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Assessment of livelihood security among fish farmers engaged in fish processing and value-addition activities in Chhattisgarh

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Abstract

Fish processing and value-addition activities have emerged as important strategies for enhancing income, employment, and livelihood resilience among fisheries-dependent households. However, empirical evidence on their contribution to livelihood security remains limited, particularly in inland fisheries-dominated states such as Chhattisgarh. Therefore, the present study was conducted to assess the livelihood security of fish farmers engaged in fish processing and value-addition activities in Bilaspur and Rajnandgaon districts of Chhattisgarh. An ex-post-facto research design was adopted, and primary data were collected during 2023-2024 from 120 respondents selected through simple random sampling. Livelihood security was assessed using a composite Livelihood Security Index (LSI) comprising seven dimensions, namely infrastructural, health, educational, food, economic, institutional, and social security. The index was developed using Min-Max normalization and aggregated standardized scores. The findings revealed that the majority of respondents were middle-aged (70.00%), belonged to Scheduled Tribe (40.00%) and Scheduled Caste (36.67%) communities, possessed medium levels of fisheries experience (73.33%), and operated medium-sized water areas ranging from 0.50 to 1.00 ha (76.67%). The livelihood security assessment indicated that infrastructural security was the strongest dimension (LSI = 0.81), followed by health security (0.76), educational security (0.73), food security (0.69), and economic security (0.65). Institutional security (0.58) and social security (0.44) recorded comparatively lower scores, indicating gaps in institutional outreach, social support systems, and access to development services. The overall Livelihood Security Index of the respondents was found to be moderate, indicating a reasonably secure livelihood status with scope for improvement in institutional and social dimensions. The study concludes that fish processing and value-addition activities contribute significantly to livelihood enhancement; however, strengthening institutional support, extension services, credit access, fisheries cooperatives, and social protection mechanisms is essential for improving the long-term livelihood security and resilience of fish farming households in Chhattisgarh.

Keywords: Livelihood security index, fish processing, value addition, inland fisheries, Chhattisgarh, fish farmers

1. Introduction

Fisheries and aquaculture have emerged as one of the fastest-growing food-producing sectors globally, contributing significantly to food security, nutritional well-being, employment generation, and economic development and the livelihoods of over 600 million people worldwide (FAO, 2024) ^[15]. In India, fisheries have transformed into a key component of the agricultural economy, contributing to national income, employment, and export earnings. India currently ranks as the second-largest aquaculture producer globally (MFAHD 2021; Government of India. (2022a) ^[21, 22]. The sector recorded fish production exceeding 18 million tonnes during 2023-24, with inland fisheries accounting for more than 75 percent of total production, reflecting a structural shift from marine capture fisheries toward inland aquaculture and reservoir fisheries (FAOSTAT 2021; Fisheries Statistics Division, 2023) ^[17, 18]. Recognizing the

sector's strategic importance, the Government of India launched the Pradhan Mantri Matsya Sampada Yojana (PMMSY), which emphasizes infrastructure development, value-chain strengthening, post-harvest management, and livelihood enhancement for Fish Farmers (Government of India. (2022b) ^[21, 22]. While production growth remains essential, increasing fish harvest alone does not necessarily guarantee sustainable livelihood improvement for fishing communities. A significant proportion of economic losses in fisheries occurs during post-harvest stages due to improper handling, poor storage facilities, inefficient transportation networks, and weak market linkages (FAO, 2022) ^[16]. In many developing regions, post-harvest losses in fish and fishery products continue to undermine income realization and food availability, particularly among small-scale producers (FAO, 2022; Chauhan *et al.*, 2025) ^[9, 16].

Fish processing and value-addition activities have gained

increasing policy and research attention as mechanisms for enhancing profitability and livelihood resilience. Value-added fish products, including dried fish, smoked fish, fermented fish, fish pickles, fish powder, ready-to-cook, and ready-to-eat products, extend shelf life, reduce wastage, improve marketability, and generate additional income opportunities (Suresh *et al.*, 2025) ^[39]. Post-harvest enterprises create substantial off-farm employment and entrepreneurship opportunities, especially for women, who constitute a major workforce in fish processing, preservation, packaging, and marketing activities across rural India (Bhaumik *et al.*, 2021; Tanjay *et al.*, 2024) ^[41]. Therefore, strengthening value-addition systems is increasingly recognized as a critical pathway for improving livelihood outcomes and promoting inclusive fisheries development.

