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Invisible labour, Unequal power: Gendered dynamics and a Transformative Policy Roadmap for Malpe harbor's post-harvest fisheries sector

Amrutha Prakash*[1], Swathilekshmi P.S.[2] and Kalidoss Radhakrishnan[3]

[1]*ICAR-Central Marine Fisheries Research Institute, Vizhinjam Regional Centre, Thiruvananthapuram, India*
[2] *ICAR-Central Marine Fisheries Research Institute, Veraval Regional Station, Gujarat, India*
[3] *ICAR-Central Institute of Fisheries Education, Mumbai, India*
**E.mail: amruthajayasree1995@gmail.com*

ABSTRACT

The Indian marine fisheries sector, a cornerstone of coastal livelihoods, remains deeply gendered, with structural inequalities disproportionately disadvantaging women, particularly in the post-harvest domain. Despite their critical role, women's contributions are often rendered invisible within policy and academic discourse, which predominantly centers on male-dominated activities. This study investigates gender-based disparities in the secondary fisheries sector at Malpe Fishing Harbour, Karnataka, with the aim of unpacking the socio-economic and institutional dimensions of inequality. A total of 60 respondents (31 women and 29 men) were selected through random sampling. Quantitative analysis employed Principal Component Analysis (PCA), Mann-Whitney U Tests, and Discriminant Function Analysis (DFA). Results reveal significant gender differentials: men possessed greater access to income, productive resources, and decision-making power, while women's labour remained confined to reproductive and supportive roles. DFA yielded a statistically significant discriminant function (Wilks' $\lambda = 0.148$, $\chi^2 = 93.52$, $p < 0.05$) with an eigenvalue of 5.74. PCA extracted six components, with the first two explaining 70.98% of cumulative variance. Key determinants included family structure, experience, income disparities, and educational attainment. The study highlights the imperative of embedding gender-disaggregated data collection and longitudinal monitoring within fisheries governance and, accordingly, delineates a suite of targeted policy interventions, including mandatory gender-specific reporting, collateral-free microfinance schemes, dedicated funding for women-led activities, periodic gender audits to drive mainstreaming, and the establishment of digital literacy hubs, to redress structural inequities and promote a sustainable, inclusive small-scale marine fisheries sector.

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1. Introduction

Women constitute approximately 56 million individuals within global small-scale fisheries workforce, encompassing the entire value chain from foundational to advanced tiers. They have contributed significantly in secondary and post-harvest operations, although direct involvement in fishing activities remains limited (Kelleher *et al*., 2012; Swathilekshmi *et al.*, 2022). This acknowledgement has amplified discussions on the urgent need for socio-economic and community empowerment, emphasising the imperative to address deeply rooted gender inequities that continue to pervade these communities. Unlike other economic sectors, the fisheries industry is uniquely characterised by persistent gender disparities, exacerbated by higher incidences of gender-based violence and occupational discrimination, making it a critical domain for in-depth research and strategic interventions aimed at fostering equity and inclusivity (Harper *et al*., 2020).

While women are indispensable to advancing fisheries resource management and sustainability, particularly in the secondary sector, existing policy frameworks and management strategies have disproportionately prioritised the economically dominant primary sector, which is predominantly controlled by men (Williams, 2016). This shift has marginalised the post-harvest sector, redirecting focus to capture fisheries and diminishing the visibility of women's substantial contributions in statistical representation and policy deliberations (Frocklin *et al*., 2013; Gopal *et al*., 2020). The deliberate exclusion of women from key roles within the fisheries sector poses significant implications for equitable community development and the sustainability of coastal ecosystems (Lawless *et al*., 2019). Such systemic exclusions further compound women's vulnerability to entrenched societal norms and traditional gender roles, often confining them to domestic responsibilities at the expense of their participation in skilled and productive activities comparable to those of their male counterparts (Kleiber *et al*., 2015; Rohe *et al*., 2018). Addressing these inequities requires the full inclusion of women in decision-making processes, alongside equitable access to technological resources and support systems, which can serve as catalysts for advancing progress toward achieving sustainable development goals (United Nations, 2015).

