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Institutional Innovations towards Sustainable Small-Scale Fisheries: An Assessment of Co-Management Approach in Lobster and Giant Freshwater Prawns Fisheries, Sri Lanka

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ABSTRACT

Institutions are critical components of fisheries governance, playing a significant role in its operation and effectiveness. While various institutions facilitate the functioning of the fisheries sector, their role is particularly critical in the small-scale fisheries subsector, which faces greater threats from anthropogenic pressures such as high resource exploitation and increasing fishing pressure. This study evaluates the institutional frameworks governing lobster and giant freshwater prawn fisheries to identify gaps and propose innovative interventions based on Small-Scale Fisheries (SSF) guidelines. Primary data were collected from both industries through stakeholder meetings with experts, key informant interviews with exporters, and interviewer-administered questionnaires with fishers. The analysis revealed that the institutional framework involves local and central government bodies, NGOs, and community organizations, tasked with access provision, regulation, risk reduction, operational structuring, and resource conservation. However, significant gaps were identified, including outdated legislative frameworks, limited research and development efforts, time and financial constraints, insufficient export promotion programs, and weak institutional linkages. To address these issues, the study recommends institutional innovations such as strengthened government-private partnerships and community-based co-management approaches. These strategies can

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enhance governance and sustainability in Sri Lanka's lobster and giant freshwater prawn fisheries, ensuring their alignment with global trends and contributing to long-term resource conservation and economic resilience.

Keywords: Aquaculture; Fishery Co-Management; Institutional Analysis; Marine; Small-Scale Fishery

1. Introduction

The old proverb, "Give a man a fish and you feed him for a day; teach him how to fish and you feed him for a lifetime," no longer applies. As human populations grow and natural fishery resources decline, simply knowing how to fish is no longer sufficient for today's fishers and their families. Sustainable management of fisheries resources and the social welfare of those involved in the fisheries sector are critical issues that must be addressed through effective governance and policy implementation^[1].

The small-scale fisheries (SSF) sector is responsible for 40% of the global fish catch, with an estimated value of US\$77 billion while sheltering 60 million people who are directly employing and supporting 379 million people (7% of the global population) indirectly^[2]. Even though SSF contributes vitally to global food production and significantly impacts national and local economies, this sector is overexploited worldwide due to weak governance, poor management, corruption, open access, and harmful fishing practices^[3]. Furthermore, small-scale fisheries suffer from inadequate planning, regulation, funding, and neglect compared to the broader global food economy as well^[4].

In Sri Lanka, over 586,000 people are employed in the fisheries sector, which supports the livelihoods of 2.7 million people, generates income, earns foreign exchange, and provides natural proteins to the population. In 2021, marine fish production was recorded as 331,675 metric tons, while inland fish production was 104,235 metric tons. The fisheries sector contributed 1.1% to the GDP in 2021^[5]. Moreover, the total export value and quantity of fish and fish products were US\$318 million and 26,749 metric tons, respectively^[5]. The majority of the fishers in Sri Lanka are involved in small-scale fishing^[6]. The small-scale fisheries sector is vital to the livelihoods, food security, and nutritional needs of a significant portion of Sri Lanka's population. Within

the broader fisheries industry, coastal fisheries, predominantly driven by small-scale fishers (SSF), have consistently made a substantial contribution^[7].

Lobster fishing is a crucial, high-value coastal marine activity in Sri Lanka with a market that is primarily export-oriented, while local consumption remains minimal^[8]. Major export destinations include Japan, Hong Kong, the UK, Singapore, and Korea. In 2021, the export-oriented lobster fishery generated 879 million LKR (US\$)^[9]. Similarly, Giant Freshwater Prawns (GFP) are a significant candidate for aquaculture fisheries due to their high market value and demand. Most GFP harvests are supplied to high-end restaurants and hotels in Sri Lanka or exported, with Thailand and China being the main export destinations^[10]. Both species belong to the small-scale fisheries which provide a source of rural employment; generating rural revenue and means of food and nutrition security. As illustrated in **Figure 1**, lobster volumes were significantly high before 2000. However, due to overfishing, these volumes declined. With the implementation of regulations, the catch increased again but has recently declined rapidly, indicating over-exploitation. Similarly, for GFP fisheries, the increasing capacity of post-larval stocking has enabled many reservoirs in Sri Lanka to operate with GFP, showing a steady growth in catch volume over time.

Despite their economic potential, both lobster and GFP fisheries face significant challenges. Overfishing, poor management practices, outdated technologies, globalization pressures, and market competition have hindered their sustainability and profitability^[11]. For instance, while lobster export markets experience growing demand fueled by health awareness and increased spending on premium foods, the use of outdated handling and storage methods limits profit margins. Similarly, GFP aquaculture has shown growth through increased post-larval stocking capacity in reservoirs, but it remains constrained by inefficient practices and weak institutional support^[12].

