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Research article

Vulnerability Assessment of Agricultural Produce to Flooding in Libacao, Aklan, Philippines

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Abstract: Climate change affects agricultural productivity, food security, and rural livelihoods globally. Changes in temperature, rainfall patterns, and extreme weather events like droughts, floods, and stronger typhoons cause substantial damage to crops, livestock, and infrastructure and harm the agricultural sector as a whole. The Philippines is highly vulnerable to natural disasters due to its geographical and environmental setting. Aklan Province in Western Visayas, Philippines, boasts of its high geographic diversity, having five major river systems. Aklan River is the largest, longest, and third-largest drainage basin on the island. A conducted geohazard mapping and assessment identified Libacao to be vulnerable to the threat of flooding. This study focused on assessing the vulnerability of the agricultural produce in the Municipality of Libacao, Aklan, which is one of the communities along the Aklan River. The barangays of Calacabian, Calamcam, Casit-an, Dalagsaan, Guadalupe, Janlud, Julita, Loctuga, Magugba, Manika, Ortega, Oyang, Pampango, Pinonoy, and Rivera were assessed as they were situated along the Aklan River. The assessment identified rice, abaca, coconuts, bamboo, and banana as the top agricultural produce in Libacao. Vulnerability assessment showed that rice production in Calacabian, Calamcam, Casit-an, Loctuga, Pampango, Pinonoy, and Rivera was highly vulnerable. Also, Casit-an, Loctuga, Pampango, and Rivera were assessed to be very highly vulnerable to coconuts. For bananas, the barangays of Calacabian, Casit-an, Pampango, and Pinonoy were identified to have very high vulnerability. With the vulnerable areas identified, the Local Government Unit (LGU) of Libacao may consider the results in their planning and strategies.

Keywords: Agricultural vulnerability; flood hazard; adaptive capacity

1. Introduction

The significant impacts of climate change, especially on the agricultural sector, have been concerning. The Food and Agriculture Organization (FAO) of the United Nations reported that climate change is affecting agricultural productivity, food security, and rural livelihoods across the globe [1]. Some impacts of climate change on agriculture include changes in temperature, rainfall patterns, and extreme weather events like droughts, floods, and stronger typhoons. Extreme weather events cause substantial damage to crops, livestock, and infrastructure, which in turn leads to a considerable economic loss for farmers and the agricultural sector as a whole. The Philippines, due to its geographical and environmental setting, is highly vulnerable to natural disasters as an archipelago situated in the Pacific Ring of Fire, with more than 7,000 islands and 36,000 kilometers of coastline [2]. The Philippines has endured enormous losses from one disaster after another and has experienced 317 extreme weather events during the last decade. It incurred damages worth at least PHP 515.51 billion due to disasters from 2010 to 2020, of which 98% were climate-related [3]. Aklan Province in Western Visayas, Philippines, boasts of its high geographic diversity, ranging from rivers to white sandy beaches, mangroves, and mountainous landscapes. The province has five major river systems. Aklan River is the largest, longest, and third-largest drainage basin on the Island of Panay. The Aklan River system is part of the vital Aklan River Forest Reserve, which serves several municipalities along its banks.

The Philippines is among the top ten countries in Asia affected by flooding due to annual monsoonal rains and numerous typhoons [4]. Flooding is a type of natural disaster caused by extreme rainfall and has direct local effects. In such a way that it transforms the morphology of the riverbed, damages materials, or destroys infrastructures. In addition, it causes the loss of human life and has a significant socioeconomic impact over time. As stated by dela Torre et al. [4], flood damages are unavoidable, but by identifying which areas are susceptible to severe effects of this hazard due to underlying biophysical and socioeconomic factors, mitigating measures can be adopted by agricultural planners and farm managers. As such, the Aklan River causes disruptions when there is prolonged heavy rain. The increase in the average water level of the river leaves the residents living along the riverbanks or low-lying areas to take immediate action, such as evacuation. Likewise, damaged farmlands were prevalent.

A report by the Mines and Geosciences Bureau [5] identified towns in the Province of Aklan that were vulnerable to the threat of flooding. Results showed that Libacao, along with Madalag, Banga, Malinao, Lezo, Numancia, and the capital town of Kalibo, were the most vulnerable to the threat of flooding. These towns were situated along the Aklan River and experienced the impacts and consequences of river floods in recent years. The unceasing heavy rainfall has caused the Aklan River to overflow into the areas along the river. In the June 2008 Panay Island flooding resulting from Typhoon "Frank", there were reports of widespread landslides in the mountain range of Panay Island, also including the Aklan River headwaters. It suggested the possibility of damming tributaries that may have contributed to the flooding [6]. In 2014, Typhoon "Seniang" hit and threatened the municipality of Libacao along with neighboring towns with heavy downpours and uninterrupted rainfall that led to flooding, which affected the residents living along the Aklan River, especially farm households, and damaged the infrastructure. Tropical Depression "Agaton" in 2018 also flooded the areas along the Aklan River in the towns of Libacao, Kalibo, Madalag, Numancia, Banga, and Malinao. Severe Tropical Storm "Paeng" has also recently devastated the province of Aklan. The province reported a total of eight deaths in Aklan, of which five deaths were in Libacao, and the agriculture sector incurred the most significant amount of damage with around PHP 119.30 million [7].