The sustainability of the fisheries sector inherently relies on the collaborative contributions of men and women within the secondary sector and is shaped by the multifaceted challenges and structural conditions encountered across various nodes of the fisheries value chain (Prieto-Carolino *et al.*, 2021). However, in economic sectors such as agriculture, livestock, and small-scale fisheries, women's contributions are often undervalued, inadequately compensated, and excluded from official records, perpetuating their invisibility on a global scale (McDougall *et al*., 2021). This pattern is particularly pronounced in small-scale fishing communities, where women are largely relegated to fishery-related roles and systematically marginalised from frontline activities due to the dual

burden of domestic responsibilities and deeply entrenched societal norms (Harper *et al*., 2013; Biswas and Rao, 2014).

Women's participation in pre-harvest activities, such as bait collection and preparation, net mending and repair, and documentation management, remains largely unrecognised in official records. This systemic oversight leads to the undervaluation of their substantial contributions across the fisheries value chain (FAO, 2017). Conversely, their active engagement in post-harvest operations is more visible, as they collaborate with men in activities such as salting, drying, fish trading, loading and unloading, sorting, grading, and labouring in processing units. These contributions underscore their indispensable role in sustaining the fisheries sector (Benson *et al*., 2018). Despite their critical involvement in ensuring the sector's sustainability, women's roles have only recently received attention and remain largely unacknowledged in policymaking processes (Harper *et al.*, 2020). The secondary fisheries sector, employing a substantial workforce, encompasses an extensive range of activities initiated post-landing. A detailed examination of the specific roles and responsibilities undertaken by men and women—individually or collaboratively—along with the time allocated and frequency of participation, provides invaluable insights into the gender dynamics of the post-harvest segment in small-scale fishing communities. Such analyses offer a quantitative and qualitative understanding of gendered participation, revealing how societal constructs shape and influence their roles (Weeratunge *et al*., 2010). In Indonesia, women play a pivotal role in prawn processing for export markets, utilising advanced techniques and making significant contributions to the national fisheries value chain (Siason *et al*., 2002). Similarly, in Sri Lanka, women are predominantly engaged in marketing high-value fish species, working alongside men to sustain their livelihoods (Nuruzzaman *et al*., 2014). In the Philippines, approximately 40% of women in small-scale fishing communities are exclusively engaged in pre- and post-harvest activities, underscoring their integral role in the fisheries sector (Siason, 2013).

The lack of comprehensive gender-disaggregated data within small-scale fishing communities poses a significant barrier to accurately assessing gender roles and dynamics (Rice *et al*., 2024). This data gap hampers global efforts to investigate gender disparities in the fisheries sector, ultimately limiting the development of inclusive and effective policy interventions (Bennett e*t al*., 2018). Additionally, the socio-economic documentation of women engaged in land-based activities in these communities remains insufficient, with collective action and representation conspicuously absent even at the most basic levels (Bosma *et al*., 2019). Women's contributions are predominantly concentrated in land-based and auxiliary roles, such as shoreline gleaning, rather than direct fishing activities. This exclusion perpetuates their invisibility within formal records and policy frameworks, further marginalising their essential contributions to the fisheries value chain (Frangoudes, 2008). Addressing deeply entrenched gender inequities requires a policy-oriented approach rigorously grounded in systematic evaluation and continuous monitoring of existing governance frameworks. To dismantle the structural barriers and persistent inequities within the small-scale fisheries sector, it is imperative to implement strategic policy modifications informed by empirical evidence and inclusive stakeholder engagement (Kleiber *et al.,* 2017). Such targeted interventions are essential for fostering equitable participation across gendered roles and ensuring the long-term sustainability and resilience of the sector.

The Indian marine fisheries sector holds a distinguished position on the global stage as a leading fish producer, underpinned by a robust and expanding export market. During the fiscal year 2022–23, the sector achieved a significant milestone by exporting approximately 1.73 million tonnes of fish, generating a record revenue of USD 8.09 billion (₹63,969.14 crore). This remarkable performance was predominantly driven by the export of frozen shrimp, which continues to dominate the export portfolio (MPEDA Annual Report, 2022–23). The Marine Products Export Development Authority (MPEDA) has emphasised the strategic importance of the processing sector, particularly in the development of value-added products. MPEDA has prioritised the enhancement of processing infrastructure and the optimisation of value extraction from fishery byproducts. As part of these initiatives, the authority has facilitated the establishment of advanced processing units equipped with state-of-the-art cold storage facilities. Additionally, MPEDA has implemented comprehensive training programs targeting personnel in the seafood processing industry, with a special focus on empowering marginalised women. These efforts aim to foster skill development, drive sectoral innovation, and contribute to the sustainable growth of the marine fisheries sector (MPEDA Annual Report, 2022–23).

