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From supporting roles to leaders: women driving change in Odisha's fisheries sector

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ABSTRACT

Women are involved across all parts of the fisheries and aquaculture value chains; however, their access to productive assets, technical skills, capital, markets, and decision-making remains unequal. This study investigates changes in women's participation and enterprise performance among women self-help groups (WSHGs) engaged in fisheries and aquaculture in Balasore District, Odisha, India. A retrospective programme evaluation synthesized field records from WSHG enterprises supported by public access to water bodies, capital subsidies, technical training, market linkages, and collective branding. The descriptive analysis encompassed hygienic dry-fish processing, community pond aquaculture, reservoir cage culture, brackishwater polyculture, ornamental fish production, and fish-seed activities. For example, the installation of polyhouse solar dryers in Talapada expanded batch processing capacity by approximately 300% and reduced curing times by over 20%. In the primary production sector, the OMM Sairam community pond increased fish harvest from 27,000 kg in 2021–22 to 40,000 kg in 2023–24, driving an improvement in the stock-to-yield ratio from 6.00 to 7.02 kg/kg despite intermittent seasonal fluctuations. Financially, high-capital brackishwater ventures reported robust operating margins reaching 62.2% in Gudu and 59.7% in Bardhanpur. Monthly per-member income increased by 75%, 150%, and 500% in Sugo, Talanagar, and Sabira, respectively, although baseline income levels and group numbers varied by location. The findings indicate that women's involvement in primary production and higher-value processing was associated with a combination of institutional and technological interventions rather than any single input. However, the evidence is observational, enterprise-level records are inconsistent, and formal empowerment and governance outcomes were not assessed using a standardised index. The results suggest continued funding for women-led producer groups, market infrastructure, technical training, working capital, and participation in fisheries governance.

Keywords: Women in Fisheries, Women Self-Help Groups, Odisha, Fish Value Addition, Community Ponds

1. Introduction

Fisheries and aquaculture are central to food supply, livelihoods and rural economies. The Food and Agriculture Organisation reported that 195 million tonnes of aquatic animals were produced globally in 2024, within a total fisheries and aquaculture production of 235 million tonnes, including algae. Aquaculture surpassed the 100-million-tonne threshold for the first time to reach 103 million tonnes (53% of global aquatic animal output), validating the importance of aquaculture technologies, value-chain organization and involving institutions in future aquatic-food systems (FAO, 2026) [1]. India produced about 17.55 million tonnes of fish in 2022–23 and remains one of the world's major fish-producing countries (Department of Fisheries, 2023) [2].

Despite the expansion of fisheries and aquaculture, equal participation has not been achieved. Women contribute across the entire value chain, including harvesting, farming, post-harvest handling, and retail. Globally, women constitute 27% of those employed in primary production and 56% in fish processing, with the exception of Bangladesh, where the total is 28%, indicating a strong presence in post-harvest stages (FAO, 2026) [1]. Gendered employment patterns are shaped by market conditions, mobility, capabilities, social networks, governance structures, and women's rights to productive resources (Weeratunge *et al.*, 2010) [3]. Research on small-scale fisheries highlights a persistent lack of quantitative data on women's involvement, which can obscure their economic contributions during resource planning and allocation (Kleiber *et al.*, 2015) [4]. Gopal *et al.* (2020) [5] emphasize that women's participation should be recognized throughout the fisheries and aquaculture system, rather than being limited to traditional post-harvest roles.

