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Vulnerability assessment of agri-aqua production areas for climate resilient communities and livelihoods in Cagayan, Philippines

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Abstract

The Cagayan province, being bounded by mountain ranges and traversed by the great Cagayan River, is vulnerable to different climate hazards. Most of which are typhoons which further cause more destructive aftermaths such as flooding, soil erosion, pests and diseases, economic crises, and others. These incur great losses not only on agriculture, fisheries and infrastructures, but also on human lives. With these, strategies and practices to increase the level of awareness of the communities on the perils brought about by climate change shall be adapted. This paper addresses these problems through vulnerability assessment and mapping using Geographic Information System (GIS) to identify the level of vulnerability of three selected municipalities in the province, with regards to their agriculture and aquaculture production systems. Vulnerability indicators from each study sites and their respective barangays were identified and the vulnerability indices of each were obtained. From this information, vulnerability maps were generated. These maps identify the hazards experienced in each study site, the frequency of hazard occurrence and the level of their vulnerability of each area to these hazards. The maps will also guide policy makers and the government on adopting climate resilient practices and technologies that could help mitigate the adverse effects of changing climate patterns in agri-aquaculture sectors.

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Introduction

Cagayan Valley is the largest political administrative region located within the Cagayan River Basin. The river basin is the largest catchment area in the Philippines covering about 273 hectares. It stretches from the province of Cagayan up to the mountains of the province of Aurora, bounding 127 municipalities. With agriculture as the primary economic sector in the region, the impacts of climate change are extremely affecting the majority of the population that depends much of their livelihoods in various agri-aqua production activities. Accordingly, the Office of Civil Defense (OCD) in Cagayan Valley Region (Region 2), reported that the total damages due to floods alone from 2004 to 2006 reached about Php 4.57 billion. Ninety percent (90%) of which is accounted for damages to agriculture. Other climate change events other than flooding also have overwhelming socio-economic impacts.

Vulnerability and adaptive capacity assessment for agriculture is a method for assessing vulnerability of agricultural production systems and communities to climate change based on the interaction of three factors: (a) exposure to climate hazards, (b) sensitivity to damages that the hazard may bring, and (c) the adaptive capacity to cope with the adversities (IPCC, 2001). As a tool, it was designed to capture baseline information on local climate scenario, extreme weather events pattern, income sources and community resilience, cropping practices (cropping calendar and management), crop requirements, behavior abnormalities and tolerance to weather extremes and the adaptation practices of the community including the efficiency, cost and practicality of the different management options applied. It can also be helpful in prioritizing needs, alternatives and planning appropriate actions for a better informed decision towards climate-resilient communities and livelihoods (Garcia *et al.*, 2010).

In this study, the vulnerability indicators from three (3) representative municipalities of Cagayan with regards to their agri and aquaculture production areas were identified. The vulnerability indices for each indicator were calculated and tabulated. Information gathered from focus group discussions, key informant interviews, field validations and other data provided by the local government units and agencies were analyzed and used in generating vulnerability maps. These maps will greatly help the national and local government units in decision-making on which climate change mitigation practices and technologies to adapt and improve existing policies and programs. It will help increase the level of disaster-preparedness of the community and mitigate the adverse effects of climate change to reduce losses in the agri-aqua sectors.

Materials and methods

Site selection and scoping

Three (3) municipalities in the province of Cagayan were selected as study sites based on their vulnerability to climate change resiliency and potential for agriculture and fisheries development. These are the municipalities of Amulung, Camalaniugan and Gonzaga. Several meetings with the local government officials: Municipal Mayor, Municipal Agriculture Officer (MAO), Municipal Environment and Resources Officer (MEnRO), Municipal Planning and Development Officer (MPDO), Municipal Disaster Risk Reduction and Management Officer (MDRRMO) in three separate sessions to serve as courtesy call and to provide project briefing for the different stakeholders of the study.