In 2023, marine landings along the Indian coastline totalled approximately 3.53 million tonnes, reflecting a 1.2% increase over the previous year and underscoring a consistent upward trend (CMFRI Marine Fish Landings, 2024). According to the *Annual Marine Fish Landings of India (2023)*, Karnataka ranked third in marine fish landings, with a reported volume of 6.04 lakh tonnes. A significant proportion of these landings originated from the Mangalore (44%) and Malpe (41%) fishing harbours, highlighting their critical contribution to the state's fisheries sector. Malpe Harbour has emerged as a pivotal fisheries hub, offering sustenance, employment opportunities, and economic stability to thousands of individuals. Its essential role in ensuring food security and supporting livelihoods has increasingly attracted researchers' attention, particularly in investigating the intricate gender disparities and socio-economic profiles of fisherfolk communities reliant on this vital coastal resource. As a prominent landing site with a substantial workforce comprising both men and women in the secondary fisheries sector, Malpe Harbour lacks comprehensive gender-disaggregated data. This gap underscores the critical need for a thorough gender analysis at the grassroots level to illuminate the dynamics of participation and contribution across gender lines. To comprehensively address gender inequalities within

these small-scale fishing communities, it is imperative to delve into the complexities of their livelihoods rather than limiting the analysis to their responsibilities and participation alone (Kawarazuka *et al.,* 2017). Women engaged in the secondary sector at Malpe Harbour exhibit proactive participation and play an indispensable role in fisheries resource management. Despite their significant contributions, their efforts remain largely unrecognised, overshadowed by deeply entrenched traditional gender stereotypes. Recognising that women's contributions are as substantive and productive as those of men under comparable conditions (FAO, 2012), this study seeks to critically evaluate the extent of gender involvement and the specific disparities prevalent in the post-harvest sector of Malpe Harbour.

Given the dearth of comprehensive research addressing the socio-economic and sociological dimensions of gender in the fisheries sector, this study undertakes a rigorous analysis of socio-economic and socio-psychological factors to delineate the profiles of men and women engaged in fisheries. Furthermore, it aims to identify the key determinants driving gender-based inequities. By adopting this approach, the study aspires to develop actionable, gender-transformative strategies that mitigate these disparities and foster inclusivity within the governance frameworks of small-scale fisheries.

Finally, we treat post-harvest fisheries as a distinct socio-technical system, drawing on feminist political-economy (Bakker 2007; Pearson & Elson 2015) and intersectionality (Crenshaw 2013; Collins 2000). In this view, gendered power operates simultaneously via formal institutions (markets and policies) and via informal community and household norms. This conceptual lens allows us to situate the statistical outcomes not simply as quantitative outputs, but as manifestations of deeper structural and functional inequities in resource access, decision-making power, and the recognition of women's contributions across the fisheries value chain.

2. Materials and Methods

2.1 **Study site**

The study focuses on Malpe Fisheries Harbour (13.3485° N, 74.7002° E), situated in the Udupi district of Karnataka (Fig. 1). This harbour plays a pivotal role in sustaining local livelihoods and driving regional economic growth. The respondents exclusively included fisherwomen and fishermen engaged in post-harvest operations. As Karnataka's largest harbour, Malpe receives central government funding of ₹4.26 crores and surpasses other state harbours, such as Mangalore and Tadri, in size and facilities. Malpe Harbour serves as a hub for a wide spectrum of maritime activities, including fishing, post-harvest handling, and seafood processing. After the catch, fish are meticulously sorted and graded before undergoing advanced processing and preservation. The harbour was purposively selected for this study due to its significant female workforce and their active involvement in both pre- and post-harvest operations, which distinguishes it from other harbours in the region. Furthermore, its facilities for value addition and advanced seafood processing contribute substantially to the local economy and enhance the livelihoods of the fisherfolk.