Chhattisgarh is one of the leading inland fisheries states in India, with a strong resource base that supports fish production and rural livelihoods. During 2021-22, the state produced 5.91 lakh tonnes of fish, while fish seed production reached 30,257 lakh standard fry, significantly exceeding the estimated requirement of 142 crore standard fry, with actual production touching 302 crore standard fry (FAO, 2022) ^[16]. The fisheries sector is supported by an extensive infrastructure network comprising 82 circular hatcheries, 59 fish farms, and 1,126 fish seed rearing units covering approximately 646.73 ha under both government and private ownership (DoF, 2024). The state also possesses substantial inland water resources, including 1,23,261 rural ponds covering 1.17 lakh ha and 1,770 irrigation reservoirs covering 0.83 lakh ha, providing nearly 2.0 lakh ha of water area for fisheries development. Furthermore, around 2.21 lakh fish farmers are actively engaged in fisheries-related activities, generating approximately 352 lakh man-days of employment annually, highlighting the sector's significant contribution to livelihood generation and rural economic development in the state (FAO, 2024) ^[15]. The fisheries sector plays a significant role in the economy of Chhattisgarh and contributes substantially to agricultural growth and rural livelihoods (Tanjay and Chauhan 2026) ^[40, 42]. The sector contributed approximately ₹3,422 crore to the state's Gross Domestic Product (GDP) during 2015-16, accounting for 13.10 per cent of the agricultural GDP and 1.57 per cent of the overall state GDP. Inland fisheries, particularly freshwater aquaculture, have emerged as an important source of income, employment, and livelihood security for rural households across the state. Beyond direct employment in fish farming, the sector generates additional livelihood opportunities through fish seed production, input supply, harvesting, transportation, processing, marketing, and value-addition activities. Fish culture in Chhattisgarh is predominantly based on Indian Major Carps (Catla, Rohu, and Mrigal), exotic carps such as Common Carp, Grass Carp, Silver Carp, and Black Carp, along with *Pangasius*, which has gained popularity due to its fast growth and market demand (DoF, 2024). Despite this impressive growth, many fisheries-dependent households continue to face livelihood challenges. A large proportion of Fish Farmers belong to economically and socially vulnerable communities and remain exposed to income instability, seasonal employment fluctuations, inadequate post-harvest infrastructure, limited access to institutional credit, dependence on intermediaries, and insufficient cold-chain facilities (Tanjay *et al.*, 2025) ^[41].

Traditional fish processing and marketing practices continue to dominate many rural areas, limiting product quality, market competitiveness, and value realization. Therefore, growth in fish production alone may not ensure sustainable livelihood improvement unless accompanied by strengthened post-harvest management, value-addition enterprises, market integration, and institutional support mechanisms (Girish *et al.*, 2020; Sonanla *et al.*, 2026) ^[19, 37].

The concept of livelihood security provides a comprehensive framework for understanding the well-being of households engaged in fisheries and allied activities. The Sustainable Livelihoods Framework developed by the Department for International Development (DFID) emphasizes that livelihoods are shaped by access to and interaction among five forms of capital: human, social, natural, physical, and financial assets (DFID, 2000; Scoones, 2016) ^[12, 32]. Human capital encompasses education, skills, health, and knowledge; social capital reflects social networks, collective action, and institutional participation; natural capital includes access to fisheries resources and environmental assets; physical capital comprises infrastructure, equipment, storage, and transportation facilities; while financial capital relates to income, savings, credit, and economic security (Chambers and Conway, 1992; Ellis, 2000) ^[7, 13]. Livelihood security is achieved when households possess adequate capabilities and resources to withstand shocks, maintain or enhance their well-being, and pursue sustainable economic opportunities over time (Scoones, 2016) ^[32]. In fisheries, livelihood security extends beyond production outcomes and requires assessment of multidimensional factors influencing the resilience and welfare of fishing households engaged across the value chain, including post-harvest processing and value-addition activities. (Singh *et al.*, 2020) ^[36]. Most previous studies have mainly focused on fish production and income generation, while giving less attention to the broader livelihood benefits of post-harvest activities. As a result, there is limited information on how fish processing and value-addition activities influence different aspects of livelihood security, such as human, social, physical, natural, and financial well-being. Therefore, the present study was undertaken to assess the livelihood security of fish farmers engaged in fish processing and value-addition activities in Chhattisgarh and to identify the major factors influencing their overall livelihood status and well-being.

