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Analysis of the Sustainability, Vulnerability, and Challenges of Aquaculture Livelihood Projects

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Abstract. **Background:** Aquaculture is the best source of sustainable livelihood for communities, as long as the technology is in place and environment friendly. The aquaculture in southern Negros Occidental continues to experience a crisis that includes this recent COVID-19 pandemic, in addition to rapid financial and structural changes and awareness of farming's enormous influence on ecosystem health. Oyster and fish cages farmers were familiar with and associated terms such as environmental protection, small-scale aquaculture, profitability, and productivity with sustainable oyster and fish production. Furthermore, the researcher, who has experience in the aquaculture industry, desires to investigate sustainability and recognizes this aquaculture owners/operators' vulnerability and challenges in their livelihood. Thus, the paper analyzed the sustainability, vulnerability, and challenges of aquaculture livelihood projects in Southern Negros.

Methods: Using a descriptive quantitative research design, 50 aquaculture operators/owners answered a checklist questionnaire to analyze the sustainability, vulnerability, and challenges of aquaculture livelihood projects. Frequency count and percentage distribution were used in analyzing the quantitative data.

Results: In human capital, the operators/owners have at least a high school graduate to engage in aquaculture livelihood and range 0-1 year of experience. They are aware of health and safety practices, and the skills they know are feeding and harvesting. They are sole workers, and the physical skill they perform is swimming.

For natural capital, all operators/owners gained access to the Nanunga River permit from the Local Government Unit of Municipality of Hinigaran. The size of the fishing ground and fish pens is at 5x5meters, and they conduct monthly coastal cleaning for the maintenance of the surroundings. The timeline and growth and water sensitivity affect the timeline growth of the oyster shell and fish species, respectively. They are also given an action plan to prepare the climate change and initiate the monthly coastal cleanup to maintain cleanliness in the coastal.

In terms of financial capital, the income of operators/owners is higher compared to expenses, debt, and taxes paid per harvest. As a result, they can set aside a net amount for savings. Also, they received support from the government

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every year. They were given a three-year projected financial statement to know the income, expenses, debt, savings, and taxes.

Regarding social capital, the aquaculture livelihood helps their community by providing livelihood to their families, providing food supplies, and contributing to economic gain. The operators/owners are trusted, and they follow norms in the community. They are also involved in the monthly meetings to discuss the concerns about their aquaculture livelihood projects. They also avail of the financial assistance loan from the government through the Department of Labor and Employment (DOLE) Pangkabuhayan Program. These imply scheduling a mandatory monthly meeting for the Aquaculture owners/operators, which is also open to the community.

In physical capital, most operators/owners have fish pen infrastructure, fish boats, materials for oyster farming, and fish cage fishing. They also used electricity and fuel as a source of energy. They sent an application for financial aid to the Department of Labor and Employment (DOLE) to purchase new materials for Aquaculture.

The major vulnerabilities are the Covid-19 pandemic, climate change, oil spills, seasonality, and technological changes. The major challenges that the Aquaculture operators/owners face are lack of knowledge, high/low tide, no preparation of unforeseen expenses, lack of participation among members in monthly association meetings, and cannot afford to purchase new materials for fish pens and fishing boats.

Overall, the findings in the light of the Department for International Development (DFID) Sustainable Livelihood Framework, the results were validated as aquaculture livelihood projects are sustainable in terms of human, natural, financial, social, and physical capital.

Conclusion: The aquaculture livelihood projects of aquaculture growers in Southern Negros were sustainable in terms of human, natural, financial, social, and physical capital. It shows that the aquaculture operators/owners have various knowledge and skills in the industry, preservation of water resources and cleanliness of coastal areas, more income and less expenses and debts growers, improve the economy and the people's standard of living and relationships and more fish pens infrastructure and increase of supplies of materials. Notwithstanding the existing vulnerabilities and challenges, the aquaculture livelihood projects were manageable and could easily cope with unforeseen events.

Practical Value of the Paper: The local government agency may explore the possibility of assisting aquaculture livelihood projects in gathering information for periodic evaluation and monitoring of the financial status of aquaculture livelihood projects for reporting purposes. It is hoped that future researchers utilize this study as the basis for further research, especially studies focusing on the sustainability, vulnerability, and challenges of other livelihoods like agriculture industries. Also, the Aquaculture owners/operators can use the strategic plan to present to the Department of Labor and Employment (DOLE) and other organizations to avail the financial assistance and funding in the future.

Keywords. livelihood, sustainability, vulnerability, challenges, aquaculture, capital, descriptive, Philippines.

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1. Introduction

1.1 Background of the Study

Aquaculture is necessary for attaining the United Nation's Sustainable Development Goals (SDG 2). To help the well-being of coastal communities economically (SDG 14), sustainable aquaculture can help fulfill other goals, including terminating poverty (SDG 1), reaching food and nutrition security (SDG 2), facilitating inclusive and sustainable economic growth (SDG 8), and declining inequalities (SDG 10) (Wu et al., 2021). The Food and Agriculture Organization (FAO) calls on countries such as Africa, wherein aquaculture plays an important role in their economy, to support the sustainable development goal 2 (SDG 2) to eliminate hunger, ensure food security, improve nutrition, and promote sustainable aquaculture (Zacharie et al., 2021).

In the Philippines, aquaculture is well-established and thriving. Consistently keeping pace with declining capture fisheries and the specific technologies that attest to sustainability in the long term prevent ecological disruption and do not rescind mangroves and other essential habitats (Thomforde, 2018). According to Geronimo (2018), climate change is anticipated to affect the distribution and abundance of several finfish species in the Philippines and other species worldwide (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019). This raises uncertainties about future vulnerability, exposure, and responses of interlinked human and natural systems (Intergovernmental Panel on Climate Change [IPCC], 2014).

The Hinigaran River of Negros Occidental Western Philippines is home to various aquaculture facilities, ranging from very large fish pens to small structures such as oyster culture stakes (Cabanlit et al., 2019). Aquaculture in southern Negros Occidental, particularly in Hinigaran, Ilog, and Himamaylan, continues to experience quick financial and structural changes, and a lack of awareness of farming has an enormous impact on ecosystem health (Ordonio et al., 2017).