In India, women's self-help groups have increasingly been used as institutional platforms for collective savings, enterprise development, technical training and for gaining access to productive assets. Similar benefits for socio-economic development have been recorded in other states with respect to producer organisations of fish farmers (Rathod *et al.*, 2024a; Rathod *et al.*, 2024b; Rathod *et al.*, 2026) [6, 7, 8]. In the case of Odisha, it has been found that women's aquaculture initiatives can have a positive effect on people's livelihoods and on

their level of empowerment if they are based on scientific aquaculture methods and are accompanied by training and direct support (Jayasankar *et al.*, 2022) [9]. More recent state-wide evidence from Odisha has also shows that carp–mola aquaculture carried out through women's self-help groups can increase productivity and lead to higher incomes as well as greater household consumption of fish (Dubey *et al.*, 2024) [10]. Furthermore, evidence from Jagatsinghpur shows that women's empowerment in aquaculture is linked to their income, access to information, level of social participation, experience with extension services, participation in training and degree of innovativeness (Das *et al.*, 2023) [11]. The Balasore District serves as a case study illustrating the progression of women from supportive and informal roles to enterprise management. The programme integrated Women's Self-Help Groups with access to waterbodies managed by the Gram Panchayat (Known as GP Tanks), along with production facilities, capital assistance, technical training, and collective branding. Activities encompassed community pond aquaculture, reservoir cage culture, brackishwater polyculture, ornamental fish farming, fish seed production, and hygienic dry-fish processing. This diversity of activities enables comparison of production, processing, and income pathways within a consistent institutional context. This study aimed to document and analyze changes in women's participation and enterprise performance across fisheries and aquaculture interventions in Balasore District. The research addressed four primary questions: (i) What changes occurred in processing capacity and capability following the adoption of new technology? (ii) What production and resource-use patterns emerged in community aquaculture? (iii) What project-level financial returns were realized from higher-value systems? (iv) How did individual income and participation levels change as a result of institutional integration?

2. Materials and methods

2.1 Study area

The study was conducted in Balasore District in northern coastal Odisha. The source materials state that the district has an area of 3,806 km² and includes 12 blocks, 360 Gram Panchayats, 3,051 villages, and a fishers' population of 88,487. The baseline aquaculture productivity reported was 5.80 t ha⁻¹ for fresh water systems and 6.50 t ha⁻¹ for brackish water systems. Since the district has marine, inland, and brackish-water production environments, it offers opportunities for diversified fisheries enterprises. The fisheries intervention sites studied were the Gram Panchayats in the Basta, Jaleswar, Nilgiri, Oupada, Simulia, Bhograi, Soro, Baliapal, Bahanaga, Remuna

and Sadar blocks. The enterprises included community pond culture, fish seed production, dry fish processing and marketing, reservoir cage culture, ornamental fish production, and brackishwater polyculture.

2.2 Data sources and study design

The study employed a retrospective programme evaluation method (Desai, 2023) [12] combined with a descriptive case series approach. Data were extracted from secondary enterprise records maintained by the state's Department of Fisheries. The field-based nature of these interventions provided a unique opportunity to establish innovative practices, leading to the analytical classification of enterprises into four distinct operational models to assess pre- and post-intervention metrics. These models include hygienic post-harvest processing utilising polyhouse solar dryers; inland community aquaculture in Gram Panchayat tanks; high-value production in reservoir cages and brackishwater polyculture systems; and specialised micro-enterprises such as ornamental fish breeding, fish-seed production, biofloc planning, and hatchery development. Income data were available for selected Gram Panchayats and were analysed only in cases where both pre- and post-intervention figures were reported. The study includes a descriptive analysis. The percentage change was calculated by using the formula

$$\frac{\text{post-intervention value} - \text{pre-intervention value}}{\text{pre-intervention value}} \times 100.$$

The stock-to-yield ratio was calculated by dividing the harvested quantity by the seed stocking quantity. The project-level net return on outlay was determined by dividing the net profit by the reported project outlay, and then multiplying by 100.

3. Results

3.1 Expansion of women-led enterprise activity

The data indicate a significant shift among women's self-help groups towards activities that involve direct control over productive assets and operational decision-making. These enterprises include pond preparation and management, fingerling collection and stocking, feeding, harvesting, transport, ornamental fish rearing, fish seed production, dried fish processing and packaging, live fish marketing, and brackishwater culture. Consequently, the intervention expanded beyond post-harvest activities to include primary production and enterprise management. A representative set of documented enterprises is summarized below. The following table lists some of the fisheries and aquaculture enterprises led by WSHG that were recorded in the study.