The staggering effects of climate change, particularly the effects of flooding on crops, have become a grave concern worldwide [8]. As the Aklan River continues to threaten the natural resources, physical resources, and the inhabitants along the river, it is imperative to assess the vulnerability of these communities to hydrologic hazards, specifically flooding. The study focused on the assessment of vulnerability of the agricultural produce in one of the communities along the Aklan River, the Municipality of Libacao. The study aimed to determine the profile of the communities within the municipality that are exposed to hydrologic hazards, specifically flooding, and to assess their vulnerability in terms of their agricultural resources. Results can provide an objective and scientific basis for risk management decisions, priority setting, and resource allocation in environmental disaster management, and provide a rational basis for an enhanced implementation and policy development of the Local Government Unit (LGU).

2. Materials and Methods

2.1 Study area

The Municipality of Libacao in the Province of Aklan is located in Panay Island of the Western Visayas (Region VI), Philippines. It is a landlocked third-class municipality with a determined population of 28,272 as of the 2020 Census [9]. The municipality has a land area of 254.98 square kilometers or 98.45 square miles, which makes up around 14.49% of Aklan's total area. It is divided into 24 barangays. Libacao is situated along the Aklan River, which is the largest and longest river, with a primary waterway of 1,761.6 kilometers downstream [10]. This is the major river basin that traverses several municipalities in the province and is also within the Proclaimed Aklan Watershed and Forest Reserve of the province, with an area of 2,064 km^2 located in the municipalities of Libacao and Madalag. The map of the study area is shown in Figure 1.

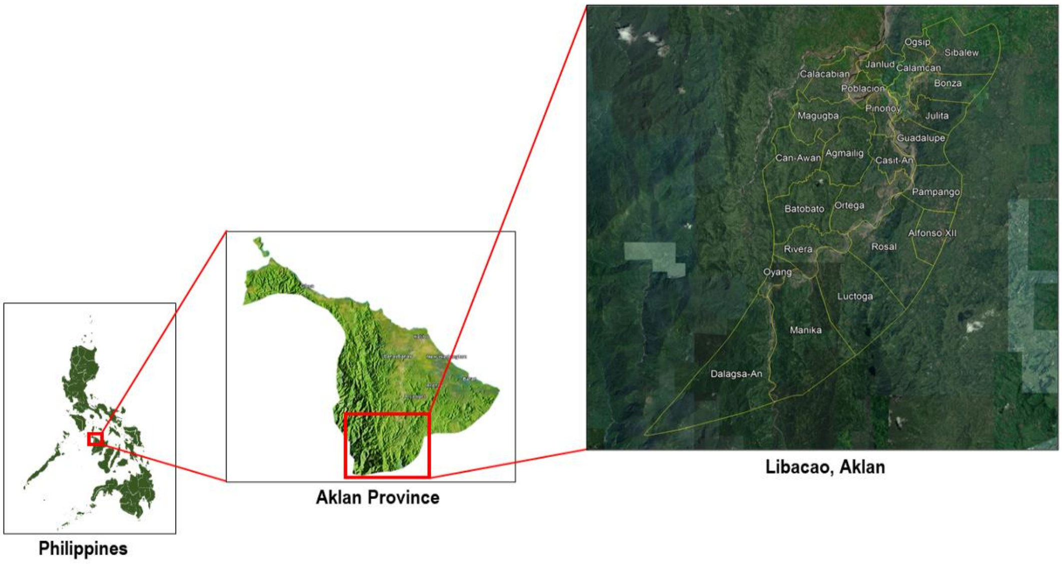

Figure 1. Map of the study area of Libacao, Aklan [11]. Yellow lines represent political boundaries

2.2. Vulnerability assessment

Vulnerability assessment of agricultural produce to flooding in Libacao was based on indicators clustered into respective components, such as the exposure, sensitivity, and adaptive capacity. Selected 15 barangays along the Aklan River were the following: Dalagsaan, Manika, Oyang, Rivera, Loctuga, Ortega, Pampango, Casit-an, Guadalupe, Pinonoy, Julita, Calamcam, Janlud, Magugba, and Calacabian. Participatory assessments such as Participatory Rural Appraisal (PRA) were also done with the participation of the community residents to assess and draw out information on the status, problems, and issues of the community. Stakeholders' participation in Disaster and Climate Risk Assessments (CDRA), focus group discussions (FGDs), and key informant interviews (KIIs) was also performed for the assessment. Field assessment and secondary data analysis were also done for the validation of the community [12].