2. Theoretical and Conceptual Framework

The theoretical framework of the present study assumes that the livelihood security of fish farmers is influenced by their personal, social, and economic characteristics, as well as their involvement in fish processing and value-addition activities, as presented in table-1. Factors such as age, education, experience in fisheries, income, training exposure, social background, and operational area affect the ability of fish farmers to adopt improved practices and utilize available opportunities. Fish processing and value addition help farmers increase the value of their fish products, reduce post-harvest losses, improve market access, and generate additional income (Porter, 1985; Kaplinsky and Morris, 2000; FAO, 2024) ^[15, 24, 31]. These activities ultimately contribute to improving different dimensions of livelihood security, including infrastructural, health, educational, food, economic, institutional, and social security. The combined

effect of these dimensions determines the overall Livelihood Security Index (LSI) of the respondents. Thus, the framework suggests that better socio-economic conditions and active participation in fish processing and value-addition activities

can lead to improved livelihood security and overall well-being among fish farming households (Chambers and Conway, 1992; DFID, 2000; Scoones, 2016)^[7, 12, 32].

Table 1: Theoretical Framework for Assessing Livelihood Security among Fish Farmers Engaged in Fish Processing and Value-Addition Activities

Components of Framework	Variables/Indicators	Theoretical Justification	Expected Influence on Livelihood Security
Socio-personal Characteristics	Age, Social Strata, Education, Experience in Fisheries	Human capital influences decision-making ability, technology adoption, and livelihood outcomes (Chambers & Conway, 1992; DFID, 2000; Scoones, 2016) ^[7, 12, 32] .	Better education and experience enhance participation in fisheries enterprises and improve livelihood security.
Socio-economic Characteristics	Annual Household Income, Fisheries Income, Operated Area, Resource Ownership	Financial and natural assets determine production capacity and economic resilience (Allison <i>et al.</i> , 2001; WorldFish, 2022) ^[2, 45] .	Higher income and larger productive resources contribute positively to livelihood security.
Institutional Characteristics	Training Exposure, Extension Contact, Access to Support Services	Institutional support enhances knowledge, skill development, and access to innovations (DFID, 2000) ^[12] .	Increased training and institutional support improve livelihood outcomes and adaptive capacity.
Fish Processing and Value-Addition Activities	Processing, Preservation, Packaging, Marketing of Fish Products	Value Chain Theory suggests that value addition increases profitability and market competitiveness (Porter, 1985; Kaplinsky & Morris, 2000) ^[24, 31] .	Generates additional income, reduces post-harvest losses, and improves market access.
Livelihood Security Dimensions	Infrastructural Security, Health Security, Educational Security, Food Security, Economic Security, Institutional Security, Social Security	Livelihood security is a multidimensional outcome reflecting household well-being and sustainability (Lindenberg, 2002; Sullivan <i>et al.</i> , 2006) ^[27, 38] .	Improved livelihood dimensions enhance overall livelihood security and resilience.
Outcome Variable	Overall Livelihood Security Index (LSI)	Composite measure of household livelihood status based on multiple dimensions (Sullivan <i>et al.</i> , 2006) ^[38] .	Higher LSI indicates greater livelihood security and sustainability.

3. Methodology

Study Area and Sampling Procedure

The present investigation adopted an ex-post-facto research design, which is considered appropriate when the independent variables have already occurred and cannot be manipulated by the researcher. According to Kerlinger (1976)^[25], ex-post-facto research is a systematic empirical inquiry in which the scientist does not have direct control over the independent variables because their manifestations have already occurred or because they are inherently not manipulable. The study was conducted in Chhattisgarh, one of the rapidly emerging inland fisheries states in central India. The state possesses abundant inland water resources comprising reservoirs, tanks, ponds, lakes, and irrigation impoundments that support fisheries and aquaculture-based livelihoods. Inland fisheries have become increasingly important for rural employment generation, nutritional security, and income diversification. Among the districts of Chhattisgarh, Bilaspur and Rajnandgaon were purposively selected for the study owing to their substantial fisheries potential, active participation in aquaculture and reservoir fisheries, and the prevalence of fish processing and value-addition activities. These districts possess extensive networks of ponds, tanks, and reservoirs and have consistently recorded significant fish production and fisheries-related economic activities. Furthermore, the presence of organized fisher groups, processing units, and market-oriented fisheries enterprises provided a suitable setting for examining livelihood security among Fish Farmers engaged in post-harvest fisheries activities. Then, respondents were selected

using simple random sampling from the finalized sampling frame to ensure equal probability of selection and to minimize sampling bias. A total of 120 respondents were included in the study, comprising 60 respondents from Bilaspur district and 60 respondents from Rajnandgaon district.