Fig. 1. Map of the study site

2.2 Data Collection

This study adopted an ex post facto research design to gather both primary and secondary data pertinent to the research objectives. Primary data were collected from June to December 2023, employing simple random sampling to ensure representativeness, while key informants were purposively selected. The sample comprised 60 respondents, including 31 women and 29 men, all of whom were exclusively engaged in secondary operations. Data collection relied on field observations and a meticulously pretested, structured interview schedule that addressed various socio-personal, economic, and psychological dimensions. Conducting face-to-face interviews posed significant challenges, particularly during respondents' working hours and in the local dialects of Kannada and Tulu. The pre-testing phase revealed linguistic barriers, prompting the inclusion of a local facilitator or translator to enhance data accuracy. Additionally, pre-testing helped refine the interview timing to better align with respondents' availability. Key Informant Interviews (KIIs) served as a valuable complement to the primary data collection process. Secondary data were systematically obtained from diverse sources, including the State Fisheries Department, journals, magazines, academic publications, and indigenous knowledge repositories. Nineteen socio-personal, economic, psychological, and sociological variables were selected for the study through an extensive literature review and consultations with experts. These variables included age, family type, family size, gender, education, marital status, experience, annual income, social participation, self-confidence, information-seeking behaviour, information-sharing behaviour, achievement motivation, credit orientation, material possessions, decision-making ability, access to resources and services, reproductive roles, and productive roles. All data were disaggregated by gender to facilitate nuanced analysis and interpretation.

2.3 Data Validation

The collected data underwent rigorous validation to ensure precision and reliability. A meticulous cross-verification process was employed to detect and address any discrepancies or inconsistencies. To enhance the credibility of the data, fisheries officials and key informants reviewed and authenticated the completed responses. Additionally, respondents were re-engaged to resolve any ambiguities or inaccuracies in the previously gathered information. In accordance with stringent ethical research standards, informed consent was obtained from all participants, thereby safeguarding the integrity of the data collection process and mitigating the risk of data falsification. This comprehensive validation framework ensured the robustness and reliability of the dataset.

2.4 Variables

The key variables of this study are presented in Table 1, classified into four groups. The first group comprises seven socio-personal variables that highlight the respondents' social and demographic characteristics: age, educational status, gender, marital status, family type, family size, and experience. The second group consists of four socio-economic variables, which collectively define economic capacity, individual participation in economic activities, and social mobility. These attributes are particularly relevant to evaluating economic empowerment and the financial insecurities that women face in improving their livelihoods. The third category encompasses six socio-psychological variables, identified through extensive literature reviews and personal interviews. These variables are crucial for assessing personal empowerment, societal influence, and decision-making authority, thereby exploring the psychological constraints and social dynamics that shape gender roles. Lastly, the sociological category includes two variables that focus on societal norms and cultural practices. Since these variables focus clearly on gender-specific roles, both reproductive roles and productive roles automatically fall under the Sociological category. We can empirically assess how gendered norms influence time allocation and labour division in post-harvest activities and connect our quantitative findings to the power relations central to intersectionality frameworks.

2.5 Data Analysis

The data collected were analysed using R and Python to perform inferential statistics and generate visualisations. The analysis incorporated a range of statistical techniques, including frequency analysis, percentages, Principal Component Analysis (PCA), Discriminant Function Analysis, and the non-parametric Mann-Whitney U test. Frequency analysis and percentages were utilised to summarise the demographic and socio-economic profiles of the respondents, providing insights into the distribution of key attributes. To assess the dataset's suitability for PCA, the Kaiser-Meyer-Olkin (KMO) test was performed, confirming sample adequacy. PCA was selected for its ability to reduce data dimensionality by extracting linear combinations of variables, thereby capturing essential patterns in large datasets and simplifying complex multivariate structures. Discriminant Function Analysis was employed to assess and compare gender-based inequalities, focusing on key predictor variables. To explore gender disparities in detail, the Mann-Whitney U test was applied. This non-parametric test identified significant differences in distributions between male and female respondents for critical variables such as annual income, decision-making authority, access to resources and services, workload distribution, and engagement in various activities. Additionally, the location map of Malpe Harbour was developed in ArcGIS version 10.8, enhancing spatial understanding of the study area.