2.3 Data collection and analysis

A collection of primary datasets was done through farmer household (HH) surveys on the 55 households located along the Aklan River. In addition, a Key Informant Interview (KII) was conducted with 5 representatives of the barangays, which include the Barangay Captain, Barangay Health Worker, Barangay Kagawad in-charge of the Enviroment and Agriculture, Barangay Secretary, and Barangay Risk Reduction Management Officer and focus group discussion with the Municipal Environment and Natural Resources Office (MENRO), Municipal Disaster Risk Reduction and Management Office, and Municipal Agriculturist Officer. Hence, data validation was conducted online with the presence of the Municipal Mayor and MENRO. A copy of the vulnerability result was presented to the municipal level. Survey materials consisted of questions investigating the status and characteristics of the farmlands and the socioeconomic and agroecological attributes of the farmer households. A descriptive research method was used in the data collection. The situation or given state of affairs in terms of specified aspects or factors was described in this. Described were the characteristics of individuals or groups of households in the community or physical environments and the conditions of the communities along the Aklan River basin, specifically the agricultural practices or the farming systems in the community. Descriptive statistics were used to analyze the qualitative and quantitative data gathered from the community, and situational analysis was done to validate further the information generated. Significant differences between means were evaluated by One-way Analysis of Variance (ANOVA) at $p<0.05$ using IBM SPSS Statistics 26. Frequencies and means were used in the study. The vulnerability scoring (LGU Guidebook on the Formulation of Local Climate Change Action Plan [13] using the formula and matrix below:

$$\text{RELATIVE VULNERABILITY} = \frac{\text{THREAT LEVEL (based on the exposure and sensitivity analysis)}}{\text{ADAPTIVE CAPACITY}}$$

MATRIX:

HAZARD	THREAT LEVEL	ADAPTIVE CAPACITY	RELATIVE VULNERABILITY
EXAMPLE: DROUGHT	**4 (Medium High)**	**3 (Medium)**	**4/3 = 1.33 (Low vulnerability)**

LEGEND:

THREAT LEVEL	ADAPTIVE CAPACITY SCORE					RELATIVE VULNERABILITY
	High (5)	Medium High (4)	Medium (3)	Medium Low (2)	Low (1)	
High (5)	1	1.25	1.66	2.5	5	High (4-5)
Medium High (4)	0.8	1	1.33	2	4	Medium High (2.1-3.9)
Medium (3)	0.6	0.75	1	1.5	3	Medium (1.5-2)
Medium Low (2)	0.4	0.5	0.66	1	2	Medium Low (1-1.49)
Low (1)	0.2	0.25	0.33	0.5	1	Low (>1)

3. Results and Discussion

3.1 Profile of the area and the respondents

Shown in Table 1 is the profile of the selected barangays situated along the Aklan River in terms of their population, number of households, number of farmers, agricultural land use, and total land area. The population in each barangay varies from 344 to 2,090. The barangay of Casit-an was the least populated, and Manika was the most populated. Moreover, the number of households ranged from 90 households in Casit-an to 631 households in Manika. It was observed that Janlud had 115 farmers tilling 44.0 ha of land, while Manika had the highest number of farmers at 975. Furthermore, the amount of land used for agricultural activities ranged from 44 to 591 hectares.

Table 1. Profile of selected barangays situated along the Aklan River.

Barangay	Population	No. of Households	No. of Farmers	Agricultural Land Use (ha)
Calacabian	943	235	410	54.50
Calamcam	1,012	166	180	378.97
Casit-an	344	90	255	153.66
Dalagsaan	1,908	393	450	390.50
Guadalupe	1,784	453	551	446.00
Janlud	1,306	319	115	44.00
Julita	2,077	483	690	271.50
Loctuga	1,832	346	290	578.00
Magugba	904	243	305	177.00
Manika	2,090	631	975	63.00
Ortega	1,295	310	640	368.50
Oyang	935	268	720	68.00
Pampango	1,504	396	896	515.80
Pinonoy	828	183	262	591.00
Rivera	648	160	157	207.00

Aklan is mainly an agricultural province since almost 110,452.0 hectares or 60.44% of its total land area is vast plains or rolling hills devoted to rice and other crops [10]. In Libacao, the top agricultural produce from the selected barangays was identified as shown in Table 2. The most common produce that was cultivated includes Rice, Abaca, Banana, Coconuts, Bamboo, and other produce.

Table 2. Agricultural Produce, Area Planted, and Crop Exposure/Vulnerability Rating of selected barangays situated along the Aklan River.

