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Main title: Vulnerability assessment of Pacific whiteleg shrimp (*Penaeus vannamei*) farms and vendors in Davao, Philippines using FishVool

Short title: Vulnerability assessment of Pacific whiteleg shrimp farms and vendors in Davao, Philippines

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ABSTRACT

The Philippine shrimp industry has been affected by the impacts of marine pollution, diseases and climate change variabilities. This study assessed the vulnerability to climate change of selected small-scale shrimp farms of *Penaeus vannamei* and market vendors in Davao, Philippines using a modified Fisheries Vulnerability Assessment Tool (FishVool). Shrimp farmers and vendors were interviewed using two separate semi-structured questionnaires. A total of thirty nine (39) shrimp farmers and forty eight (48) market vendors from various market areas within the region were interviewed. Data regarding exposure (E), sensitivity (S), and adaptive capacity (AC) were collected following the FishVool parameters with modifications. Results revealed that overall climate change vulnerability of the shrimp farmers was medium (M), where both exposure and adaptive capacity were low (L) while sensitivity was medium (M). In addition, the shrimp market vulnerability of the various sites examined revealed medium (M) scores for markets in Pantukan, Mabini, Tagum, Maco, Lupon, Davao City, and Digos. But high (H) vulnerability scores for the markets in Panabo and Sta Cruz. Overall, the study provided a better understanding about shrimp farming in relation to climate change impacts and vulnerability and provided information for future shrimp farm management, marketing and conservation in the region.

Keywords: Aquaculture, Climate change, Davao Oriental, FishVool, Management, Mati City, Shrimp culture

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INTRODUCTION

Shrimp production provides a wide range of economic benefits, for instance, food security, livelihood and well-being of fisherfolk, fish farmers and processors [1,2] . Hence, the culture of shrimp in coastal communities makes significant contributions to national and global economies, poverty reduction and food security for the world's well-being and prosperity [3]. The production value of white shrimp (*Penaeus setiferus*) aquaculture in the Philippines was estimated at 1,175 mt valued at Php 216 million and 1,018 mt valued at Php 288 million in 2019 and 2020 [4]. Meanwhile for *Penaeus vannamei* this was 19,152 mt valued at Php 4.9 billion and 20,632 mt valued at Php 5.2 billion in 2019 and 2020 [4]. For the tiger prawn (*Penaeus monodon*), the production volume was 45,732 mt valued at Php 23 billion and 42,093 mt valued at Php 20.4 billion in 2019 and 2020 [4]. The total area of shrimp farms in the country in 1992 was 49,478 ha, of which 47,774 was devoted to the black tiger shrimp; 1,006 ha was alloted to endeavor shrimp (*Metapenaeus ensis* or "hipong suahe"); and 638 ha to white shrimp (*Penaeus indicus*, *Penaeus setiferus* or "hipon puti"). The total hectarage under shrimp production constitutes 23% of the country's brackishwater fishponds. Luzon has 20,940 ha (44%) of total shrimp farm area; Visayas has 14,314 ha (30%); and Mindanao has 12,519 ha (26%) [5]. On the other hand, there were 260,000 ha of brackishwater ponds, 6,700 ha of freshwater pens and about 500 ha of marine pens and cages used to culture milkfish [6]. However, shrimp production in the past years have been affected by various challenges, including diseases, stricter biosecurity measures, marine pollution, lack of premium access to markets abroad, and climate change impacts. Shrimp farming have brought about widespread social and economic benefits. However, a wide range of environmental issues including climate change have recently been identified to threaten the sustainability of coastal aquaculture [7].

Globally, shrimp farming has been under intense criticism because of its socioeconomic and environmental impacts [8-10]. During the 1980s and 1990s, the rapid growth of shrimp farming caused widespread destruction of mangroves in a number of

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countries, including Bangladesh, Brazil, China, India, Indonesia, Malaysia, Mexico, Myanmar, Sri Lanka, the Philippines, Thailand, and Vietnam [11,12]. Today, most of these mangrove areas have been seriously damaged or replaced with ponds with devastating effects on mangroves [7,13,14].