There were several studies conducted on the sustainability, vulnerability, and challenges of the livelihood like livelihood system profiling (Berchoux et al., 2017), analysis of poverty (Biru et al., 2020), sustainable fisheries livelihood (Stephenson et al., 2019) and vulnerability, and sustainable fisheries livelihoods (Pittaluga et al., 2003), but they are limited studies found regarding the sustainability, vulnerability, and challenges of the aquaculture livelihood projects in the Philippines specifically in the Municipality of Hinigaran.

Hence, the study analyzed the sustainability, vulnerability, and challenges of aquaculture livelihood projects in the Municipality of Hinigaran. The findings of this study served as a basis for formulating a strategic plan for the aquaculture livelihood projects in Sitio So-ol, Brgy. Nanunga in Municipality of Hinigaran, Negros Occidental.

2. Literature Review

2.1 Sustainability of aquaculture livelihood project

Aquaculture is one of the fastest-growing food-producing sectors worldwide, making it desirable to assess the sustainability of aquaculture systems (Valenti et al., 2018). The aquaculture industry is moving into a new era of production and processing. A diverse range of products can be produced from a single species, and sustainability will be sought throughout the value chain (Stevens et al., 2018).

2.1.1 Human Capital. Human capital's livelihood capability comprises social development, economic growth, productivity improvement, employment dynamics, ecological improvement, education accumulation, health assurance, security measures, etc. Based on research findings and observation of local conditions, human capital includes the standard of living, welfare level, the number of opportunities for entertainment, income level, employment possibilities,

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ecological security awareness, energy use, and rural attachment (Su et al., 2021). Global aquaculture production now supplies around 50% of human consumption of seafood. With anticipated population increase and per capita seafood consumption growth, production is foreseen to rise from the current 63 million tonnes to almost 100 million tonnes by 2030. Therefore, an investigation analyses and thinks of strengthening the role of education and training in boosting the human capital of the European aquaculture sector as support to overall sector development (Bostock & Seixas, 2015).

2.1.2 Natural Capital. Fish-catching from natural water bodies was the only alternative to satisfy the fish market. Indigenous fishing tribes were vigorously involved in a fish-catching activity for their livelihood. Sustainable livelihoods will help the community with its goods and services by sharing pride and self-esteem with the worker. They will produce more economic and social equity, especially for women and the disadvantaged, without impacting the natural environment (Khadka & Tiwari, 2020).

Freshwater aquaculture is becoming more observable today, beginning from aquaculture households, the number of cage units, the area of the pond, the growth in the number of productions, and community hatchery units. Based on water quality, soil type, transportation access, and other socioeconomic factors, this study recommends fish farming activities like the cultivation of tilapia, catfish, pomfret, gourami, and African catfish, both in ponds and in floating net cages (Effendi et al., 2021).

2.1.3 Financial Capital. The influence of financial literacy can fix performance and investigate the moderating impact of financial capital availability on financial literacy. Since businesses rely on monetary capital to finance, expand and thrive, policymakers should put standards on bridging the access to support gap and, thus, guarantee that entrepreneurs are released from financing pressures (Ngek, 2016).

2.1.4 Social Capital. In pursuance of a better and participatory democracy, scholars have long-established the accurate effects of social capital, values obtained from resources rooted in social ties with others, describing the structure of possibility and progress in cities. Today, social media support digital communities' capability to relate in new ways (de Zuñiga et al., 2017).

Some studies contribute to the debate over the sustainability of the sharing economy by using the Social Capital Theory to expand explanations of the sharing economy's role and scope of relationships with local communities in the context of over-tourism (Zmyslony et al., 2020). Aquaculture-based sustainability can be defined as continuous and harmonic interaction with the aquaculture ecosystems in the local communities. The present study was based on an empirical analysis of some environmental and socioeconomic databases to accentuate the sustainability of aquaculture activity and the quality of the standard of living (Mallick & Rudra, 2021).

2.1.5 Physical Capital. Physical capital refers to the human-created tangible assets or inputs used to support the production of goods and services. It is one of the main factors of production in classical and neoclassical economics. Physical capital includes machinery, buildings, vehicles, equipment, etc. (CFI Team, 2021). Water infrastructure development has greatly enhanced the role of agriculture in coastal livelihoods over the last ten years. Further irrigation infrastructure development should only be prioritized after issues of water governance, and inequity across agricultural and aquacultural livelihoods are addressed (Bernier et al., 2016).

2.2 Vulnerability and challenges of aquaculture livelihood projects

Aquaculture is often in danger from various climatic factors, including calamities like cyclones, drought, floods, global warming, and natural changes like ocean acidification, rainfall variation, salinity, and sea level rise. For aquaculture development to be sustainable, its impacts on the environment must decline considerably (Ahmed et al., 2019).

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2.2.1 Human Capital. Climate change has caused challenges to natural resource-based livelihoods. Current endeavors designed to improve livelihood stability fail to reduce gender discrepancies and enhance women's source of income. When designing sustainable livelihood policies and interventions, greater attention should be paid to gender to increase adoption and participation, negotiate trade-offs, improve environmental conditions, and promote broadly beneficial welfare outcomes (Call & Sellers, 2019).

2.2.2 Natural Capital. The degradation of natural and artificial bodies of water is increasing, impacting fish production and the environmental condition of the waters. The expansion of water hyacinth closure from the surface water column by reducing the concentration of dissolved oxygen in the bottom water column induces disruption to the growth of aquaculture fish, so it is essential to eradicate the water hyacinth weed (Nastiti et al., 2020). Currently, the effect of aquaculture on the environment has obtained the most attention (Wu et al., 2021). Fishers are exposed to constant stresses, trends, and seasonality, such as decreasing mud crab population, sand mining, saltwater intrusion, and increased water temperature. Middlemen play an important role in accessing the export market, thus enabling fishers to obtain a higher price per animal than village markets (Apine et al., 2019).

2.2.3 Financial Capital. Community-based aquaculture (CBA) has been implemented as an essential alternative income-generating activity to lessen the overdependence on marine natural resources and foster biodiversity preservation. Limitations included a shortage of seed and feed supplies, low investment, lacking specialized competence, inadequate government support, and the absence of a transparent approach to aquaculture development. These are caused by a lack of engagement of local community members, with decisions often overpowered by contributors, development agencies, and private sector partners. Many of the region's CBA projects are developed in an impossibly short period, operated by donors rather than entrepreneurs. They cannot attain financial sustainability, restricting the chance for capability and longer-term development (Atewerberhan et al., 2018). Inadequate financial capital hinders favorable livelihood results by restricting investment in manufacturing facilities, high-quality fry, and advanced aquaculture technologies (Wu et al., 2021).