3.2 Data Collection

Primary data were collected using a semi-structured interview schedule specifically designed for the objectives of the study. The instrument was developed after an extensive review of the literature on fisheries livelihoods, sustainable livelihood frameworks, livelihood security assessment, and post-harvest fisheries value chains (DFID, 2000; Allison and Ellis, 2001; Scoones, 2016)^[2, 12, 32]. Before the final survey, a pilot study involving 30 respondents from non-sampled areas possessing similar socio-economic and fisheries characteristics was conducted to assess the clarity, comprehensibility, reliability, and relevance of the interview schedule. Based on feedback obtained during the pilot phase, necessary modifications were made regarding question wording, response categories, and sequencing of items. The revised schedule was finalized for field application. Primary data collection was carried out during the period 2023-2024 through face-to-face personal interviews with the selected respondents. Personal interviewing was preferred as it facilitated greater respondent interaction, improved data completeness, enabled clarification of questions whenever required, and minimized non-response and measurement errors.

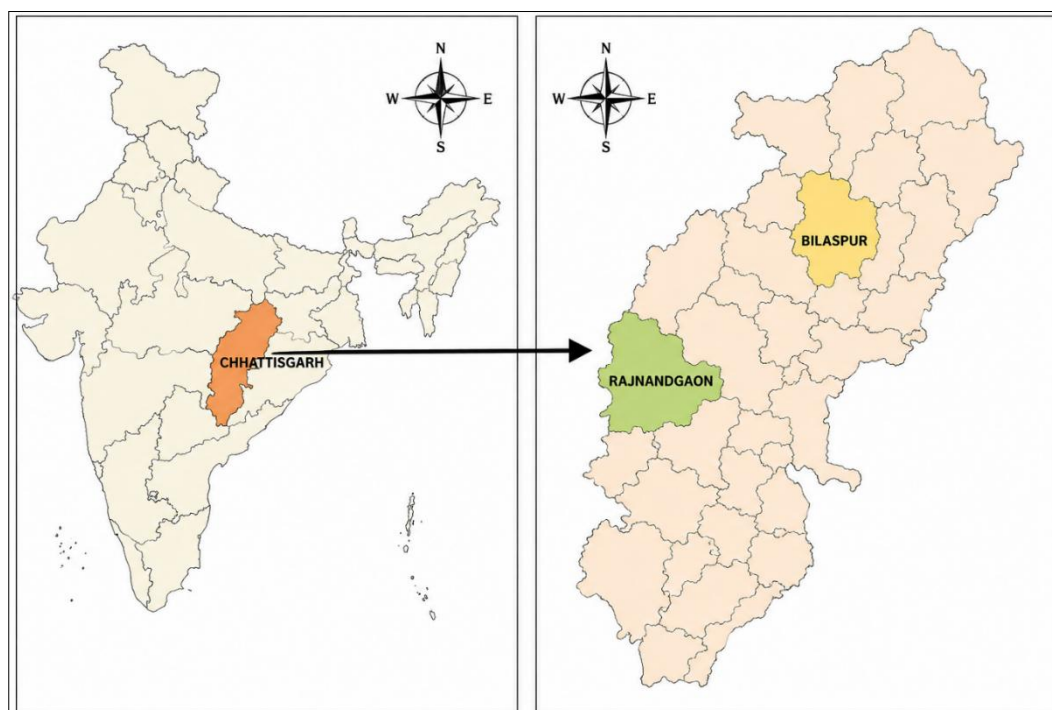


Fig 1: Location of the study area

3.3 Variables consideration

The independent variables included age, education, annual household income, fisheries experience, operational fishery resources, and training exposure. These variables were selected based on an extensive review of the literature on livelihood security, fisheries value chains, and rural livelihood studies (Allison *et al.*, 2001; Scoones, 2016; Béné, 2009) [2, 5, 32]. The dependent variable, namely livelihood security, was assessed using a multidimensional Livelihood Security Index (LSI) encompassing various dimensions of household well-being along with several indicators presented in Table 2. The selected variables were operationalized and measured using appropriate scales and indices to facilitate quantitative analysis.