Table 1. Selected WSHG-led fisheries and aquaculture enterprises documented in the study.

Location/enterprise	WSHGs	Members	Main asset/activity	Reported performance
Mirzapur (Chandipur), dry fish	1	11	Polyhouse solar dryer	Higher-priced hygienic dried fish; ODOP award nomination
Talapada (Remuna), dry fish	10	43	Solar dryer	40–50 to 180 kg/batch; ₹180–200/kg
Avana (Bahanaga), dry fish	8	80	Dry-fish unit and direct retail	Started with 50 kg raw fish; direct sales at Barikpur Haat/local markets
Sutei (Remuna), pond culture	9	105	4.82 ha community water area	398 kg seed; ₹5,000 gross surplus/member/cycle
Kharid Mukhura (Remuna), pond culture	11	120	2.28 ha community water area	3,900 kg seed; ₹3,500 gross surplus/member/cycle
Anko (Sadar), ornamental fish	3	32	22 tanks; 3 units	₹3.0 lakh investment; ₹18,000 gross surplus/month
Gudu (Sadar), brackishwater	6	60	43 tanks; 20.50 acres	₹22.50 lakh outlay; ₹14.00 lakh gross surplus
Bardhanpur (Sadar), brackishwater	6	52	44 tanks; 46.00 acres	₹42.50 lakh outlay; ₹25.38 lakh gross surplus
Rissia Dam (Nilgiri), cage culture	3	36	3 floating cages	609 kg fingerlings; 800–1,200 g harvest size
Gunasartha (Bhograi), pond culture	13	150	14 tanks; 2.0 ha	12 lakh spawn; 4 lakh fry; grow-out fish ~700 g

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3.2 Post-harvest processing and solar drying

Among the fisheries interventions in the study, the most noticeable technological change was the hygienic drying of fish. It was reported that conventional open-air drying took about 4 to 5 days, whereas WSHGs using polyhouse solar dryers reduced the drying time by 1 to 1.5 days. According to the different combinations of baseline times and reductions, this amounted to a reduction in drying time of approximately 20 to 37.5 per cent; the programme summary, however, gave the figure as about 30 to 35 per cent. Thus, the available field data indicate a significant shortening of the drying time.

At the Talapada GP, 10 WSHGs comprising of 43 members were given a solar dryer which cost ₹137,000, together with a reported subsidy of 30% amounting to ₹41,100. The processing capacity had increased from 40 to 50 kg per batch to 180 kg per batch. At the mid-point of the original capacity range (45 kg), the increase amounts to 300%; expressed as a range, the rise from 40 kg to 180 kg is 350%, and the increase from 50 kg to 180 kg is 260%. Hence, the more conservative estimate is that the unit's capacity after the intervention was about 3.6 to 4.5 times that of the pre-intervention era. The dried product was said to fetch ₹180 to ₹200 per kg in local markets.

The Mirzapur Badekhan WSHG began solar drying in December 2021, collectively purchasing raw marine fish and processing shrimp or prawns, ribbon fish, ghol fish, golden anchovies, and hilsa. The

group received a nomination for a National ODOP award. Gangamata WSHG in Avana established direct retail channels, while the Chandipur cluster integrated dry-fish processing with net marketing, achieving an average group income of ₹48,000 per month. Khirkona WSHGs developed a raw-material supply route from Dhamara to local and regional markets. These cases demonstrate that the economic impact of drying technology extends beyond reduced processing times, resulting in larger batch sizes, enhanced product positioning, and increased control over marketing.

The results from the field observations are in agreement with the findings in the research literature, which show that enclosed solar drying is better than traditional sun drying for improving the hygiene and quality of dried fish (Patterson *et al.*, 2018; Nagori *et al.*, 2014) [14, 13].