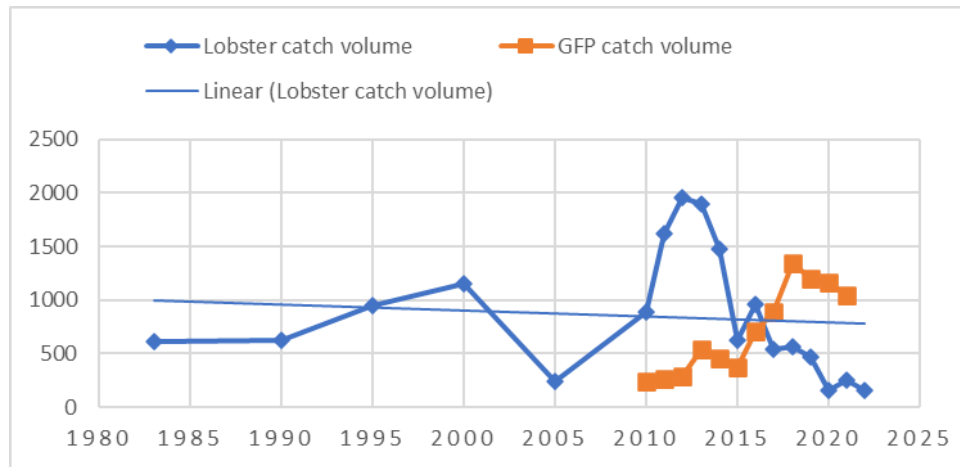


Figure 1. Giant Freshwater Prawns Production (Mt.) 2010–2021 and Lobster Catch Volume (Mt.) 1983–2022 - Ministry of Fisheries.

Effective management of fisheries resources requires robust governance frameworks that ensure sustainable production while addressing the social welfare of fishing communities^[13]. However, top-down approaches in fisheries management have often excluded fishing communities from decision-making processes, creating disconnects and undermining efforts to achieve sustainability^[1]. Evidence suggests that stakeholder participation and strong partnerships are essential for restoring ecological integrity and improving community livelihoods^[14]. Yet, the current institutional frameworks in Sri Lanka lack the capacity to address these issues effectively, leaving critical gaps in governance, regulation, and innovation^[15].

This study seeks to analyze the institutional frameworks governing lobster fisheries and GFP aquaculture in Sri Lanka, identify the challenges hindering their sustainable development, and propose innovative interventions based on the Small-Scale Fisheries (SSF) guidelines. By addressing these gaps, the study aims to contribute to more effective governance, enhance stakeholder participation, and promote the long-term sustainability of these economically significant fisheries.

1.1. Conceptual Framework of the Study

Generally, institutions possess a common set of defining features, such as systems of rules, decision-making processes, and frameworks that establish social practices, define roles for participants within these practices, and direct interactions among individuals fulfilling

these roles^[16]. The institutional economic literature emphasizes that institutions reduce transaction costs, address collective action problems, and mitigate resource depletion, making them essential in sectors like fisheries where common-pool resources are at risk of over-exploitation.

The institutional involvement in sustainability includes both governance (such as quality and legality) and management (including regulation, reporting, monitoring, and protection) of fisheries. It emphasizes organizational practices that are shaped and enforced through formal behavioral rules and evaluates their effectiveness, guided by legal frameworks and culturally accepted norms or codes of conduct^[17]. Furthermore, in theory, sustainability in fisheries should encompass social, cultural, institutional, and ethical aspects. However, in practical scenarios, it is often narrowly focused on a limited range of biological and economic factors^[17, 18].

For institutions to function efficiently, it is essential to foster interactions among public/government entities, private businesses, and non-governmental organizations^[19]. Additionally, meaningful collaboration is required among diverse groups that vary in scale and operational contexts^[20]. Since the 1990s, the discourse around fishery co-management has grown, leading to efforts to establish local and regional co-management systems in numerous European countries^[21]. Co-management is a collaborative arrangement where resource-user groups, such as local fishers, and other entities, like government agencies, NGOs, and

private sectors, share management responsibilities and authority through vertical and horizontal connections^[22-24]. This approach is widely regarded as an effective strategy for achieving sustainable fisheries by balancing local knowledge and institutional support^[25]. Moreover, Waithaka et al.^[24], Warawarin, Cangara and Muhadar^[26], Persada Fachrudin and Mangujjaya^[27], Soselisa^[28], and Tilley et al.^[23] also highlighted that co-management is a useful innovative strategy for the management of the small-scale fisheries sector.

In Sri Lanka, small-scale fisheries such as lobster and GFP fisheries are governed by a fragmented institutional framework. While national, district, and community-level institutions play roles in governance, gaps in coordination and enforcement hinder their effectiveness. Drawing from the above theories, a conceptual framework for this study can address these challenges by emphasizing co-management and institutional innovation.

As illustrated in **Figure 2**, the institutional framework of lobster and GFP fisheries is comprised of national, district, and grassroots levels, with the participation of the government, private sector, and NGOs. Although these institutions are responsible for governance, policy and regulation implementation, research and development, export promotion, and capacity development operations. Both lobster and GFP fisheries have high market value and the potential to support the livelihood development of rural fishers in Sri Lanka. However, the supply of lobsters is limited due to the overexploitation of this resource, coupled with increasing demand^[29,30]. Similarly, the supply of GFP is restricted due to a lack of freshwater prawn seeds^[31] and the strategy for culturing GFP has been implemented without a scientific basis^[32].

Therefore, an innovative approach would involve scaling up the existing framework and bridging the gaps more effectively.

