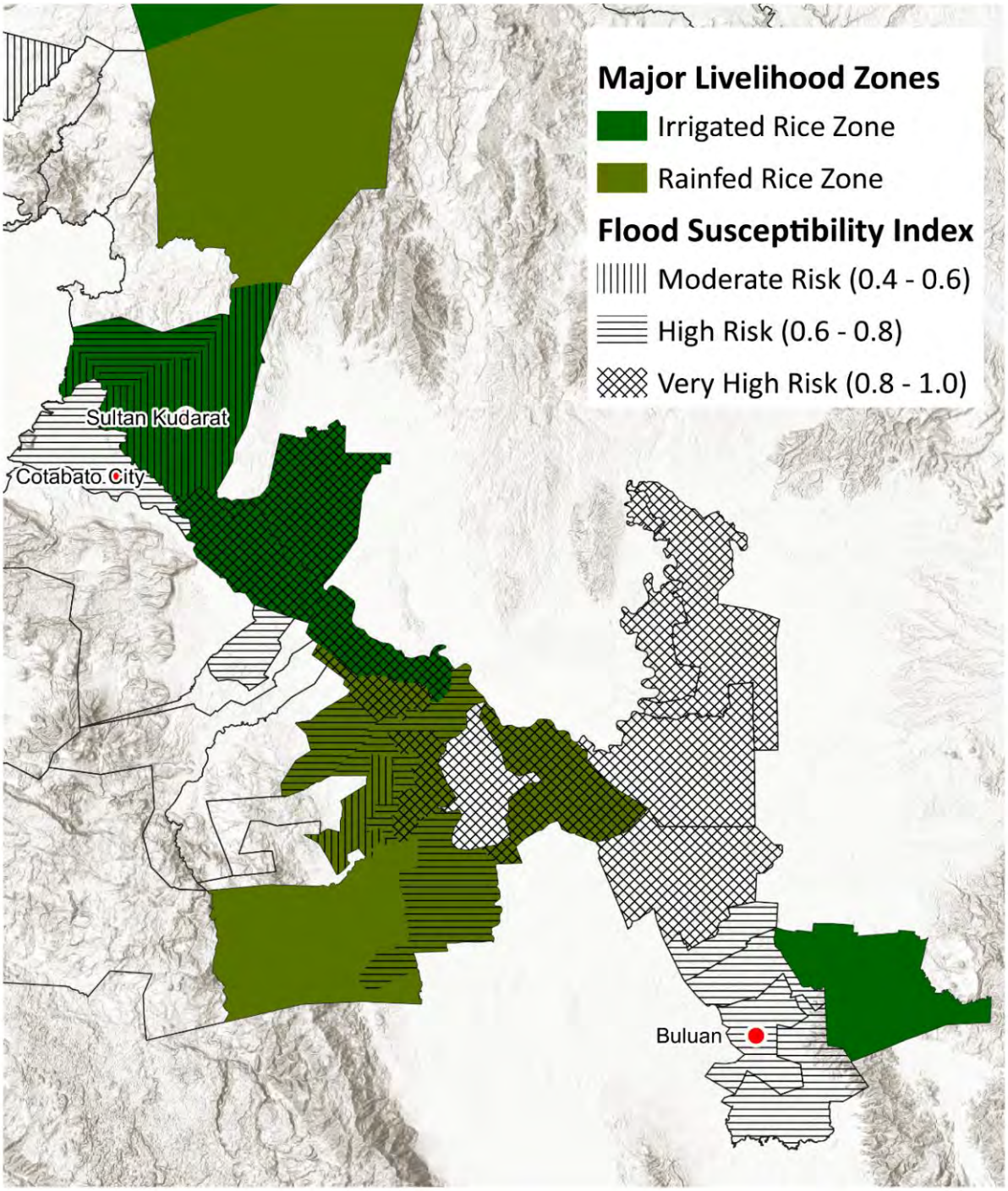
In this section, we have sampled areas in the region based on the level of vulnerability to climate change, to demonstrate how LHZ maps can be integrated with different datasets such as climate-related hazards, poverty, and nutrition, to develop context-specific analyses.

Drought and flood are the top climate-related hazards that significantly affect most of the livelihoods in BARMM. © WFP/Dante Diosina

Using the LHZ tool to develop adaptation strategies in addressing the impacts of climate-related hazards: The increase in temperature and amount of rainfall affects both the intensity and frequency (including timing) of flood and drought events. Consequently, this will intensify the magnitude of impacts in areas that are most at-risk. Therefore, understanding such potential climate-related extremes is critical to guide policy decisions and ensure adequate adaptation measures are implemented at the local level.

For instance, Figure 23 shows the susceptibility to flooding of municipalities in the provinces of Maguindanao del Norte and Maguindanao del Sur, and the specific LHZs that will be affected. The Irrigated Rice LHZ in the municipalities of Kabuntalan and Northern Kabuntalan (Maguindanao del Norte), Datu Piang (Maguindano del Sur), and the Rainfed Rice LHZ in the municipalities of Sultan sa Barongis, Datu Salibo, and Mamasapano (Maguindanao del Sur) were classified to have “very high susceptibility” to flooding based on their FSI.

Figure 23. FSI of municipalities in the province of Maguindanao



In August 2022, it was reported that the province of Maguindanao (presently Maguindanao del Norte and Maguindanao del Sur) was placed under the state of calamity due to a series of flooding events caused by continuous heavy rains which lasted for almost three (3) weeks (Fernandez, 2022). The intense flooding submerged 15 municipalities including the six (6) aforementioned areas, displaced a total of 46,922 families, and destroyed at least PHP 103.5 million worth of crops, mostly palay, with no chances of recovery as reported by the disaster response and agriculture officials.

Meanwhile, Irrigated Rice LHZ in the municipality of Sultan Kudarat and Rainfed Rice LHZ in the municipality of Shariff Aguak were categorized as “moderately susceptible” to flooding.

In terms of adaptation strategies, rice production areas with “high” to “very high” susceptibility to flooding will require the use of flood-tolerant varieties and development of flood forecasting and early warning systems (Vidallo et. al., 2019). On the other hand, short-term interventions that may be prioritized for rice production areas under “moderate” flood susceptibility are improvements on drainage system, temporary flood barriers, and early planting or shifting of crop calendars. Improvement of crop storage facilities and enhancement in the provision of insurance should also be considered.

Vegetable farming is an example of secondary or tertiary livelihood activity in the region. In this photo, women and other community members in Piagapo, Lanao del Sur assist in the management and maintenance of their community gardens. © WFP/Jane Buenaobra

Additionally, diversification of livelihood is seen to be beneficial particularly to rice production areas that are highly susceptible to climate-related hazards. The list of Secondary/Tertiary LHZs that can be generated from the LHZ database can guide policymakers in identifying other potential sources of income and skills development that can be further promoted and given investment in the locality. Oher

livelihood support activities focusing on community protection and resilience, rehabilitation of productive infrastructure, and restoration of lost assets should be considered.

Table 7 shows the list of Secondary/Tertiary LHZs in the six (6) areas having "very high" susceptibility to flooding in the provinces of Maguindanao del Norte and Maguindanao del Sur.