Focus Group Discussion and Key Informant Interview

Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted for each study site. The participants were the stakeholders of the project including the Local Government Units (LGUs) and the citizens who are directly involved in agri-aqua production areas. Questionnaires were used as tools in gathering information on the different hazards that the communities experienced. Highly technical terminologies were explained and other hindering factors on the understanding of the questions were addressed.

Computation of Vulnerability Indices

The vulnerability of an area for every hazard was determined using three components: sensitivity, exposure and adaptive capacity. Sensitivity accounts the biophysical characteristics of an area. It is interpreted by the amount of rainfall, the number of rivers, the soil type, elevation, slope, and other physical properties of an area. It also considers the stage of crop production as to when a hazard usually occurs. Exposure is the identification of climate hazards for the last three to five years. It includes data such as the number of affected households, extent of damage of the hazards, and others. The frequency of a climate hazard determines its importance. Adaptive capacity evaluates the awareness of the community and the mitigation procedures they have adapted such as early warning systems, evacuation centers, updated hazard maps, and insurances of farmers if there are any (Garcia, *et al.,* 2010).

In sensitivity and exposure, the scores are 0.2 (Very Low), 0.4 (Low), 0.6 (Moderate), 0.8 (High) and 1.0 (Very High). For Adaptive Capacity component, the scores are 1.0 (Very Low), 0.8 (Low), 0.6 (Moderate), 0.4 (High) and 0.2 (Very High). The average value for each component scores was obtained. The vulnerability index was computed using Equation 1:

Eq. (1) $Vulnerability\ Index\ (VI) = (S \times 30\%) + (E \times 30\%) + (AC \times 40\%)$

Where: S = Average of the values under sensitivity
E = Average of the values under exposure
AC = Average of the values under adaptive capacity

Vulnerability Mapping

The obtained vulnerability indices and the data gathered from FGDs and KIIs were used in generating vulnerability maps through ArcGIS 10.3. These maps show the level of vulnerability and hazard occurrences on each study site with regards to their agri-aqua production areas.

Data Validation

The generated maps were validated for errors with the help of the municipal officials and field officers for all three study sites. The identified errors were taken into account and corrections were applied for further revision of the maps. Focal survey and on-site validation were done to ensure the quality, accuracy and validity of the maps.

Results and discussion

Study Site Description

Location

The municipality of Amulung (17° 50' 17" N; 121° 43' 32" E) is a second class municipality with a total land area of 24, 220 hectares covering 47 barangays. It is divided into two districts centrally dissected by the Cagayan River. The municipality of Camalaniugan (18°16’5” N; 121 ° 40’57” E) is bounded by four (4) other municipalities. On its North is the municipality of Aparri, on its south is Lal-lo, Buguey on its east and Allacapan on its west. It is politically subdivided into twenty-eight (28) barangays. The municipality of Gonzaga (18°15’40” N; 120 59’49” E) is located on the northeastern tip of Cagayan, bounded by two bodies of water and three municipalities.. It is the fifth largest town in the province representing approximately 6.30% (56,743 has.) of the total provincial land area. The municipality is composed of twenty-five (25) barangays.

Elevation

Amulung is characterized by complex geographical features such as broad alluvial plains, low-lying hills, mountain ranges and level or flat surfaces with low relief. Similar to the municipality of Camalaniugan, majority of its land area falls under elevation <100 meters ASL, characterized with the following topography such as very low relief, low relief, flat and gently sloping relief. Gonzaga is a mixture of various land terrains classified as: lowland (elevation <100 m ASL), gently sloping to sloping land (100-300m ASL), sloping hilly land (300-500m ASL) and hilly to mountainous land (500-1,000m ASL).

Slope

It can be observed that most of the land area in the municipality of Amulung has level to nearly level (0-3%) slope. In its eastern and western parts are moderately undulating to rolling lands and level to gently sloping lands at its center. The areas with very steep slopes are where the mountains bordering the town’s eastern and western parts are located.