Livelihood security of the fish farmers engaged in Fish Processing and Value-Addition Activities

"Livelihood security" was defined as having proper access to income and other resources to satisfy needs such as food and nutrition, health care, educational opportunities, participation in the community, and social integration. The livelihood security of Fish Farmers was measured by "Livelihood Index," with indicators like food security, Economic security, health security, educational security, social security, institutional security, and infrastructural security (Sullivan *et al.*, 2006; Lindenberg, 2002) [27, 38].

In this study, standardised scores for each sub-indicator were calculated by the formula:

$$Z_{\text{indi}} = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

Where X_i , $X_{\max}$, and $X_{\min}$ were the original values for indicator i ,

Z_{indi} = value of standardised indicator i

Then the livelihood security values of each respondent will be calculated by using the given formula:

$$LS_j = \frac{\sum_{i=1}^n W_i Z_{\text{indi}j}}{\sum W_i}$$

Where,

LS_j = Livelihood security value of the j respondent

$Z_{\text{indi}j}$ = Value of standardised indicator i for the j respondent

$\sum W_i$ = Summated value of the weightage of all i indicators

Table 2: Dimensions and Indicators of Livelihood Security

Dimension	Indicators
Infrastructural Security	Road connectivity, transportation, electricity, communication facilities, and water availability
Health Security	Access to healthcare, sanitation, drinking water, and health services
Educational Security	Literacy level, educational attainment, and educational facilities
Food Security	Food availability, food consumption, and nutritional adequacy
Economic Security	Household income, fisheries income, employment opportunities
Institutional Security	Training exposure, extension contact, access to credit, and schemes
Social Security	Membership in groups, social participation, community support

Statistical tools used for data analysis included Frequency, percentage, mean, standard deviation, Min-Max normalization, and Composite Livelihood Security Index (LSI) estimation. The data were analysed using SPSS v20 to process both qualitative and quantitative survey data.

4. Results

Socio-personal, Socio-economic Profile of Fish Farmers engaged in Fish Processing and Value Addition Activities in Chhattisgarh

The socio-personal and socio-economic profile of the selected respondents presented in Table 3 revealed that the

majority of respondents belonged to the middle-aged category (70.00%), indicating active participation of economically productive individuals in fisheries-based livelihood activities, while only 3.33 per cent were above 45 years of age. The social composition was predominantly represented by Scheduled Tribe (40.00%) and Scheduled Caste (36.67%) communities, highlighting the important role of fisheries in supporting the livelihoods of socially marginalized groups. In terms of education, half of the respondents (50.00%) had completed middle school, followed by 35.00 per cent with high school and above education, whereas illiteracy was relatively low (3.33%), suggesting a moderate level of human capital among the fish farmers. A substantial proportion of respondents (73.33%) possessed medium levels of fisheries experience, indicating sustained engagement in fisheries activities. The income profile revealed that the majority of households were concentrated in the annual income range of ₹1.0-1.5 lakh (41.67%) and ₹1.5-2.0 lakh (38.33%), reflecting a moderate

economic status. Fisheries contributed significantly to household earnings, with 58.33 per cent of respondents generating more than ₹30,000 annually from fisheries-related activities. Training exposure was found to be relatively high, as two-thirds (66.67%) of the respondents had attended formal training programmes, demonstrating considerable institutional outreach and capacity-building efforts. The majority of respondents (76.67%) operated medium-sized water areas ranging from 0.50 to 1.00 ha, followed by 16.67 per cent operating more than 1.00 ha. Only 6.67 per cent operated water areas below 0.50 ha, indicating moderate access to productive fisheries resources among the respondents. The findings indicate that fisheries in the study area are primarily practiced by moderately educated, middle-aged farmers from socially disadvantaged communities who possess adequate experience, training exposure, and access to productive water resources, thereby providing a strong foundation for livelihood enhancement and fisheries enterprise development.