Table 7. List of Secondary/Tertiary LHZs in selected rice production areas in the province of Maguindanao del Norte and Maguindanao del Sur

Province	Municipality	Major Zones	Secondary/Tertiary
Maguindanao del Sur	Datu Piang	Irrigated Rice	built-up areas (commercial), aquaculture/freshwater fisheries, perennial crops, rainfed rice, and vegetable farming
Maguindanao del Norte	Kabuntalan	Irrigated Rice	built-up areas (commercial), aquaculture/freshwater fisheries, perennial crops, rainfed rice, and vegetable farming
Maguindanao del Norte	Northern Kabuntalan	Irrigated Rice	Irrigated rice mixed with aquaculture/freshwater fisheries, rainfed rice, and vegetable farming
Maguindanao del Sur	Sultan Sa Barongis	Rainfed Rice	aquaculture/freshwater fisheries, perennial crops, vegetable farming, and livestock/pasture
Maguindanao del Sur	Datu Salibo	Rainfed Rice	aquaculture/freshwater fisheries, perennial crops, vegetable farming, and livestock/pasture
Maguindanao del Sur	Mamasapano	Rainfed Rice	perennial crops, irrigated rice, vegetable farming, and livestock/pasture

As seen in the table, aquaculture/freshwater fisheries and perennial crops are the most common Secondary/Tertiary LHZs among the six (6) municipalities. Several studies indicate that community-based and climate-resilient freshwater aquaculture practices are promising livelihood adaptation strategies in areas with prolonged low-level flooding (Oulaytham, 2014). Some of the relevant practices being promoted by the DA are adoption of aqua-silviculture activities (e.g., fish production in a mangrove reforestation areas), organic aquaculture (e.g., fish production based on the sustainability approach), and communal stocking and rehabilitation of fish (e.g., community-based fish stock enhancement) (CIAT; DA-AMIA, 2017).

Significant positive impacts on farm income and sustainability of fish production have already observed in other regions using these practices (CIAT; DA-AMIA, 2017). Additionally, statistics show that aquaculture is also profitable and is a growing industry in BARMM. Maguindanao (presently Maguindanao del Norte and Maguindanao del Sur) particularly contributed 16.15% of the total regional production and 44.28% of the total value of aquaculture in BARMM in 2020 (PSA, 2020).

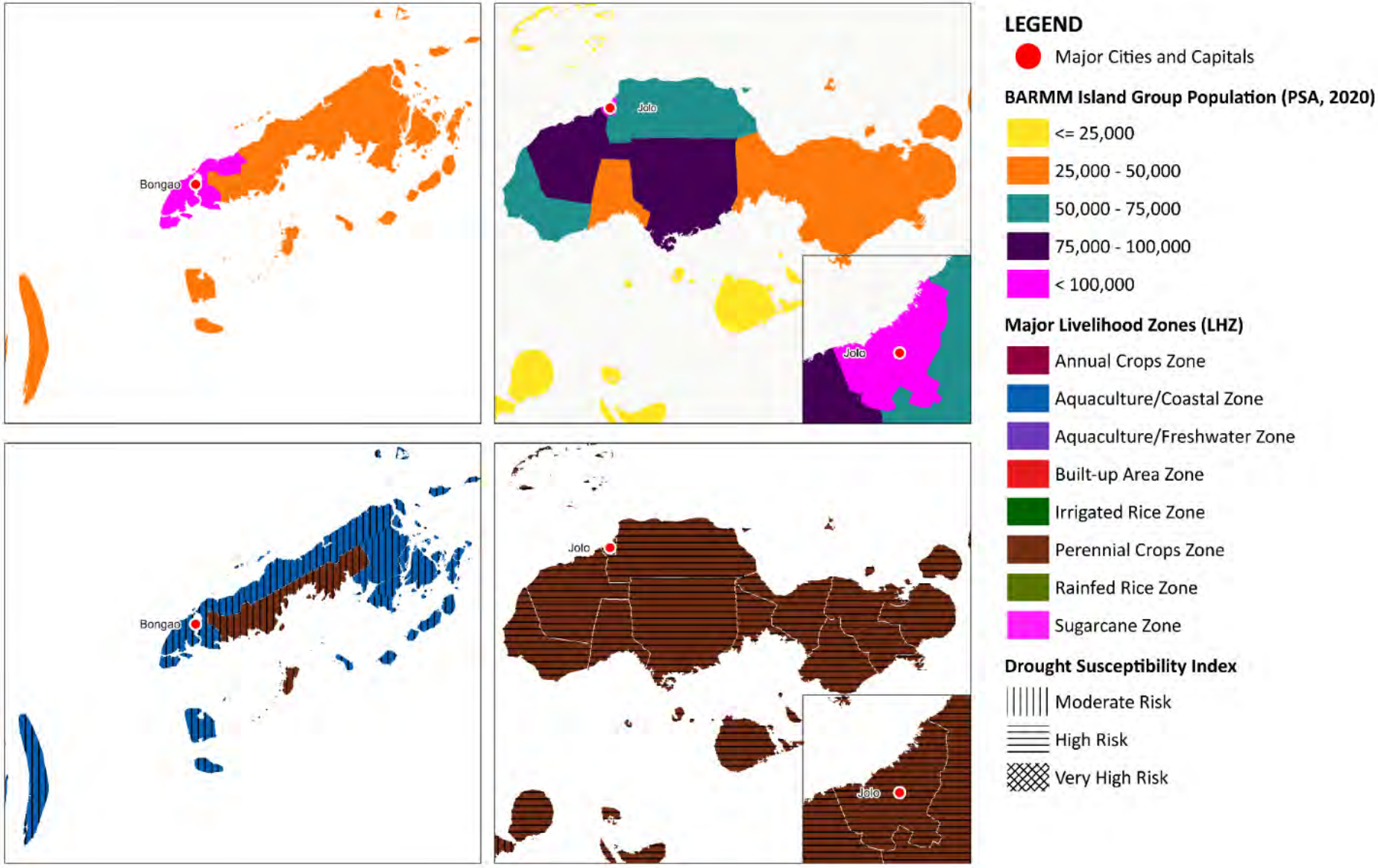
On the other hand, perennial crop production is also a promising livelihood because these crops are considered more permanent, do not require replanting to produce yield annually, and can grow with fewer soil-intensive practices and less water requirements (Davis, 2023). These crops are also characterized by a deep rooting system which can hold the soil persistently, making the crops survive a long duration of flood. These characteristics make perennial crops more resilient to climate change impacts as compared to rice and other annual crops, hence, can be considered as alternative planting material to diversify sources of income.

For the municipalities in island provinces in BARMM (Sulu and Tawi-Tawi), the previous sections (Figures 12 and 13) showed that these areas have relatively low susceptibility to sea-related hazards such as Storm Surge (SS) and Sea Level Rise (SLR) based on historical data. However, a study of the Department of Science and Technology (DOST) (Project NOAH, 2014) revealed that Sulu is one of the top cities and provinces in the Philippines expected to be at-risk of high SS levels given the scenario of an extreme rainfall event in the future. Based on simulations conducted by Project NOAH, Sulu can have a maximum surge height of 3.46 meters exposing 100-250 people in every square kilometer (Lapidez et. al., 2015).

Moreover, the island municipalities are also considerably exposed to drought with moderate to high susceptibility indices (Figure 24). It was discussed in the previous section that, apart from the low amount of rainfall (mm), drought in the island group could also be attributed to the low availability of freshwater resources in the localities (Asadi, 2018). Majority of these island municipalities are classified as Perennial LHZ and among the impacts of drought to perennial crops such as abaca, banana, coffee, and coconut are reduction in fruit yield due to the impeded ability of the plant to absorb nutrients from the soil, and crop failure due to potential pest infestation (FAO, 2017). Among the adaptation options identified by the DA-AMIA program are the establishment of rainwater harvesting system for irrigation and diversified farming and intercropping to control pest infestation.