2.2.4 Social Capital. Although studies on the broad social implications of climate change have been conducted, researchers have only recently started to regard the gendered inequality of the global concept of vulnerability, exposure, and adaptive ability to environmental stressors and shocks. Historically, there is a rare consideration of policies and interventions addressing natural resource-based livelihoods despite the global pervasiveness of gendered differences in economic opportunities and welfare outcomes (Call & Sellers, 2019). A study pointed out the critical nexus between marginalized communities' experiences of climate change, disaster risk reduction, and how they can come collectively to make a whole society strong and sustainable (Khalil, 2016).

2.2.5 Physical Capital. Coastal regions are most exposed to the impacts of climate change. To improve the infrastructure-resilience of such regions, there is a need to decrease the livelihood vulnerability of people living in these areas and train them with appropriate livelihood strategies. Governments have funded heavily coastal infrastructure such as polders (Nath et al., 2020).

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3. Theoretical Framework

This paper theorizes that sustainability is attained through adaptive strategies built on participation, empowerment, contemporary knowledge, technology, financial services, and improvement in government policies. A sustainable livelihoods approach to development generally focuses on the existing capital of local people in five capital-based assets: natural, financial, physical, human, and social (Department for International Development [DFID], 2001; Helmore & Singh, 2001; Scoones, 1998).

This study is anchored on the Department for International Development (DFID) Sustainable Livelihood Framework (SLF), which aims at increasing the effectiveness of the agency's poverty reduction projects. DFID focused not only on the importance of people-centered policies but also on responsive policies (involving the poor in decision making to better understand their challenges), applicable at multi-levels, conducted in partnership (involved both public and private sector), sustainable (includes economic, institutional, social, and environmental sustainability) and dynamic. One of the noted strengths of impact assessment using the Sustainable Livelihood Framework (SLF) approach is that it is useful for identifying unanticipated impacts (DFID, 2001).

According to Allison and Horemans (2006), the Sustainable Livelihood Framework (SLF) helped to align aquaculture policy with wider poverty reduction initiatives and to identify means of contributing to poverty reduction that does not directly increase fully or over-exploited fish resources. The Sustainable Livelihood Framework (SLF) also analyzed the vulnerability of Himalayan communities and their potential to adapt to these challenges using the five forms of capital leading to a sustainable livelihood, i.e., human, natural, financial, social, and physical capital. It was assessed for each of these forms of capital using the said framework (Pandey et al., 2017). Using the DFID Sustainable Livelihood Framework (SLF) shows the relatively good status of the farmers' livelihood sustainability with indicators from livelihood capitals (Tran et al., 2021).

Therefore, DFID's Sustainable Livelihood Framework (SLF) is relevant to this study by analyzing the sustainability, vulnerability, and challenges in aquaculture livelihood projects in the Municipality of Hinigaran.

4. Conceptual Framework

The conceptual framework for this paper is based on DFID’s Sustainable Livelihood Framework (SLF), which was developed to help understand and analyze the livelihoods of the poor. DFID aims to increase the sustainability of poor people's livelihood through improving access to high-quality education (human capital), more secure access to and better management of natural resources (natural capital), more secure access to financial resources (financial capital), more supportive and cohesive social environment (social capital) and better access to basic and facilitating infrastructure (physical capital). Also, the framework views people as operating in a context of vulnerability (DFID, 2001).

The findings of the study served as a basis for the formulation of the strategic plan for aquaculture livelihood projects.

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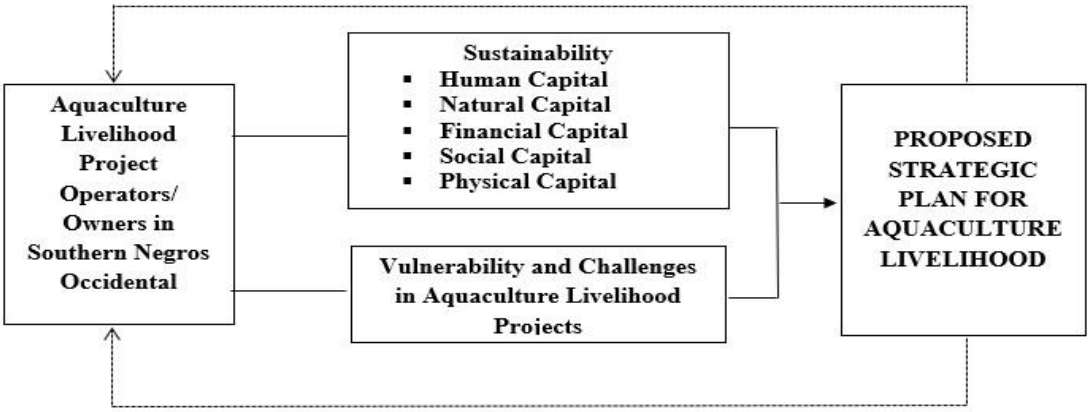

Figure 1: Conceptual Model

5. Research Methodology

5.1 Research Design

This study utilized the descriptive research design. Quantitative research will be used for this study as it emphasizes the development of arguments and reasonable solutions to real societal issues and the construction of appropriate theories (Creswell & Creswell, 2017).

Also, the design was used to provide information and identify characteristics, frequencies, trends, and categories about the sustainability, vulnerability, and challenges of aquaculture livelihood projects in terms of livelihood capital such as human, natural, financial, social, and physical capital (McCombes, 2019).

5.2 Respondents

The respondents of the study were the total enumeration of 50 active aquaculture operators/owners who are members of Aquaculture Livelihood Growers in Southern Negros Occidental.

5.3 Research Instruments

The researcher-made questionnaire utilized the checklist for sustainability, vulnerability, and challenges of aquaculture livelihood projects. The checklist is composed of 3 parts. Part 1 contains a profile of the respondents. Part 2 consists of the sustainability of aquaculture livelihood projects in terms of human, natural, financial, social, and physical capital. Part 3 includes the vulnerability and challenges of aquaculture livelihood projects in terms of human, natural, financial, social, and physical capital.

The results of the Content Validity Index (CVI) from the ten experts using Lawshe's (1975) Content Validity Ratio (CVR) is 1.00, which means that the items in the research instrument are closely linked to the objectives of the study.