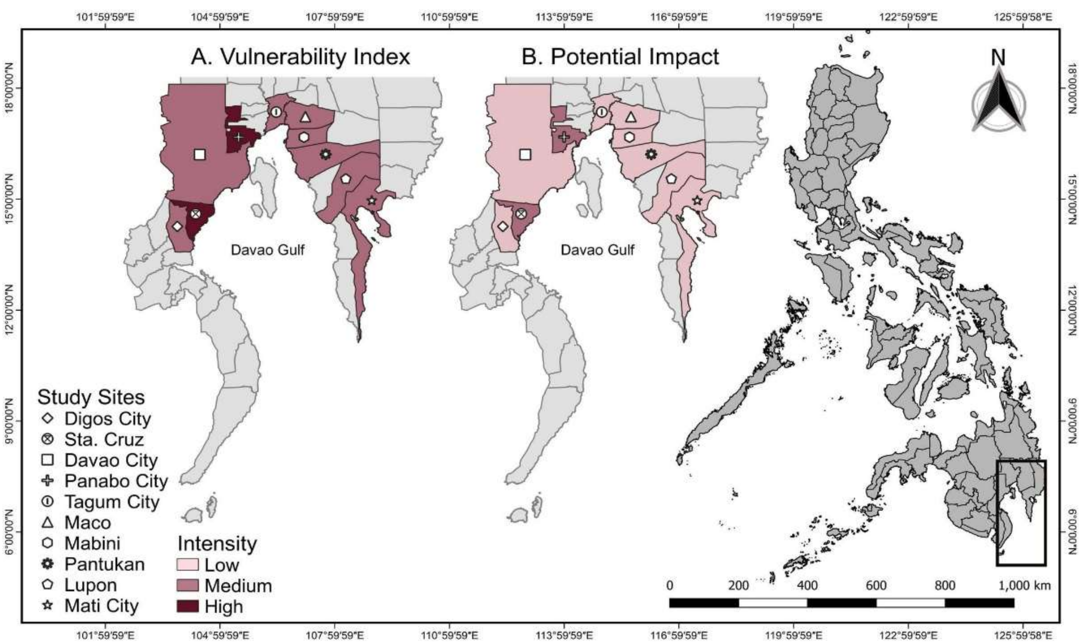
Changes in climate variables largely affect the shrimp production and market by increasing frequency of shrimp disease, causing physical damage to farm structure and deteriorating quality of water. Shrimp farmers try to adapt to those changes in various ways, including increasing pond depth, exchanging tidal water, strengthening earthen dike and netting and fencing around the dike [15]. However, there is a lack of understanding about the adaptation measures taken by the local shrimp farmers with respect to the emergence of specific impacts from changes of climatic variables. It is essential to understand the adaptations of locals to get more insights into the resilience of this aquaculture system [15].

Climate change impacts have also been implicated as one possible cause of destruction of ponds as well as the spread of disease [2]. According to the study of Eckstein et al. [16], the Philippines ranks fourth (4th) overall among the most affected by extreme weather events due to climate change based on the long-term climate risk index (CRI). Vulnerability is particularly defined by the IPCC [17] as “the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” [18,19]. Given the possible impacts of climate change on various aquaculture systems, there is a need for vulnerability assessment to be conducted from time to time to provide status, course of action and possible adaptation to the impacts of climate change [19]. Vulnerability assessment (VA) provides a framework for climate change impacts evaluation over a broad range of systems. Vulnerability assessments, especially for fisheries and aquaculture, provide a better way to understand the interactions among the natural system, pressures, and threats, which serves as a basis for the development of climate change adaptation (CCA) options [20,21]. Tools such as Fisheries Vulnerability Assessment Tool (FishVool) have been developed to do vulnerability assessments in the fisheries [2,22,23]. In the past, this was applied to assess the vulnerability of tuna fishers in General Santos City and sardine fishers in Zamboanga City where fifty local fishermen were interviewed at selected landing sites, of which 25 were from General Santos and 25 were from Zamboanga City. The vulnerability indices for tuna fishers in General Santos and sardines in Zamboanga City indicate medium overall vulnerability which indicate that the tuna and sardine resources are vulnerable to climate change. In this study, we assessed the level of vulnerability of Pacific whiteleg shrimp (*Penaeus vannamei*) on the impacts of climate change and measured the impacts of climate change variability on the shrimp farming sector using a modified FishVool tool.