2.5.1. Principal Component Analysis

The PCA is one of the most widely utilised multivariate statistical techniques, with applications across numerous interdisciplinary fields (Abdi and Williams, 2010). Originally introduced by Pearson (1901) and later refined by Hotelling (1933), PCA is a robust transformation technique designed to analyse datasets in which specific observations are described by several intercorrelated dependent variables. The primary objective of PCA is to extract the most significant information by transforming the original

Table 1. Operationalisation and measurement of variables

Variable Category	Variables	Score administered
Socio-Personal	Age	Young= < 35 years Middle=35-50 years Old => 50 years
	Gender	Men=1 Women=2
	Educational status	Illiterate =0 Primary education=1 Middle school level of education=2 Secondary education=3 Collegiate education =4
	Marital Status	Married= 1 Unmarried=2
	Family type	Nuclear= 1 Joint=2
	Family size	Small=1 Medium =2 Large =3
	Experience	Less than 10 years=1 10-15 years=2 16-20 years=3 21-25 years=4 More than 25 years=5
Socio-Economic	Annual Income	For every Rs 50,000, a score of 1 was given
	Credit Orientation	Measurement consisting of 5 items with scores ranging from 0-4
	Access to resources/services	Always=2 Sometimes=1 Never=0
	Material Possession	Yes=1 No=0
Socio-Psychological	Social Participation	Always=2 Sometimes=1 Never=0
	Self-confidence	The self-confidence scale consists of eight statements measured on a five-point continuum with a score of 5, 4,3,2,1 for positive statements and a score of 1, 2,3,4,5 for negative statements respectively.
	Information seeking behavior	A score of 4-1 for frequency of use i.e. “Regular”, “Sometimes”,” Rarely” and “Never”
	Information sharing behavior	A score of 4-1 for frequency of use i.e. “Regular”, “Sometimes”,” Rarely” and “Never”
	Decision-making behavior	Self without consulting others =4 Consulting with Spouse/elders =3 Consulting all the family members =2 No participation in decision-making =1
	Achievement motivation	The achievement motivation scale consisted of five items (one negative and four positive) with a score of 5,4,3, 2, 1 (Strongly Agree, Agree, Undecided, Don’t Agree, Strongly Don’t Agree) for positive responses and score reversed for negative responses
Sociological	Reproductive roles (Cooking, Washing, cleaning, buying groceries, Care and maintenance of livestock, Taking care of elders and children)	Always (Daily or nearly every day) =2 Sometimes (occasionally)=1 Never (Not performed at all) =0
	Productive Roles (Craft maintenance, Segregation of fish, Transportation of fish to market, Marketing of fish, Gear making, Gear repair, Fish drying)	Always (Daily or nearly every day) =2 Sometimes (occasionally)=1 Never (Not performed at all) =0

variables into a new set of orthogonal variables, referred to as principal components (Jolliffe, 2002). PCA effectively reduces the dimensionality of large datasets into a smaller set of coherent principal components while retaining the essential patterns within the data. This study adopted the PCA methodology outlined by Wood (1987), incorporating standard modifications proposed by Shlens (2014), as detailed below. Provided a data matrix X (size n×p, where n=number of observations, p=number of variables), and the data matrix is standardised by subtracting the mean of every variable ($X_c=X-\bar{X}$), validating a zero mean value for each variable. The data's variance structure was captured by computing the covariance matrix.

The covariance matrix is calculated as,

$$C = (1 / (n - 1)) * X^T * X$$

where X is the centred data matrix, n = number of observations, and X^T= transpose of X.

The eigenvalue decomposition of C yields the eigenvectors (u_i) and eigenvalues (λ_i), which constitute the principal components and their explained variances. The principal components were extracted as

$$Z=X_cU$$

where U is the matrix of eigenvectors.

Alternatively, Singular Value Decomposition (SVD) was considered as an alternative approach, where the principal components were computed as:

$$Z=X_cV,$$

where V represents the matrix of singular vectors derived from SVD

Principal Component Analysis (PCA) was employed to distil the 19 key variables into a smaller set of coherent and interpretable dimensions, such as "socio-personal empowerment" and "economic capacity." Although PCA does not directly test hypotheses about group differences, its inclusion is justified by the analytic value it provides in uncovering latent structures corresponding to policy-relevant domains. These dimensions offer a nuanced understanding of complex, intersecting factors and hold significant potential to inform intersectionality-based theoretical frameworks and the development of targeted policy interventions.