5.4 Data Collection Procedure

The researcher acquired permission from the Local Government Unit (LGU) of the Municipality of Hinigaran, Brgy. Captain of Brgy. Nanunga and the President of Aquaculture Livelihood Growers of Southern Negros Occidental send them a formal letter request. Before administering the instrument, the respondents were given an orientation about the purpose and scope of the study.

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During the data gathering, the researcher gives instructions to the respondents on how to properly answer the checklist questionnaire and assists some of them with clarification on questions they do not understand.

After collecting the information, the data are tabulated and analyzed using the appropriate statistical tools.

5.5 Data Analysis Procedure

Descriptive analysis was used to analyze and interpret the data on the sustainability, vulnerability, and challenges of aquaculture livelihood projects of Aquaculture Livelihood Growers in Southern Negros Occidental in terms of their capital assets as assessed by owners/operators for the period covered in 2022. Frequency count and percentage distribution were used as statistical treatments.

5.6 Ethical Considerations

5.6.1. Social relevance. This study contributed to the aquaculture growers to determine the strengths and weaknesses of the aquaculture industry in Southern Negros Occidental. The findings helped them increase operational efficiency and profitability in the aquaculture livelihood due to more sustainability as it has considered the potential opportunities, trends, and threats that might affect it in the long run.

5.6.2. Informed consent. It was highlighted to the participants that their participation in the study was voluntary, and they have a right to withdraw. During the orientation, the researcher gathered the names of participants willing to participate and signed the informed consent form.

5.6.3. Vulnerability of research participants. There is no vulnerability in the research participants because most of them are literate and very knowledgeable to answer the survey questions.

5.6.4. Risk and benefits. It is necessary that the participants must be free from potential harm, risks, and threats relative to the data gathering process. In this view, the participants should not be subjected to these harmful circumstances in the study, including physical and mental harm. If they feel discomfort or inconvenience when answering the survey questionnaire, they opt not to answer the questions that make them feel any physical pressure or psychological stress.

The participants' benefits include access to information, knowledge about the sustainability of their aquaculture livelihood, and the opportunities to share experiences and greater solidarity with others.

5.6.5. Justice. The respondents of this study were exclusively fairly selected from the members of the Aquaculture Livelihood Growers Association in Southern Negros Occidental. The participants were given the token as appreciation and reimbursement for their voluntary participation. The association members were informed of the result of the study and were consulted to prepare the output of the study.

5.6.6. Privacy and confidentiality. The researcher kept the records as this study is confidential in adherence to the Data Privacy Act of 2012. No information that discloses their identity is released or published without their specific consent to the disclosure, except, if necessary, to protect their rights or welfare. Likewise, the researcher does not release information about their participation to those not connected to the study. The researcher ensured that the research might not involve gathering and sharing data or confidential information beyond the initially given consent and the involvement of means to identify anonymous/unnamed participants. The information obtained is stored in the external hard drive with a password for protection and deleted after the study for disposal.

5.6.7. Transparency. This paper is available, accessible, and readily presented to the stakeholders, including the potential publication of this study. Thus, the researcher declares no conflict of interest in this study since he may never gain monetary or administrative benefits.

5.6.8. Qualification of the researcher. The researcher has extensive business management knowledge, including a Bachelor's in Business Administration major in Management

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Accounting and Economics, and currently taking a Master's in Business Administration (MBA), hands-on skills, experience, and familiarity with the content research method of aquaculture livelihood.

5.6.9. Adequacy of facilities. The researcher provided a conductive facility such as a multi-purpose hall in Sitio So-ol, Brgy. Nanunga for the convenience of the respondents to administer the survey instrument. Also, the researcher used library sources like ProQuest to find the references in the literature.

5.6.10. Community involvement. The researcher asked permission from the Local Government Unit (LGU) of the Municipality of Hinigaran, Aquaculture Growers, and they assisted by sending a representative to help the researcher discuss the benefits of the study during the orientation. Also, the Officers and members of the Aquaculture Livelihood Growers Association in Southern Negros Occidental for their participation and use of information and other data during the entire course of the study. They were also given a strategic plan based on the formulation of the results of the study to implement more sustainable operations in their livelihood.

The findings of the study and the strategic plan were presented to the Aquaculture operators/owners for discussion of results and allowing them to give comments and suggestions.

6. Results and Discussion

6.1 Sustainability of Aquaculture Livelihood Projects in terms of Human Capital

Table 1 survey result for the sustainability of aquaculture livelihood projects in terms of Human capital for education shows that most of the operators/owners graduated at least high school with a frequency of 15 or 30%. In terms of experience, most operators/owners operate for ranges of 0-1 year with a frequency of 18 or 36%. In terms of knowledge, with a frequency of 32 or 64% of operators/owners knows about health and safety practices in operating oyster farming and fish cages fishing. In terms of skills/expertise, with a frequency of 34 or 68% of operators/owners applied skills, including feeding, and harvesting oysters and fish. In terms of workforce, half of the operators/owners are sole workers with a frequency of 25 or 50% and do not hire contractual workers with a frequency of 25 or 50%. In terms of physical abilities, with a frequency of 37 or 74% of them perform swimming.

To operate or invest in oyster farming and fish cage fishing livelihood, it is not necessary to graduate from any academic institutions if you are willing to learn and engage and livelihood training is enough for expanding the knowledge and skills in aquaculture. Many of them are investors outside the municipality who have the least experienced in the aquaculture industry. They must be familiar with these practices to prevent accidents, sickness, and unfortunate incidents while operating their livelihood. Feeding and harvesting are common in oyster farming and fish cage fishing because it involves nurturing and farming oysters and fishes. Most operators/owners are sole workers because they cannot afford to pay the wages or additional costs for the workers. It is essential that the operators/owners know to swim for them to easily transfer from one fish pen to another fish pen. Thus, the human capital of aquaculture livelihood projects is sustainable.

According to Slaus and Jacobs (2011), human capital is the critical determinant of long-term sustainability. Efforts to accelerate the evolution of human consciousness and the emergence of mentally self-conscious individuals will be the most effective approach for ensuring a sustainable future. Education is the primary lever.