3.3 Production trends in OMM Sairam WSHG

At the OMM Sairam WSHG in Routpada, the 6.70 ha Bidyadhar Pokhari Gram Panchayat tank was cultured with Indian Major Carps, and *Amblypharyngodon mola* was present. In the 2021–22 period, production was 27,000 kg from 4,500 kg of fish seed; in 2022–23, it was 26,000 kg from 4,800 kg of fish seed; and in 2023–24, it reached 40,000 kg from 5,700 kg of fish seed.

Production and stocking efficiency in the OMM Sairam WSHG community pond as shown in Table 2.

Table 2. Production and stocking efficiency in the OMM Sairam WSHG community pond.

Season	Seed stocked (kg)	Harvest (kg)	Stock-to-yield (kg/kg)	Change in harvest vs. previous season
2021–22	4,500	27,000	6.00	—
2022–23	4,800	26,000	5.42	–3.7%
2023–24	5,700	40,000	7.02	+53.8%

Between 2021–22 and 2023–24, the harvest increased by 48.1%, rising from 27 to 40 tonnes. The stock-to-yield ratio improved from 6.00 to 7.02 kg of harvest per kg of seed, representing a 17.0% increase. However, this trend was not linear; in 2022–23, production declined slightly despite an increase in seed stocking from 4,500 kg to 4,800 kg, and the efficiency ratio decreased to 5.42. Production rose sharply in 2023–24 as both stocking and management performance improved. This pattern underscores that higher input levels alone do not guarantee increased output; factors such as operating conditions, survival rates, feed utilization, water quality, and management practices also influence harvest outcomes. In other instances of community aquaculture there was a shift towards production management. The Sutei GP project included 9 WSHGs and 105 members over an area of 4.82 ha, using 398 kg of seed and a gross operating surplus of ₹3,500 per member being reported. The Kharid Mukhura GP project involved 11 WSHGs and 120 members on 2.28 ha, with 3,900 kg of fish seed being stocked and a net profit of ₹3,500 per member being reported. The Gunasarthi GP project had 13 WSHGs and 150 members who managed 14 tanks on 2.0 ha, having a nursery and grow-out system that stocked 12 lakh spawn, harvested 4 lakh fry and kept the

grow-out fish at an average weight of about 700 g. These examples show an increasing level of technical complexity and a greater sense of collective responsibility, although differences in area, stocking density, species composition and the length of the production cycle make it impossible to compare the profitability of the various sites.

3.4 Financial performance of higher-value systems

The brackish water projects at Gudu and Bardhanpur achieved the highest project-level financial returns of all the completed high-value cases. At Gudu, 6 WSHGs consisting of 60 members ran 43 tanks over 20.50 acres, the reported project outlay being ₹22.50 lakh and the gross operating surplus amounting to ₹14.00 lakh; the operating margin on the reported project outlay thus reached 62.2%. In the case of Bardhanpur, 6 WSHGs made up of 52 members looked after 44 tanks on 46.00 acres, the reported outlay being ₹42.50 lakh and the gross operating surplus amounting to ₹25.38 lakh, which gave an operating margin of 59.7%.

Table 3 gives the financial performance of a number of higher-value enterprises. *The figure for Anko is the monthly net profit relative to the original investment; it cannot be directly compared with the one-cycle or annual project returns.

Table 3. Reported financial performance of selected higher-value enterprises. *The Anko figure is the reported monthly gross operating surplus relative to the initial investment; it is not directly comparable with one-cycle or annual project returns.

Enterprise	Project outlay (₹ lakh)	Gross operating surplus (₹ lakh)	Operating margin (%)	Operational scale
Gudu brackishwater polyculture	22.50	14.00	62.2	43 tanks; 20.50 acres; 60 members
Bardhanpur brackishwater polyculture	42.50	25.38	59.7	44 tanks; 46.00 acres; 52 members
Anko ornamental fish	3.00	0.18/month	6.0% of initial outlay per month*	22 tanks; 32 members

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Enterprise	Project outlay (₹ lakh)	Gross operating surplus (₹ lakh)	Operating margin (%)	Operational scale
Rissia reservoir cages	11.77	Not reported as completed net profit	—	3 cages; 36 members; 609 kg seed