METHODOLOGY

Description of Study Area

The study was conducted in selected shrimp farms areas in Davao Region. The areas were selected according to the list given by BFAR XI thru the Municipal Agriculture offices of the selected Municipalities and Barangays. Davao Region is located in the Southeastern portion of the island of Mindanao surrounding the Davao Gulf. It is bounded on the north by the provinces of Surigao del Sur, Agusan del Sur and Bukidnon. In the east it is bounded by the Philippine Sea; and in the west by the Central Mindanao provinces. Within the broader



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geographic context, the Davao Region area faces Micronesia in the Southern Pacific Ocean to the east, and the Eastern Indonesia through the Celebes Sea to the south.

Data Collection and Analysis

The Fisheries Vulnerability Assessment Tool (FishVool) was used to gather information on exposure, sensitivity, and adaptive capacity through key informant interviews[22]. In data gathering, key informants were interviewed using the questionnaires derived from FishVool with some modifications. There were N=39 shrimp farmers interviewed and N=48 market vendors. Data were analyzed following FishVool rubrics with minor modifications similar to previous studies [22,23]. These modifications were discussed in each criterion; for the farm vulnerability index and the market vulnerability index.

Farm Vulnerability Index criteria:

Exposure. Exposure (E) factors are those climate variables included in the

Figure 1. Map of the study area including its Climate Change Vulnerability Index (A) and Potential Impacts (B).

assessment that could impact the shrimps (e.g., typhoons, tidal fluctuations, sea-level rise, flood, unpredictable rainfall, and increasing water temperature). Here, exposure factors were chosen based on the criteria adapted from Jacinto et al. [22]. E1 is for the shrimp pond exposure, which pertains to the frequency and severity of exposure of shrimp ponds to extreme weather disturbances. E2 is for the exposure of households site and E3 is for the exposure of the community sites to extreme weather disturbances, pertaining to human exposure and to the community.

Sensitivity. Sensitivity (S) represents the present state of the shrimps in response to the exposure factors arising from climate change. S1 is the mortality rate which measures the rate of damage or dead shrimps during culture period. S2 is the growth rate which measures the average length of shrimp which pertains to the age or size from stocking period up to harvest. S3 is for the water quality of the pond, and S4 is for the water temperature, which pertains to probabilities of changes which was compared to the past 5 years. S5 is the source of pond water, which measures the quality of water if it is good or have experienced siltation. S6 if the source of fry, which refers to the quantity of fry delivered to farm from the source hatchery. Lastly, S7 is the change in salinity level experienced in the past 5 years.

Adaptive Capacity. Adaptive capacity (AC) pertains to the ability of the system to cope with the impacts associated with the changes in climate. AC1 is the level of awareness and the extent of shrimp farmers' knowledge on climate change and its impacts on their livelihood. AC2 is for access to information or the shrimp farmers' accessibility to climate-related knowledge through different means. AC3 is for the adaptive strategies, which refers to the precautionary measures that the shrimp farmers undertake before, during, and after an extreme weather events. AC4 is for the shrimp farming modification or changes adopted for better and effective shrimp farming practices. AC5 is for the community support systems and programs. Lastly, AC6 is for literacy which pertains to the educational attainment of the farmers.

Market Vulnerability Index criteria:

Exposure. Exposure (E) factors are those climate variables included in the assessment that could impact the shrimps (e.g., typhoons, tidal fluctuations, sea-level rise, flood, unpredictable rainfall, and increasing water temperature). Here, exposure factors were chosen based on the criteria adapted from Jacinto and others [22]. E1 is for the stall or market place exposure, which pertains to the frequency and severity of exposure of the market place to extreme weather disturbances. E2 is for the exposure of households site and E3 is for the exposure of the community sites to extreme weather disturbances, pertaining to human exposure and to the community.

Sensitivity. Sensitivity (S) represents the present state of the shrimps in response to the exposure factors arising from climate change. S1 is the volume of supply, which measures the quantity of delivered shrimp in the market. S2 is for the damage shrimp during transportation which measures the rate of damage or dead shrimps during the delivery of shrimps to the market place. S3 is the growth of sale which measures the income of vendor/seller in a span of time. S4 is for the dependence on resource, which pertains to the sellers' source of income. S5 is for the change in temperature, which pertains to changes in temperature in the market place and comparing it from 5 years ago. Lastly, S6 is the health condition, which refers to the health and health needs of the vendors/sellers.