2.5.2. Mann-Whitney U test

The Mann-Whitney U test is a widely used nonparametric statistical method for evaluating whether two independent groups differ significantly. Unlike parametric tests, it does not rely on the assumption of normality, as it ranks the data rather than relying on specific parametric hypotheses (Fay and Proschan, 2010). Fundamentally, the test assesses whether the two samples under investigation originate from the same population (Wonu and Anaekwe, 2023). Initially developed by Wilcoxon, Mann, and Whitney, it has since undergone modifications and is now commonly referred to as the Mann-Whitney test (McKnight and Najab, 2010). In this study, the Mann-Whitney U test was applied to determine whether key characteristics—including socio-personal, socio-economic, socio-psychological, and sociological variables—differ significantly between male and female respondents. The robustness of the test ensures that the presence of outliers does not distort the results, making it particularly suitable for analysing real-world datasets. The test evaluates differences between the two groups by calculating the U-statistic, which measures the extent of overlap between their distributions. The computation of U in this study followed the methodology outlined by Martinez-Murcia *et al.* (2012) and is described as follows.

Calculation of U_1:

$U_1=R_1-n_1(n_1+1)/2$

Where:

n_1 is the sample size for sample set 1,

R_1 is the sum of the ranks in the sample set 1.

Calculation of U_2:

$U_2=R_2-n_2(n_2+1)/2$

Where:

n_2 is the sample size for sample set 2,

R_2 is the sum of the ranks in the sample set 2.

Final Test Statistic:

The final U value is taken as the minimum of U_1 and U_2:

$U=\min(U_1,U_2)$

This value is then compared with the significance tables to determine statistical significance.

The sum of U_1 and U_2 is derived as $U1 + U2 = n_1n_2$.

This relationship is determined by acknowledging that $R_1+R_2=N(N+1)/2$, where $N=n_1+n_2$

2.5.3. Discriminant Function Analysis

Discriminant Function Analysis (DFA) is a powerful statistical technique commonly used to distinguish between groups by leveraging linear models based on pre-existing predictor variables (Moore, 2013). This method is particularly effective in deriving functions that optimally differentiate sets of observations belonging to two or more predefined groups (Agrawal *et al*., 2012). One of DFA's notable advantages is its applicability to datasets with small and unequal sample sizes, making it a flexible tool for group discrimination. The technique generates new variables that are linear combinations of the predictor variables, facilitating clearer differentiation between groups (Adams, 2004). In this study, DFA was utilised to assess the significance of interval-scale variables in distinguishing between genders (male and female groups). The discriminant function enables the evaluation of the net effect of each variable while controlling for the influence of others. In essence, a linear discriminant function is a weighted linear combination of key predictor variables, designed to maximise discrimination between groups while minimising error (Swathilekshmi, 2017). The general form of the discriminant function is expressed as:

$$D=L_1 X_1 +L_2 X_2 +\ldots\ldots\ldots\ldots+L_K X_K$$

Here, X_i represents the predictor variables, L_i denotes the discriminant coefficients, and D is the discriminant function value for an individual respondent. The respondents were categorised into two groups by gender (Group 1 and Group

2), and the predictor variables comprised 18 socio-personal, socio-economic, and socio-psychological factors. The Discriminant Function applied in this study is as follows:

$D=L_1\ X_1 +L_2\ X_2+L_3\ X_3+L_4\ X_4+L_5\ X_5+L_6\ X_6+L_7\ X_7+L_8\ X_8+L_9\ X_9+L_{10}\ X_{10}+L_{11}\ X_{11}+L_{12}\ X_{12}+L_{13}\ X_{13}+L_{14}\ X_{14}+L_{15}\ X_{15}+L_{16}\ X_{16}+L_{17}X_{17}+L_{18}\ X_{18}$

where, D= Total discriminant score for the discriminating group, X_1, X_2, ….., X_{18} are respective predictor variables and Lk is the coefficients of linear discriminant function (k=1,2,3,.....18)

Discriminant Function Analysis (DFA) was selected over logistic regression because our primary objective is not the prediction of binary outcomes but rather the exploration of the relative contributions of multiple continuous predictor variables across distinct gender groups. Nonetheless, we recognise DFA's sensitivity to heteroscedasticity and have accordingly tested and confirmed the assumption of variance homogeneity for the principal discriminating variables Although Gender (V3) was included in the PCA to explore its structural associations with other variables, it was not used as a predictor in the DFA. Instead, Gender served exclusively as the grouping variable, defining the two predefined groups (men and women) against which the remaining 18 socio-personal, socio-economic, socio-psychological, and sociological variables were evaluated as predictors.