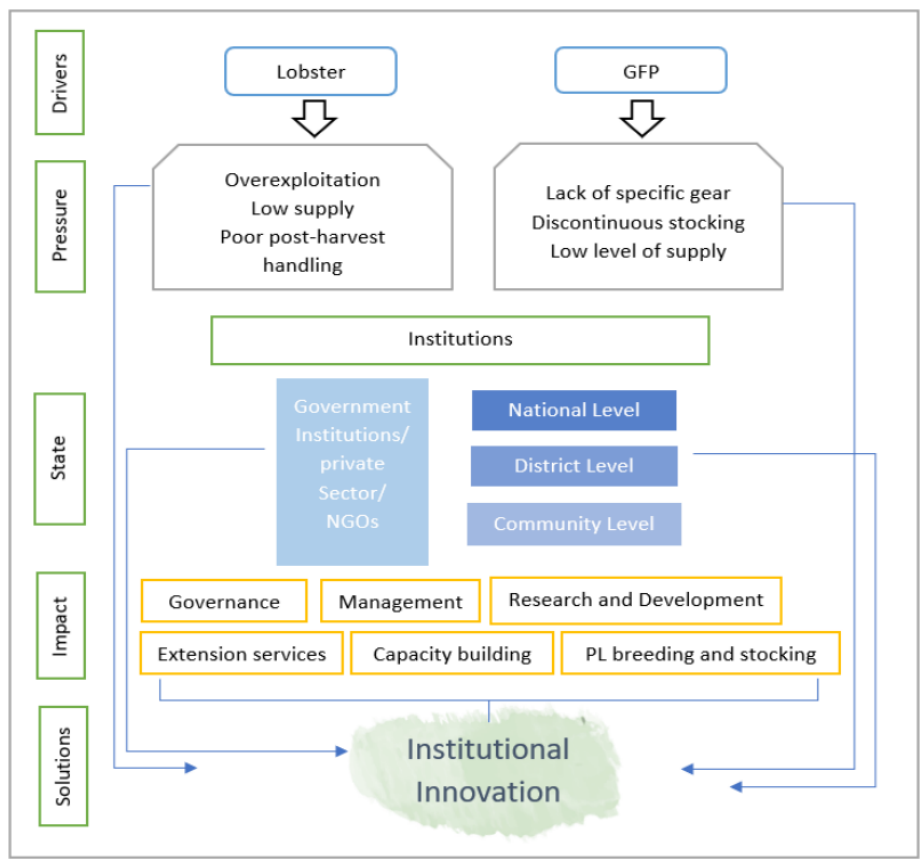


Figure 2. Conceptual framework of the study.

Source: Adopted by Natan et al.^[25].

2. Materials and Methods

The research employed a deductive approach, utilizing both primary and secondary data to analyze the institutional frameworks of lobster fisheries and Giant Freshwater Prawn (GFP) aquaculture in Sri Lanka. A mixed-methods strategy combining participatory, qualitative, and quantitative methods was adopted to ensure a comprehensive understanding of the issues in the current institutional system.

Data for lobster fisheries were collected from southern, western, and eastern coastal regions, while data for GFP fisheries were obtained from 17 reservoirs in the North-Central, Southern, and Sabaragamuwa provinces. Participants were purposefully selected to represent various stakeholders, including fishers, traders/exporters, government institutions, NGOs, and private-sector entities. The following **Table 1** explains each data collection method utilized to collect data from each value chain member.

Table 1. Data Collection Methods and Sample Size of Target Groups.

Target Group	Sample Size	Data Collection Tool	Variables
Fishermen	Lobster: 273 GFP: 475	Interviewer-administered Questionnaire	<ul style="list-style-type: none"> • Institutions at different levels • Connections (inter-institutions, intra-institutions) • Satisfaction level-Likert scale
Trader/exporter	Lobster: 09 GFP: 03	Key informant interviews	<ul style="list-style-type: none"> • Services rendered from institutions • Satisfaction Level • Relationship with the institutions
Government institutions/private sector and NGOs	Lobster: Academics-05, Scientists-02, Industry Experts-12 (National level:08, District level:03, NGOs:01) GFP: Academics-05, Scientists-04 (04-National level), Industry Experts-10 (03-NGOs, 01 - Private sector, 02: District level, 04-National level)	Stakeholder meeting	<ul style="list-style-type: none"> • Institutional mandates • The role of each institution • Constraints of each institution • Market opportunities and challenges • Existing regulating policies • Gaps in fisheries management • Potential institutional innovations

Two stakeholder meetings were conducted for each fishery to gain deeper insights into current challenges and potential solutions. Participants included representatives from the Department of Fisheries and Aquatic Resources (DFAR), Ministry of Fisheries (MoF), Export Development Board (EDB), National Aquatic Resources Research and Development Agency (NARA), the National Aquaculture Development Authority (NAQDA) of Sri Lanka, the Market Development Facility (MDF), and the GFP breeding centers of NAQDA. Meetings lasted 1–2 hours and were audio-recorded for transcription.

Quantitative Analysis: To investigate the relationship between the monthly net profit of fishers and the strength of institutional support, a linear regression analysis was conducted. Key variables included:

- **Dependent Variable:** Monthly net profit of lobster and GFP fishers.
- **Independent Variables:** Institutional Relations: relationship with each institute (Likert scale score), Char-

acteristics of fishers: age, years of experience, level of education, satisfaction with institutional support (Likert scale score), Community engagement: membership in fisheries cooperatives

The model is as follows:

$$\text{Net Profit} = \beta_0 + \beta_1(\text{relationship with each institute}) + \beta_2 (\text{Satisfaction with Institutional Support}) + \beta_3(\text{Years of Experience}) + \beta_4(\text{Age}) + \beta_5(\text{level of education}) + \beta_6(\text{Community Engagement}) + \epsilon$$

Quantitative analysis was conducted using Microsoft Excel 2019 and SPSS 22.0 software.