Barangay	Agricultural Produce	Total Area (ha)	Crop exposure/Vulnerability Rating
Calacabian	Abaca	2	Very low
	Bamboo	15	Very High
	Banana	2	Very High
	Coconuts	10	High
	Corn	2	Very High
	Rice	20	Very High
	Root crops (Sweet potato, Peanut)	2	Very High
	Vegetable	1.5	Very High
Calamcam	Abaca	13.25	Medium
	Copra	138	Medium
	Rice	57.75	Very High
	Root crops	174.97	Medium
Casit-an	Abaca	15.54	Very low
	Bamboo	45.94	Very low
	Banana	15	Very High
	Coconuts	16	Very High
	Corn	10	Very High
	Rice	41.18	Very High
	Root crops	10	Very High
Dalagsaan	Abaca	200	Very low
	Bamboo	20	Very low
	Banana	5	Very low
	Rice	165.5	Very low
Guadalupe	Abaca	100	Very Low
	Bamboo	5	Very Low
	Banana	100	Very Low
	Copra	100	Very Low
	Corn	25	Low
	Fruit Trees	66	Very Low
	Rice	25	Low
	Root crops/ Vegetables	25	Medium
Janlud	Abaca	7	Very Low
	Coconuts	10	Very Low
	Rice	25	Low
	Root crops	2	Very Low

Table 2. Agricultural Produce, Area Planted, and Crop Exposure/Vulnerability Rating of selected barangays situated along the Aklan River. (Continues)

Barangay	Agricultural Produce	Total Area (ha)	Crop exposure/Vulnerability Rating
Julita	Abaca	170.25	Very Low
	Bamboo	170.25	Very Low
	Coconuts	170.25	Medium
	Fruit Trees	170.25	Very Low
	Root crops	217.50	Medium
	Rice	217.50	Medium
	Vegetables	217.50	Medium
Loctuga	Abaca	500	Very Low
	Coconuts	10	Very High
	Fruit Trees	5	Very Low
	Rice	50	Very High
	Root crops	10	Very Low
	Vegetables	3	Very Low
Magugba	Abaca	10	Very Low
	Banana	15	Very Low
	Bamboo	67	Low
	Cassava	15	Very Low
	Coconuts	5	Very Low
	Corn	15	Medium
	Rice	50	Low
Manika	Abaca	50	Very Low
	Bamboo	10	Very Low
	Coconuts	1	Very Low
	Corn	1	Very High
	Rice	1	High
Ortega	Abaca	139	Medium
	Coconuts	118	Medium
	Corn	45	Medium
	Rice	66.50	Low
Oyang	Abaca	35	Very Low
	Bamboo	3	Very Low
	Banana	2	Very Low
	Coconuts	2	Very Low
	Rice	25	High
	Root crops (Taro)	1	Very Low
Pampango	Abaca	350	Medium
	Bamboo	50	Medium
	Banana	30	Very High
	Copra	20	Very High
	Fruit Trees	8	Very High
	Ginger	5	Very High

Table 2. Agricultural Produce, Area Planted, and Crop Exposure/Vulnerability Rating of selected barangays situated along the Aklan River. (Continues)

Barangay	Agricultural Produce	Total Area (ha)	Crop exposure/Vulnerability Rating
	Rice	52.8	Very High
Pinonoy	Abaca	20	Very Low
	Bamboo	4	Very Low
	Banana	2	Very High
	Coconuts	509	High
	Fruit Trees	15	Very Low
	Peanut	1	Very High
	Rice	40	Very High
Rivera	Abaca	150	Very Low
	Bamboo	15	Low
	Coconuts	5	Very High
	Rice	37	Very High

