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Farm management practices and resilience strategies among fishpond operations in the Province of Quirino facing environmental disruption

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Abstract

This study examines management practices and resilience measures among fishpond operators in Quirino Province amid environmental disruptions. A quantitative descriptive-correlational design was employed using a validated structured questionnaire administered to 100 purposively selected operators. Data were analyzed using frequency distribution, weighted mean, standard deviation, Mann-Whitney U test, Kruskal-Wallis H test, and Spearman's rho correlation. Results show that operators consistently apply essential management practices across all stages of pond management. Preventive and adaptive resilience measures are commonly practiced, while transformative measures were less frequently practiced than preventive and adaptive measures. Operators also reported strong experiences of environmental disruptions. No statistically significant differences were found in practices and strategies when grouped by sociodemographic and operational characteristics ($p > 0.05$). Correlation analysis revealed statistically significant but weak relationships. Notably, adaptive strategies showed a weak inverse association with water and soil quality disturbances ($\rho = -0.209$, $p = 0.037$). These findings indicate that environmental disruptions were associated with selected resilience strategies, although the observed relationships were generally weak. This study addresses a research gap in inland aquaculture by providing empirical evidence from disaster-prone Quirino Province, where limited studies exist. Findings highlight the need for interventions beyond awareness, emphasizing technical support, capacity-building, financial assistance, and infrastructure development to strengthen resilience.

Keywords: *fishpond management, fish farming, environmental disruption, aquaculture sustainability*

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1. Introduction

Aquaculture is now an essential part of the global food system and contributes to achieving food security and economic empowerment; however, the continued growth of this industry is threatened by a number of challenges in the social, environmental, and operational fields (Yoshida, 2024). Although it has been a fast-growing sector over the last two decades, its sustainable development in the future should depend upon how successful the aquaculture industry is able to address the issues related to environmental degradation, to cope with the negative effects of water quality, and to adapt to climate violations (Naylor et al., 2021; Troell et al., 2023; Troell et al., 2014). Climate-related stresses can affect aquaculture through changes in water availability, temperature, and other environmental conditions, making adaptation an important part of sustaining production. Abisha et al. (2022) emphasize that climate-resilient aquaculture requires practical adaptation measures that consider the different environmental stresses faced by farming systems.

In the Philippines, research on aquaculture has been directed towards coastal areas and large production zones (i.e., Lopez et al., 2026; Kurekin et al., 2022; Tahiluddin et al., 2025). Inland fishponds, such as the fishpond operations in provinces like Quirino, have been poorly researched. Environmental damage, adaptation, and aquaculture development have previously been discussed; however, little is known about how farmers in inland aquaculture adapt to environmental changes and what preventive, adaptive, and transformative mechanisms they have adopted. The aquaculture sustainability literature has focused on understanding the governance, advanced knowledge, and innovative systems that are needed to solve environmental interrelated issues (Partelow et al., 2023).

This study attempts to fill these gaps with the help of Socio-Ecological Resilience (SER) framework, which defines resilience as the ability of people and systems to adapt to environmental change while still being able to perform important functions. The study combines agricultural management techniques, environmental disturbances, and the three types of resilience (preventive, adaptive, and transformative) to analyze how these aspects interact with one another in small-scale inland fishpond business models. Furthermore, research into climate influence in fishing and aquaculture also stresses that it is very important to take into account local situations and the ability of producers to adapt themselves to environmental changes (Tran et al., 2022).

The study aims to provide local data from Quirino Province to improve aquaculture management and resilience programs that are suited to the conditions of inland fishpond operators. In particular, the study intends to: (1) assess farm management practices; (2) evaluate the preventive, adaptive, and transformational resilience strategies; (3) investigate variations in management practices and resilience strategies among operators and farm operations; and (4) establish relationships between environmental disturbances, farm management practices, and resilience strategies.