3.5 Changes in individual income and participation

In the case of the three Gram Panchayats, directly comparable monthly income figures were available both before and after the intervention. At Sugo GP the average monthly income per member rose from ₹1,200 to ₹2,100, an increase of 75 per cent, and at the same time participation grew from 20 to 108 members, a rise of 440 per

cent. For Talanagar GP monthly income per member increased from ₹400 to ₹1,000, a 150 per cent increase, while participation rose from 60 to 82 members (36.7 per cent). In the case of Sabira GP monthly income per member went up from ₹500 to ₹3,000, a 500 per cent increase, and the number of participants reported rising from 51 to 68 (33.3 per cent).

Table 4. Changes in reported monthly income and participation in three Gram Panchayats.

Gram Panchayat	Members before	Members after	Income before (₹/member/month)	Income after (₹/member/month)	Income change	Membership change	Absolute Income Gain (₹/member/month)
Sugo	20	108	1,200	2,100	+75.0%	+440.0%	+₹900
Talanagar	60	82	400	1,000	+150.0%	+36.7%	+₹600
Sabira	51	68	500	3,000	+500.0%	+33.3%	+₹2,500

Percentage changes alone do not provide a direct ranking of economic benefit. For example, Sabira exhibited the highest percentage increase, but the baseline was only ₹500 per month, resulting in an actual increase of ₹2,500 per member per month. In contrast, Sugo had the smallest percentage increase, yet the absolute gain was ₹900 per member per month, and participation expanded more than fivefold. These findings indicate that both absolute income changes and group expansion should be evaluated alongside percentage growth.

The data also mention other enterprises at Parikhi, Panchapada, Kasafal, Chhanua, Dublagadi, Srirampur, Srikona, Gopinathpur, and Bahabalpur in the Sadar block, as well as at Khirkona in *Simulia*, Baniadiha in Baliapal, and other places. According to these records, there is a growing diversification into packaging dried fish, grading prawns, cultivating live fish and shrimp, operating biofloc systems, and marketing both fresh and dried fish.

4. Discussion

4.1 Institutional convergence rather than single-input intervention

In all the cases the key feature is not merely the introduction of a technology but rather the combination of a number of different kinds of support. Public access to Gram Panchayat water tanks or to other water resources provided the basis for production; subsidies alleviated the problem of initial capital; training raised technical capability; and the establishment of market arrangements improved the chances of selling the output. This combination of elements is in line with the substantial body of literature which shows that women's involvement in fisheries is influenced at the same time by access to resources, capabilities, markets, networks and governance (Weeratunge *et al.*, 2010; Gopal *et al.*, 2020) [3, 5].

The extent of capital assistance is especially evident in cases like reservoir cages and solar dryers. According to the operational guidelines of the Government of India under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), greater government assistance is offered to women beneficiaries than to other beneficiaries in certain activities, such as support for Women Self Help Groups (Department of Fisheries, 2020) [15]. The records from Balasore illustrate how this kind of support was turned into tangible assets that would have otherwise needed a relatively large initial outlay. In the case of the Rissia Dam, three Women Self Help Groups received a reported subsidy of 60% against a total project cost of ₹11.77 lakh. In the OMM Sairam case, a reported subsidy of ₹6.03 lakh enabled a pond project with a total cost of ₹10.05 lakh.

Institutional convergence also seems important since having access to assets without the necessary management skills may not be enough to

ensure sustainable enterprise performance. According to the Department of Fisheries, training is provided through the Rural Self-Employment Training Institute (RSETI) and institutional support is given for various activities such as biofloc, hatchery development, stocking, feeding and water management. This situation is in line with the evidence from Odisha which shows that extension exposure and training are linked to better empowerment outcomes for women in aquaculture (Das *et al.*, 2023) [11], and with the evidence that combining scientific aquaculture interventions with skill development can improve women's livelihoods (Jayasankar *et al.*, 2022) [9].