It can also be noted that the municipalities in island provinces have larger populations as compared to the mainland. These municipalities are Jolo (Sulu) and Bongao (Tawi-Tawi) with a population greater than 100,000, and Indanan and Talipao (Sulu) with a population ranging between 75,000 and 100,000 (Figure 24). The municipalities of Jolo, Indanan, and Talipao (Sulu) are classified under the Perennial Crops LHZ, while the municipality of Bongao (Tawi-Tawi) belongs to the Aquaculture/Coastal Fisheries LHZ. With the continuous change in climatic conditions, these islands may experience more intense and frequent sea-related hazards affecting resource availability and local livelihoods (Añasco, 2021). LGUs are urged to prioritize interventions such as plans and programs focused on developing disaster risk reduction measures and adaptation strategies (NEDA, 2018), tailored to address the projected impacts of hazards such as SS and SLR. Good examples of interventions tailored to SS and SLR are coastal protection through the Department of Environment and Natural Resources (DENR) – Enhanced National Greening Program (ENGP) which focuses on the restoration and protection of mangrove forests and coral reefs. Mangrove restoration will benefit local communities not only in terms of protection to SS and SLR, but it will also increase fish population and shellfish availability, which in turn can enhance the aquaculture-based livelihoods. LGUs are likewise encouraged to consider supplemental income generating activities that support livelihoods diversification. These may include activities such as food processing, and e-commerce that may complement the value chain of the major livelihood activities in the local areas.

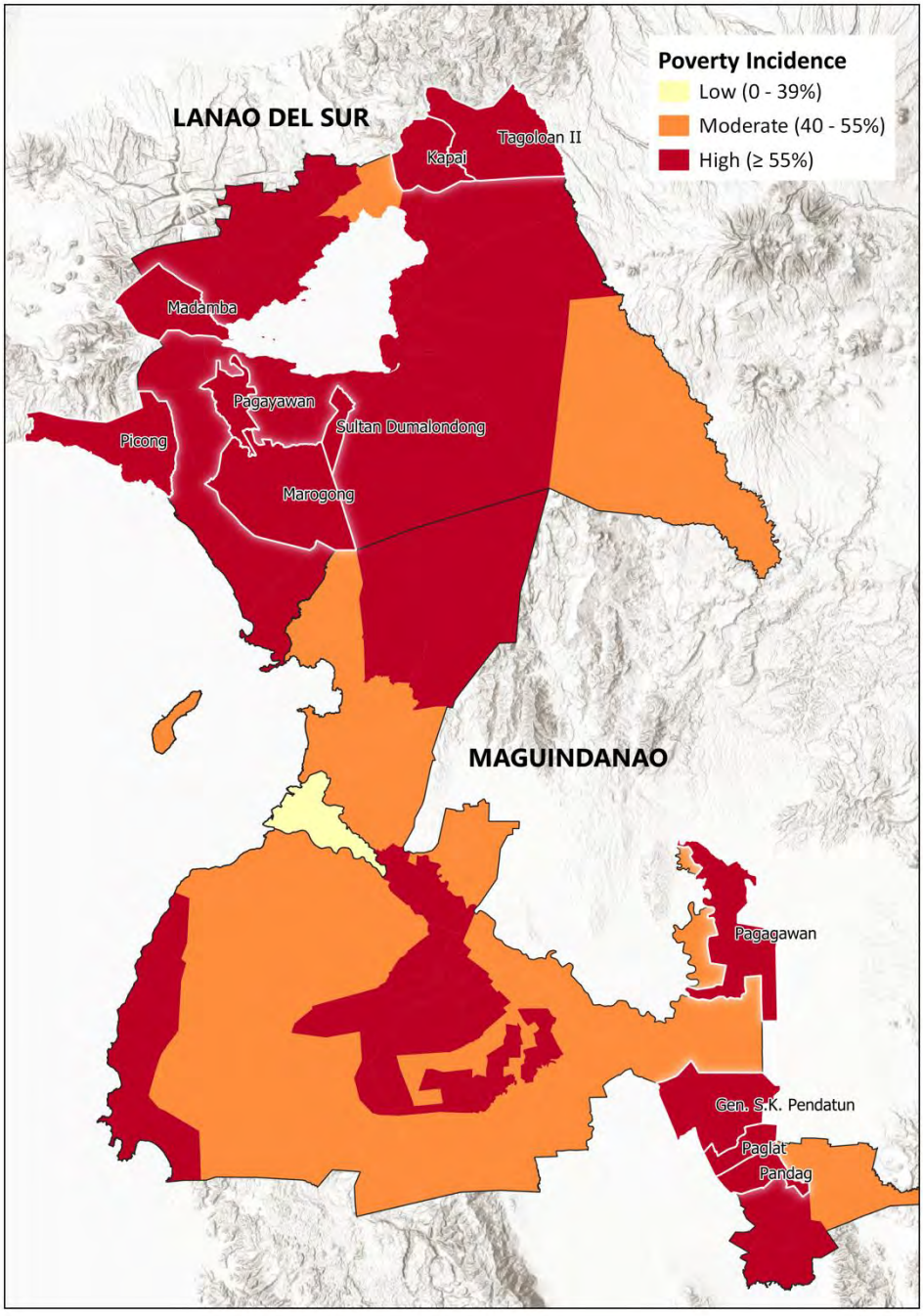
Figure 24. Level of population in the Island Group of BARMM and exposure to drought of the LHZs



Using the LHZ tool to support the development of plans for poverty alleviation:

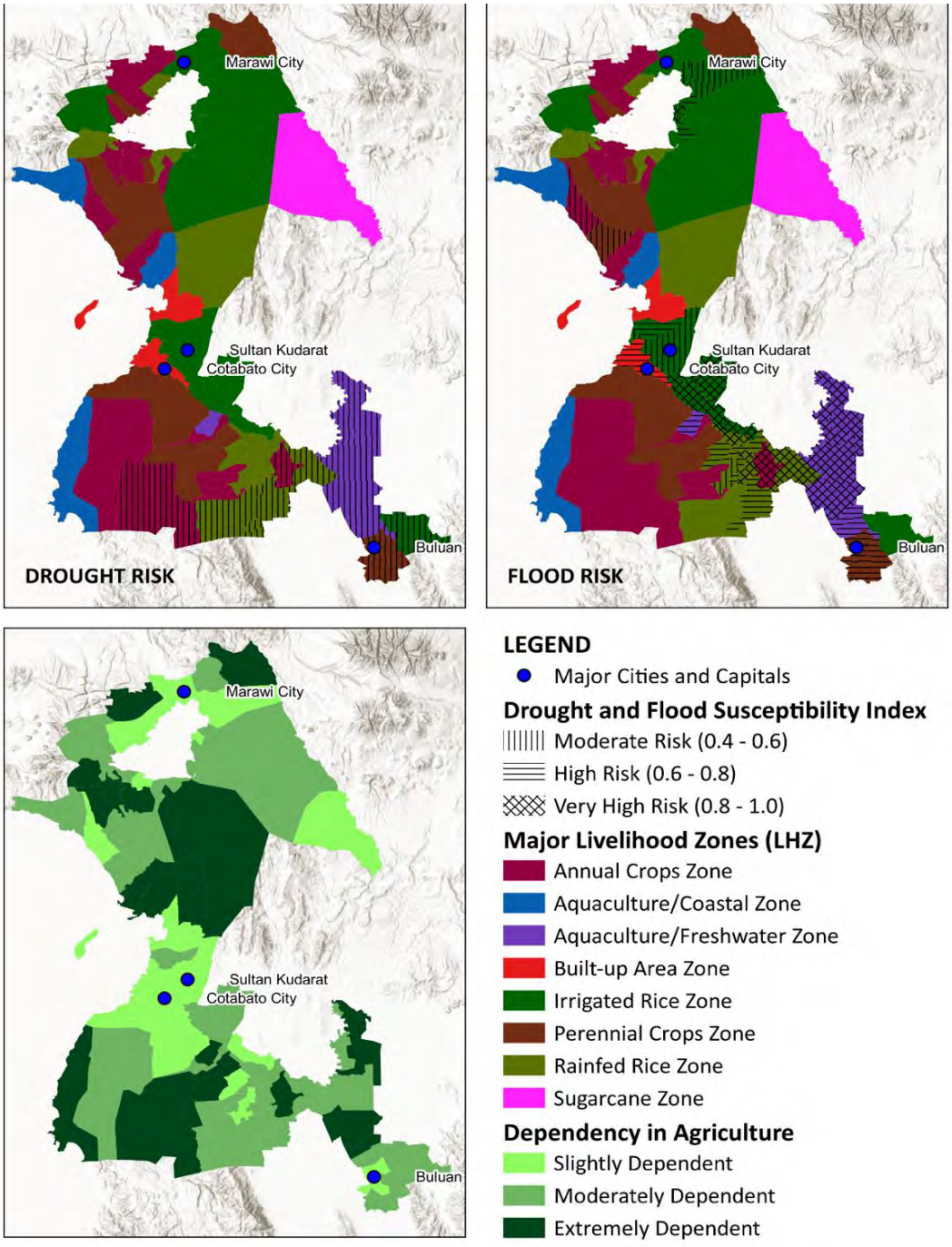
In 2015, Lanao del Sur was recorded as the poorest province in the Philippines wherein 71.9% or seven (7) out of 10 persons in the province lived below the poverty threshold (PSA, 2017). As shown in Figure 25, most of the areas in the province have moderate to high poverty incidences, particularly the municipalities of Kapai, Madamba, Marogong, Pagayawan, Picong, Tagoloan II, and Sultan Dumalondong which recorded poverty incidences greater than 70% (PSA, 2019). These municipalities comprised the poorest areas in the Philippines in 2015.