2. Literature Review

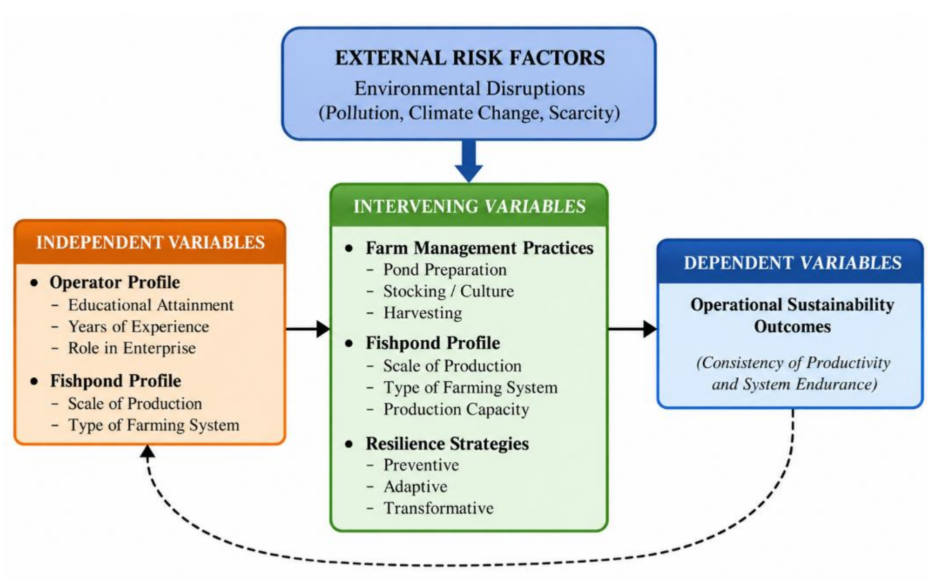
2.1. Theoretical and Research Framework

The Socio-Ecological Resilience (SER) framework serves as the basis of this study since environmental aspects, availability of resources, technologies, knowledge and institutions play a part in fishpond operations. Resilience refers to maintaining functions of importance while the environment changes. On the other hand, preventive strategies refer to actions taken before the occurrence of disruptions while adaptive strategies involve strategies of reacting to the situation continuing to change and transformative strategies involve changing practices and technologies over a long period. Therefore, resilience is not limited to the responses of individuals since other important factors like resources, information, institutions and relationships also determine the resilience level of operators.

Based on this theory, the research framework is developed as shown in Figure 1.

Figure 1

Research framework



The framework explains how the characteristics of operators and ponds provide important contextual information for interpreting farm management practices, resilience strategies, and perturbation in the environment. It should be noted that the framework makes no assumptions about the existence of a direct causal relationship between variables. Instead, it provides an analytical structure for examining differences and associations among farm management practices, resilience strategies, and environmental disruptions. This perspective is consistent with the socio-ecological resilience approach, which emphasizes the interaction between environmental pressures and the capacity of individuals and systems to respond to change.

2.2. Farm Management Practices

Effective farm management plays a very crucial role in aquaculture processes as well as addressing ecosystem challenges. While advancements in stocking, feeding, and production systems have largely driven progress in the field of aquaculture, small-scale farmers still grapple with diseases and limited resources (Naylor et al., 2021; Ahmed et al., 2025). This means that farm management consists of not only undertaking the daily activities on the farm but also adjusting to the changes in conditions.

The current ecologies and resource base affect the way these practices are implemented. Tran et al. (2022) have shown that the influence of climate change on aquaculture differs across locations and cultural practices. In Agusan del Sur, Formento et al. (2023) found that small-scale farmers generally followed important practices such as pond preparation and regular feeding but continued to experience water-quality problems during rainy periods. Kanwal et al. (2024) likewise found that limited access to monitoring technologies can make it difficult for farmers to detect water-quality problems early.

2.3. Resilience Strategies

Resilience in aquaculture involves preparing for environmental disruptions, adjusting practices when conditions change, and making longer-term improvements that can strengthen future operations. Tran et al. (2022) emphasized the need for both preparation and adaptation when responding to climate-related threats. Studies of small-scale fish farming also show that adaptation is influenced by farmers' resources, experience, and understanding of climate risks (Formento et al., 2023; Maulu et al., 2024; Bargo et al., 2025). Partelow et al. (2023) further emphasized the importance of knowledge, innovation, and governance in supporting longer-term transformation. These perspectives show that resilience can involve both actions taken within the farm and support provided by institutions and other stakeholders.

3. Methodology

3.1. Research Design

This study employed a quantitative descriptive-correlational design to describe farm management practices and resilience strategies and to examine differences and relationships among the study variables. The design was appropriate because the study observed the existing conditions of fishpond operations without manipulating the environment or the respondents' practices. Spearman's Rho was used to examine relationships among the variables, while the Mann–Whitney U and Kruskal–Wallis H tests were used to examine differences between groups.

3.2. Participants of the Study

The study involved 100 small-scale inland fishpond operators in Quirino Province, Philippines, selected through purposive sampling. To qualify in this study, the participants must (1) be the fishpond owner or manager in Quirino Province, (2) have no less than one year experience in fishpond operation, (3) have been impacted by climatic events such as rainfall and pollution of water supply. Though the sampling method applied is ineffective for making generalizations about the results outside this research area, the participants provide the information based on their own experience with the inland aquaculture industry.

As shown in Table 1, the samples are predominantly male accounting for 86% of the participants, while only 3% were aged 18–25. The small proportion of younger operators may indicate limited participation of younger individuals in the sector; however, the present study did not examine the reasons behind this age distribution. The most prominent issue in this group is a clear contradiction: majority have received tertiary education but still operate their fish ponds less than five years. More than one-third earn less than PHP 5,000 a month from their fishponds alone. It is evident that fish farming is used as an auxiliary source of income hence the reason most of their education is left unutilized as they do not have enough financial capacity to absorb future problems. Moreover, almost two-thirds of the operators were not affiliated with a farmers' association or cooperative. This may limit opportunities for cooperation, capacity building, and access to support. Similar concerns were reported by Manlosa et al. (2023), who found that farmers' associations can strengthen small-scale aquaculture producers' access to information, resources, and institutional support.