Qualitative Analysis: Transcripts from interviews and stakeholder meetings were analyzed using a thematic coding system. An iterative code list was developed by the research team to identify recurring themes related to institutional roles, challenges, and opportunities.

Socio-Economic profile of participants recorded as

follows: Fishers: The majority of lobster fishers were aged 36–45 years (68.9%) and had over 15 years of fishing experience (53.8%), while GFP fishers were predominantly aged 36–45 years (56.6%) with 10–15 years of experience (49.5%). Lobster fishing was entirely male-dominated (100%), whereas 24% of GFP fishers were female. Traders/Exporters: Most exporters were aged 51–60 years, with 37.5% of lobster exporters having over 15 years of experience, while 95% of GFP exporters had 10–15 years of experience.

The chosen methods ensured a comprehensive understanding of the institutional frameworks by integrating diverse perspectives from various stakeholders. Quantitative tools, including regression analysis, provided statistical insights into the relationship between institutional support and fisher profitability. Combining qualitative and quantitative approaches allowed for a holistic analysis of challenges and opportunities, addressing both structural and experiential dimensions of fisheries governance. By employing this robust and multidimensional approach, the study aimed to generate actionable insights and propose innovative interventions tailored to the unique challenges of Sri Lanka’s lobster and GFP fisheries.

3. Results

3.1. Evaluate the Gap of Existing Institutional Framework

3.1.1. Institutional Environment

The institutional environment encompasses the regulations, customs, and widely accepted norms that in-

fluence states, societies, professions, and organizations. The findings reveal that the lobster fisheries sub-sector comprises fishermen or divers, collectors, exporters, local traders, and foreign and local consumers. At the community level, fisheries organizations, cooperatives, and welfare societies actively operate to facilitate discussions on issues, share new knowledge, and provide financial support at the community level. At the district level, District Offices of the Department of Fisheries and Aquatic Resources (DFAR) primarily engage in monitoring and implementing policies and procedures, collaborating closely with upstream actors. Additionally, regional research centers under the National Aquatic Resources Research and Development Agency (NARA) disseminate knowledge to the public and operate small-scale laboratories to conduct research studies.

Key national-level institutions include the Ministry of Fisheries (MoF), DFAR, NARA, and the Sri Lanka Coast Guard (SLCG). The MoF and DFAR are responsible for governance, management practices, and policy enforcement, while NARA focuses on research and development, awareness, and training sessions. Exporters are further supported by institutions like the Export Development Board (EDB), Sri Lanka Customs, the National Chamber of Exporters, and animal quarantine services, which facilitate export processes. Essential service providers such as freight forwarders, packaging and labeling suppliers, warehouse operators, and transport providers play crucial roles in downstream lobster supply chain operations. Banks, insurance companies, and financial institutions operate across the value chain, serving all actors. The results are shown in the following **Table 2**.

Table 2. Institutional environment: Lobster fisheries.

Value Chain Actor: Lobster Fisheries	Government Institutions			Private Sector and NGOs		
	Community Level	District Level	National Level	Community Level	District Level	National Level
Fisher	Fisheries organizations Fisheries Cooperatives Welfare societies	District offices – DFAR: Fisheries Inspectors Regional Research Centers- NARA	MoF DFAR NARA Sri Lanka Coast Guard Insurance/banks and Financial institutions			FAO World Bank Insurance/Banks and Financial institutions

Table 2. Cont.

Value Chain Actor: Lobster Fisheries	Government Institutions			Private Sector and NGOs		
	Community Level	District Level	National Level	Community Level	District Level	National Level
Collector		District offices – DFAR: Fisheries Inspectors	MoF DFAR NARA Insurance/Banks and Financial institutions	Logistic services		Insurance/Banks and Financial institutions
Trader/exporter			EDB Sri Lanka Customs National Chamber of Exporters Animal Quarantine (AQ) Insurance/Banks and Financial institutions			Freight forwarders, Packaging and labeling suppliers, Warehouse and transport providers Insurance/Banks and Financial institutions

The institutional environment for Giant Freshwater Prawn (GFP) fisheries includes fishermen or fisherwomen, collectors, exporters, local traders, tourist hotels, restaurants, and consumers. Community-level fisheries organizations operate based on landing sites, with 2–3 associations often active within a single reservoir. Coastal Aquaculture Development Centers and Coastal Aquaculture Monitoring and Extension Units, managed by the National Aquaculture Development Authority (NAQDA), are key district-level institutions.

At the national level, institutions such as the Ministry of Fisheries (MoF), DFAR, NAQDA, and the Ministry of Irrigation play critical roles. NAQDA, in particular,

oversees GFP production, trade, and research and development, along with distributing fingerlings to fishermen. Exporters are supported by the EDB, Sri Lanka Customs, and animal quarantine services, with additional contributions from government universities, the Market Development Facility (MDF), and the Australian Centre for International Agricultural Research (ACIR). Banks, insurance companies, and financial institutions provide monetary support across all value chain nodes. MDF and ACIR, both Australian-funded initiatives, are instrumental in advancing GFP production and marketing. The results are shown in the following **Table 3**.

Table 3. Institutional environment: GFP fisheries.

Value Chain Actor: GFP Fisheries	Government Institutions			Private Sector and NGOs		
	Community Level	District Level	National Level	Community Level	District Level	National Level
Fisher	Fisheries organizations Fisheries Cooperatives Welfare societies	Coastal Aquaculture Development Centers Coastal Aquaculture Monitoring and Extension Unit	MoF DFAR NAQDA Ministry of Irrigation Freshwater Prawn Breeding Centers Insurance/Banks and Financial institutions			Market Development Facility (MDF) Australian Centre for International Agricultural Research (ACIR) Insurance/Banks and Financial institutions
Collector			MoF DFAR NAQDA Insurance/Banks and Financial institutions	Logistic services		Insurance/Banks and Financial institutions

Table 3. Cont.