Figure 25. Poverty incidences of municipalities and cities in Lanao del Sur, Maguindanao del Norte, and Maguindanao del Sur in 2015 (PSA, 2017)



Using this data and the LHZ map, strategic plans to alleviate poverty can be drawn. Figure 26 shows that the seven (7) poorest municipalities in Lanao del Sur are extremely dependent[13] on agriculture. These areas are mainly Irrigated and Rainfed Rice LHZs; hence, prioritizing programs that will boost rice productivity is of prime importance.

Figure 26. Agriculture dependence and drought and flood susceptibility indices of municipalities/cities in BARMM



[13] Dependency in agriculture was computed by getting the ratio of the agricultural workers over the total population of the municipality, based on the available data of gainful workers with ages 15 years old above from PSA (2017).


Farmers and fisherfolks continue to be the poorest among the basic sectors in the Philippines. © WFP

A study by OECD (2011) showed that increasing agricultural productivity and income of farmers results to sustainable progress that reduces extreme poverty, particularly in developing countries such as the Philippines. However, the adverse impacts of climate change pose greater risks particularly to the poorest areas that heavily rely on farming. To address these problems, the local government needs to ensure that farmers have access to sustainable sources of irrigation, low-cost farm inputs, more efficient crop insurance system, and climate-resilient technologies, machineries, and equipment.

On the other hand, the province of Maguindanao (presently Maguindanao del Norte and Maguindanao del Sur) had the second highest poverty incidence (57.2%) in BARMM in 2015 according to PSA (2017). The municipalities of Paggawan, Gen S.K. Pendatum, Paglat, and Pandag, which were classified as Aquaculture/Freshwater LHZs, were also among the poorest areas in Maguindanao. These municipalities were also “moderately” susceptible to drought and “very highly” susceptible to flooding (Figure 25).

Aside from farmers, fisherfolks had the highest poverty incidence (34%) among the basic sectors in the Philippines in 2015 (PSA, 2017). At present, they remain to be the poorest of the poor with the highest poverty incidence at 30.6% (PSA, 2023). This data calls for the local government to support the development of fishery industries in the said municipalities. Given the persistent threats of climate change and the susceptibility of these poorest areas to hazards, it is necessary to invest in programs that will help increase the adaptive capacity of fisherfolks. According to FAO (n.d.), adaptation measures to sustain aquaculture production include change in aquaculture feed management – fishmeal and fish oil replacement, improvement on water-use efficiency and sharing efficacy (e.g., with rice paddy irrigators), and aquaculture infrastructure investments (e.g., nylon netting and raised dykes in flood-prone pond systems).

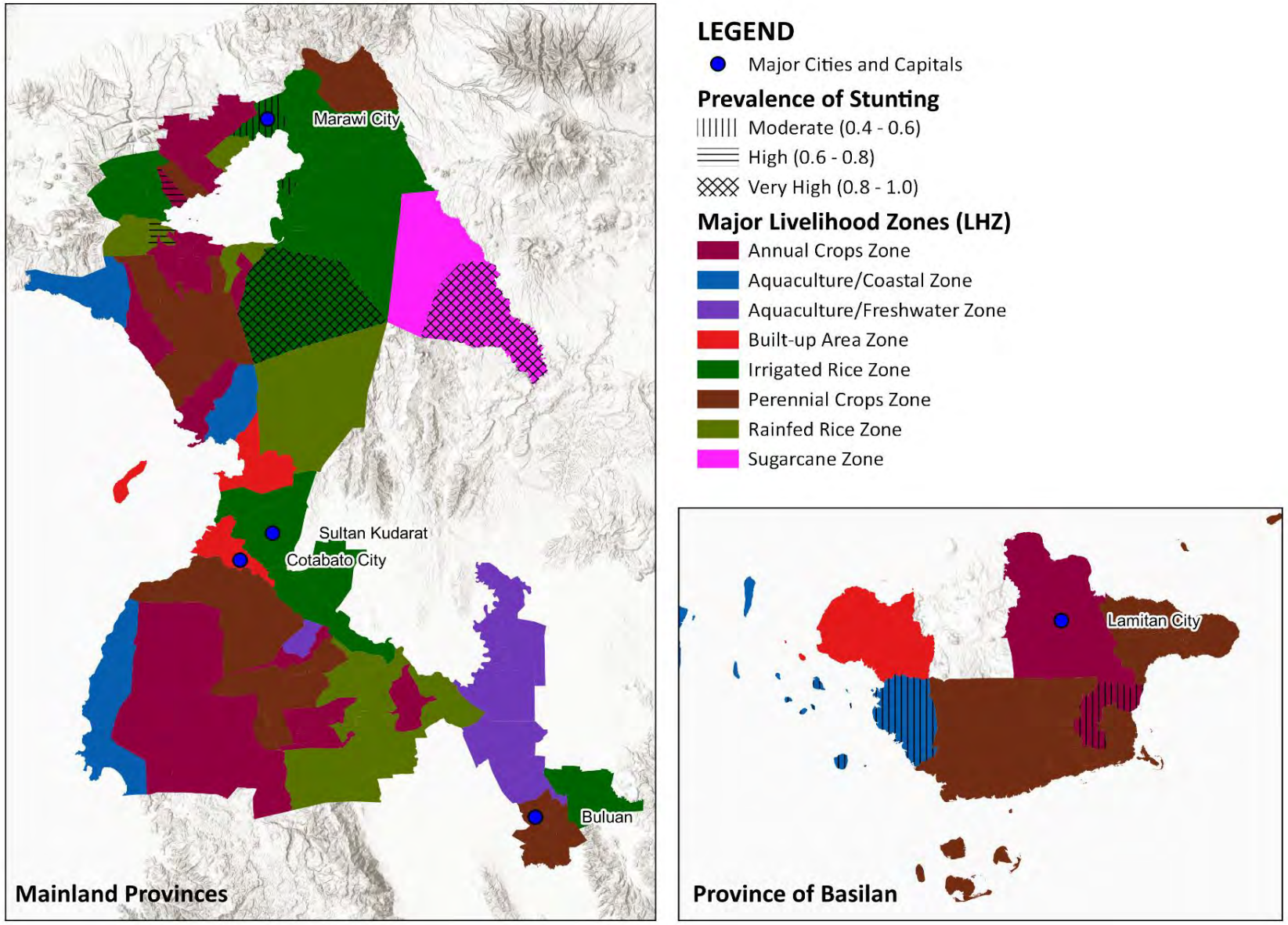
Using the LHZ tool to support the development of plans for improving health and nutrition: Stunting[14] is considered as one of the leading problems related to undernutrition, particularly among children in the Philippines. In BARMM, Figure 27 shows that there are low to moderate cases of stunting in the mainland provinces, except for the province of Lanao del Sur which has a moderate to high prevalence of the condition. Notably, very high cases of stunting were recorded in the municipalities of Butig and Wao, and moderate conditions were recorded in the city of Marawi and in the municipalities of Bacolod-Kalawi, Ganasi, and Taraka.