3.2 Vulnerability assessment

The Intergovernmental Panel on Climate Change [14] stated that vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. It involves a combination of factors that determine the degree to which someone's life, livelihood, property, and other assets are at risk from an event or cascade of events in nature [15]. Vulnerability can be a function of the system's sensitivity to climate change, exposure to climatic hazards, and its adaptive capacity to these changes. Vulnerability assessment is a process of identifying and evaluating the potential risks and impacts of a hazard or stressor on a system or population. These vulnerability assessments identify the factors that contribute to vulnerability and inform the development of strategies to reduce or manage those risks. Exposure is one of the dimensions of vulnerability assessment. It is defined as the degree to which a system is exposed to climatic variations, considering both the frequency and extent of its contact with a hazard [16]. Shown in Figure 2 is the exposure of the top crops, such as rice, abaca, coconuts, bamboo, and banana, to flooding. In terms of rice (Figure 2a), six barangays were evaluated to have high exposure (>40%), namely: Calacabian, Pampango, Calamcam, Ortega, Rivera, and Loctuga. This resulted in the economic value of crop loss that ranged from Php1,620,000.00 to Php103,685,400.00 with an exposed area of 20 to 50 ha (Table 3). Calacabian was assessed to have the highest exposure among them. Pinonoy, Manika, and Casit-an were assessed to have medium exposure (<40%) in the area exposed from 0.3 to 15 ha. The crop economic value lost ranged from Php21,048.00 to Php1,800,000.00 (Table 3). The barangays of Guadalupe, Janlud, Magugba, Oyang, and Julita were evaluated to have low exposure to flooding hazards. On the other hand, Dalagsaan has no areas exposed to flooding hazards. For abaca, Barangay Ortega was highly exposed, and Calamcam and Pampango had low exposure (≤20%), while the rest were not exposed, as shown in Figure 2b. For coconuts (Figure 2c), four barangays were highly exposed areas (Pampango, Loctuga, Ortega, and Rivera), and Casit-an had medium exposure. The highly exposed areas ranged from 2 to 57 ha with an economic value lost of 75,000.00 to 1,425,000.00, while the Casit-an area exposed was 5 ha with an economic loss of 150,000.00 (Table 3). Calacabian, Calamcam, Pinonoy, and Julita were areas with low exposure. In terms of areas with bamboo (Fig. 2d), Pampango, Rivera, and Magugba were found to have low exposure. The rest of the areas, namely: Calacabian, Casit-an, Dalagsaan, Guadalupe, Julita, Manika, Oyang, and Pinonoy, were not exposed to the identified hazard. Shown in Figure 2e are the areas of Libacao that have high exposure when it comes to bananas. It was assessed that Pampango, Pinonoy, and Calacabian were highly exposed areas. The economic value lost from these barangays ranges from Php5,000 to Php1,020,000.00 from 1 to 25 ha of bananas. Also, Casit-an was evaluated to have medium exposure (5 ha) with an economic value of Php50,000.00 for bananas. Areas in Dalagsaan, Guadalupe, Magugba, and Oyang were not exposed. In the rice areas with high and medium exposure, trainings were conducted on rice production using varieties suited to flooded conditions. While in the areas of coconuts and bananas with high and medium exposure, off-farm livelihood training (fruits and food processing) was conducted.

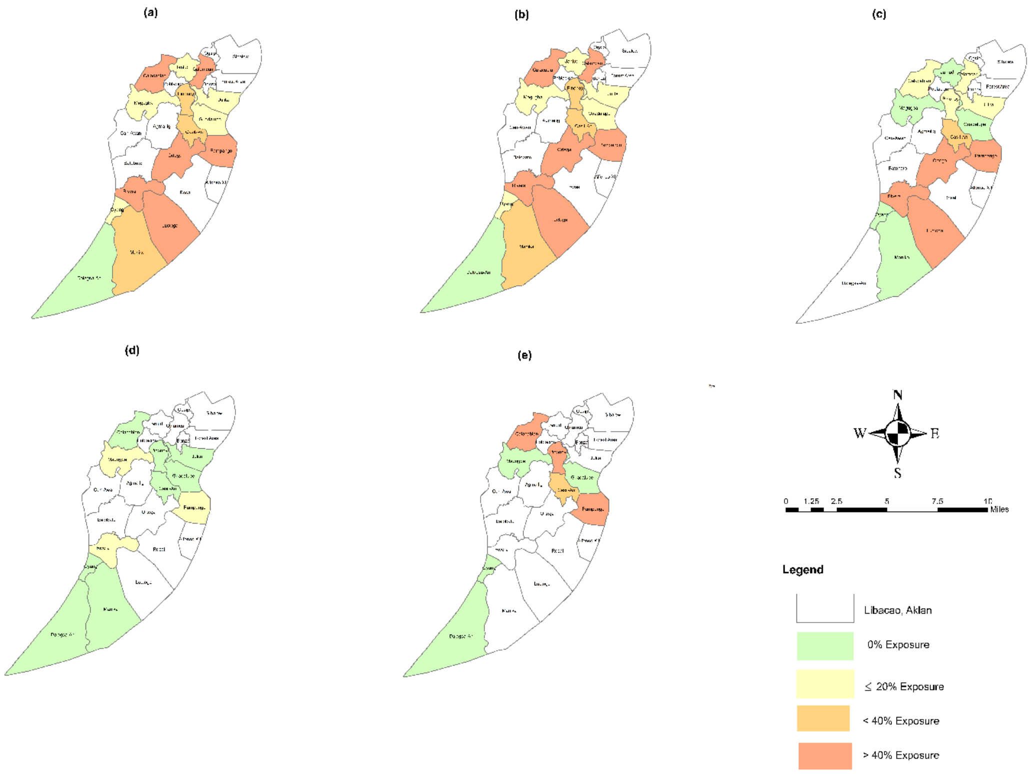

Figure 2. Exposure to flooding hazard of the top agricultural produce: (a) rice, (b) abaca, (c) coconuts, (d) bamboo, and (e) banana in Libacao, Aklan, Philippines.