The terrain of Camalaniugan is classified into three categories represented as M, N and O. Slope category M is described as level to very gently sloping lands with a slope range of 0-3% (7,251.04 has.), N represents the gently sloping to undulating land with a slope range of 3 to 8% (1,532.13 hectares) and O which is best described as undulating to rolling lands with a slope range of 8-15% (499.37 has.). Gonzaga is a mixture of lowlands (0-3% slope), gently sloping to sloping lands (8-18%), sloping to hilly lands (18-30%), and hilly to mountainous lands (30-50%). Almost 49% of its total municipal land area has a rolling slope.

Soil

Amulung has ten soil series, six for Camalaniugan and ten for Gonzaga to include beach sand.

Rainfall and Temperature

The two weather stations in the province are in Aparri and Tuguegarao. The weather data in Amulung are based from the Tuguegarao data and the weather data in Camalaniugan and Gonzaga are based from Aparri. Tuguegarao has a daily temperature averaging from 22 to 29.8 degrees Celsius (25 year average) with highest temperature reading of 40.7 degrees Celsius during the year 1995. Aparri experiences temperatures averaging from 24 to 29.6 degrees Celsius (20 year average) and peak of the wet season during November. Both Aparri and Tuguegarao experiences almost the same amount of rainfall during the peak of wet season, almost 300 mm (Fig. 7).

Vulnerability/Risk Assessment and Mapping

Indicators used to assess vulnerability per hazard

All three project sites have fisheries and aquaculture systems. Amulung and Camalaniugan culture *Tilapia* in freshwater ecosystems such as the Cagayan River and the Small Farm Reservoirs (SFRs) and Small Water Impounding Projects (SWIPs) that were installed by the government as supports for rice production; Gonzaga utilizes river tributaries and the Balintang Channel to culture fresh and brackish water organisms such as *tilapia*, mudcrab and milkfish. As experienced by each study sites in their production areas, the following hazards were identified: siltation, typhoon, temperature increase, storm surge, erosion on coastal areas and fish kill. For their agriculture production areas, soil erosion, flood, drought/heat stress, pests and diseases, sea level rise, and typhoons were identified as hazards.

Vulnerability Indices

The vulnerability indices for the three study sites were obtained through FGD and KII using vulnerability indicators. These were measured using the sensitivity, exposure and adaptive capacity components of each sites. Tables 1, 2 and 3 shows the vulnerability indices of selected barangays in the three municipalities.

Table 1. Vulnerability indices of hazards in selected barangays of Amulung, Cagayan (Agriculture and Fishery sector).

Barangay	Agriculture				Fishery	
	Soil Erosion	Pest and Diseases	Drought	Flooding	Typhoon	Siltation
Abolo	0.93	0.91	0.72	0.93	0.79	0.73
Agguirit	0.91	0.93	0.55	0.91	0.48	0.71
Annabuculan	0.92	0.81	0.24	0.79	0.74	0.79
Annafatan	0.21	0.75	0.22	0.76	0.74	0.83
Anquiray	0.92	0.91	0.73	0.91	0.91	0.55
Babayuan	0.91	0.91	0.79	0.91	0.52	0.65
Baccuit	0.91	0.91	0.72	0.92	0.71	0.73
Bacring	0.32	0.48	0.74	0.47	0.59	0.62
Baculud	0.61	0.57	0.74	0.57	0.62	0.23
Balauini	0.58	0.91	0.41	0.93	0.73	0.77
Unag	0.92	0.91	0.92	0.90	0.82	0.77

Table 2. Vulnerability indices of hazards in selected barangays of Camalaniugan, Cagayan (Agriculture and Fishery sector).