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Table 1. Sustainability of Aquaculture Livelihood Projects in terms of Human Capital

Questions	f	%
What is your highest educational attainment?		
High School	15	30
Bachelor's Degree	11	22
Elementary	10	20
Vocational Course	9	18
College Undergraduate	5	10
Doctorate	0	0
Master's	0	0
How long have you been exposed to the business before owning the aquaculture livelihood?		
0-1 year	18	36
2-5 years	16	32
6-9 years	8	16
10 or more years	8	16
What is your knowledge about Oyster Farming and Fish Cage Fishing livelihood?		
Awareness of health and safety practices	32	64
Train, supervise, manage and assess staff	27	54
Keep records of the growth and health of oysters and fish	26	52
Plan work schedules and prepare budgets	23	46
Seasonality schedule for growing fish and oyster	19	38
What are your skills applied to Oyster Farming and Fish Cage Fishing livelihood?		
Feeding	34	68
Harvesting	34	68
Connecting ropes	31	62
Driving boats	29	58
Tying knots	26	52
Troubleshooting boats	25	50
Navigating boats	23	46
Dive to clear any debris or dead fish for fish cages	19	38
Packing	17	34
Operate underwater net cleaning machines	16	32
Maintain marine farm equipment	16	32
How often do you hire workers?		
Not Applicable	25	50
Quarterly	24	48
Weekly	1	2
Daily	0	0
Monthly	0	0
How many contractual/monthly worker/s are waged under your supervision?		
Sole worker	25	50
5 or more workers	8	16
2 workers	6	12
4 workers	6	12
3 workers	5	10
What are the physical abilities you perform for oyster farming and fishing?		
Swimming	37	74
Carrying Heavy Loads	34	68
Jumping	31	62
Paddling	27	54

6.2 Sustainability of Aquaculture Livelihood Projects in terms of Natural Capital

Table 2 shows that all the owners/operators with a frequency of 50 or 100% gain access to water resources by getting a periodic permit from the Local Government Unit (LGU). They get annual business permits to operate in Nanunga River with a frequency of 50 or 100% legally. They

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have also said that the usage of Nanunga River is not exclusively used by the association with a frequency of 50 or 100%. Most sizes of fishing grounds or pens by the operators/owners are 5x5 meters with a frequency of 20 or 40%. The coastal community cleanup is conducted monthly with a frequency of 43 or 86%. They say that water level has affected the timeline of the growth of oyster shells with a frequency of 50 or 100%, and the water resources are sensitive to any kind of fish species with a frequency of 50 or 100%.

If the aquaculture operators/owners comply to get business permits, they can operate in Nanunga River if they maintain the cleanliness of the coastal area. The operation of Nanunga River is open to the community and not exclusively used by aquaculture growers. The common measure by the fish pens is 5x5 meters to easily uphold the foundation of the bamboo surface. It is important to maintain the cleanliness of the Nanunga River because it affects the timeline of the growth of oyster shells, and the fishes are very sensitive to water contamination. Therefore, the natural capital is sustainable.

To maintain the natural capital for water resources, activities must promote sustainable aquaculture practices, the benefits of its products to consumers, and how they satisfy end users' needs are also needed to implement and sustain coastal areas (Correia et al., 2020). Therefore, environmental sustainability must deliver an excellent opportunity to train students and inform the public, advance ocean literacy, and enhance social acceptance of aquaculture products, improving their consumption (Shuve et al., 2009).

Table 2. Sustainability of Aquaculture Livelihood Projects in terms of Natural Capital

Questions	f	%
In what manner have you accessed water resources for Oyster Farming and Fish Cages Fishing?		
Periodic permit from LGU	50	100
Free Access	0	0
Access exclusively for association membership	0	0
In which areas of bodies of water are suitable for your oyster farming & fish cages fishing?		
Nanunga River	50	100
Hinigaran Poblacion River	0	0
Tanulo River	0	0
Linao Lake	0	0
Gargato Sea	0	0
Does your water resources in the fishing ground or fish pens exclusively use for the members of the association?		
No	50	100
Yes	0	0
How large are your fishing ground or fish pens?		
5 x 5 meters	20	40
10 x 10 meters	18	36
2 x 2 meters	10	20
Others	2	4
How often do you conduct coastal cleaning near your fishing ground or fish pens?		
Monthly	43	86
Weekly	3	6
Others	3	6
Daily	1	2
Never	0	0
Does the water level affect the timeline of the growth of the oyster shell?		
Yes	50	100
No	0	0
Does your water resources sensitive to any kind of fish species?		
Yes	50	100
No	0	0

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6.3 Sustainability of Aquaculture Livelihood Projects in terms of Financial Capital

Table 3 shows that the harvest of oyster and fish products is only once a year with a frequency of 25 or 50%. The income per harvest ranges from P100,001.00-P200,000.00 per year with a frequency of 16 or 32%. The expenses per harvest range from P50,000.00 & below per year with a frequency of 43 or 86%. The savings per harvest ranges from P50,000.00 & below with a frequency of 45 or 90%. The debt per harvest ranges from P50,000.00 & below with a frequency of 50 or 100%. The financial support they receive from the government every year ranges from P50,000.00 and below with a frequency of 50 or 100%, and they pay taxes per harvest ranges P50,000.00 & below with a frequency of 50 or 100%.

It shows that the income per harvest is higher than expenses and debt. Therefore, the owners/operators can still have savings from their harvest. It is part of the local tax policy in the Municipality of Hinigaran that they must declare their income and pay taxes per harvest. Therefore, the financial capital is sustainable.

Wu et al. (2021) suggest that secure access to sea areas, provision of financial options to aquaculture smallholders, and diversification in aquaculture type and variety could promote the socioeconomic sustainability of aquaculture development.

Table 3. Sustainability of Aquaculture Livelihood Projects in terms of Financial Capital

Questions	f	%
How often is your harvest in a year?		
Once	25	50
Twice	19	38
Every 4 months	5	10
Every 3 months	1	2
How much is your income per harvest?		
P100,001.00 – P200,000.00	16	32
P50,000.00 & below	14	28
P50,001.00 – P100,000.00	11	22
P300,001.00 & above	5	10
P200,001.00 – P300,000.00	3	6
How much is your expense per harvest?		
P50,000.00 & below	43	86
P50,001.00 – P100,000.00	7	14
P100,001.00 – P200,000.00	0	0
P200,001.00 – P300,000.00	0	0
P300,001.00 & above	0	0
How much is your savings per harvest?		
P50,000.00 & below	45	90
P50,001.00 – P100,000.00	4	8
P100,001.00 – P200,000.00	1	2
P200,001.00 – P300,000.00	0	0
P300,001.00 & above	0	0
How much is your debt per harvest?		
P50,000.00 & below	50	100
P50,001.00 – P100,000.00	0	0
P100,001.00 – P200,000.00	0	0
P200,001.00 – P300,000.00	0	0
P300,001.00 & above	0	0
How much is your financial support from the government every year?		
P50,000.00 & below	50	100
P50,001.00 – P100,000.00	0	0
P100,001.00 – P200,000.00	0	0
P200,001.00 – P300,000.00	0	0
P300,001.00 & above	0	0
How much is your tax paid per harvest?		
P50,000.00 & below	50	100
P50,001.00 – P100,000.00	0	0