Adaptive Capacity. Adaptive capacity (AC) pertains to the ability of the system to cope with the impacts associated with the changes in climate. AC1 is the level of awareness and the extent of shrimp vendors' knowledge on climate change and its impacts on their livelihood. AC2 is for access to information or the vendors'/seller's accessibility to climate-related knowledge through different means. AC3 is for the adaptive strategies, which refers to the precautionary measures that the shrimp farmers undertake before, during, and after an extreme weather events. AC4 is for the modification on marketing strategies adopted for better and effective selling of shrimp. AC5 is for the community support systems and programs for shrimp vendors about climate change. Lastly, AC6 is for the literacy, which refers to the seller's educational background.

RESULTS

Exposure (E) analysis revealed 1.5 and 1.3 values for E1 and E2 criteria (Table 1). These values indicate that both shrimp ponds(E1) and household and community(E2), experienced rare (0-2 times) occurrence of weather disturbances, such as typhoons, floods, tidal fluctuations, and etc.

Table 1. Average scores and vulnerability index for sensitivity, exposure, and adaptive capacity of shrimp farming in Davao Oriental.

Vulnerability Assessment (VA) Components	Parameters	Score	Average Score	Vulnerability Index
Sensitivity (S)	S1: Mortality rate	2	**2.3**	**M**
	S2: Growth	2.9		
	S3: Water quality of pond	2.2		
	S4: Water temperature	2.1		

	S5: Source of pond water	2.5		
	S6: Source of fry	2.5		
	S7: Change in salinity	1.7		
Exposure (E)	E1: Exposure of shrimp ponds to weather disturbances/natural hazard	1.5		
	E2: Household site assessment	1.3	**1.4**	**L**
	E3. Community site assessment	1.3		
Adaptive Capacity (AC)	AC1: Climate change awareness	2.5		
	AC2: Source of information	o.4		
	AC3: Adaptive strategy	2.3		
	AC4: Modification of cultural practices	1.8	**2**	**L**
	AC5: Support on climate change organization	1.5		
	AC6: Literacy	3.8		

Sensitivity (S) analysis on whiteleg shrimps revealed values of 2, 2.9, 2.2, 2.1, 2.5, and 1.7 for S1, S2, S3, S4, S5, S6, and S7 criteria respectively (Table 1). Thus, most shrimp farmers experienced low mortality rate and observed no changes in growth of shrimps in the past 5 years of farming. In terms of other criteria, like water quality, water temperature, water source, and source of fry, those were observed to be on a neutral to medium parameters that ranges from 2-3 times respectively. In addition, the changed in salinity level of the water in the pond was low for the past 5 years.

Adaptive Capacity (AC) of the whiteleg shrimp farms in terms of climate change activities revealed values of 2.5, 0.4, 2.3, 1.8, and 1.5 for AC1, AC2, AC3, AC4, and AC5 criteria (Table 1). These findings revealed that some of the shrimp farmers have modest knowledge of what climate change is and how such a phenomenon may affect their lives and livelihood. The basic source of information of shrimp farmers on climate change mostly comes from television, internet, and school. Most of them has minor precautionary measures undertaken to mitigate the impacts of weather disturbances that might occur, like deep excavation of water drainage, and elevated dikes, to prevent the possible damage of ponds and shrimps. However, there were slight modifications applied to their culture practices (feeding, water management, etc.) including attending seminars to increase knowledge, yet no additional resources but still found to have no changed in harvest or yield. Also, most of the shrimp farmers doesn't receive any kind of support from any organization with regards to climate change related programs.

Overall average vulnerability assessment score revealed Medium (M) (2.3). Low (L) (1.4), and Low (L) (1.6) for Sensitivity (S), Exposure (E), and Adaptive Capacity (AC), respectively. The scores indicated Low (L) Potential Impact and Medium (M) Vulnerability of whiteleg shrimp (*L. vannamei*) in Davao Region (Table 2 and 3).

Table 2. Overall average values of sensitivity, exposure, and adaptive capacity.

OVERALL AVERAGE ASSESSMENT VALUES		
Sensitivity	2.3	**M**
Exposure	1.4	**L**
Adaptive Capacity	2	**L**

Table 3. Overall average values for potential impact and vulnerability index of whiteleg shrimp.

POTENTIAL IMPACT				
		Sensitivity		
		L	**M**	H
Exposure	**L**	L	L	M
	M	L	M	H
	H	M	H	H
POTENTIAL IMPACT			L	

VULNERABILITY				
		Adaptive Capacity		
		L	M	H
Potential Impact	**L**	M	L	L
	M	H	M	L
	H	H	H	M
VULNERABILITY			M	

In getting the climate change vulnerability index of the markets in Davao Region, the Fisheries Vulnerability Assessment Tool (FishVool) was used to gather information on exposure, sensitivity, and adaptive capacity through surveys of shrimp vendors, with some questions modification.