Table 3: Socio-personal and Socio-economic Profile of Selected Fish Farmers engaged in Fish Processing and Value Addition Activities in Chhattisgarh (N = 120)

Variables	Category	Frequency	Percentage
Age group (years)	Young (18-35)	32	26.67
	Middle (>35-45)	84	70.00
	Old (>45)	4	3.33
Social strata	Scheduled Tribe	48	40.00
	Scheduled Caste	44	36.67
	Other Backward Caste	20	16.67
	General Caste	8	6.66
Education level	Illiterate	4	3.33
	Up to Primary	14	11.67
	Middle School	60	50.00
	High School and Above	42	35.00
Experience in Fisheries Activities	Low	10	8.33
	Medium	88	73.33
	High	22	18.34
Annual Household Income	₹50,000-₹1,00,000	12	10.00
	₹1,00,000-₹1,50,000	50	41.67
	₹1,50,000-₹2,00,000	46	38.33
	₹2,00,000-₹2,50,000	8	6.67
	₹2,50,000-₹3,00,000	4	3.33
Annual Income from Fisheries post-harvest Activity	₹20,000-₹25,000	8	6.67
	₹25,000-₹30,000	42	35.00
	Above ₹30,000	70	58.33
Training Exposure	Attended Training Programme	80	66.67
	Not Attended	40	33.33
Operated Water Area (ha)	Low (<0.50 ha)	8	6.67
	Medium (0.50-1.00 ha)	92	76.67
	High (>1.00 ha)	20	16.66

Note: N = 120 respondents

Assessment of the Livelihood Security of Fish Farmers engaged in Fish Processing and Value Addition Activities in Chhattisgarh (N = 120)

The livelihood security of the selected fish farmers was assessed using seven dimensions, namely infrastructural security, health security, educational security, food security, economic security, institutional security, and social security (Fig. 2). The results revealed that infrastructural security was the strongest component (LSI = 0.81), indicating better access to roads, transportation, electricity, communication facilities, water resources, and fisheries-related infrastructure

that support fish production and marketing activities. Health security (LSI = 0.76) ranked second, reflecting reasonable access to healthcare facilities and government health services, while educational security (LSI = 0.73) ranked third, suggesting moderate to high levels of education, knowledge, and access to information among the respondents. Food security (LSI = 0.69) and economic security (LSI = 0.65) were found to be moderately strong, indicating that fisheries contribute significantly to household nutrition, income generation, and employment opportunities. However, institutional security (LSI = 0.58) recorded a

comparatively lower score, suggesting moderate access to training programmes, extension services, credit facilities, and government support schemes. Social security emerged as the weakest dimension (LSI = 0.44), highlighting limitations in social support systems, welfare benefits, community participation, and access to social protection measures. the

findings indicate that the livelihood security of fish farmers is largely supported by strong infrastructural, health, and educational conditions, whereas social and institutional aspects remain relatively weak and require greater policy attention to achieve balanced and sustainable livelihood development.

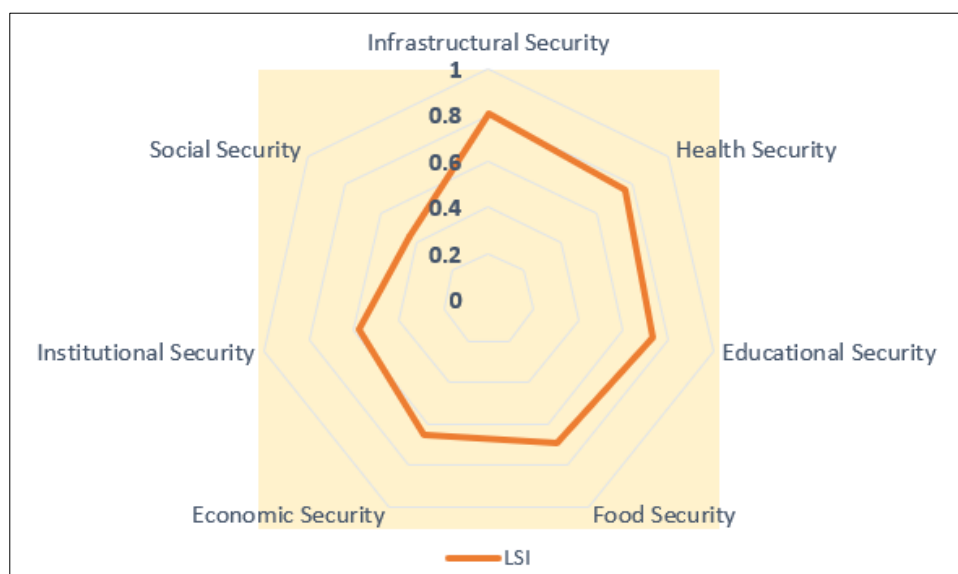


Fig 2: Dimension-wise Livelihood Security Index (LSI) of Fish Farmers Engaged in Fish Processing and Value-Addition Activities in Chhattisgarh