Generally, these areas are not exposed to climate-related hazards. The cases of undernutrition causing stunting, however, may be attributed to livelihood displacement and loss due to the Marawi conflict in 2018 (UNICEF Philippines, 2018). Similarly, limited access to healthcare facilities and disruption in food production systems due to the history of conflict in the province of Basilan (UNICEF, 2017) may explain why moderate cases of stunting are present in the municipalities of Maluso and Tipo-tipo (Figure 27).

Studies also show links between agriculture and stunting, particularly in conflict-prone areas. The study of Mary and Shaw (2020) revealed that 10% increases in agricultural GDP per capita significantly reduces child stunting by 2.9%. Moreover, Mary et. al. (2020) suggested that agricultural and food aid inflows are the most effective strategies to promote food security in conflict areas. Given that the cases of stunting in the provinces of Lanao del Sur and Basilan are situated in agricultural LHZs (Irrigated Rice LHZ, Rainfed Rice LHZ, Annual Crops LHZ and Aquaculture/Coastal LHZ) as shown in Figure 27, the aforementioned studies support the need to further boost agricultural development in these areas. Additionally, while climate-related hazards were found to not directly cause stunting of children in BARMM, climate-related hazards including flooding and drought may still impact major LHZs such as crops (rice and annual crops) and aquaculture areas that are crucial in food production. Therefore, it calls for the government and local policymakers to develop sustainable solutions towards mitigating the effects of climate change on agriculture to improve food production and ultimately, health and nutrition.

[14] Stunting is "the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation" (World Health Organization, 2015).

Figure 27. Prevalence of stunting in municipalities/cities in BARMM and their corresponding LHZs



5. Summary and Conclusion

This report highlights the research findings of the CCFSA in BARMM. Temporal and spatial risks and impacts of climate change on food security and nutrition were assessed through a modeling approach and spatial analysis using GIS. Specific areas and population that are most susceptible to climate change, particularly the types of livelihoods that will be most affected, were characterized in the report.

The LHZ map and its corresponding datasets were validated and refined as necessary. Secondary/Tertiary LHZ, as well as complementary activities, of all the municipalities in BARMM were well-defined and characterized in this report. Identification of these zones provides a more holistic view of the livelihood profile of BARMM and the various opportunities available in the region aside from its major LHZs.

The livelihood profile of BARMM shows that it remains to be an agriculture-based region relying largely on farming and fishing livelihoods, with limited commercial, industrial, and manufacturing activities. However, the analysis showed that climate-related hazards, particularly drought and flood, will continue to adversely impact agriculture, livestock, and aquaculture LHZs. Specifically, the municipalities under the Rainfed and Irrigated Rice LHZs are the most susceptible due to the specific requirements of rice farming in terms of water and soil management, and its preferred optimal condition in terms of temperature for the plant to grow.

Using crop models, future suitability of rice, maize, and banana were mapped under high GHG emissions scenarios. Results show that by the year 2050, existing areas will be generally less conducive for growing of these crops in BARMM due to the projected increase in temperature and changes in the amount of rainfall (mm). The variability and changes in temperature and rainfall patterns can also drive the spread and proliferation of pests and diseases, which may result in production losses and lower income among farmers.

These projected changes in temperature and amount of rainfall are also expected to directly affect oceanic systems resulting in induced sea-based hazards. These may have direct and indirect impacts on the abundance and distribution of fishery resources and the suitability of some areas dedicated to aquacultural production. Such phenomenon may affect many areas in BARMM given that second to agriculture, aquaculture-based activities were considered as the region's major livelihood.

For the livestock and poultry sector, climate change poses a risk to animal health and the viability of pasturelands and fodder crops that are used as animal feed. It will particularly have effects on the animal's growth and weight, reproductive performance, and susceptibility to pests and diseases.

Aquaculture is another major livelihood source in BARMM. In this photo, a woman feeds fish in a pond built by community members as part of FFA activities. © WFP/Dale Rivera

By integrating these climate risk datasets with the LHZ map, planners and decisionmakers can target specific locations of the livelihoods that are most at-risk to potential climate-related hazards. This will also give insights for food security monitoring and analysis, implementation of strategies leading to food and nutrition improvement, and development of plans and programs for poverty alleviation.

The findings also show that agriculture plays a significant role in the economy of BARMM. However, the region remains to be one of the poorest areas in the country and food insecurity continue to persist affecting health and nutrition of many families and individuals in BARMM. Moreover, analysis of climate risks and hazards reveal that climate change impacts will potentially disrupt crop productivity, and in turn affect domestic agricultural production, consumption, and food security in the region.

Given its high dependence in agriculture, developing climate change adaptation strategies to safeguard the sector from potential risks is of utmost importance not only to sustain production, but also to promote resilience and structural transformation among the most susceptible areas in the region. As agriculture faces several threats in the future, there is also a need to 1) remove dependency on only one form of livelihood, 2) diversify livelihoods and introduce other income generating activities through skills development and/or micro-enterprise development, and 3) integrate climate-resilient interventions into local policies, based on the prevailing susceptibility to climate risks. The LHZ map, together with other relevant databases, can serve as a tool to conduct a highly localized analysis of the impacts of climate change on specific livelihood groups which can support the development of appropriate adaptation strategies.

6. Recommendations

The report aimed at understanding the potential impacts of climate change on the livelihoods in the context of BARMM, demonstrating the role of livelihoods on food security of the population in this region. Using this report, further studies can be built that can further help in addressing vital issues related to climate change, food security, nutrition, and gender and development.

Integration of Climate Risk and Vulnerability Assessment (CRVA): This assessment encompasses the identification and analysis of key climate risks, as well as the adaptive capacity or ability of the population to cope with or adapt to climate change impacts. This integration can provide a more holistic view on the vulnerabilities of an area and its corresponding livelihoods which has a significant implication to food security and nutrition.

Inclusion of Data on Yield for Key Crops: Using data on current yield and historical trends on food production can facilitate a more comprehensive analysis of the projected impacts of future climate scenarios on the performance of a crop. Ultimately, such data is useful to identify factors that can directly and indirectly affect food production and security.

Use of Granular Data on Nutrition: A comprehensive understanding of the nutritional status of the region will help policy makers enable a more targeted policy to enhance and prioritize the production of more diverse food sources. It is crucial to assess availability and accessibility of food, especially that both are affected by crop suitability in the area. Hence, the use of higher resolution and more defined data on nutrition at the local level is crucial to further promote food security.

Inclusion of Gender in Agriculture: Understanding the nexus between gender, climate change, and agriculture, and incorporating it to the development of agricultural plans and programs ensures social inclusivity, equality, and equity. While climate change impacts affect everyone, several studies have shown that women farmers are more exposed to climate risks due to unequal gender relations within households and communities particularly in developing countries such as the Philippines. Hence, integrating gender considerations in the analysis will provide a more holistic approach in developing gender-responsive and climate-resilient livelihoods and communities.