Table 1

Socio-demographic profile of fishpond operators.

Category	Frequency	Percentage (%)
Sex		
Male	86	86.00
Female	14	14.00
Age		
18–25	3	3.00
26–35	14	14.00
36–45	37	37.00
46–55	24	24.00
56 and above	22	22.00
Civil Status		
Single	18	18.00
Married	76	76.00
Widowed	2	2.00
Separated	4	4.00
Educational Attainment		
Elementary	6	6.00
High School	36	36.00
College	53	53.00
Postgraduate	4	4.00
Vocational	1	1.00
Years in Fishpond Operation		
Less than 5 years	54	54.00
5–10 years	38	38.00
11–15 years	2	2.00
16 years and above	6	6.00
Position / Role in Fishpond Operation		
Owner	80	80.00
Manager	20	20.00
Caretaker	0	0.00
Co-owner	0	0.00
Average Monthly Income		
Below 5,000.00	35	35.00
5001-10,000	16	16.00
10,001-15,000	28	28.00
15,001 and above	21	21.00
Membership to farmer association/cooperative		
Yes	37	37.00
No	63	63.00
Total	**100**	**100.00**

Table 2 shows the participants’ operational profile of fishponds in Quirino province. The profile includes the size of the ponds, their farming system, culturing method, capacity to produce, sources of funds, and availability of technical assistance.

Table 2

Participants' profile of fishpond operations in Quirino Province

Category	Frequency	Percentage (%)
Size of Fishpond Area (per range)		
Small Scale	26	26.00
Medium Scale	60	60.00
Large Scale	14	14.00
Farming System		
Pond	97	97.00
Cage	2	2.00
Tank	1	1.00
Culture Method		
Extensive (natural food only)	1	1.00
Semi-intensive (natural food and commercial feed)	97	97.00
Others	2	2.00
Scale of Production / Capacity		
Small Scale	21	21.00
Medium Scale	64	64.00
Large Scale	15	15.00
Source of Capital		
Personal Savings	89	89.00
Bank Loan	5	5.00
Cooperative	1	1.00
Others	5	5.00
Source of Technical or Extension Support		
Local Government (Municipal/Provincial Agriculture Office)	68	68.00
None	32	32.00
Total	**100**	**100.00**

Most participants used relatively low-input production systems. Nearly all operated earthen and semi-intensive ponds (97%), while 89% relied on personal savings to finance their operations. These conditions provide context for the limited use of alternative technologies. Similar resource and technology constraints have been reported in small-scale aquaculture (Densing & Matutes, 2025; Formento et al., 2023). Although 68% of the operators received technical assistance from local government units, 32% reported receiving none. This difference in access to support may be important when considering the operators' ability to adopt additional technologies, although institutional support was not directly tested as a factor in this study.

3.3. Instrumentation and Data Gathering Process

Data has been collected using a structured questionnaire. This was done with respect to the objectives of the study and to previous studies from literature on farm management, resiliency, and environmental change in aquaculture. The instrument evaluated the practices in farm management along with preventive, adaptive and transformative strategies of resiliency relative to environmental disturbance. Evaluation of the appropriateness and clarity of the instrument was executed by five experts coming from aquaculture and agricultural sciences. A pilot test involving 10 fishpond operators who were not included in the final sample was conducted before the actual data collection. The questionnaire obtained a Content Validity Index above 0.80, while Cronbach's alpha values ranged from 0.78 to 0.91, indicating acceptable internal consistency.

3.4. Data Analysis

Descriptive statistics were utilized to provide a descriptive summary of the respondents' characteristics, farm management, practices, resilience techniques, and perceived environmental impact. Spearman's rho statistic was used to perceive relationship between variables because the study variables used ordinal responses and the normality assumption did not hold. The Mann–Whitney U method was used for significance testing among two independent groups while Kruskal–Wallis H test was applied among three or more independent groups in the study. The alpha level of significance was set to 0.05., the lower p-value than 0.05 represented significant statistic results and the p-value equal to or above 0.05 indicated no significant statistic difference. The interpretation of the correlation results were based on its strength and directional relationship rather than assuming a causation.

3.5. Research Ethics

Approval was received from the institutional ethics committee prior to the collection of data for the research. Information regarding the purpose and how the study will be carried out was explained properly to the participants, and informed consent was collected voluntarily. The participants were told that they had the right to withdraw from the research at any point of time without any penalty. Data was collected at convenient times for the participants and there was no personal identifying information in the data file. Responses were coded and secured for confidentiality and privacy reasons.