4.2 From post-harvest labour to control over primary production

The study underscores a transition from supporting roles to leadership among women in fisheries. Evidence confirms this shift at the level of enterprise responsibility. Women in the WSHGs studied were no longer confined to sorting, drying, or vending; they also participated in pond preparation, stocking, feeding, harvesting, cage management, fish-seed production, ornamental breeding, and brackishwater culture. This transition represents a significant change in women's roles within the value chain, as primary production and asset management generally provide greater control over production decisions than post-harvest activities. As a result, the fisheries interventions expanded women's operational roles and enterprise responsibilities. While these women may not yet hold formal political positions in macro-level fisheries governance, their successful transition into primary production and asset management represents a foundational shift in community leadership and household economic autonomy.

4.3 Technology, value addition and market upgrading

The case of dry fish clearly illustrates value-chain upgrading. Solar dryers have altered the method of production by reducing the time needed for drying, increasing the amount that can be processed in each batch, and providing a more controlled drying environment. Scientific studies on solar drying also indicate that it leads to better hygienic or sensory results than traditional open-air drying (Nagori *et al.*, 2014; Patterson *et al.*, 2018) [13, 14]. This method of processing is still important in developing economies since, although cured products make up 10% of all aquatic animal foods worldwide, about 20% of these are still sold in cured form in low- and middle-income countries because of weaknesses in the cold-chain infrastructure and local dietary preferences (FAO, 2026) [1]. For other highly perishable coastal products such as green mussels and edible oysters, similar needs for secondary processing and product diversification—including smoke-drying and canning as well as marinating—have been identified in order to deal with bottlenecks in the cold chain and to ac

cess untapped commercial markets (Pandey *et al.*, 2026a; Pandey *et al.*, 2026b) [16, 17].

In the Balasore cases, technological advancements were complemented by direct local marketing and a collective branding strategy under the name KOSHAMBEE. This combination is significant because higher-quality products yield economic benefits only if producers can capture a portion of the market premium. As WSHGs introduce branded or newly processed commodities, understanding and influencing consumer perception will be essential for realizing these premiums, as demonstrated by the successful market acceptance of circular-economy products such as fish skin leather derived from discarded fish skins (Soni *et al.*, 2026) [18].

The evidence from the income cases also shows that market integration may be just as significant as production technology. Talanagar and Sabira not only recorded the adoption of machinery but also noted the convergence of the fisheries department and the marketing arrangements. Sugo combined a fish-seed enterprise with a major increase in group participation. This is consistent with a value-chain approach, according to which productivity gains and market access strengthen one another.

4.4 Interpreting the production and income patterns

The OMM Sairam SHG's production experience shows that enterprise performance can vary from one cycle to the next. The fact that the harvest fell in 2022–23 despite increased stocking numbers, followed by a significant recovery in 2023–24, proves that production systems are affected by management and biological conditions. The stock-to-yield ratio increased from 6.00 to 7.02 over the full period, along with some variations.

The income data show another important pattern: the largest percentage increase occurred in the enterprise with the lowest starting income. The most useful comparison for programme evaluation is therefore a combination of percentage change, absolute income gain, group size, enterprise scale and the stability of income over time.

The extensive evidence from Odisha supports the direction of these outcomes. Jayasankar *et al.* (2022) [9] reported substantial improvements in income and household expenditure among women participating in scientific freshwater aquaculture interventions, while Dubey *et al.* (2024) [10] documented the spread of community-based carp-mola aquaculture and the associated productivity, income, and nutrition benefits across Odisha. The present Balasore cases add a more enterprise-specific perspective by documenting several pathways—pond culture, solar processing, cages, brackishwater culture, ornamental fish, and fish seed production—within a single district.

4.5 Persistent constraints and suggestions

Despite the observed gains, the programme records identify three persistent bottlenecks: market access and dependence on intermediaries, limited access to working capital, and socio-cultural constraints on women's mobility and decision making. These constraints are consistent among the broader gender literature. Women may participate in fisheries but still have less control over mobility, assets, market information or governance opportunities (Weeratunge *et al.*, 2010; Gopal *et al.*, 2020) [3, 5].