Exposure (E) analysis revealed that most of the market places in Davao region were low expose to weather disturbances and natural hazards that may occur and either the exposure of their household site and their community (Table 4). These values indicate that the market place/stall (E1) and household site (E2) and community site (E3), experienced rare (0-

2 times) occurrence of weather disturbances in a year, such as typhoons, floods, tidal fluctuations, and etc. Exposure was also categorized to have an indirect and direct effect.

Table 4. Vulnerability Index of Sensitivity, Exposure, and Adaptive Capacity by Market of Davao Region.

Site/Market	Vulnerability Index		
	Sensitivity	Exposure	Adaptive Capacity
PANTUKAN	M	L	L
MABINI	M	L	L
TAGUM	M	L	L
MACO	M	L	L
LUPON	M	L	L
PANABO	M	M	L
DAVAO	M	L	L
DIGOS	M	L	L
STA CRUZ	M	M	L

Sensitivity (S) analysis on whiteleg shrimps in the market revealed to have medium score in all the market places in Davao region in corresponds to the factors that were taken. Sensitivity is usually defined as the natural degree to which biophysical, social and economic conditions are likely to be influenced by foreign stresses or hazards [24]. Medium sensitivity score, is an indication that the vendors in the market experiences frequent changes in the supply of shrimp, also medium counts of damaged shrimps during transportation, observed no change of sales or the sold kilogram per day, and most of the interview vendors were not so dependent on the income they got from selling shrimp from five years ago. Some of them also sell fish and other vendors have other non-shrimp selling related incomes. In terms of the temperature, they haven't noticed any change of weather in their market place. And most of the vendors, are slightly/occasionally suffers from ailments/diseases.

Adaptive Capacity (AC) of the vendors in the market were low (L). This score indicates that the shrimp vendors in different markets of Davao Region were not that really aware of what climate change is, and its potential impacts to them as well as to their livelihood. Their source of information towards climate change is not that equipped for them to be fully

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knowledgeable of the topic. When tackling about climate change, they're just aware of it, but not that knowledgeable. Same thing about the adaptive strategies, they're don't have much precautionary measures undertake to mitigate the possible impacts of weather disturbances brought by the changing climate. Another factor that has been looked at the adaptive capacity criteria was the vendors' modification or change in marketing strategies, most of the vendors haven't change any of their marketing techniques. It's just the season and the pandemic that has change the things in the market. There were no program or support from the government that the vendors have received regarding climate related programs.

Table 5. Vulnerability assessment by Market of Davao Region.

Site/Market	Potential Impact (Sensitivity x Exposure)	Vulnerability (Adaptive Capacity x Potential Impact)
PANTUKAN	L	M
MABINI	L	M
TAGUM	L	M
MACO	L	M
LUPON	L	M
PANABO	M	H
DAVAO	L	M
DIGOS	L	M
STA CRUZ	M	H

Overall, the climate change vulnerability assessment score of markets in Davao region, revealed Medium (M) scores for markets of Pantukan, Mabini, Tagum, Maco, Lupon, Davao, and Digos. Also revealed High (H) Vulnerability scores for the markets of Panabo and Sta Cruz. Showing Low (L) and Medium (M) potential impacts, accordingly (Table 5).

DISCUSSION

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Davao region is blessed with good climate as it experiences Types II and IV climate and lies outside the typhoon belt. Type II climate is characterized by fair distribution of rainfall and sunlight throughout the year; with very pronounced rainfall from November to January. This affects Davao Oriental and most parts of Compostela Valley. The region's annual rainfall based on climatological data of Davao City ranges from 1,673.3 mm to 1,941.8 mm with an average temperature in the region that ranges from 28 ^{0}C to 29 ^{0}C. Warm temperatures is experienced from February to October while the coolest months start from November up to January. (http://davao.da.gov.ph/index.php/about-us/regional-profile).