4. Findings and Discussion

Table 3 shows the mean scores, standard deviations, and descriptive ratings for these early-stage management procedures.

Table 3

Farm management practices

Practices	Mean	SD	Interpretation
Stage 1: Pond Preparation	3.82	0.18	Always
Stage 2: Stocking and Culture	3.90	0.17	Always
Stage 3: Harvesting and Post Harvesting	3.97	0.10	Always

Legend: 3.25 – 4.00 Always; 2.50 – 3.24 Often; 1.75 – 2.49 Sometimes; 1.00 – 1.74 Never

Pond preparation practices were consistently applied. Full pond drying (M = 3.96) and checking the water source (M = 3.95) were among the most frequently practiced activities, while liming (M = 3.77) and fertilization (M = 3.51) received slightly lower ratings (see Appendix A). Operators generally follow basic pond-preparation practices, although some activities may depend on available resources and local conditions. Similar resource constraints have been reported in Philippine smallholder aquaculture (Densing & Matutes, 2025). During stocking and culture, operators consistently followed key practices, particularly acclimatizing fingerlings (M = 3.99) and selecting healthy stocks (M = 3.98). Recommended stocking density had the lowest mean (M = 3.71, SD = 0.56) (see Appendix A). Kolek and Irnazarow (2022) noted that improvements in pond productivity can be supported through appropriate production technologies, including better use of pond resources, aeration, and diversification of culture practices. In the present study, the consistently high ratings for stocking, feeding, and water-management practices indicate that operators already apply basic management measures, while more advanced technologies may provide additional opportunities for improving productivity.

Table 4 presents the practical risk management measures used by the operators to reduce environmental hazards.

Table 4

Resilience strategies deployed in fishpond operations

Strategies	M	SD	Interpretation
Stage 1: Preventive Strategies	3.48	0.24	Always
Stage 2: Adaptive Strategies	3.47	0.25	Always
Stage 3: Transformative / Long-Term Strategies	3.21	0.57	Often

Legend: 3.25 – 4.00 Always; 2.50 – 3.24 Often; 1.75 – 2.49 Sometimes; 1.00 – 1.74 Never

Operators commonly used preventive measures that were relatively simple and affordable, particularly seasonal farm calendars (M = 3.92) and the use of more resilient fish species (M = 3.88). Regular water replenishment was less common (M = 2.08, SD = 0.91) (see Appendix B). The low rating for water replenishment may reflect the practical limitations of managing water availability in small-scale ponds. Tiwari et al. (2024) showed that affordable monitoring technologies can help farmers track important water-quality conditions such as temperature, turbidity, and pH. Such tools could complement the practices already used by operators and help them identify changes in pond conditions earlier.

Operators mainly relied on adjustments that could be made within their existing farm systems. The most commonly practiced measures were using alternative water sources or aeration (M = 3.97) and adjusting feeding schedules (M = 3.90). In contrast, temporary harvesting or transferring fish was rarely practiced (M = 1.49) (see Appendix B). Mwangi et al. (2024) similarly found that small-scale fish farmers used practical measures such as topping up pond water and providing shade to cope with climate-related changes, while limited funds, skills, and water resources constrained their options.

Operators relied most on lessons learned from previous disruptions (M = 3.91) and recovery planning (M = 3.77). In contrast, collaboration with research institutions or experts was the least practiced strategy (M = 2.49) (see Appendix B). Macusi et al. (2024) similarly examined resilience among fishing communities in Surigao del Sur in terms of preparedness, coping, and adaptation. Although their study involved coastal fishing communities rather than inland fishponds, it provides a useful Philippine context for understanding resilience as a combination of actions taken before, during, and after environmental disturbances. Pham and Saizen (2023) also found that adaptation strategies can differ according to producers' circumstances and available resources.

Table 5 presents the environmental disruptions experienced by fishpond operators in terms of climate-related disturbances. The high ratings show that climate-related disturbances are a serious concern among the operators. Strong winds and typhoons received the highest mean (M = 4.99, SD = 0.10), followed by floods and heavy rainfall (M = 4.67, SD = 0.73) (see Appendix C). This finding is in line with previous studies showing that climate-related hazards can pose challenges to small-scale aquaculture, especially when farmers have limited resources and protective facilities (Brugere et al., 2023; Formento et al., 2023; Tran et al., 2022).