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P100,001.00 – P200,000.00	0	0
P200,001.00 – P300,000.00	0	0
P300,001.00 & above	0	0

6.4 Sustainability of Aquaculture Livelihood Projects in terms of Social Capital

Table 4 shows that in most instances, Aquaculture owners/operators answered that oyster farming and fish cages fishing help their community by providing livelihood to their families, providing food supplies, and contributing to the economic gain with a frequency of 50 or 100%. They are often trusted with a frequency of 44 or 88% and follow the norms in their social community with a frequency of 36 or 72%. They are not the beneficiaries of the DSWD 4ps program with a frequency of 50 or 100%. Also, all of them are active members and participate in the association with a frequency of 50 or 100%, and some operators/owners avail of the financial assistance loans, specifically the DOLE Pangkabuhayan Program with a frequency of 47 or 94%.

The aquaculture livelihood in Southern Negros Occidental improves the quality of life in the social community. When the aquaculture operators/owners are trusted and follow the norms of the community, the relationships between them and society become stronger; thus, the operation will be less aggravating to the operation of the aquaculture livelihood. Some did not avail of the loan because they already had outstanding debt in other institutions. This only shows that the social capital in aquaculture livelihood projects is sustainable.

The results showed how aquaculture stakeholders consider the extent of sustainability. Due to low legitimacy and acceptance of the content, the stakeholders perceived social sustainability as an interesting tug of war. These two factors are prerequisites for sustainable industry growth. A lack of legitimacy and acceptance may affect procedures and long-standing institutional setups (Sonvisen & Vik, 2021).

Table 4. Sustainability of Aquaculture Livelihood Projects in terms of Social Capital

Questions	**f**	**%**
In what instances do oyster farming and fish cages fishing help your community?		
Provides livelihood to the families	50	100
Provides food supplies to the community	50	100
Contribute to the economic gain	50	100
Can you be trusted in your social community?		
Often	44	88
Sometime	6	12
Never	0	0
Do you follow norms in your social community?		
Often	36	72
Sometimes	14	28
Never	0	0
Are you one of the beneficiaries of the DSWD 4ps program?		
No	50	100
Yes	0	0
Do you participate in your livelihood association?		
Yes	50	100
No	0	0
Do you avail of financial assistance loans from the government?		
Yes	47	94
No	3	6
If yes, what program do you avail of?		
DOLE Pangkabuhayan Program	47	94
OWWA	0	0
DSWD Livelihood Assistance Grant (LAG)	0	0

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6.5 Sustainability of Aquaculture Livelihood Projects in terms of Physical Capital

Table 5 shows that the owners/operators say that they have fish pen infrastructures with a frequency of 29 or 58% and owned with a frequency of 23 or 46%. Also, they say they do not have fishing boats with a frequency of 22 or 44%. They currently use materials for oyster farming operations: poly straps/pikit, kawayan/bamboo, and tipaka, with a frequency of 50 or 100%. The materials used for the operation of fish cage fishing include kawayan/bamboo, pataw, screen (green), terilen, taklob (cover), and drum with a frequency of 50 or 100%. The most used energy source they use is electricity, with a frequency of 49 or 98%. Managat fish is the common fish species they nourish in fish cages with a frequency of 30 or 60%.

Not all owners/operators can afford to build the fish pen because of the high cost of material and labor. But through a financial loan from DOLE Livelihood Program, they can procure materials they can use in operation. Based on the results, the aquaculture operators/owners have adequate infrastructure and resources; thus, their physical capital is sustainable.

According to Ene and Mihai (2020), modern aquaculture infrastructures describe a significant innovation in fish production. They have been the fastest-growing food production sector, reaching an average worldwide growth rate of 6-8% per year. Aquaculture offers significant opportunities and yields substantial challenges, especially regarding the ecological sustainability of the production, as well as the quality and safety of the products.

Table 5. Sustainability of Aquaculture Livelihood Projects in terms of Physical Capital

Questions	f	%
Do you have fish pen infrastructure?		
Yes	29	58
No	21	42
If yes, is it owned or rented?		
Owned	23	46
Rented	6	12
Not Applicable	21	42
How many fishing boats do you have?		
None	22	44
1	16	32
2	10	20
3	2	4
What materials do you currently use for operation in oyster farming?		
Poly Straps/Pikit	50	100
Kawayan/Bamboo	50	100
Tipaka	50	100
What materials do you currently use for operation in fish cage fishing?		
Kawayan/Bamboo	50	100
Pataw	50	100
Screen (Green)	50	100
Terilen	50	100
Taklob (Cover)	50	100
Drum	50	100
What energy sources do you use for your operation?		
Electricity	49	98
Fuel	9	18
Solar	0	0
What kind of fish do you currently nourish in your fish pens/fish cages?		
Managat	30	60
Inid	28	56
Milkfish/ Bangrus	17	34
Bulgan	2	4
Kikiro	1	2

6.6 Vulnerability of Livelihood Projects in terms of Human Capital

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Table 6 shows that all operators/owners have been affected by the Covid-19 pandemic with a frequency of 50 or 100%. Half of the owners/operators say that they have existing health concerns with a frequency of 25 or 50%, on which they have high/low blood pressure with a frequency of 8 or 16%.

The Municipality of Hinigaran in Southern Negros Occidental has experienced lockdowns due to severe virus cases; thus, they are affected by the COVID-19 pandemic. The results show that the aquaculture operators/owners experience health concerns, but it does not hinder the operation of their aquaculture livelihood.

According to Becker (2007), health is an important factor for human capital, like training and education, and this should be maintained. All four standards analyzed predominantly prescribe human capital as a means of standard compliance rather than social, financial, natural, and physical capital. Human capital remains the most important capital for standard compliance; therefore, it should be properly observed, especially the health concerns (Samerwong et al., 2020).