3. Results

3.1 Descriptive statistics

Descriptive statistics for selected explanatory variables were analysed to explore disparities between men and women. A summary of key frequencies is presented in Table 2. Regarding the variable Age, a significant proportion of male respondents were categorised as young (41.38%), compared to only 12.9% of female respondents, whereas 48.39% of women belonged to the middle-aged group. Additionally, 38.71% of women were classified as elderly, surpassing the 27.59% observed in men. In terms of educational attainment, the data revealed that women had a higher rate of illiteracy (25.8%) than men (3.44%), although both groups displayed comparable levels of middle-level education. Notably, men exhibited a greater percentage of respondents with secondary and graduate-level education than women. Marriage status was another distinctive factor, with approximately 91.67% of all respondents being married. All female respondents (100%) were married, compared with 82.7% of male respondents.

Furthermore, most of the men and women belonged to nuclear family structures, accounting for 85% of the total population. Both groups predominantly lived in medium-sized households consisting of up to five members. These findings provide a detailed understanding of socio-demographic variations, underscoring gender disparities in age distribution, education, marital status, and family structure.

The group statistics for various variables highlight notable differences between male and female respondents engaged in the post-harvest fisheries sector. The mean values and standard deviations provide valuable insights into the central tendency and variability of each variable. As shown in Table 3, men exhibited higher mean scores than women in variables such as Annual Income (2.24), Experience (2.34), Self-confidence (24.52), Decision-making (13.79), Access to Resources (4.52), and Productive Roles (2.34). Conversely, women outperformed men in Age (2.23), Family Size (1.23), Social Participation (1.35), and Reproductive Roles (9.81), with significantly higher mean scores on these variables. Both genders showed comparable mean values for variables such as Information-sharing Behaviour, Information-seeking Behaviour, and Credit Orientation, indicating differences in these areas. Moreover, men exhibited significantly greater variability (standard deviation) than women, indicating considerable heterogeneity within the male group for certain variables. For the remaining explanatory variables, no statistically significant differences were observed between the genders.

3.2 Mann-Whitney U Test

The Mann-Whitney U test was conducted to assess significant differences at the 0.05 level between male and female respondents on selected variables. Figure 2 presents a comparison of gender-specific mean ranks for key predictor variables among male and female respondents in the secondary sector, with statistically significant differences denoted by an asterisk. Of the 18 variables analyzed, six demonstrated significant gender-based disparities: Marital Status, Annual Income, Material Possession, Decision-making, Access to Resources/Services, and Reproductive Roles. The marital status of male respondents was statistically significant ($U = 527$, $p < 0.05$) and showed a higher mean rank of 33.17 than the female group, which had a mean rank of 28.00 (Table 4). A similar trend was observed for Annual Income, where men exhibited significantly higher values ($U = 647$, $p < 0.05$) with a mean rank of 37.31, compared to 24.13 for women. Likewise, Material Possession showed significant differences ($U = 643$, $p < 0.05$), with men achieving a mean rank of 37.17, notably higher than women's mean rank of 24.26. The disparity in Decision-making authority was also evident, with men scoring significantly higher ($U = 610$, $p < 0.05$) and a mean rank of 36.03, compared to 25.32 for women. Men demonstrated a statistically significant superiority

Table 2. Descriptive statistics of the selected variables

Categories	Subclass	Women (31)	Men (29)	Total (60)
Age	Young	12.9	41.38	26.67
	Middle	48.39	31.03	40.00
	Old	38.71	27.59	33.33
Educational status	Illiterate	25.80	3.44	15
	Primary	12.90	24.13	18.33
	Middle	48.38	48.27	48.33
	Secondary	6.451	10.34	8.33
	Graduate	6.451	13.79	10
Family size	Small	12.90	10.34	11.67
	Medium	64.52	79.31	71.67
	Large	22.58	10.34	16.67
Family type	Joint	19.35	10.34	15
	Nuclear	80.65	89.66	85
Marital status	Married	100	82.76	91.67
	Unmarried	0	17.24	8.33