Table 5

Environmental disruptions experienced by fishpond operators

Indicators	Mean	SD	Interpretation
Stage 1: Climate-Related Disturbances	4.91	0.15	Strongly Agree
Stage 2: Water and Soil Quality Disruptions	4.77	0.26	Strongly Agree
Stage 3: Operational and Production Impacts	4.84	0.17	Strongly Agree

Legend: 4.20 – 5.00 Strongly Agree; 3.40 – 4.19 Agree; 2.60 – 3.39 Neutral; 1.80 – 2.59 Disagree; 1.00 – 1.79 Strongly Disagree

Water and soil quality disruptions were also strongly experienced by the operators, with an overall weighted mean of 4.77 (Strongly Agree). Stagnant water or poor drainage associated with ammonia buildup received the highest rating (M = 4.96, SD = 0.20), followed by water contamination associated with fish disease and mortality (M = 4.94, SD = 0.28). Waste discharge from surrounding areas received the lowest mean (M = 4.41, SD = 0.53), although the relatively larger standard deviation suggests greater variation in operators' experiences (see Appendix C). The predominance of earthen and semi-intensive systems in the study area provides an important operational context for these environmental concerns. The findings also point to the importance of water availability and pond condition in maintaining aquaculture operations. Kanazoe et al. (2025) found that water insufficiency and pond degradation were among the concerns affecting farmers' willingness to integrate fish farming into water-harvesting ponds. This supports the need for practical water-management measures that are suited to the conditions and resources of small-scale operators.

Environmental disruptions placed considerable financial and operational pressure on the fishpond operators, as reflected in the overall mean of 4.84 (SD = 0.17). Financial losses and reduced profitability received the highest rating (M = 4.98), followed by water scarcity during drought (M = 4.97). Reduced fish production had the lowest mean (M = 4.57), indicating that the effects on production were not the same across all farms (see Appendix C). Ragasa et al. (2022) similarly found that good aquaculture practices were associated with higher productivity and positive farm returns among pond farmers, while difficulties in accessing inputs and markets affected competitiveness and resilience.

The operators' available resources also provide an important context for these findings. Most relied on personal savings (89%) and used semi-intensive earthen ponds (97%). They reported reduced fish survival (M = 4.88), lower carrying capacity (M = 4.82), and less predictable harvest schedules (M = 4.90) as important effects of environmental disruptions (see Appendix C). Similar challenges involving infrastructure, monitoring technologies, and financial support have been reported in small-scale aquaculture (Formento et al., 2023; Kanwal et al., 2024; Maulu et al., 2024). Macusi et al. (2022) also reported climate-related vulnerability among small-scale shrimp farms in the Philippines.

Table 6 shows the comparison of perceived operational effects and resilience measures among various demographic categories of operators and operational profiles.

Table 6

Test of significant differences in operational and production impacts and management and resilience strategies when grouped according to respondents' profiles

Profile	Operational Impacts				Management & Resilience Strategies			
	Mean	Mean rank	H value/ U static	P value	Mean	Mean rank	H value/ U static	P value
Sex								
Male	3.89	50.26	581.5	0.834	3.42	49.55	520.5	0.415
Female					3.46	56.32		
Age								
18–25	3.86	43.25	3.722	0.445	3.17	14	4.155	0.385
26–35	3.90	48.57			3.46	55.57		
36–45	3.89	51.72			3.46	51.36		
46–55	3.86	43.24			3.39	47.2		
56 and above	3.93	58.59			3.44	52.89		
Civil Status								
Single	3.89	49.25	3.648	0.302	3.45	57.69	1.433	0.698
Married	3.89	50.33			3.41	49.11		
Widowed	3.98	86.25			3.38	44.25		
Separated	3.90	41.5			3.79	47.63		
Educational Attainment								
Elementary	3.93	57.75	3.157	0.532	3.46	57.08	2.007	0.734
High School	3.88	44.78			3.39	45.64		
College	3.90	53.86			3.45	53.39		
Postgraduate	3.91	51.75			3.46	48.63		
Vocational	3.88	30			3.42	40.5		
Years in fishpond operation								
Less than 5	3.88	44.89	9.196	0.27	3.42	45.93	4.377	0.224
5-10	3.91	56.2			3.45	58.18		
11-15	3.86	25.25			3.42	43.25		
16 and above	3.96	73.33			3.43	45.42		
Position/Role in fishpond operation								
Owner	3.90	50.86	771	0.797	3.45	52.44	645	0.179
Manager	3.89	49.05			3.36	42.75		
Monthly Income								
Below 5,000.00	3.91	54.77	3.841	0.279	3.49	62.81	9.949	0.193
5,001-10,000	3.85	39.72			3.36	42.16		
10,001-15,000	3.88	48.05			3.42	45.13		
15,001 above	3.91	54.86			3.40	43.5		