Table 6. Vulnerability of Aquaculture Livelihood Projects in terms of Human Capital

Questions	f	%
Are you affected by the Covid-19 pandemic?		
Yes	50	100
No	0	0
Do you have any existing health concerns?		
Yes	25	50
No	25	50
If yes, what are your specific health conditions?		
No Specific Condition	25	50
High/low blood pressure	8	16
Asthma	8	16
Diabetes	3	6
Heart Disease	3	6
Influenza and pneumonia	2	4
Stroke	1	2
In what category as an operator do you belong?		
Not Applicable	41	82
Out of School Youth	6	12
Senior Citizen	3	6
PWD	0	0
Mentally Unstable	0	0
In what category does your contractual worker/s belong?		
Not Applicable	47	94
Out of School Youth	2	4
Senior Citizen	1	2
PWD	0	0
Mentally Unstable	0	0

6.7 Vulnerability of Aquaculture Livelihood Projects in terms of Natural Capital

Table 7 shows that the most common vulnerability they have faced in recent years is climate change, with a frequency of 49 or 98%. The calamity that frequently affects their water resources is oil spills, with a frequency of 34 or 68%. Due to climate changes, water resources may result in oxygen deficiency, with a frequency of 38 or 76%. The water becomes more acidic with a frequency of 31 or 62. Seasonality affects the growth of oysters and fishes with a frequency of 50 or 100%.

This is a common problem for the operators/owners because sudden or untimely weather changes affect the growth of oysters and fish. It is a common incident in the locality because the riverbank is located beside the residential and commercial areas in the Municipality of Hinigaran, where many residents dump unwanted oil spoilage in the river. This may result

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in limited species of fish to nourish on the riverbanks. This may result in limited species of fish to nourish on the riverbanks.

Governments and businesses are beginning to account for natural capital but must collaborate to promote sustainability, combat climate change, and improve decision-making (Agarwala et al., 2014). Coastal areas are more vulnerable to climate change and natural disasters. Due to increased weather extremes caused by climate change, coastal communities fall at high risk of casualties and damages (Didar-UI Islam, 2015).

Table 7. Vulnerability of Aquaculture Livelihood Projects in terms of Natural Capital

Questions	f	%
In what form of vulnerability did your water resources face in recent years?		
Climate Change	49	98
Ocean Acidification	40	80
Species Sensitivity	39	78
What calamities frequently affect your water resources?		
Oil Spill	34	68
Typhoon	29	58
Earthquake	16	32
In what aspects that climate change impacts water resources?		
Oxygen Deficiency	38	76
Degradation of Water Quality	19	38
Changes in the altimetric level of water	19	38
In what aspects that ocean acidification impacts water resources?		
The water becomes more acidic	31	62
Decreasing carbonate concentrations	29	58
Does seasonality affect the growth of oysters and fishes?		
Yes	50	100
No	0	0

6.8 Vulnerability of Aquaculture Livelihood Projects in terms of Financial Capital

Table 8 shows that the Covid-19 pandemic affects the income of the operators/owners with a frequency of 50 or 100%. The common financial constraint they encountered in the aquaculture livelihood is the high overhead costs with a frequency of 31 or 62%. The highest overhead costs are repair and maintenance of fish pens, with a frequency of 49 or 98% due to replacing the bamboo surface. Most of the operators/owners do not sell on credit 26 or 52% during the time of harvest.

Due to the limited transportation between cities and municipalities, the closing of the establishment, specifically the seafood restaurants, and declining order demands from foreign buyers, the price of oysters and fish suddenly drop resulted in the low income of the operators/owners.

The COVID-19 outbreak has generated unprecedented disruptions to the global economies, leading to income loss and high unemployment rates (Dang & Nguyen, 2021).

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Table 8. Vulnerability of Aquaculture Livelihood Projects in terms of Financial Capital

Questions	f	%
Does the Covid-19 pandemic affect your income?		
Yes	50	100
No	0	0
Do financial constraints encountered in your aquaculture livelihood?		
High overhead costs	31	62
Bad debts	18	36
High Taxes	16	32
Delayed payments	14	28
Common overhead costs incurred in oyster farming and fish cage fishing?		
Repairs and Maintenance	49	98
Taxes	48	96
Utilities	47	94
Fish pens rental	9	18
Do you sell oyster and fish harvest on credit to your buyers?		
No	26	52
Yes	24	48
If yes, what are the often contracted/agreed terms of payment collections?		
Not Applicable	26	52
61-90 days	13	26
0-30 days	9	18
31-60 days	2	4

6.9 Vulnerability of Aquaculture Livelihood Projects in terms of Social Capital

Table 9 shows that the Covid-19 pandemic affects the relationship between the operators/owners and the association member with a frequency of 28 or 56%. Most operators/owners experience social pressure with a frequency of 42 or 94%, specifically socioeconomic pressure with a frequency of 32 or 64%. They do not encounter legal action and do not experience conflict between the supplier and buyers, with a frequency count of 43 or 96%.

The restriction of transportation within the Municipality due to the local Covid-19 protocols resulted in the lack of involvement in the monthly meeting of some members because of occupational status, educational attainment, and inequities in access to health care. They must build relationships with those stakeholders because they become part of the product's marketability.

The social capital of individuals in impacted communities from the COVID-19 pandemic is asked to curtail daily life activities and increasingly spend their time at home. They are necessarily cut off from most normal face-to-face interactions with all but the members of their immediate household (Pitas & Ehmer, 2020).

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Table 9. Vulnerability of Aquaculture Livelihood Projects in terms of Social Capital

Questions	f	%
Does the Covid-19 pandemic affect your relationship with your co-operators and other members of the association?		
No	28	56
Yes	22	44
What particular social shocks that you encounter in your aquaculture livelihood?		
Social Pressure	47	94
Legal Action	1	2
Consumer Boycotts	1	2
Operational Stoppage	1	2
How does social pressure affect your livelihood?		
Socioeconomic pressure	32	64
Peer pressure	26	52
Academic pressure	20	40
Not Applicable	3	6
Do you experience legal action from the community due to the operation of your livelihood?		
No	48	96
Yes	2	4
Do you experience conflict between your supplier and buyers?		
No	48	96
Yes	2	4

6.10 Vulnerability of Aquaculture Livelihood Projects in terms of Physical Capital

Table 10 shows that the Covid-19 pandemic affects the use of fish pen infrastructure and transport systems with a frequency of 50 or 100%. The technological change problem they experience in the fish pen infrastructure is that they cannot afford to buy engine materials, with a frequency of 43 or 86%. Most of the operators/owners do not have enough capital. They need more time to learn the usage of the equipment/facility, with a frequency of 28 or 56%. Most fishing boat owners conduct monthly maintenance to extend the fishing boats' durability with a frequency of 40 or 80%.