It is also recommended that the findings of the study be shared to as many communities as possible to provide more information about climate change and its impact on food security and help individuals and groups at the local level to make guided decision about their livelihood activities. While doing these dissemination activities, it would also be advisable to undertake dialogues with local people using both quantitative and qualitative methods to generate more up-to-date information that can further reinforce the current analysis. The information that will be gathered can then help the study elaborate more on other issues like overgrazing and soil erosion and degradation and come up with more appropriate knowledge products like a seasonal calendar simulating the impact of climate change at present and in the near future.

Through WFP's FFA activities, Bangsamoro women participate in building community-based assets that improve livelihoods, food and nutrition security, and climate resilience. © WFP

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ANNEX 1: List of BARMM Livelihood Zones

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Basilan	Akbar	Perennial Crops Zone	aquaculture/coastal fisheries, vegetable farming	livestock/pasture
BARMM	Basilan	Al-Barka	Perennial Crops Zone	vegetable farming	
BARMM	Basilan	City of Lamitan	Annual Crops Zone	built-up areas and tourism	
BARMM	Basilan	Hadji Mohammad Ajul	Perennial Crops Zone		livestock/pasture
BARMM	Basilan	Hadji Muhtamad	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture
BARMM	Basilan	Lantawan	Built-up Area Zone	aquaculture/coastal fisheries, perennial crops, irrigated rice, vegetable farming, and tourism	
BARMM	Basilan	Maluso	Aquaculture/Coastal Zone	vegetable farming and tourism	
BARMM	Basilan	Sumisip	Perennial Crops Zone	aquaculture/coastal fisheries, vegetable farming	livestock/pasture
BARMM	Basilan	Tabuan-Lasa	Perennial Crops Zone	aquaculture/coastal fisheries and vegetable farming	
BARMM	Basilan	Tipo-Tipo	Annual Crops Zone	built-up areas	
BARMM	Basilan	Tuburan	Perennial Crops Zone	aquaculture/coastal fisheries, vegetable farming	livestock/pasture
BARMM	Basilan	Ungkaya Pukan	Perennial Crops Zone	aquaculture/coastal fisheries and vegetable farming	
BARMM	Cotabato City	Cotabato City	Built-up Area Zone	aquaculture/coastal zone, vegetable farming, and tourism	
BARMM	Lanao del Sur	Bacolod-Kalawi	Annual Crops Zone	perennial crops	
BARMM	Lanao del Sur	Balabagan	Perennial Crops Zone	aquaculture/coastal fisheries, vegetable farming	livestock/pasture

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Lanao del Sur	Balindong	Annual Crops Zone	perennial crops, rainfed rice	livestock/pasture
BARMM	Lanao del Sur	Bayang	Annual Crops Zone	aquaculture/coastal fisheries, perennial crops, and rainfed rice	
BARMM	Lanao del Sur	Binidayan	Annual Crops Zone	aquaculture/coastal fisheries, perennial crops, and rainfed rice	
BARMM	Lanao del Sur	Buadiposo-Buntong	Irrigated Rice Zone	aquaculture/coastal fisheries	
BARMM	Lanao del Sur	Bubong	Irrigated Rice Zone		
BARMM	Lanao del Sur	Bumbaran	Sugarcane Zone	aquaculture/coastal fisheries, perennial crops, and vegetable farming	
BARMM	Lanao del Sur	Butig	Irrigated Rice Zone	perennial crops and vegetable farming	
BARMM	Lanao del Sur	Calanogas	Perennial Crops Zone	rainfed rice	
BARMM	Lanao del Sur	Ditsaan-Ramain	Irrigated Rice Zone		
BARMM	Lanao del Sur	Ganassi	Rainfed Rice Zone	perennial crops and vegetable farming	
BARMM	Lanao del Sur	Kapai	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Kapatagan	Annual Crops Zone	irrigated rice and vegetable farming	
BARMM	Lanao del Sur	Lumba-Bayabao	Irrigated Rice Zone	perennial crops and vegetable farming	
BARMM	Lanao del Sur	Lumbaca-Unayan	Perennial Crops Zone	vegetable farming	
BARMM	Lanao del Sur	Lumbatan	Rainfed Rice Zone	perennial crops and vegetable farming	
BARMM	Lanao del Sur	Lumbayanague	Rainfed Rice Zone	perennial crops and vegetable farming	
BARMM	Lanao del Sur	Madalum	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Madamba	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Maguing	Irrigated Rice Zone	vegetable farming	

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Lanao del Sur	Malabang	Annual Crops Zone	aquaculture/coastal fisheries and perennial crops	
BARMM	Lanao del Sur	Marantao	Rainfed Rice Zone	aquaculture/coastal fisheries and vegetable farming	
BARMM	Lanao del Sur	Marawi City	Irrigated Rice Zone	built-up areas (commercial) and vegetable farming	
BARMM	Lanao del Sur	Marogong	Perennial Crops Zone	vegetable farming and rainfed rice	
BARMM	Lanao del Sur	Masiu	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Mulondo	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Pagayawan	Annual Crops Zone	irrigated rice and perennial crops	
BARMM	Lanao del Sur	Piagapo	Annual Crops Zone	irrigated rice	
BARMM	Lanao del Sur	Picong	Aquaculture/Coastal Zone	perennial crops and rainfed rice	
BARMM	Lanao del Sur	Poona Bayabao	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Pualas	Rainfed Rice Zone	aquaculture/coastal fisheries	
BARMM	Lanao del Sur	Saguiaran	Annual Crops Zone	perennial crops	
BARMM	Lanao del Sur	Sultan Dumalondong	Annual Crops Zone	irrigated rice	
BARMM	Lanao del Sur	Tagoloan II	Perennial Crops Zone	irrigated rice	
BARMM	Lanao del Sur	Tamparan	Irrigated Rice Zone		
BARMM	Lanao del Sur	Taraka	Irrigated Rice Zone	vegetable farming	
BARMM	Lanao del Sur	Tubaran	Annual Crops Zone	perennial crops and rainfed rice	
BARMM	Lanao del Sur	Tugaya	Perennial Crops Zone	vegetable farming	
BARMM	Lanao del Sur	Wao	Sugarcane Zone	irrigated Rice, perennial crops, and rainfed rice	

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Maguindanao del Sur	Ampatuan	Rainfed Rice Zone	perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Barira	Rainfed Rice Zone	perennial crops, vegetable farming, and tourism	
BARMM	Maguindanao del Norte	Buldon	Rainfed Rice Zone	perennial crops, vegetable farming, and tourism	
BARMM	Maguindanao del Sur	Buluan	Perennial Crops Zone	aquaculture/freshwater fisheries, irrigated rice, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Sur	Datu Abdullah Sangki	Rainfed Rice Zone	perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Datu Anggal Midtimbang	Annual Crops Zone	irrigated rice, perennial crops, rainfed rice	livestock/pasture
BARMM	Maguindanao del Norte	Datu Blah T. Sinsuat	Aquaculture/Coastal Zone	perennial crops, rainfed rice	
BARMM	Maguindanao del Sur	Datu Hoffer Ampatuan	Annual Crops Zone	irrigated rice and rainfed rice	
BARMM	Maguindanao del Norte	Datu Odin Sinsuat	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Maguindanao del Sur	Datu Paglas	Irrigated Rice Zone	perennial crops, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Sur	Datu Piang	Irrigated Rice Zone	built-up areas (commercial), aquaculture/freshwater fisheries, perennial crops, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Sur	Datu Salibo	Rainfed Rice Zone	aquaculture/freshwater fisheries, perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Datu Saudi-Ampatuan	Rainfed Rice Zone	perennial crops, irrigated rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Datu Unsay	Annual Crops Zone	perennial crops and rainfed rice	