Value Chain Actor: GFP Fisheries	Government Institutions			Private Sector and NGOs		
	Community Level	District Level	National Level	Community Level	District Level	National Level
Trader/exporter			EDB Sri Lanka Customs National Chamber of Exporters Animal Quarantine (AQ) Insurance/Banks and Financial institutions	Private Freshwater Prawn Breeding Centers		Market Development Facility (MDF) Insurance/Banks and Financial institutions

3.1.2. Institutional Involvement

As shown in **Figures 3 and 4**, the Ministry of Fisheries (MoF) and the Department of Fisheries and Aquatic Resources (DFAR) play a significant role in formulating policies, rules, and regulations, as well as conducting community capacity-building and awareness programs. Meanwhile, the National Aquatic Resources Research and Development Agency (NARA) in lobster fisheries and the National Aquaculture Development Authority (NAQDA) in GFP production are instrumental in research and development, ensuring sustainable and continuous production. These institutions play a pivotal role in supporting the proposed co-management model by providing scientific knowledge and facilitating collaboration between stakeholders.

Furthermore, organizations such as the Food and Agriculture Organization (FAO) and World Bank-funded projects are actively involved in sustainable resource management, policy establishment, and providing research grants both locally and internationally to investigate challenges in small-scale fisheries and identify solutions. These contributions are essential for the proposed co-management model, enabling better resource governance and value chain efficiency. However, it was observed that key players show a lack of involvement in the marketing and trade of both lobster and GFP. Despite having socio-economic and marketing divisions, these institutions have been unable to maintain a proper trade database or implement effective market planning and forecasting operations.

Additionally, many institutions engage in community-level capacity-building activities related to

value addition, GFP fingerling management before reservoir release, and conducting awareness and training programs. These programs focus primarily on post-harvest handling, conflict management in the use of common resources, and emphasizing adherence to policies, particularly within the lobster industry. These initiatives are integral to the co-management framework, enhancing the capacity of local communities to sustainably manage resources and align with market demands.

The issuance of diving licenses for lobster harvesting and monitoring inspections during the closed season for lobsters are directly managed by the Ministry of Fisheries and DFAR, along with their district offices, with the support of the Sri Lanka Coast Guard and the Sri Lanka Navy.

The level of involvement was coded based on the ratings provided by stakeholders during the stakeholder meeting. Ranks 5-4 were categorized as major involvement, rank 3 as significant involvement, and rank 2-1 as low or no involvement.

In general, there were no local community-level institutions involved in the governance decision-making process for GFP. In lobster fisheries, however, fishermen-level organizations were present to voluntarily manage this overexploited resource. Nevertheless, the district-level offices of DFAR lacked representation at the chiefdom and village community levels. Additionally, there was minimal focus on research and development in both industries, primarily due to resource constraints and funding challenges. This lack of attention to research and development was a notable limitation in the industry matrix.

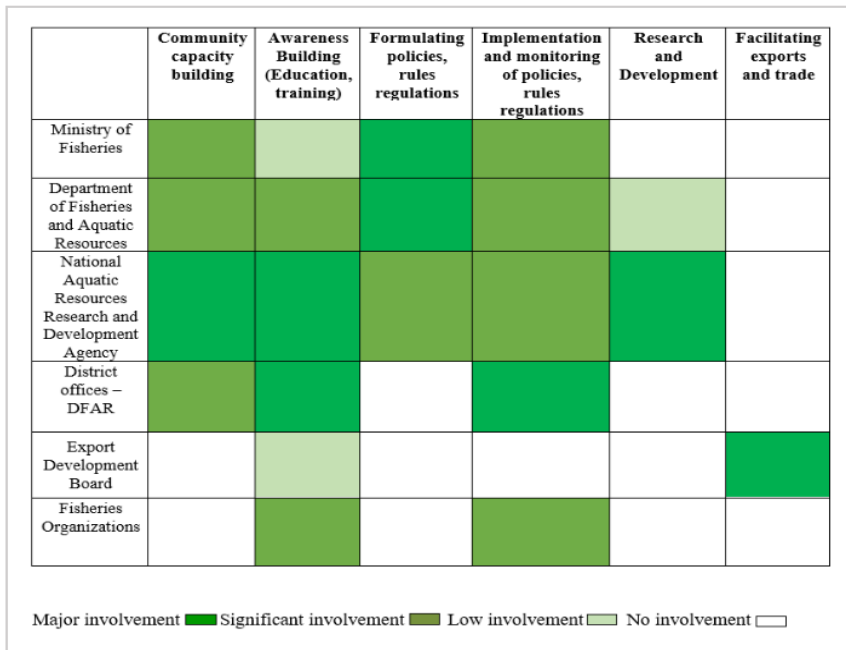


Figure 3. Institutional involvement: Lobster.