Discussion

Socio-personal and Socio-economic Characteristics of Fish Farmers engaged in Fish Processing and Value Addition Activities in Chhattisgarh

The socio-personal and socio-economic profile of the selected fish farmers indicates that fisheries and fisheries-related value-addition activities serve as an important livelihood source for economically active and socially marginalized households (Bhendarkar *et al.*, 2017) [6]. The predominance of middle-aged respondents suggests that fish farming activities are largely managed by individuals in their productive years who possess adequate experience, decision-making ability, and resource management skills, which are essential for sustaining fisheries enterprises. (Thakur, 2015) [44]. The higher representation of Scheduled Tribe and Scheduled Caste communities highlights the significant role of fisheries in supporting the livelihoods of vulnerable and resource-constrained populations, particularly in rural areas where alternative employment opportunities are limited (Singh *et al.*, 2016; Das, 2026) [10, 35]. The moderate educational attainment observed among the respondents reflects a reasonable level of human capital that can facilitate the adoption of improved aquaculture practices, participation in training programmes, and access to institutional services (Sharma, 2015) [33]. The majority of respondents possessed a medium level of fisheries experience, reflecting their long-term involvement in fish farming and the development of practical skills required for managing fisheries enterprises. Fisheries also contributed significantly to household income, with many respondents depending on fisheries-related activities as an important source of livelihood, thereby enhancing income diversification and economic security. (Lahiri *et al.*, 2024) [26]. However, the concentration of

households within the low- to middle-income categories suggests continued vulnerability to production risks, market fluctuations, and limited financial resources. The relatively high level of training exposure among respondents reflects the effectiveness of fisheries extension and capacity-building programmes in enhancing technical knowledge, entrepreneurial skills, and awareness of scientific fish farming practices (Sharma *et al.*, 2014; Tanjay *et al.*, 2025) [34, 41].

Livelihood Security

The livelihood security assessment revealed considerable variation across the seven dimensions, indicating that the well-being of fish farmers engaged in fish processing and value-addition activities is influenced by multiple socio-economic, institutional, and infrastructural factors. Among the dimensions, infrastructural security emerged as the strongest component, suggesting relatively better access to roads, transportation facilities, electricity, communication networks, water resources, and fisheries-related infrastructure. Chhattisgarh has witnessed substantial investments in fisheries infrastructure under the Blue Revolution and Pradhan Mantri Matsya Sampada Yojana (PMMSY), including fish seed farms, hatcheries, reservoir development, fish transportation facilities, and cold-chain infrastructure, which have strengthened fisheries production and marketing systems. The availability of extensive inland water resources and reservoir fisheries has further enhanced physical capital among fish farmers. Similar findings emphasizing the role of infrastructure in improving livelihood outcomes have been reported by Sharma *et al.* (2014) [34] and Girish *et al.* (2020) [19]. Health security and educational security emerged as the second and third strongest dimensions, respectively, indicating a relatively