Direct effects of climate change include changes in the abundance and distribution of exploited species and assemblages, and the increases in the frequency and severity of extreme events, such as floods and storms, which affect fishing operations and infrastructure this is connected to exposure of cultured species such as *P. vannamei* [25-28]. Indirect effects of climate change include: first, changes in aquatic habitat quantity and quality, ecosystem productivity and the distribution and abundance of aquatic competitors and predators [29-33]; second is the impacts on other food production sectors that affect people's food security and livelihoods [31,34-36], and third is the impacts on aspects of people's lives unrelated to their economic activities, such as diseases or damage to their homes [37-40]. The growing occurrence of disasters and extreme weather events, as well as the consequences of a changing climate have a composite impact on aquatic ecosystems and the livelihoods of those who depend on them. In addition, complex emergencies, conflict and prolonged crises can increase pressure on fisheries and aquaculture because shifting populations and rising food prices cause more fishing. Those dependent on fisheries and aquaculture for their livelihoods must navigate the increasing disaster risks that flow from climate change and human-induced hazards. Effective resilience and emergency response strategies require in-depth understanding of fisheries and aquaculture as well as damage and loss monitoring and assessment systems and practices.

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Fortunately, most of the *Penaeus vannamei* farmers in Mati City observed that the shrimp volume production did not shrink, but also it did not grow. Accordingly, the shrimp farmers were still able to achieved their volume targets including the average weight of the shrimp after a period of culture (e.g 24 g – 30 g / 70-100 days of culture). Under the parameter of sensitivity in the FishVool tool, no growth corresponds to a medium score. Which was the case of the the *P. vannamei* farmers of Mati. There were few farmers who answered that there was an increase in the volume of shrimp produced compared five years ago. But predominantly most of the respondents, gave an answer of no observed changes. Changes in ecosystem have severe effects on the growth and production of shrimps and it is highly sensitive to ecological conditions [1,8]. With regards to climate change awareness, most of the shrimp farmers understood the word "climate change" but are not informed about the possible effects of this phenomena on their cultural practices and livelihood.

Some of the shrimp farmers did not perceive the effects of climate change occurring around them. They are more focused on technicalities of production and neglecting the presence and effects of climate change to their production. Most of the farmers are not new to the climate inside their ponds. In contrast to the people outside their vicinity who noticed the change in temperature and the weather condition. Shrimps inside the pond were experiencing a controlled environment, controlled by the farmers. Many of the farmers that were interviewed were unaware of the uncontrolled weather events caused by the changing climate which was in contrast to the small-scale fishers who perceived that the weather changes erratically [41]. The reality about change in weather conditions can be observed in some situations before they can really be noticed e.g. the signs of possible rain. But if their working environment are not completely affected even by incessant rains or typhoons, then they are in a stable location.

The assessment of the literacy of shrimp farmers was high because some of the operators interviewed were college graduates while most of the others were elementary graduates, this led to a medium score in literacy. Education, including extension education

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can provide the necessary foundation needed for growth and development of every individual farmer or fisher by empowering them with new technologies and knowledge that can help them in their trade[42]. Through additional trainings and participation in extension education, they can be equipped to understand environmental factors that is affecting their cultured shrimps [43]. Also, they are more open to ideas, and more connected to other business men or other farmers in the community. In other areas such as in the small-scale fisheries, education and awareness of fishers were necessary for success of conservation measures [44-46].

Adaptation refers to the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects [17]. In this study, the adaptation capacity of shrimp farmers towards the changing climate, reflects a low score. This score is due to lack of support from government or non-government organizations in battling the impacts of climate change. Shrimp farmers are not fully informed of what climate change is, and its capabilities. There were no programs and seminars conducted for the farmers in connection to climate related incidents. No support programs like having technical advices for the betterment of shrimp farming from local to regional agencies that could be of great help for the fishers' cultural practices as well as to their livelihood. The adaptive strategies taken by the shrimp farmers to mitigate the impacts of climate change were barely from their own experiences and not from the experts. The farmers understanding on climate change was too shallow which drive them to have a low score in the adaptive capacity. Adaptations for the possible impacts of climate change can be achieve through better management practices in site selection, pond construction and preparation, selection of post larvae for stocking, pond management, bottom sediment management and disease management together with reducing non-climate stressors such as pollution, conservation of sensitive ecosystems and adoption of dynamic management policies [3].