Another dimension considered in vulnerability assessments is sensitivity. It refers to the degree to which a system is affected, either adversely or beneficially, by a hazard [17]. Some crops may be more sensitive to changes in rainfall or water availability, which makes them more vulnerable to the impacts of flooding. Sensitivity indicators utilized in this study include the ratio of farmers with access to climate information, the ratio of farmers employing sustainable production techniques, and the ratio of farmers with access to irrigation. Based on the conducted surveys (Table 4), it was revealed that more than half (59.00%) of abaca farmers had access to climate information. However, less than half (46.67%) of them reported not employing sustainable production techniques. Furthermore, a significant ($p<0.05$) number of them do not have access to irrigation. Abaca is considered a less water-intensive crop. However, extended dry spells could harm production and farmer livelihoods, reducing their ability to adjust. For bamboos, more than half have access to climate information (57.73%) and were employing sustainable production techniques (50.91%). Conversely, none of them have access to irrigation. The lack of an irrigation system during critical growth periods of bamboo will limit their ability to manage water stress, hence affecting their overall ability to respond to climate variability. About 46.25% of banana farmers have access to climate information for their production, and about 51.88% of the banana farmers employ sustainable production techniques. Also, none of them have access to irrigation for their crops. Their adaptive capacity is naturally diminished by this reliance on natural rainfall, which could result in significant crop losses during dry seasons. As for coconuts, a high number of them (60.36%) have access to climate information.

On the other hand, only around 40.71% of coconut farmers were employing sustainable production techniques, and none of them had access to irrigation. Despite its resilient, prolonged exposure to dry spells, it constrains their overall adaptive capacity. Abaca, bamboo, banana, and coconut farmers do not have access to irrigation since these crops do not necessarily require irrigation. Around 65.47% of rice farmers have access to climate information. Fewer rice farmers were reported to be employing sustainable production practices (27.00%) and have access to irrigation (20.67%). The limited use of sustainable methods and insufficient irrigation infrastructure resulted in rice farmers' limited ability to adapt and overall vulnerability. A significant number ($p<0.05$) of farmers for abaca, bamboo, banana, coconuts, and rice were dependent on rainfall and other means of water for their crops since they do not have access to irrigation. These will later result in crop yield losses, food insecurity (rice, bananas, and coconuts), financial strain, soil degradation, limited early warning and response effectiveness, and psychological and social impact. It is recommended to do better extension activities through translating climate data, demonstrating sustainable practices, farmer field schools, and digital extension. In addition, capacity building for extension workers, strengthening research-extension-farmer linkages, promoting flood-resilient crop varieties, and rainwater harvesting are suggested for adaptive capacity.

Table 3. Different crops, barangays, annual average output per hectare, exposed area, and exposed value

Crops	Barangay	Annual Average Output per hectare (Philippine peso (Php) per ha)	Exposed Area (ha)	Exposed Value (Php)
Rice (High Exposure)	Calacabian	100,000.00	20	2,000,000.00
	Pampamgo	33,600	50	1,680,000.00
	Calamcam	2,184,000.00	47.48	103,685,400.00
	Ortega	36,000	45	1,620,000.00
	Rivera	107,500	22.2	2,386,500.00
	Loctuga	65,000	25	1,625,000.00
Rice (Medium Exposure)	Pinonoy	120,000	15	1,800,000.00
	Manika	70,160	0.3	21,048.00
	Casit-an	85,680	11	942,480.00
Coconuts (High Exposure)	Pampango	17,280	10	172,800.00
	Loctuga	15,000	5	75,000.00
	Ortega	25,000	57	1,425,000.00
	Rivera	93,296	2	186,592.00
Coconuts (Medium Exposure)	Casit-an	30,000	5	150,000.00
Bananas (High Exposure)	Pampango	40,800	25	1,020,000.00
	Pinonoy	5,000	1	5,000
	Calacabian	15,000	1	15,000
Bananas (Medium Exposure)	Casit-an	10,000	5	50,000.00

Table 4. Sensitivity indicators for the top agricultural produce of Libacao, Aklan, Philippines.

Parameter*	Abaca	Bamboo	Banana	Coconut	Rice
Access to climate information (%)					
With	59.00 ± 27.66^a	57.73 ± 34.74^a	46.25 ± 28.75^a	60.36 ± 28.32^a	64.47 ± 24.97^a
Without	41.00 ± 27.66^a	42.27 ± 34.74^a	53.75 ± 28.75^a	39.64 ± 28.32^a	35.53 ± 28.74^a
Employing sustainable production techniques (%)					
Yes	46.67 ± 41.52^a	50.91 ± 43.92^a	51.88 ± 45.19^a	40.71 ± 38.92^a	27.00 ± 28.90^a
No	53.33 ± 41.52^a	49.09 ± 43.92^a	48.13 ± 45.19^a	59.29 ± 38.92^a	73.00 ± 28.90^b
Access to irrigation (%)					
With	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00 ± 0.00^a	20.67 ± 36.93^a
Without	100.00 ± 0.00^b	100.00 ± 0.00^b	100.00 ± 0.00^b	100.00 ± 0.00^b	79.33 ± 36.93^b

* means with different letters in each section per crop are significantly different from each other ($p<0.05$)