Barangay	Agriculture				Fishery	
	Soil Erosion	Flooding	Drought	Pests and Diseases	Temperature Increase	Siltation
Abagao	0.77	0.59	0.95	0.60	0.83	0.46
Batalla/Gang-Ngo	0.93	0.94	0.40	0.74	0.55	0.67
Bulala	0.94	0.96	0.62	0.66	0.64	0.63
Casili Norte	0.70	0.96	0.51	0.57	0.45	0.81
Casili Sur	0.58	0.68	0.70	0.52	0.30	0.41
Catotoran Norte	0.57	0.57	0.44	0.74	0.58	0.43
Catotoran Sur	0.59	0.59	0.57	0.64	0.58	0.66
Centro Sur	0.66	0.63	0.55	0.54	0.52	0.54
Dugo	0.94	0.95	0.78	0.59	0.68	0.44
Dammang Norte	0.51	0.56	0.56	0.57	0.94	0.93
Ziminila	0.68	0.51	0.34	0.96	0.52	0.69

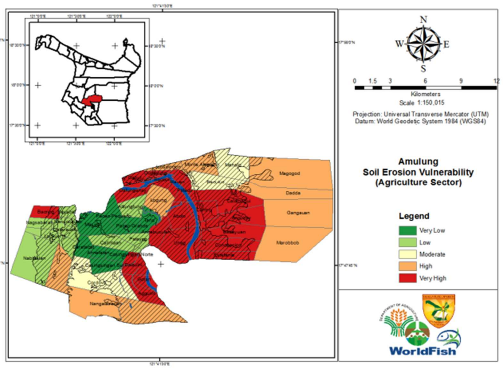
Table 3. Vulnerability indices of hazards in selected barangays of Gonzaga (agriculture and fishery sector).

Barangay	Agriculture		Fishery	
	Pests and Diseases	Flooding	Fish Kill	Siltation
Amunitan	0.70	0.95	-	0.35
Cabiraoan	0.79	0.30	-	0.44
Caroan	0.53	0.95	0.94	0.91
Casitan	0.64	0.94	0.28	0.27
Ipil	0.53	0.95	-	0.30
Minanga	0.27	0.76	-	0.20
San Jose	0.60	0.83	0.58	0.40
Santa Cruz	0.53	0.92	-	3.17
Smart	0.36	0.46	0.78	-
Tapel	0.66	0.00	-	0.40

Mapping

The obtained vulnerability indices were used to generate the initial vulnerability maps. Data were validated and adjustments were applied to ensure the accuracy of the data.

Fig. 1 shows the most vulnerable parts of Amulung from climate change events such as soil erosion, farm pests and diseases and flooding with regards to its agri-aqua production areas. These are the barangays situated near the Cagayan River. During dry season, the most drought-vulnerable are the barangays located on areas with high relief.



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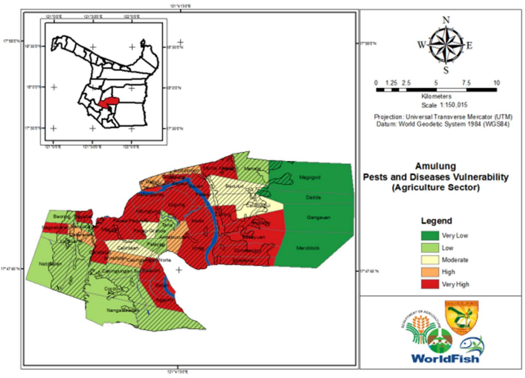

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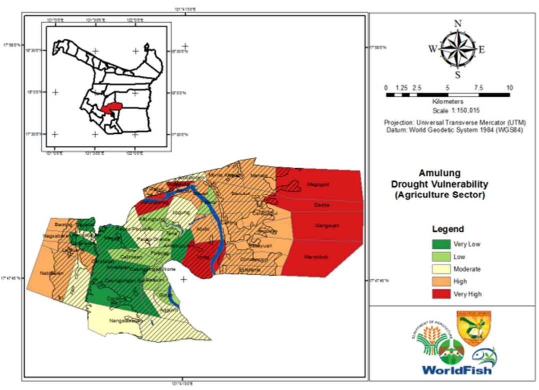