Profile	Operational Impacts				Management & Resilience Strategies			
	Mean	**Mean rank**	**H value/ U static**	**P value**	**Mean**	**Mean rank**	**H value/ U static**	**P value**
Membership to farmer association/cooperative								
Yes	3.90	53.93	1038.5	0.352	3.47	60.5	795.5	0.708
No	3.89	48.48			3.40	44.63		
Size of fishpond area (per range)								
Small scale	3.88	50.52	6.328	0.422	3.49	51.19	3.875	0.144
Medium scale	3.91	54.48			3.43	53.43		
Large scale	3.85	33.39			3.34	36.64		
Farming system								
Pond	3.89	50.77	0.558	0.756	3.43	50.66	1.169	0.557
Cage	3.92	47.5			3.46	57.5		
Tank	3.88	30			3.33	21		
Culture method								
Extensive (natural food only)	3.88				3.33			
Semi-intensive (natural food and commercial feed)	3.89	30	0.501	0.479	3.43	20	1.103	0.294
Others	3.98	49.7			3.36	49.8		
Scale of production/capacity								
Small scale	3.89	52.79	6.666	0.361	3.50	51.71	4.787	0.091
Medium scale	3.90	53.81			3.43	53.59		
Large scale	3.85	33.17			3.34	35.6		
Source of capital								
Personal savings	3.89	48.21	0.959	0.619	3.43	48.38	4.545	0.103
Bank loan	3.92	49.4			3.30	32		
Cooperative	3.84	22			3.79	94		
Others	3.87				3.45			
Source of technical or extension support								
Local government (Municipal/provincial agricultural office)	3.90	34.5	1045	0.367	3.46	34.5	104	0.367
None	3.89	0			3.37	0		

Legend: = significant at 0.01 level; * = significant at 0.05 level

The results show no statistically significant differences in perceived operational impacts and management and resilience strategies across the operator and operational characteristics examined (all $p > 0.05$). The observed patterns were relatively similar across the groups included in the study. The similarity may be associated with the common operational conditions of the respondents, including the predominance of earthen ponds, reliance on personal financing, and varying levels of access to technical support. However, these factors should be viewed as contextual explanations rather than established causes of the observed similarities.

The interventions may be more useful when they address common constraints shared by operators rather than relying solely on programs targeted to particular demographic groups.

Access to shared equipment, technical training, affordable inputs, and appropriate extension services may provide practical opportunities for operators to strengthen their resilience. This emphasis on shared constraints is consistent with the broader literature on farm resilience. Pret et al. (2025) noted that resilience among smallholder farms is shaped by attributes such as available reserves, diversity, connectivity, and the capacity to adjust to climatic risks. They also emphasized the importance of examining farm-level constraints and institutional support when designing resilience measures. In the present study, the support programs may be more useful when they address common operational needs rather than focusing only on particular demographic groups.

Table 7 contains the Spearman's rho correlation for farm management practices, resilience measures, and environmental disruptions such as climate, water, and operational disruptions.

Table 7

Correlations among farm management practices, resilience strategies, and environmental disruptions

		Environmental Disruption		
		Climate	**Water**	**Operational**
Pond Preparation	Spearman's rho	-0.144	0.072	-0.07
	Sig. (2-tailed)	0.152	0.477	0.487
	N	100	100	100
Post Harvesting	Spearman's rho	0.134	-0.063	-0.125
	Sig. (2-tailed)	0.185	0.531	0.214
	N	100	100	100
Resilience Strategies - Preventive	Spearman's rho	**.232***	**-.251***	-0.02
	Sig. (2-tailed)	0.02	0.012	0.84
	N	100	100	100
Resilience Strategies - Adaptive	Spearman's rho	-0.085	**-.209***	0.144
	Sig. (2-tailed)	0.403	0.037	0.153
	N	100	100	100
Resilience Strategies - Transformative	Spearman's rho	0.041	**.299****	0.107
	Sig. (2-tailed)	0.682	0.003	0.288
	N	100	100	100

Note: *. Correlation is significant at the 0.05 level (2-tailed); Correlation is significant at the 0.01 level (2-tailed). Statistical tool used: Spearman rho.

The results show that environmental disruptions were significantly associated with selected resilience strategies, although the relationships were generally weak. Preventive strategies had a weak positive association with climate disruptions ($\rho = 0.232$, $p = 0.020$) and a weak negative association with water and soil quality disruptions ($\rho = -0.251$, $p = 0.012$). Adaptive strategies also had a weak negative association with water and soil quality disruptions ($\rho = -0.209$, $p = 0.037$), while transformative strategies showed a weak positive association ($\rho = 0.299$, $p = 0.003$). These results indicate association rather than causation because the study used a cross-sectional correlational design. Similar patterns have been reported among small-scale pond-based fish farmers in the Philippines, where climate-related risks were linked with different risk-management practices (Formento et al., 2023).

The absence of significant relationships between environmental disruptions and pond preparation and post-harvest activities suggests that these routine practices remained relatively consistent despite environmental challenges. Operators appeared to rely mainly on measures that could be carried out within their available resources. Improved access to technical guidance, shared equipment, affordable inputs, and institutional support may provide additional options for responding to unfavorable water and weather conditions.