Adaptive capacity is another important dimension considered in vulnerability assessments. Adaptive capacity refers to the ability of a being or a system to adjust to the impacts of a hazard [17] or evolve [18] to accommodate environmental hazards and neutralize potential damages, or to take advantage of opportunities of planning to expand its range of variability for coping [16]. Access to financing, such as crop insurance, availability of alternative livelihoods, and access to government extension programs, were chosen as adaptive capacity indicators for this study. Access to crop insurance provided by the Philippine Crop Insurance Corporation (PCIC) program, the Philippine Coconut Authority (PCA), the Department of Agriculture (DA), agricultural cooperatives, and others was based on the conducted HH, FGDs, and the data provided by PCIC. Shown in Table 4 are the mentioned adaptive capacity indicators for the study. It was reported that crop insurance was available through PCIC, DA, PCA, and the Libacao Cooperative. Also, alternative livelihoods mentioned included backyard gardening, poultry, livestock, cash for work, and others. Furthermore, there were several government extension programs available provided by DA, Department of Labor and Employment (DOLE), Department of Social Welfare and Development (DSWD), Department of Trade and Industry (DTI), and Philippine Fiber Industry Development Authority (PhilFIDA) which include programs such as Abaca Trainings, Farm Schools, Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, and Sustainable Livelihood Programs.

Table 4. Adaptive capacity indicators for the top agricultural produce of Libacao, Aklan, Philippines.

Crop	Access to financing	Alternative livelihood	Government extension programs
Abaca	Crop Insurance (PCIC, DA, Libacao Cooperative)	Backyard Gardening and Poultry, Cash for work, Livestock, SAP, Sustainable Livelihood by DOLE and DSWD, and Vegetable seedlings	Abaca Trainings, Farm Schools, Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, Sustainable Livelihood Program by DSWD
Bamboo	Crop Insurance (PCIC and DA)	Backyard Gardening and Poultry, Cash for work, Livestock, SAP, Sustainable Livelihood by DOLE and DSWD, and Vegetable seedlings	Farm Schools, Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, Sustainable Livelihood Program by DSWD
Banana	Crop Insurance (PCIC and DA)	Backyard Gardening and Poultry, Cash for work, Livestock, Sustainable Livelihood by DOLE and DSWD, and Vegetable seedlings	Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, Sustainable Livelihood Program by DSWD
Coconut	Crop Insurance (PCIC, PCA, DA, Libacao Cooperative)	Backyard Gardening and Poultry, Cash for work, Livestock, SAP, Sustainable Livelihood by DOLE and DSWD, and Vegetable seedlings	Farm Schools, Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, Sustainable Livelihood Program by DSWD
Rice	Crop Insurance (PCIC, DA, Libacao Cooperative)	Backyard Gardening and Poultry, Cash for work, Livestock, SAP, Sustainable Livelihood by DOLE and DSWD, and Vegetable seedlings	Abaca Trainings, Farm Schools, Food Processing Trainings, Livestock Trainings, Vegetable Farming Trainings, Sustainable Livelihood Program by DSWD

Vulnerability assessment is a valuable tool to identify systems that are at risk of a hazard. In terms of agriculture, it can help in identifying the areas and crops that are at risk of a hazard, such as flooding in the case of this study. By factoring in the different dimensions of exposure, sensitivity, and adaptive capacity into the consideration, these assessments help give a better understanding of the risk and vulnerabilities posed to these agricultural systems or crops.