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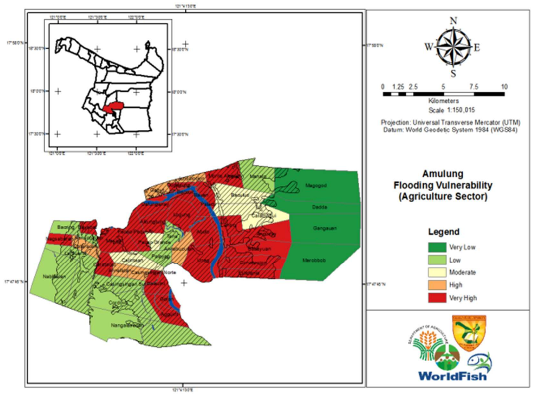

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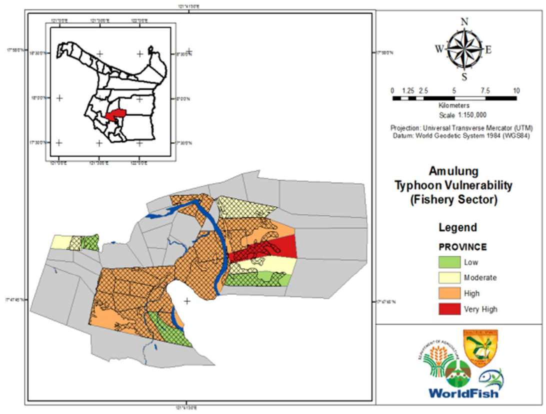

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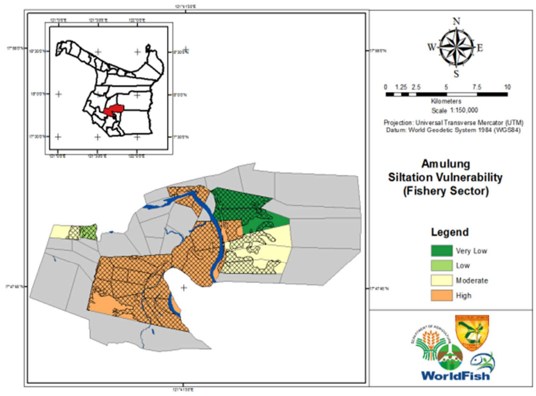
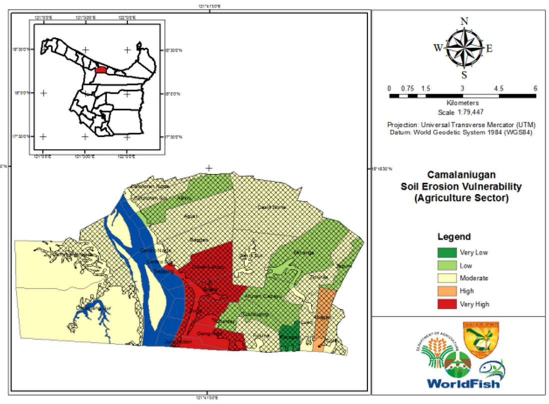


(f)

Fig. 1. Vulnerability of the agriculture sector to (a) soil erosion, (b) pest and diseases, (c) drought, (d) flooding and of the fishery sector to (e) typhoon and (f) siltation in the municipality of Amulung.

Fig. 2 shows the areas in Camalaniugan that are highly vulnerable during the events of drought, soil erosion, pests and diseases and flooding in its agricultural sector. These are the areas situated near the river while areas devoted to aquaculture experience high vulnerability to water temperature rise and siltation of pond areas.



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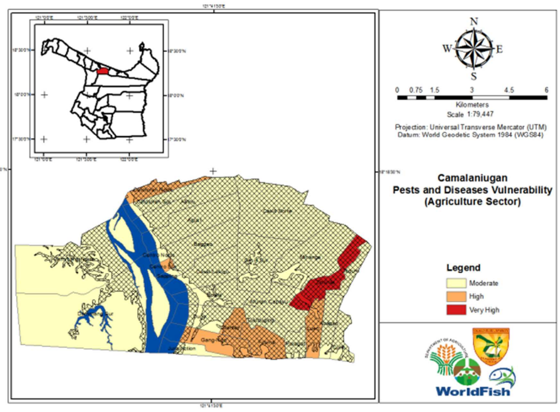