strong human capital base among respondents. Improved access to rural healthcare services, Ayushman Bharat, primary health centres, and maternal and child health programmes may have contributed to the higher health security observed in the study area (NITI Aayog, 2023; National Health Mission, 2024) ^[29]. Educational security reflects the moderate educational attainment of respondents, with the majority possessing middle-school and secondary-level education. However, educational advancement among tribal and marginalized communities in Chhattisgarh continues to face challenges related to poverty, school accessibility, and educational disparities, particularly in remote rural areas (Government of Chhattisgarh, 2023; Chauhan *et al.*, 2022) ^[8]. Education remains a critical determinant of technology adoption, enterprise management, and participation in value-addition activities, thereby strengthening livelihood resilience. Food security and economic security recorded moderate levels, indicating that fisheries contribute substantially to household nutrition and income generation but do not completely eliminate livelihood vulnerabilities. Fish farming and fish processing provide an important source of animal protein and cash income, particularly for tribal and economically weaker households (FAO, 2024; WorldFish, 2022) ^[15, 45]. Nevertheless, fluctuations in fish prices, seasonal variations in production, input costs, disease outbreaks, and limited access to organized markets continue to affect economic stability. Similar observations have been reported by Kumar (2009), Béné (2009) ^[5], and Sonanla *et al.* (2026) ^[37], who highlighted that fisheries-dependent households often experience income instability despite regular engagement in aquaculture and post-harvest activities. The moderate economic security score suggests that value-addition activities enhance income opportunities but require stronger market integration and financial support to achieve sustainable livelihood improvements. Institutional security was comparatively lower, indicating moderate access to extension services, training programmes, institutional credit, and advisory support. Although two-thirds of the respondents had attended training programmes, gaps remain in institutional outreach and access to technical assistance. Fisheries departments, Krishi Vigyan Kendras (KVKs), cooperatives, and PMMSY-supported interventions have expanded training opportunities and awareness regarding scientific aquaculture and fish processing practices in Chhattisgarh (DoF, 2024; Jhajharia *et al.*, 2013) ^[23]. However, many small-scale fish farmers continue to face difficulties in accessing formal credit, insurance services, market information, and value-chain support mechanisms. Similar concerns have been reported by Barela *et al.* (2018) ^[4], Balami *et al.* (2019) ^[3], and Rajkumar *et al.* (2024). The weakest dimension is social security, indicating limited participation in social networks, producer organizations, cooperatives, self-help groups, and collective marketing systems. Although fisheries cooperatives and SHGs are increasingly being promoted in Chhattisgarh, their coverage and effectiveness remain uneven across districts. Weak social capital reduces access to information, collective bargaining opportunities, risk-sharing mechanisms, and market linkages, thereby limiting livelihood resilience (Alam *et al.*, 2022; Béné, 2009) ^[1, 5]. The predominance of Scheduled Tribe and Scheduled Caste households among the respondents may further contribute to social and economic exclusion, restricting their access to institutional resources and development opportunities (Das, 2026; Singh *et al.*,

2016) ^[10, 35]. Strengthening community-based organizations, fisheries cooperatives, producer groups, and women-led SHGs could therefore play a crucial role in improving social security and enhancing livelihood outcomes. Overall, the livelihood security profile suggests that fish farmers engaged in fish processing and value-addition activities possess relatively strong physical and human capital but continue to experience constraints related to social and institutional capital. From the perspective of the Sustainable Livelihoods Framework (Chambers and Conway, 1992; DFID, 2000; Scoones, 2016) ^[7, 12, 32], the findings demonstrate that improvements in infrastructure, health, and education alone are insufficient to ensure sustainable livelihoods unless accompanied by stronger institutional support systems, financial inclusion, and social networks. Therefore, policies aimed at strengthening fisheries cooperatives, improving access to institutional credit, expanding extension services, promoting value-addition enterprises, and enhancing market connectivity under PMMSY are essential for improving the long-term livelihood security and resilience of fish farming households in Chhattisgarh.

Conclusion

The study concludes that fish processing and value-addition activities play an important role in improving the livelihood security of fish farmers in Chhattisgarh by enhancing income opportunities, employment generation, and food security. The findings revealed that infrastructural, health, and educational security were the strongest dimensions of livelihood security, while institutional and social security remained relatively weak. Although fish farmers possessed moderate levels of economic and food security, limited access to institutional support, credit facilities, and social networks continued to constrain their overall livelihood resilience. Therefore, strengthening fisheries cooperatives, extension services, training programmes, and market linkages under initiatives such as PMMSY is essential to enhance livelihood security and promote sustainable fisheries-based rural development in the state.

Limitations of the Study

The study was limited to two districts of Chhattisgarh and relied on cross-sectional data collected during 2023-2024. Therefore, the findings may not fully represent all fisheries-dependent households in the state. Future studies covering larger geographical areas and longitudinal assessments would provide a more comprehensive understanding of livelihood security dynamics.

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Declaration by authors

This is to certify that the manuscript has not been published previously and is not under consideration for publication elsewhere.

Declaration of Generative AI and AI-assisted technologies in the writing process

While preparing this work, the author(s) used Microsoft Copilot (GPT-5) to help generate the mathematical equations included in the supplementary material. All content produced using this tool was subsequently reviewed and revised by the authors, who accept full responsibility for the final published article.

Declaration of Competing Interest

The authors state that they have no financial or personal conflicts of interest that could have influenced the work presented in this paper.

Ethical Considerations

Prior informed consent was obtained from all respondents before conducting the interviews. Respondents were informed about the objectives of the study, and participation was entirely voluntary. Confidentiality and anonymity of responses were maintained throughout the research process.

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