5. Conclusion

The study found that fishpond operators in Quirino Province generally maintained regular farm management practices and used preventive and adaptive strategies to respond to environmental disruptions, while transformative strategies were used less frequently. Significant but weak relationships were found between selected environmental disruptions and resilience strategies. In addition, the environmental conditions are associated with some resilience responses, but they do not establish that environmental disruptions directly cause or determine operators' decisions. However, it should be considered that sampling of 100 operators, the cross-sectional design, and the use of self-reported data limit the generalizability of the results.

The findings have practical implications for local aquaculture support. The reported environmental challenges, together with operators' reliance on their own resources, point to the need for accessible technical assistance, appropriate production technologies, affordable inputs, and financing options. Extension programs may give greater attention to water and soil management, disaster preparedness, and longer-term farm planning. Local government and other support agencies may also consider training, shared equipment, and financing mechanisms that can help small-scale operators strengthen their capacity to respond to environmental disruptions. These measures should be designed according to the actual conditions and resources of inland fishpond operators rather than assuming that all operators face the same needs.

The study adds local evidence on how farm management and different resilience strategies are related to environmental disruptions in small-scale inland fishpond operations. The findings provide a basis for strengthening local aquaculture support while also pointing to the need for further research that can examine other factors influencing operators' decisions and resilience over time.

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Institutional Review Board Statement

This study was conducted in accordance with the ethical guidelines set by Wesleyan University-Philippines. The conduct of this study has been approved and given relative clearance(s) by Wesleyan University-Philippines.

AI Declaration

The author declares the use of Artificial Intelligence (AI) in writing this paper. In particular, the author used Quilbot in searching and summarizing key points and paraphrasing ideas. The author takes full responsibility in ensuring proper review and editing of contents generated using AI.

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Appendices

Appendix A

Farm management practices

Indicators	Mean	SD	Interpretation
Stage 1: Pond Preparation			
I dry the pond completely before stocking.	3.96	0.32	Always
I apply lime to condition the pond soil.	3.77	0.45	Always
I fertilize the pond to enhance natural food production.	3.51	0.5	Always
I remove or control predators and unwanted species before stocking.	3.82	0.39	Always
I repair dikes, gates, and water control structures prior to stocking to avoid water leakage.	3.88	0.33	Always
I ensure that the pond bottom is leveled with a slight slope to facilitate easier harvesting.	3.8	0.4	Always
I allow sufficient time for natural food organisms (like plankton) to develop before stocking.	3.83	0.38	Always
I check the water source to ensure that it is clean and uncontaminated before pond filling.	3.95	0.22	Always
Overall Weighted Mean	**3.82**	**0.18**	**Always**
Stage 2: Stocking and Culture			
I select healthy and uniform fingerlings or fry.	3.98	0.14	Always
I acclimatize fingerlings / fry before releasing them into the pond.	3.99	0.1	Always
I follow recommended stocking densities.	3.71	0.56	Always
I provide supplemental feeding on a regular schedule.	3.91	0.29	Always
I monitor water quality (pH, dissolved oxygen, temperature).	3.89	0.31	Always
I observe the fish for any signs of disease or abnormal behavior, such as gasping at the surface, bloated bodies, or light-colored or pale appearance.	3.93	0.26	Always
I regularly remove aquatic weeds or debris from the pond.	3.86	0.35	Always
I maintain proper water depth and flow throughout the culture period.	3.89	0.31	Always
Overall Weighted Mean	**3.9**	**0.17**	**Always**
Stage 3: Harvesting and Post Harvesting			
I sort and grade fish during harvest.	4	0	Always
I use proper methods to minimize stress and injury to fish during harvest.	3.94	0.24	Always
I immediately store harvested fish properly in aerated container before marketing.	3.99	0.1	Always
I clean the pond and remove sludge after harvest, but this is only done when the pond is dirty. Pond cleaning is usually performed through sun-drying and lime application.	3.91	0.29	Always
I record production, feed usage, and survival rates after each cycle.	3.96	0.2	Always
I plan harvesting schedules based on market demand and fish size.	3.99	0.1	Always
I properly dispose of pond waste to prevent environmental contamination.	3.96	0.2	Always
I evaluate overall performance after harvest to maintain or improve the next production cycle.	3.98	0.14	Always
Overall Weighted Mean	**3.97**	**0.1**	**Always**