Cold-chain infrastructure is a particularly important next step because growth in fish production increases the need to preserve quality between harvest and sale. Community-managed cold storage and transport could improve the timing of sales, reduce forced distress sales, and support entry into more distant markets. Working-capital finance is similarly important: capital subsidies can lower the cost of starting an enterprise, but recurrent expenditures for seed, feed, packaging, transport and repairs must be financed throughout the production cycle.

The KOSHAMBEE branding initiative also has potential, but branding alone cannot guarantee higher producer margins. The data report direct marketing by some groups, but they do not provide a systematic comparison of farm-gate prices, trader margins or consumer

prices before and after branding. Subsequent evaluations should measure these components explicitly.

4.6 Implications for policy and programme design

The study suggests that women-centred fisheries programmes are likely to be stronger when they combine access to productive assets, technical training, enterprise finance and market development. Trainings should be organized around actual enterprise decisions rather than only general awareness: water quality and disease management for aquaculture, stocking and feed management for community ponds, hatchery and biofloc management where relevant, quality assurance and packaging for dry fish, and bookkeeping and working-capital planning across all enterprises. Furthermore, future programmatic support could explore 'waste-to-wealth' value addition, as consumer research indicates active market viability for innovative by-products such as fish-skin leather made sourced from discarded fish skins (Soni *et al.*, 2026) [18], offering WSHGs highly profitable avenues for enterprise diversification. Additionally, given Balasore's extensive coastal and estuarine geography, institutional training could encourage diversification into low-trophic, high-value bivalve processing, in which value-added interventions such as ready-to-eat products, pickling, and thermal preservation provide sustainable livelihood opportunities for coastal women (Pandey *et al.*, 2026a; Pandey *et al.*, 2026b) [16, 17].

Secondly, market infrastructure should be designed around women's mobility constraints. Local collection points, shared transport, digital price information, cold storage and producer-owned sales points can reduce the need for individual producers to negotiate with intermediaries under time pressure. Third, women should be supported to participate formally in producer organizations and fisheries governance. The current evidence demonstrates enterprise responsibility, but sustained transformation requires decision-making power in the institutions that allocate waterbodies, inputs and market opportunities.

5. Conclusions

The Balasore cases demonstrate that women can enter higher-value fisheries and aquaculture enterprises when a number of institutional supports are put together. There are three major changes identified. The first is that women have moved on from mainly carrying out supportive duties to taking direct charge of pond management, cage management, fish-seed operations, ornamental fish units, brackishwater culture and processing enterprises. Second, technological integration significantly raised operational capacity. In Talapada, the adoption of solar drying expanded the reported batch size from a baseline of 40–50 kg to 180 kg, while simultaneously reducing drying time by 1 to 1.5 days. Third, several enterprises experienced strong economic gains: OMM Sairam increased its harvest by 48.1% over the three-year period; the project-level operating margins in two brackishwater cases were about 59.7–62.2%; and in three Gram Panchayats, individual monthly income rose by 75 to 500%.

The evidence also shows why programme evaluation must look beyond headline percentage increases. The OMM Sairam trajectory was non-linear; the largest percentage income gain began from the lowest baseline, and group membership changed substantially in some locations. The most defensible interpretation is therefore not that a single scheme or technology caused a uniform transformation, but that coordinated access to resources, finance, training, technology, and markets was associated with a broader expansion of women's enterprise capacity.

For sustained transformation, the next stage should focus on working capital, cold-chain and transport infrastructure, enterprise-level financial records, quality assurance, market-price information and women's participation in fisheries governance. Future analysis should use panel data and matched comparison groups, measure empowerment through standardized gender indicators, and document complete costs and revenues at the production-cycle level. Such evidence would allow the economic and social effects of women-led aquaculture programmes to

be tested more rigorously and would improve the scalability of the Balasore experience.

Conflict of interest

There is no conflict of interest among the authors.

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