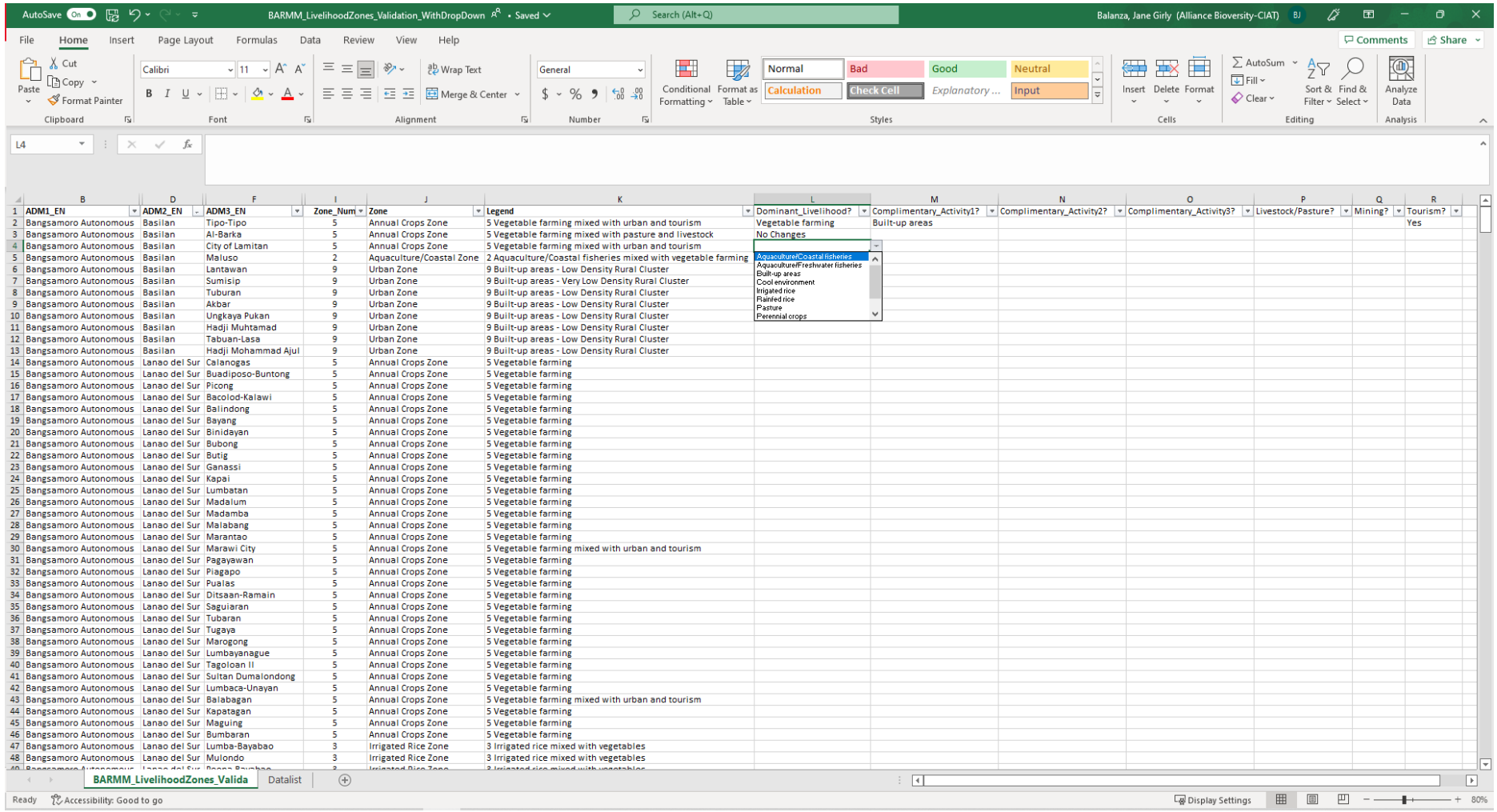
Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Maguindanao del Sur	Gen. S.K. Pendatun	Aquaculture/Freshwater Zone	perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Guindulungan	Perennial Crops Zone	irrigated rice, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Kabuntalan	Irrigated Rice Zone	built-up areas (commercial), aquaculture/freshwater fisheries, perennial crops, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Sur	Mamasapano	Rainfed Rice Zone	perennial crops, irrigated rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Mangudadatu	Perennial Crops Zone	aquaculture/freshwater fisheries, irrigated rice, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Norte	Matanog	Aquaculture/Coastal Zone	perennial crops, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Norte	Northern Kabuntalan	Irrigated Rice Zone	aquaculture/freshwater fisheries, rainfed rice, and vegetable farming	
BARMM	Maguindanao del Sur	Pagagawan/Datu Montawal	Aquaculture/Freshwater Zone	perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Pagalungan	Aquaculture/Freshwater Zone	perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Paglat	Aquaculture/Freshwater Zone	perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Pandag	Aquaculture/Freshwater Zone	perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Parang	Built-up Area Zone (free ports and special economic zones)	aquaculture/coastal fisheries, irrigated rice, perennial crops, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Rajah Buayan	Annual Crops Zone	rainfed rice	

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Maguindanao del Sur	Shariff Aguak	Rainfed Rice Zone	perennial crops, irrigated rice, and vegetable farming	
BARMM	Maguindanao del Sur	Shariff Saydona Mustapha	Rainfed Rice Zone	perennial crops, irrigated rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	South Upi	Annual Crops Zone	irrigated rice, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Sultan Kudarat	Irrigated Rice Zone	aquaculture/coastal fisheries, perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Sultan Mastura	Irrigated Rice Zone	aquaculture/coastal fisheries, perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Sultan Sa Barongis	Rainfed Rice Zone	aquaculture/freshwater fisheries, perennial crops, vegetable farming	livestock/pasture
BARMM	Maguindanao del Sur	Talayan	Perennial Crops Zone	irrigated rice, rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Talitay	Aquaculture/Freshwater Zone	rainfed rice, vegetable farming	livestock/pasture
BARMM	Maguindanao del Norte	Upi	Annual Crops Zone	irrigated rice, rainfed rice, vegetable farming	livestock/pasture
BARMM	Sulu	Hadji Panglima Tahil	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Indanan	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Jolo	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Kalingalan Caluang	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Lugus	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Sulu	Luuk	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Maimbung	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Old Panamao	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Omar	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Pandami	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Panglima Estino	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Pangutaran	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Parang	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Pata	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Patikul	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Siasi	Perennial Crops Zone	built-up areas (commercial), aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Talipao	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, rainfed rice, vegetable farming	livestock/pasture, and tourism
BARMM	Sulu	Tapul	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, vegetable farming	livestock/pasture, and tourism

Region	Province	City/ Municipality	Major LHZ	Secondary/Tertiary LHZ	Complementary Activity
BARMM	Sulu	Tongkil	Perennial Crops Zone	aquaculture/coastal fisheries, irrigated rice, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	Bongao	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	Languyan	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture, mining, and tourism
BARMM	Tawi-Tawi	Mapun	Aquaculture/Coastal Zone	perennial crops, and vegetable farming	
BARMM	Tawi-Tawi	Panglima Sugala	Perennial Crops Zone	vegetable farming	
BARMM	Tawi-Tawi	Sapa-Sapa	Aquaculture/Coastal Zone	perennial crops, vegetable farming, and tourism	
BARMM	Tawi-Tawi	Sibutu	Aquaculture/Coastal Zone	built-up areas (manufacturing), perennial crops, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	Simunul	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	Sitangkai	Aquaculture/Coastal Zone	built-up areas (trading) perennial crops, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	South Ubian	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture, and tourism
BARMM	Tawi-Tawi	Tandubas	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture
BARMM	Tawi-Tawi	Turtle Islands	Aquaculture/Coastal Zone	perennial crops, vegetable farming	livestock/pasture, and tourism