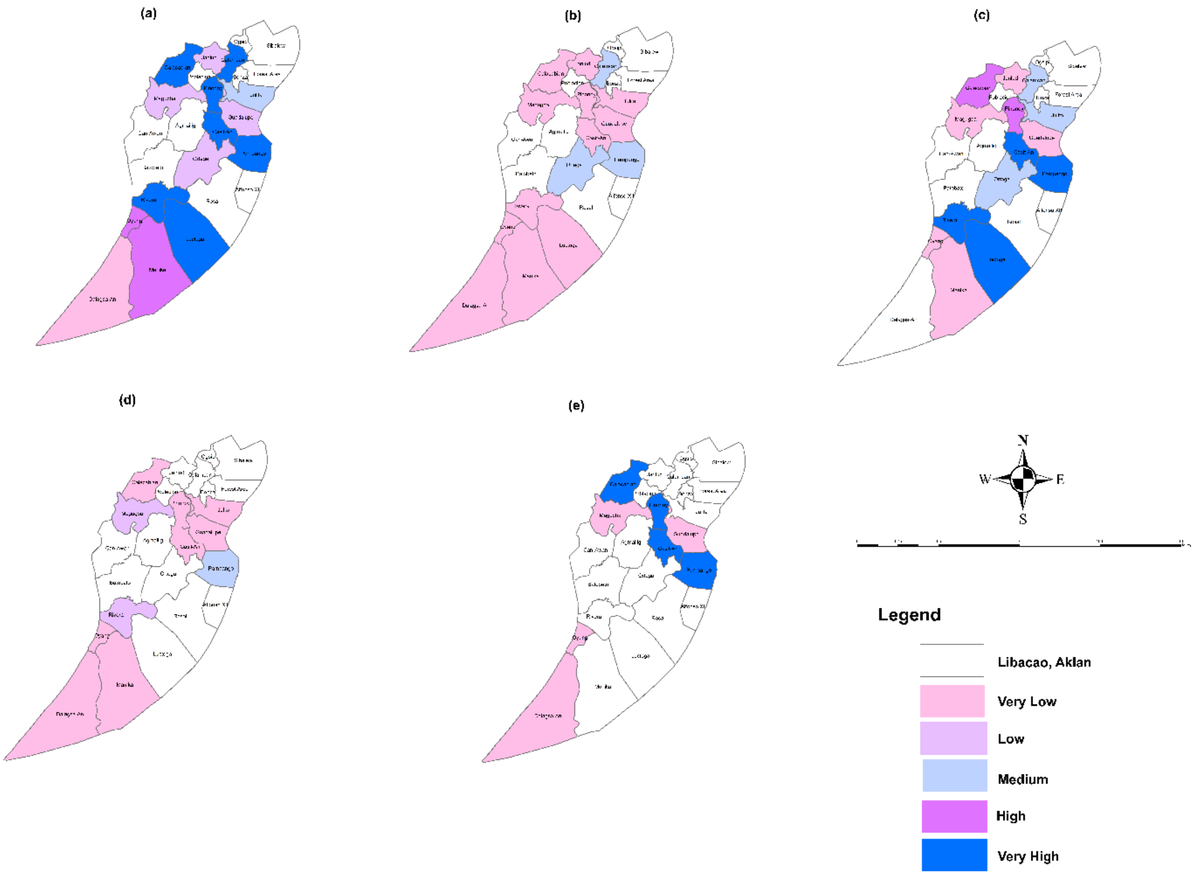

Figure 3. Vulnerability to flooding of the top agricultural produce: (a) rice, (b) abaca, (c) coconuts, (d) bamboo, and (e) banana in Libacao, Aklan, Philippines.

For rice, seven barangays were identified to have a very high vulnerability, namely: Calacabian, Calamcam, Casit-an, Loctuga, Pampango, Pinonoy, and Rivera (Fig. 3a). Likewise, the barangays of Manika and Oyang were identified to be highly vulnerable, while Julita was evaluated to have a medium vulnerability. On the other hand, the four barangays of Guadalupe, Janlud, Magugba, and Ortega were identified to have low vulnerability, while Dalagsaan had a very low vulnerability. When it comes to abaca (Fig. 3b), the three barangays of Calamcam, Ortega, and Pampango were identified as having medium vulnerability. The other barangays planting abaca had very low vulnerabilities, as follows: Calacabian Casit-an, Dalagsaan, Guadalupe, Janlud, Julita, Loctuga, Magugba, Manika, Oyang, Pinonoy, and Rivera. Additionally, Casit-an, LeLoctuga, Pampango, and Rivera were assessed to be very highly vulnerable for coconuts (Fig. 3c). Also, Calacabian and Pinonoy were highly vulnerable. The barangays of Calamcam, Julita, and Ortega were assessed to have a medium vulnerability. Moreover, the five barangays of Guadalupe, Janlud, Magugba, Manika, and Oyang were identified to have low vulnerabilities. Shown in Figure 3d are the different levels of vulnerability of bamboo in terms of the flooding hazard. It was identified that only Pampango had a medium vulnerability. Magugba and Rivera had low vulnerability. Furthermore, the remaining barangays identified had very low vulnerability, namely: Calacabian, Casit-an, Dalagsaan, Guadalupe, Julita, Manika, Oyang, and

Pinonoy. Lastly, for bananas (Fig. 3e), four barangays were identified to have very high vulnerability. These were the barangays of Calacabian, Casit-an, Pampango, and Pinonoy. On the other hand, the remaining barangays of Dalagsaan, Guadalupe, Magugba, and Oyang had very low vulnerability.

4. Conclusions

Rice production in the areas of Calacabian, Calamcam, Casit-an, Loctuga, Pampango, Pinonoy, and Rivera was highly vulnerable. Also, for coconuts, Casit-an, Loctuga, Pampango, and Rivera were assessed to be very highly vulnerable. For bananas, the barangays of Calacabian, Casit-an, Pampango, and Pinonoy were identified to have very high vulnerability. Identifying vulnerable areas for specific crops will be beneficial for Local Government Units (LGUs), policymakers, and planners in preparing and adapting to measures for flooding events. Henceforth, initiatives to increase the coping capacity of communities to such events may be included in the local government's Local Disaster Risk Reduction and Management Plan (LDRRMP) and Local Climate Change Action Plan (LCCAP).

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