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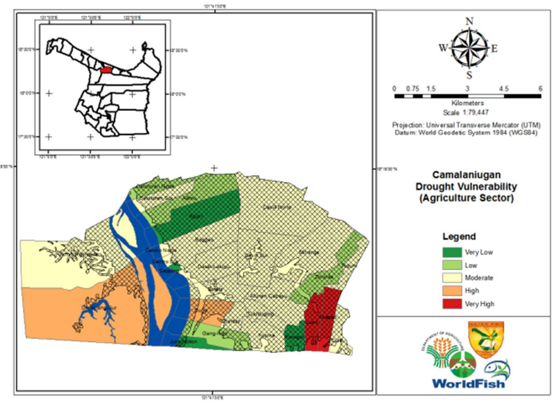

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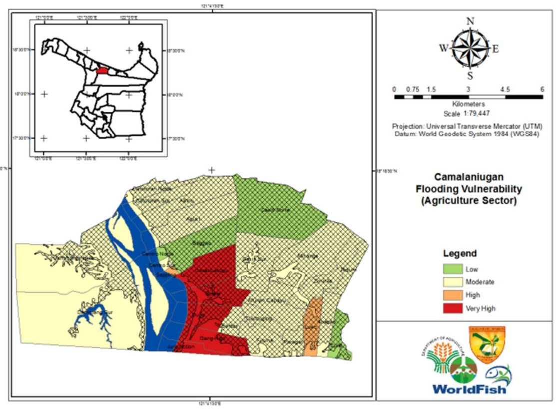

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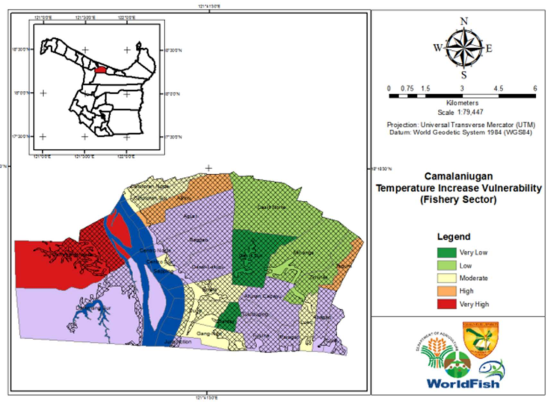

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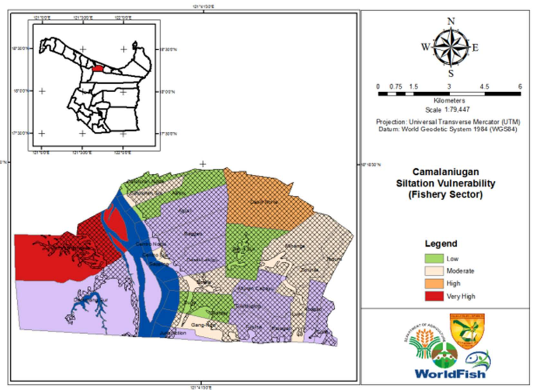
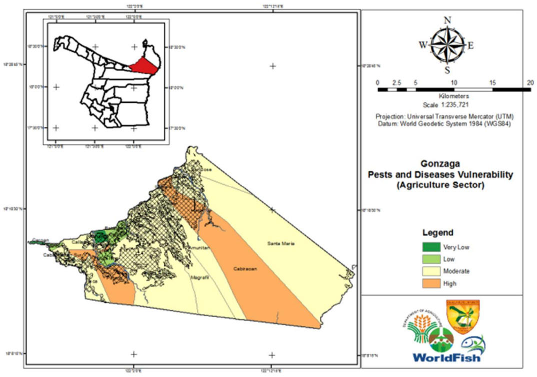


(f)

Fig. 2. Vulnerability of agriculture sector to (a) soil erosion, (b) pest and diseases, (c) drought, (d) flooding and of fishery sector to (e) temperature increase and (f) siltation in the municipality of Camalaniugan.