ANNEX 2: Sample Validation Form



	B	D	F	I	J	K	L	M	N	O	P	Q	R
1	ADM1_EN	ADM2_EN	ADM3_EN	Zone_Num	Zone	Legend	Dominant_Livelihood?	Complimentary_Activity1?	Complimentary_Activity2?	Complimentary_Activity3?	Livestock/Pasture?	Mining?	Tourism?
2	Bangsamoro Autonomous	Basilan	Tipo-Tipo	5	Annual Crops Zone	5 Vegetable farming mixed with urban and tourism	Vegetable farming	Built-up areas					Yes
3	Bangsamoro Autonomous	Basilan	Al-Barka	5	Annual Crops Zone	5 Vegetable farming mixed with pasture and livestock	No Changes						
4	Bangsamoro Autonomous	Basilan	City of Lamitan	5	Annual Crops Zone	5 Vegetable farming mixed with urban and tourism							
5	Bangsamoro Autonomous	Basilan	Maluso	2	Aquaculture/Coastal Zone	2 Aquaculture/Coastal fisheries mixed with vegetable farming							
6	Bangsamoro Autonomous	Basilan	Lantawan	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
7	Bangsamoro Autonomous	Basilan	Sumisip	9	Urban Zone	9 Built-up areas - Very Low Density Rural Cluster							
8	Bangsamoro Autonomous	Basilan	Tuburan	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
9	Bangsamoro Autonomous	Basilan	Akbar	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
10	Bangsamoro Autonomous	Basilan	Ungkaya Pukan	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
11	Bangsamoro Autonomous	Basilan	Hadji Muhtamad	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
12	Bangsamoro Autonomous	Basilan	Tabuan-Lasa	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
13	Bangsamoro Autonomous	Basilan	Hadji Mohammad Ajul	9	Urban Zone	9 Built-up areas - Low Density Rural Cluster							
14	Bangsamoro Autonomous	Lanao del Sur	Calanogas	5	Annual Crops Zone	5 Vegetable farming							
15	Bangsamoro Autonomous	Lanao del Sur	Buadiposo-Buntong	5	Annual Crops Zone	5 Vegetable farming							
16	Bangsamoro Autonomous	Lanao del Sur	Picong	5	Annual Crops Zone	5 Vegetable farming							
17	Bangsamoro Autonomous	Lanao del Sur	Bacolod-Kalawi	5	Annual Crops Zone	5 Vegetable farming							
18	Bangsamoro Autonomous	Lanao del Sur	Balindong	5	Annual Crops Zone	5 Vegetable farming							
19	Bangsamoro Autonomous	Lanao del Sur	Bayang	5	Annual Crops Zone	5 Vegetable farming							
20	Bangsamoro Autonomous	Lanao del Sur	Binidayan	5	Annual Crops Zone	5 Vegetable farming							
21	Bangsamoro Autonomous	Lanao del Sur	Bubong	5	Annual Crops Zone	5 Vegetable farming							
22	Bangsamoro Autonomous	Lanao del Sur	Butig	5	Annual Crops Zone	5 Vegetable farming							
23	Bangsamoro Autonomous	Lanao del Sur	Ganassi	5	Annual Crops Zone	5 Vegetable farming							
24	Bangsamoro Autonomous	Lanao del Sur	Kapai	5	Annual Crops Zone	5 Vegetable farming							
25	Bangsamoro Autonomous	Lanao del Sur	Lumbatan	5	Annual Crops Zone	5 Vegetable farming							
26	Bangsamoro Autonomous	Lanao del Sur	Madalum	5	Annual Crops Zone	5 Vegetable farming							
27	Bangsamoro Autonomous	Lanao del Sur	Madamba	5	Annual Crops Zone	5 Vegetable farming							
28	Bangsamoro Autonomous	Lanao del Sur	Malabang	5	Annual Crops Zone	5 Vegetable farming							
29	Bangsamoro Autonomous	Lanao del Sur	Marantao	5	Annual Crops Zone	5 Vegetable farming							
30	Bangsamoro Autonomous	Lanao del Sur	Marawi City	5	Annual Crops Zone	5 Vegetable farming mixed with urban and tourism							
31	Bangsamoro Autonomous	Lanao del Sur	Pagayawan	5	Annual Crops Zone	5 Vegetable farming							
32	Bangsamoro Autonomous	Lanao del Sur	Piagapo	5	Annual Crops Zone	5 Vegetable farming							
33	Bangsamoro Autonomous	Lanao del Sur	Pualas	5	Annual Crops Zone	5 Vegetable farming							
34	Bangsamoro Autonomous	Lanao del Sur	Ditsaan-Ramain	5	Annual Crops Zone	5 Vegetable farming							
35	Bangsamoro Autonomous	Lanao del Sur	Saguiaran	5	Annual Crops Zone	5 Vegetable farming							
36	Bangsamoro Autonomous	Lanao del Sur	Tubaran	5	Annual Crops Zone	5 Vegetable farming							
37	Bangsamoro Autonomous	Lanao del Sur	Tugaya	5	Annual Crops Zone	5 Vegetable farming							
38	Bangsamoro Autonomous	Lanao del Sur	Marogong	5	Annual Crops Zone	5 Vegetable farming							
39	Bangsamoro Autonomous	Lanao del Sur	Lumbayanague	5	Annual Crops Zone	5 Vegetable farming							
40	Bangsamoro Autonomous	Lanao del Sur	Tagoloan II	5	Annual Crops Zone	5 Vegetable farming							
41	Bangsamoro Autonomous	Lanao del Sur	Sultan Dumalondong	5	Annual Crops Zone	5 Vegetable farming							
42	Bangsamoro Autonomous	Lanao del Sur	Lumbaca-Unayan	5	Annual Crops Zone	5 Vegetable farming							
43	Bangsamoro Autonomous	Lanao del Sur	Balabagan	5	Annual Crops Zone	5 Vegetable farming mixed with urban and tourism							
44	Bangsamoro Autonomous	Lanao del Sur	Kapatagan	5	Annual Crops Zone	5 Vegetable farming							
45	Bangsamoro Autonomous	Lanao del Sur	Maguing	5	Annual Crops Zone	5 Vegetable farming							
46	Bangsamoro Autonomous	Lanao del Sur	Bumbaran	5	Annual Crops Zone	5 Vegetable farming							
47	Bangsamoro Autonomous	Lanao del Sur	Lumba-Bayabao	3	Irrigated Rice Zone	3 Irrigated rice mixed with vegetables							
48	Bangsamoro Autonomous	Lanao del Sur	Mulondo	3	Irrigated Rice Zone	3 Irrigated rice mixed with vegetables							

Aquaculture/Coastal fisheries
Aquaculture/Freshwater fisheries
Built-up areas
Cool environment
Irrigated rice
Rainfed rice
Pasture
Perennial crops

ANNEX 3: Photo Documentation

The group of participants from MAFAR-BARMM headed by Mr. Tong Abas, Director II, during the characterization of the dominant livelihoods per municipality. © CIAT/Alie Galeon

BARMM small group 1 convenes to finalize their preliminary evaluation of livelihoods and climate landscape in the region. © CIAT/Alie Galeon

ANNEX 3: Photo Documentation

BARMM small group 2 discusses the list of their province-municipality to be reviewed for the livelihood zones preliminary evaluation. © CIAT/Alie Galeon

MOLE Planning Chief Ramil Tiolo presents his group's initial assessment of livelihood activities and climate risks per municipality and province in BARMM. © CIAT/Alie Galeon

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