The transportation system is being hindered due to the restriction of carriage movement between cities and municipalities. There are some new technological materials to be used in operations, but the aquaculture owners/operators cannot afford to buy engine materials, and it takes more time to learn. Also, they repair their fish pen/fish cages semi-annually, especially by replacing the bamboo surface.

The limitation of carriages affects the infrastructure and increases transportation costs resulting from increasing business risk, food prices, and general prices (Curtis, 2007).

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Table 10. Vulnerability of Aquaculture Livelihood Projects in terms of Physical Capital

Questions	f	%
Does the Covid-19 pandemic affect the use of your fish pen infrastructure and transport system?		
Yes	50	100
No	0	0
What technological change problems do you experience in your fish pen infrastructure and transport system?		
Cannot afford to buy engine materials	43	86
Lack of knowledge in modern facilities.	23	46
How does modern equipment/facility affect your operations?		
Need more time to learn the usage of the equipment/facility	28	56
More costs to be incurred	23	46
Need to hire experts to learn the usage of the equipment/facility.	17	34
Not Applicable	4	8
How often do you conduct maintenance in your fishing boats?		
Monthly	40	80
Not Applicable	6	12
Weekly	3	6
Daily	1	2
How often do you need to repair your fish pen/fish cages?		
Semi-annually	30	60
Annually	14	28
Quarterly	4	8
Monthly	2	4

6.11 Challenges of Aquaculture Livelihood Projects

Table 11 shows that the lack of knowledge is the common challenge for human capital, with a frequency of 21 or 42%. The common challenge for natural capital is high/low tide, with a frequency of 33 or 66%. The common challenge for financial capital is the no preparation for unforeseen expenses, with a frequency of 66%. The common challenge for social capital is the lack of participation among members in monthly association meetings, with a frequency of 45 or 90%. The common challenge for physical capital is that they cannot afford to purchase new materials for fish pens and fishing boats, with a frequency of 36 or 72%.

The main excuse of the other operators/owners for being unable to attend the monthly meeting due to personal and emergency reasons. Based on the result of table 12, most operators/owners cannot afford to buy engine materials due to the higher costs of repair and maintenance of fish pens.

The most difficult challenge facing policymakers is deciding the future directions of society and the economy in the face of often conflicting requirements for short-term political success, economic growth, social progress, and environmental sustainability (Moldan & Dalh, 2007). The livelihood capital will be helpful in the long term if complemented by relative policies that enhance capital capacity and increase access to capital (Fang et al., 2014).

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Table 11. Challenges of Aquaculture Livelihood Projects

Items	f	%
Challenges face in worker's/operators experience and skills (Human Capital)		
Lack of knowledge	21	42
Lack of Management Skills	20	40
Lack of training	15	30
Shift of livelihood to other industries (construction, agriculture, etc.)	15	30
Unstable Health	14	28
Challenges face in water resources (Natural Capital)		
High/Low Tide	33	66
Climate Change	23	46
Water Pollution	20	40
Drought	13	26
Challenges face in handling finances (Financial Capital)		
No preparation for unforeseen expenses	33	66
Not Raising Enough Capital	23	46
Not using a Budget Plan	19	38
Neglecting Necessary Reporting	19	38
Too Much Debt	18	36
Poor Tax Compliance	18	36
Limited or Inconsistent Cash Flow	15	30
Not Paying Bills on Time	14	28
Challenges face within the association or in the community (Social Capital)		
Lack of participation among members in monthly association meetings	45	90
Lack of support from the Barangay	12	24
Lack of communication between the members	6	12
Miscommunication between the suppliers and buyers	5	10
Challenges faced by the usage of fish pens and fishing boats (Physical Capital)		
Cannot afford to purchase new materials for fish pens and fishing boats	36	72
High-cost maintenance	23	46
Less durable	13	26

Overall, the findings in the light of DFID's Sustainable Livelihood Framework, the results were validated as the aquaculture livelihood projects are sustainable in terms of human, natural, financial, social, and physical capital.

7. Conclusion

The aquaculture livelihood projects of aquaculture growers in Southern Negros were sustainable in terms of human, natural, financial, social, and physical capital. It shows that the aquaculture operators/owners have various knowledge and skills in the industry, preservation of water resources and cleanliness of coastal areas, more income and less expenses and debts growers, improve the economy and the people's standard of living and relationships and more fish pens infrastructure and increase of supplies of materials. Notwithstanding the existing vulnerabilities and challenges, the aquaculture livelihood projects were manageable and could easily cope with unforeseen events.

8. Limitation of Findings

Despite the novelty of the study, it has its limitations, as well. Although it used a proposed sustainability framework for analysis, the present study only used it as a guide for interpretation and a better understanding of the sustainability, vulnerability, and challenges of aquaculture livelihood projects. Also, the study was conducted during the COVID-19 pandemic, and the results were limited in the occurrence. The collection of data was exclusively collected from one aquaculture growers' association. The present study only analyzed the livelihood capitals in the form of a checklist or multiple response answers but not the focus group discussion to

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discuss the experience in the aquaculture industry. These limitations are expected to be addressed by other researchers in the same field.

9. Practical Application

The local government agency may explore the possibility of assisting aquaculture livelihood projects in gathering information for periodic evaluation and monitoring of the financial status of aquaculture livelihood projects for reporting purposes. It is hoped that future researchers utilize this study as the basis for further research, especially studies focusing on the sustainability, vulnerability, and challenges of other livelihoods like agriculture industries. Also, the strategic plan can be utilized by the Aquaculture owners/operators to present to the Department of Labor and Employment (DOLE) and other organizations to avail the financial assistance and funding in the future.

10. Direction of Future Research

Future research can continue the study after the COVID-19 pandemic, and they can replicate these studies concerning the aquaculture sectors to benchmark the sustainability, vulnerabilities, and challenges in aquaculture livelihood projects considering the DFID framework. They may explore more indicators about the human, natural, financial, social, and physical for the sustainability, vulnerabilities, and challenges in aquaculture livelihood projects.

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