Adaptation strategies in coping with the impacts of climate change on shrimp farming must be developed to achieve a green and stable economy. With regard to climate change, there is a challenge to the sustainability of coastal aquaculture. Considering extreme vulnerability to the effects of climate change, community-based adaptation strategies must be introduced to cope with the challenges [41,47,48]. The potential impacts of climate change on shrimp farming could have severe effects on food production, export earnings, livelihoods of the coastal poor and their socioeconomic conditions [49]. Shrimp farming is the main source of livelihoods for people living in the coastal region [50]. If the impacts of climate change got deteriorated, a lot of lives will be put into concern.

The effort a shrimp farmer puts in culturing shrimp is invaluable of the income they will get after disposing their products. From the stocking period until harvest. But all of the hardship and stress is paid off when all of the cultured shrimps will be successfully trade. Like any other business, culturing shrimp can be affected by a lot of problems. It can be financially, or environmentally. One big problem that the growers/farmers have faced in culturing shrimp was the pandemic. Where they can’t deliver and sell their shrimps in the markets because of the lockdown and they can’t transport their product to other areas outside the region for bigger income. Aside from the possible impacts of climate change, there are other matters that can affect the shrimp farming and the people that relies on it. Sustainable adaptive measures can be a stepping stone for a successful shrimp farming, but then it is least acknowledged [15,51]. In economic terms, vulnerability has many potential costs, not least in foregone potential economic development [52]. Both potential threat of extreme events and coping strategies when such events do occur, have been posit to result in risk minimization strategies, which have positive and significant costs [28,53]. Thus, the uncertainty of climate variation may have an economic cost in terms of resource sub-optional allocation [52].

An increase in the number of disasters in the Philippines during the 20th century is not natural in origin but rather results from an increase in people’s vulnerability in a changing society, which is linked to population dynamics, fast urbanization and economic development

[54]. In order to effectively reduce the risk of current and future disasters, it is important to distinguish what aspects of a given disaster are due to climate change and what aspects are due to other factors leading to vulnerability; such as environment, economic, social or political factors. Incorrectly attributing the cause of a specific disaster, whether it is a direct cause or a fundamental cause, may ultimately increase the vulnerability of the population at risk by taking away focus from the issues that are truly causing the vulnerability [55].

CONCLUSION AND RECOMMENDATION

Shrimp farming is an essential source of food and livelihood for people living in Mati City. Their culturing of shrimp was medium vulnerable to the impacts of climate change. This indicates a low adaptive capacity of farmers towards the impacts of climate change to their shrimps. Aside from this, farmers were affected by the COVID-19 pandemic which limits them from getting more income. The same was true with the shrimp vendors who encountered difficulties selling their shrimp harvests for the reason of less buyers and less mobility due to the pandemic [56,57]. The shrimps from the farms were sold at lesser prices and this was not good for the farmers because their investments cannot be recouped when prices were down. These are relevant issues that the government should look into, provide alternative livelihoods for the affected fish farmers, and help them to adapt to the possible impacts of climate change, the pandemic and give them additional financial support as well as trainings and seminars on how to adapt to the challenges that they might encounter in their aquaculture [18,56]. Also the government should help provide access to export markets and processing firms so that the farmers do not need to worry on disposing and selling their seafood products [2]. If this will be fulfilled, and fish farmers will be given access to premium markets with relevant government assistance, then there could be a better shrimp farming industry able to satisfy the requirements for traceable seafood products with high foodsafety standards[58-60].

As climate change may worsen or increase the frequency of extreme events such as floods, and storm events, greater awareness of climatic variability and change, which are not well understood by the public or decision-makers, should be promoted[2,31]. Increasing sensitivity and awareness to climate issues will facilitate the public engagement and successive adoption of adaptive measures to prepare for climate variability and climate change. The government should extend their support through conducting and implementing activities beneficial to the farmers. There is a need for wide implementation of strict biosecurity measures and protocols to avert the risk of exposure to possible damage and impacts of climate change towards production and the whole stocking process[61,62].

A more enhance and advance biosecurity will help the farmers achieved bountiful harvest plus, a healthy environment not just for the cultured shrimps but also beneficial to people and to the community. This recommendation should be put into actions in order to attain a sustainable food production and security [22]. To achieved this, more support like financial and technical support can be deliberated to the shrimp farmers/growers. It will strengthen the capacity of farmers for adaptation to climate change. Also, an accessible and fully equipped facilities like laboratories, for a more advance and stable monitoring of the cultured shrimp and its habitat (ponds)[2]. Given these measures that could be adopted by the the government through other cooperating private and non-government agencies, this could be lead to a successful, sustainable, and good quality harvest.

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