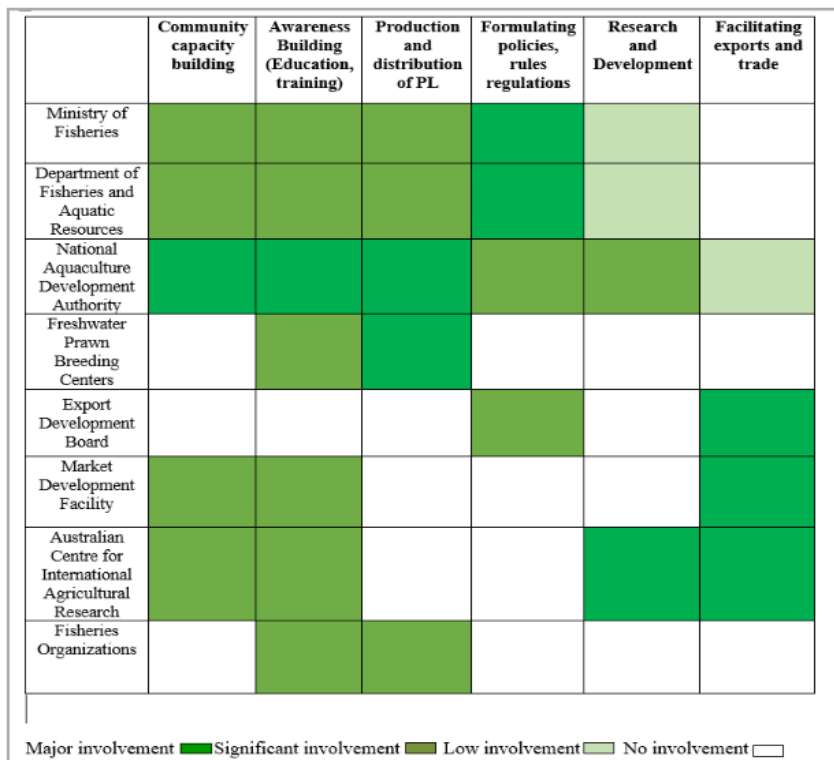


Figure 4. Institutional involvement: GFP.

3.1.3. Level of Satisfaction and Strength of Relationships

According to the results of multiple linear regression analysis in lobster fisheries, the strength of the relationship between fishers and institutions had the

strongest positive influence on net profit, with an unstandardized coefficient (B) of 27086.957 (p < 0.001). This indicates that for every unit increase in relationship, net profit increases by approximately 27,087 LKR. The standardized beta coefficient ($\beta = 0.733$) confirmed this vari-

able as the strongest predictor in the model. The satisfaction level on services of institutions had a significant negative effect on net profit, with $B = -3560.361$ ($p = 0.045$). This suggests that as satisfaction decreases, net profit declines by approximately 3,560 units per unit of change. However, this variable had a relatively weak standardized beta coefficient ($\beta = -0.087$). The membership in fisheries cooperatives also showed a positive and significant effect, with $B = 17387.270$ ($p = 0.049$), implying that being a member of fisheries cooperatives contributes to a net profit increase of approximately 17,387 units. Other factors like age, experience, and educational qualifications appear to have limited or no significant influence.

Moreover, in GFP fisheries, the level of satisfaction on services of institutions had the most significant positive influence on net profit, with an unstandardized coefficient (B) of 18,768.677 ($p < 0.001$). This indicates that for every unit increase in satisfaction, net profit increases by approximately 18,769 LKR. The standardized beta coefficient ($\beta = 0.398$) further emphasizes its impor-

tance as a key predictor of net profit. The relationship between fishers and institutions showed a marginally significant positive effect, with $B = 4,597.907$ ($p = 0.070$), implying that stronger relationships may contribute to an increase in net profit by approximately 4,598 units per unit change. However, this predictor did not meet the conventional significance threshold ($p < 0.05$). The demographic characteristics such as educational qualifications and experience emerged as significant negative predictors while age showed weaker effects, with their significance levels being marginal.

Therefore, the strength of the relationship between fishers and institutions and satisfaction level were found to have a significant impact on the net profit, emphasizing the critical role of healthy relationships in enhancing the overall performance of the value chain. Integrating these relationships within the co-management framework could foster trust and improve institutional effectiveness, leading to better economic outcomes. The findings, presented in **Table 4**, highlight these dynamics:

Table 4. Relationship between lobster production and institutional services.

	Coefficients							
			Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations
			Beta			Lower Bound	Upper Bound	Zero-Order
(Constant)	20805.352	14998.689		1.387	0.167	-8725.902	50336.606	
Relationship with institutions	27086.957	1784.756	0.733	15.177	0.000	23572.911	30601.003	0.704
Satisfaction on services	-3560.361	1763.698	-0.087	-2.019	0.045	-7032.945	-87.776	-0.029
Experience	623.567	1840.631	0.018	0.339	0.735	-3000.492	4247.626	0.227
Age	5324.385	3016.005	0.086	1.765	0.079	-613.895	11262.664	-0.006
Educational qualifications	422.457	2248.367	0.009	0.188	0.851	-4004.404	4849.318	0.141
Membership	17387.270	8788.230	0.086	1.978	0.049	83.928	34690.612	-0.027

Note: Dependent Variable: net profit.

3.1.4. Proposed Model of Institutional Innovation

Throughout history, farmers and their supporting institutions have successfully introduced technological innovations to help them respond and adapt to environmental and socioeconomic challenges. Innovation serves as a tool through which society adjusts to shifts in resource availability, and this process is shaped by social and cultural values^[32]. As resource conditions continue

to evolve, the role of institutions in driving technological innovation will be vital in mitigating the depletion of natural resources.