The entire municipality of Gonzaga is highly vulnerable. Typhoons cause rise in sea water level, which in turn floods the coastal areas. Fig. 3 shows that during typhoons, coastal areas and areas with very low relief are highly vulnerable to flooding due to seawater level rise. Moreover, pests and diseases highly affect the livestock and agricultural production areas.



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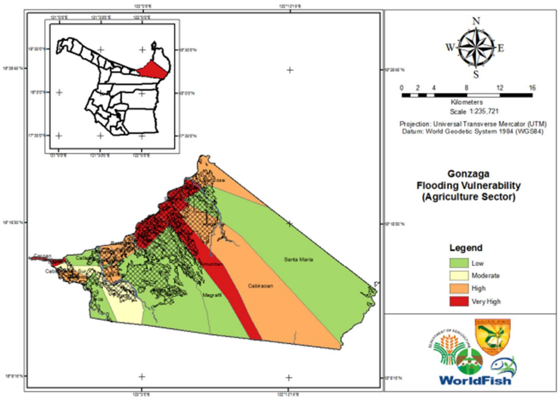

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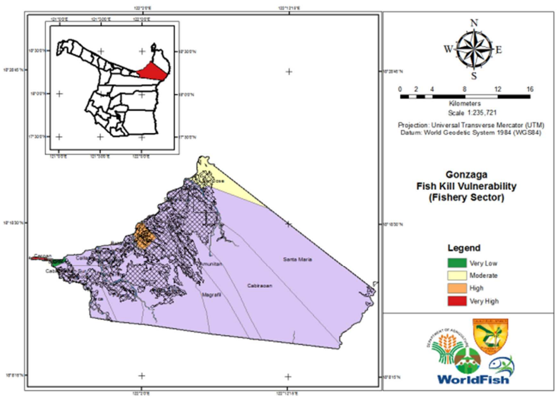

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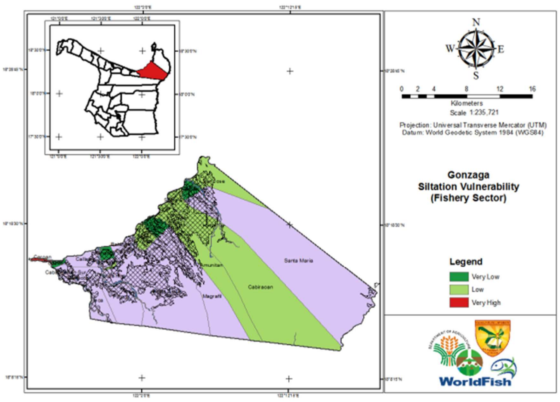

(d)

Fig. 3. Vulnerability of agriculture sector to (a) pest and diseases, (b) flooding, and of fishery sector to (c) fish kill and (d) siltation in the municipality of Gonzaga.

Vulnerability Maps Validation

The generated maps were validated by the Municipal Agriculture Officer (MAO), Municipal Environmental and Resources Officer (MENRO), Municipal Disaster Risk Reduction and Management Officer (MENRO), Municipal Planning and Development Officer (MPDO) together with their staff and field officers. This was reinforced by actual field observation. Inaccuracies were pointed out and necessary corrections were made. Insights that were left out during the FGD and KII on special cases within the barangays in the municipalities were also taken into consideration. The corrections were considered in coming up with the final vulnerability maps.

Conclusion

There were eight (8) identified hazards that highly affect the agri-aqua production areas of the selected municipalities of Cagayan. These are soil erosion, pests and diseases, flooding, drought, typhoon, siltation, water temperature rise, and fish kill. Among these, flooding is the most pronounced which affects a large portion of each municipalities' land area and a great number of households. The generated maps will serve as baseline information and guides for the national and local government units in increasing the level of awareness of their communities, reforming existing policies that are difficult to implement, and adoption of technologies and practices that will help mitigate the effects of climate change in their agri-aqua production areas. Thus, addressing the needs of the country for more climate change resilient communities and diminished losses and damages incurred by hazards in its agriculture and aquaculture production areas.

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