Appendix B

Resilience strategies deployed in fishpond operations

Indicators	M	SD	Interpretation
Stage 1: Preventive Strategies			
I regularly monitor and test the water quality of my fishpond.	3.55	0.5	Always
I clean and maintain pond facilities to prevent damage during extreme weather.	3.58	0.5	Always
I strengthen pond dikes and gates before the rainy or typhoon season.	3.34	0.52	Always
I replenish my pond water once every week or every two weeks to discharge toxins like ammonia,nitrate and excess feeds.	2.08	0.91	Often
I use organic or eco-friendly feeds and fertilizers.	3.83	0.43	Always
I inspect and repair pond structures regularly to prevent leakage and overflow.	3.66	0.5	Always
I stock more resilient fish species that can tolerate environmental stress.	3.88	0.33	Always
I create a farm calendar that considers seasonal and weather patterns.	3.92	0.27	Always
Overall Weighted Mean	**3.48**	**0.24**	**Always**
Stage 2: Adaptive Strategies			
I adjust feeding schedules or reduce feed quantity during hot or rainy days.	3.9	0.33	Always
I practice polyculture to mitigate losses from environmental changes.	3.36	0.88	Always
I use alternative water sources or aeration systems during drought or low oxygen.	3.97	0.17	Always
I modify my stocking density depending on environmental conditions.	3.85	0.39	Always
I coordinate with other fish farmers during crises for sharing resources or information.	3.49	0.56	Always
I store emergency tools or backup systems (e.g., generator, water pumps) for critical times.	3.86	0.38	Always
I use weather forecasts to guide pond management decisions.	3.86	0.38	Always
I temporarily harvest or transfer fish to other culture system when water conditions worsen.	1.49	0.76	Never
Overall Weighted Mean	**3.47**	**0.25**	**Always**
Stage 3: Transformative / Long-Term Strategies			
I attend training or seminars on sustainable aquaculture and disaster preparedness.	2.6	0.67	Often
I coordinate with government offices for technical or financial assistance during calamities.	3.15	0.95	Often
I adopt new technologies to improve pond resilience and productivity.	3.22	0.54	Often
I keep detailed records of environmental events and their effects on production.	3.76	0.43	Always
I develop a recovery plan to restore pond operations after disasters.	3.77	0.62	Always
I participate in community programs that strengthens aquaculture sustainability.	2.74	0.6	Often
I apply lessons learned from past disruptions to improve future operations.	3.91	0.35	Always
I maintain collaboration with research institutions or experts to enhance long-term resilience.	2.49	0.52	Sometimes
Overall Weighted Mean	**3.21**	**0.57**	**Often**

Appendix C

Environmental disruptions experienced by fishpond operators

Indicators	Mean	SD	VD
Stage 1: Climate-Related Disturbances			
Sudden changes in temperature affect the growth and survival of my cultured fish.	4.86	0.4	Strongly Agree
My fishpond operation is frequently affected by floods or heavy rainfall.	4.67	0.73	Strongly Agree
Long dry seasons or droughts cause water shortage in my pond.	4.96	0.2	Strongly Agree
Strong winds and typhoons cause physical damage to my pond structures.	4.99	0.1	Strongly Agree
Prolonged rainfall results in overflow or loss of fish stock.	4.96	0.2	Strongly Agree
Intense heat during summer reduces oxygen levels in pond water.	4.96	0.2	Strongly Agree
Temperature fluctuations affect the feeding and breeding of fish.	4.94	0.24	Strongly Agree
Extreme weather conditions delay my regular fish farming operations.	4.96	0.2	Strongly Agree
Overall Weighted Mean	**4.91**	**0.15**	**Strongly Agree**
Stage 2: Water and Soil Quality Disruptions			
Water pollution from nearby farms or households affects the quality of my pond water.	4.67	0.51	Strongly Agree
Waste discharge from surrounding areas affects my fishpond ecosystem.	4.41	0.53	Strongly Agree
Soil erosion around the pond affects pond water turbidity and quality.	4.72	0.49	Strongly Agree
Chemical runoff from nearby agriculture contaminates pond water.	4.77	0.42	Strongly Agree
Algal blooms frequently occur in my pond during extreme weather.	4.8	0.4	Strongly Agree
Accumulated sludge and waste materials degrade water quality.	4.9	0.3	Strongly Agree
Poor drainage or stagnant water leads to foul odor due to ammonia build up.	4.96	0.2	Strongly Agree
Water contamination causes fish diseases tending to fish mortality.	4.94	0.28	Strongly Agree
Overall Weighted Mean	**4.77**	**0.26**	**Strongly Agree**
Stage 3: Operational and Production Impacts			
Environmental disturbances have reduced my average fish production in recent years.	4.57	0.57	Strongly Agree
Unexpected algal blooms occur in my pond during extreme weather.	4.63	0.49	Strongly Agree
Poor water quality after rainfall leads to reduced fish survival.	4.88	0.33	Strongly Agree
Structural damages after storms increase my maintenance costs.	4.96	0.2	Strongly Agree
Water scarcity during drought affects feeding and growth cycles due to fish stress.	4.97	0.17	Strongly Agree
Frequent climate events make scheduling of harvest unpredictable.	4.9	0.3	Strongly Agree
Sedimentation or soil runoff reduces pond depth and carrying capacity.	4.82	0.39	Strongly Agree
Environmental disruptions increase financial losses and reduce profit.	4.98	0.14	Strongly Agree
Overall Weighted Mean	**4.84**	**0.17**	**Strongly Agree**