To reduce overexploitation, maintain sustainable production in lobster fisheries, and scale up production to meet international demand in GFP, we have identified that institutions play a significant role in fostering collaboration among ground-level fishermen. Based on our research findings and drawing from the conceptual model

adopted from the study of “Institutional Innovations for Climate Smart Agriculture: Assessment of Climate-Smart Village Approach in Nepal”^[33], we have created a new framework designed to scale up sustainable production in the lobster and GFP industries based on SSF guidelines. As shown in **Figure 5**, institutional innovation could be initiated with the collaborative partnership between public, private, and NGOs. Generally, fisheries management models are often developed by professionals who have little or no direct experience in managing fisheries and lack awareness of the practical realities involved^[6]. Therefore, in GFP and lobster fisheries sustainable production requires the utilization of knowledge, skills, and best practices as well as technological, institutional, and relational innovation. A stronger collaboration between formal research institutions, extension systems as well as informal community-based organizations, and private sectors to facilitate the practice of proper harvesting, reduce post-harvest losses, and

marketing with proper branding, labeling, and packaging will be supported to maintain a continuous supply by the end market requirements. Additionally, collaboration with research institutions and universities provides a positive beginning to the understanding of the role of science-based knowledge in these resource management in the future and implement technological innovations for mitigating existing loopholes.

Since the lobster fisheries are facing rapid depletion due to overfishing, educating and conducting community-based arrangements of resource management is essential. It is important to educate fishermen as well as hoteliers and traders, especially on the conservation and management of the lobster stocks and the ecosystem in collaboration with the resource users, which is essential to mitigate the issue. Further, awareness of the impact of over-exploitation of lobster stocks could be threatening to their income is also essential as an adaptive measure.

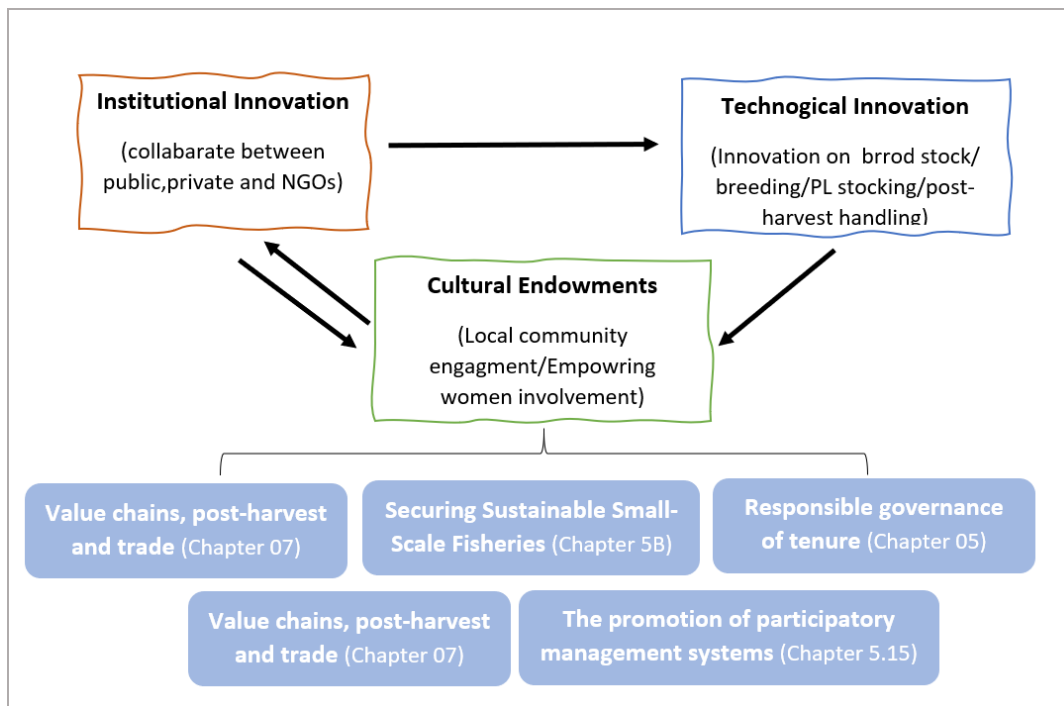


Figure 5. Proposed model illustrating interactions between institutional, cultural, and technological innovation in Lobster and GFP industries.

Furthermore, the SSF guidelines established by FAO^[34] argue that the governance of tenure, resource management, and improving the effectiveness of the fish value chain also highlight the importance of the role of

fishermen associations. As mentioned in one of the previous studies, the recognition and protection of customary rights to aquatic resources (Article 5.4), the adoption of measures for the sustainable use of fisheries re-

sources (Article 5.13), the promotion of participatory management systems, such as co-management (Article 5.15), the need for integrated and holistic approaches, including cross-sectoral collaboration (Article 6.1), the acknowledgment of the small-scale fisheries post-harvest subsector and the role its actors play in the value chain (Article 7.3), the inclusion of women and marginalized groups (found in Articles 5.15, 7.2, 8.3), and risk management (Article 9.3) support the implementation of institutional innovations in the Sri Lankan SSF sector by strengthening the upstream actors^[35].

4. Discussion

The existing institutional framework consists of multiple entities, including government, private, and international funding authorities. During stakeholder meetings, experts from various fields highlighted challenges within the lobster fisheries. One key issue is the mixing of products from different fishing levels throughout the supply chain into a single volume. This practice makes it difficult to accurately determine the origin of the catch and limits traceability from individual fishermen to the exporter level, creating opportunities for product substitution. Scientists who have been directly involved in lobster fisheries for some time also pointed out that, during the COVID-19 pandemic and the current economic crisis, the number of non-lobster fishers increased due to the high market value of lobster. Since these individuals are often unfamiliar with regulations, resource management, or closed-season periods, the industry has become highly vulnerable to overexploitation. Moreover, many of them are catching berried females on a large scale, aiming to earn high profits in a short period^[36]. In the context of GFP, although the government is directly involved in fingerling stocking, the recovery rate remains poor, leading to challenges in maintaining a continuous supply. Additionally, the lack of specific gear to trap the animals and insufficient research and development have been identified as major barriers within the industry. The high monopoly power of exporters, who control most of the key steps in the supply chain and final price and have direct links with end consumers, leaves rural fishermen unaware of market information

and requirements.

Furthermore, we have analyzed the issues in each institution and identified a common list of limitations for delivering efficient services, such as limited budget, limited access to training opportunities for industry professionals, narrow focus on research and development, time/financial constraints, legislative barriers/continued outdated rules mismatch with global trends, limited programs for export promotion, and poor links with other institutions were identified. These results were proved by the report "Fisheries Policies, Support Services and the Institutional Environment for Trade" published by the World Centre in 2018^[35] as well. The report highlighted that the fisheries-related institutions established in Sri Lanka are at a poor level (absent or uncoordinated effort with little impact on target groups) in extension and training, credit, administration, inputs, and marketing. Furthermore, from research and development and human resource skills are at a fair level, with services available but yet to make a significant impact on target groups. Moreover, the report highlighted the country has sufficient implementing agencies armed with necessary legal instruments; however, implementation effectiveness is questionable in terms of transparency and institutional capability for enforcing fisheries regulations.

The regression analysis results demonstrated a strong relationship between the strength of institutional support and fishers' net profits. Stronger relationships improve the performance of the value chain, underscoring the importance of fostering robust partnerships. This finding emphasizes the necessity of strengthening institutional collaboration and trust to achieve long-term sustainability.

As an institutional innovative practice, NARA, in collaboration with DFAR, has initiated a co-management program in areas with high levels of lobster harvesting by engaging the coastal community^[17]. The main objective of this co-management program is to manage lobster fisheries resources sustainably, encouraging the voluntary involvement of fishermen in enforcing current regulations and policies, as well as reporting any illegal lobster catching to the authorities. Additionally, district-level officers are conducting awareness programs for

local hoteliers and restaurant managers regarding current policies, particularly emphasizing the ban on selling and storing lobsters during the closed season. According to the literature although the government has imposed an off-season period, along with regulations, acts, and mechanisms to reduce excessive fishing pressure, compliance among stakeholders remains low^[15]. When comparing compliance levels, downstream members exhibited higher adherence, while upstream members showed significantly lower compliance rates, particularly due to limited knowledge and awareness of the rules, regulations, and policies governing fishing activities and illegal practices during the off-season.

Despite these efforts, compliance rates remain low among upstream actors due to limited knowledge of policies and practices, contrasting with higher adherence downstream. Addressing this gap requires intensified training and education to foster understanding and compliance with fisheries management regulations.

The findings underscore the importance of institutional innovation and participatory governance in sustainable fisheries management. Strengthening inter-institutional linkages, enhancing research and development, and promoting education among fishers and other stakeholders can contribute to improved governance and value chain efficiency. By aligning these efforts with the co-management model, it is possible to address the challenges faced by both the lobster and GFP fisheries and ensure their long-term sustainability.

5. Conclusions

The supply chain of lobster fisheries and GFP encompasses various stakeholders, including fishermen, collectors, distributors, local hotels, and exporters. Despite the existing market potential, key challenges such as unequal income distribution, over-exploitation of resources, inefficient information flow, lack of research and development, limited traceability, and absence of a strong trade brand hinder the industry's growth. The analysis revealed that both the lobster fisheries and GFP industries are regulated by multiple institutions at the community, district, and national levels. However, these

institutions often operate in isolation, with limited partnership and inadequate ground-level involvement, particularly concerning policy implementation, marketing, and trade decisions.

Our data analysis, including the linear regression model, shows that the strength of relationships with supportive institutions significantly affects fishermen's net profits. This indicates that stronger institutional support can directly improve economic outcomes for local fishers. However, the research also identifies gaps in the implementation of policies related to fishing seasons, species protection, and reducing fishing pressure. While policies are in place, enforcement bottlenecks have undermined the effectiveness of these regulations. Given these findings, we recommend the establishment of a more structured and innovative institutional framework for co-management, supported by targeted policies and legislation. This framework should clearly define the roles and responsibilities of each partner in the supply chain, fostering collaboration between public, private, and community stakeholders. Specifically, the development of public-private partnerships should be encouraged to address gaps in enforcement, facilitate the flow of information, and support research and development. The linear regression results suggest that stronger collaboration with supportive institutions could improve profitability for fishers, making institutional innovation not just desirable but essential. The proposed institutional model, which aligns with the FAO's SSF guidelines, can provide a pathway for more effective co-management, helping mitigate current challenges and secure the long-term sustainability of both industries. By improving enforcement and coordination, we can enhance the livelihoods of local communities and ensure equitable benefits for all stakeholders.

Author Contributions

R.B. was responsible for data collection, writing the original draft, and developing the methodology. A.D.S. contributed to the conceptualization of the study, provided supervision, and handled reviewing and editing tasks.

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Additional informed consent was obtained from all individuals for whom identifying information is included in this article.

Data Availability Statement

Data will be provided by the corresponding author based upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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