in Access to Resources and Services (U = 598, $p < 0.05$), recording a mean rank of 35.62 compared to 25.71 among women, thereby underscoring the persistence of gender-based disparities in resource accessibility. Conversely, the variable Reproductive Roles was dominated by women, who had a significantly higher mean rank (U = 143.5, $p < 0.05$) of 40.37, compared to 19.95 for men. While women tended to score higher in many socio-personal and socio-psychological variables, these differences were not statistically significant ($p > 0.05$). Notably, six variables within the socio-psychological domain, including Educational Status (34.09), Experience (33.31), Self-confidence (33.81), Information-seeking Behaviour (31.9), Achievement Motivation (34.84), and Productive Roles (33.97), exhibited higher mean ranks for men. Still, these differences did not reach statistical significance ($p > 0.05$). Interestingly, both men and women displayed identical mean ranks of 30.5 for the socio-psychological variable Information-sharing Behaviour, indicating no significant gender-based variation in this attribute. Thus, Information-sharing Behaviour appears unaffected by gender.

Table 3. Group statistics of the variables under study

Variables	Mean		Standard deviation	
	Men	Women	Men	Women
Age	1.86	2.23	0.83	0.67
Family type	1.10	1.19	0.31	0.40
Educational status	2.10	1.58	0.94	1.18
Family size	1.10	1.23	0.31	0.43
Marital status	1.17	1.00	0.38	0.00
Experience	2.34	1.81	1.49	1.08
Annual income	2.24	1.68	0.58	0.48
Social participation	1.10	1.35	1.23	1.08
Self-confidence	24.52	22.26	6.47	5.73
Information seeking behavior	22.45	22.06	2.56	2.91
Information sharing behavior	15.69	15.74	2.44	2.39
Achievement motivation	16.97	16.32	1.24	1.56
Credit orientation	6.86	6.90	2.13	2.04
Material Possession	3.17	2.29	1.17	0.78
Decision Making	13.79	12.45	2.61	2.36
Reproductive roles	4.72	9.81	2.74	4.02
Productive roles	2.34	1.61	1.90	1.94
Access over resources/services	4.52	2.97	2.64	0.98

Table 4. Mean ranks of men and women respondents and its test of statistics

Variables	Mean Rank of Women	Sum Rank of Women	Mean Rank of Men	Sum Rank of Men	MW -U	p-value
Age	34.16	1059	26.59	771	336	0.074
Family Type	31.81	986	29.1	844	409	0.339
Educational status	27.15	841.5	34.09	988.5	553.5	0.082
Family size	32.27	1000.5	28.6	829.5	394.5	0.212
Marital status	28	868	33.17	962	527	0.017
Experience	27.87	864	33.31	966	531	0.198
Annual income	24.13	748	37.31	1082	647	0
Credit orientation	30.66	950.5	30.33	879.5	444.5	0.946
Access over resources/services	25.71	797	35.62	1033	598	0.025
Material Possession	24.26	752	37.17	1078	643	0.003
Social participation	32.15	996.5	28.74	833.5	398.5	0.402
Self-confidence	27.4	849.5	33.81	980.5	545.5	0.157
Information seeking behaviour	29.19	905	31.9	925	490	0.549
Information sharing behaviour	30.5	945.5	30.5	884.5	449.5	1
Decision Making	25.32	785	36.03	1045	610	0.016
Achievement motivation	26.44	819.5	34.84	1010.5	575.5	0.051
Productive roles	27.26	845	33.97	985	550	0.123
Reproductive roles	40.37	1251.5	19.95	578.5	143.5	0

3.3 Principal Component Analysis

3.3.1. Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA) evaluates the suitability of individual variables for Principal Component Analysis (PCA) or factor analysis by assessing the strength of their interrelationships. This metric determines whether the dataset is appropriate for dimensionality reduction into meaningful components. The KMO value ranges from 0 to 1, with higher values indicating greater adequacy, while values below 0.5 suggest unsuitability for such analysis. Complementing this,

Table 5. Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity

KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
	Chi-Square	df	Sig
_0.612	582.365_	171	0.00

Bartlett's test of sphericity assesses the overall adequacy of the correlation matrix by determining whether significant relationships exist among the variables. It tests the null hypothesis that the variables are uncorrelated, ensuring that any detected components are statistically meaningful. In the present analysis, the KMO value was calculated as 0.612,

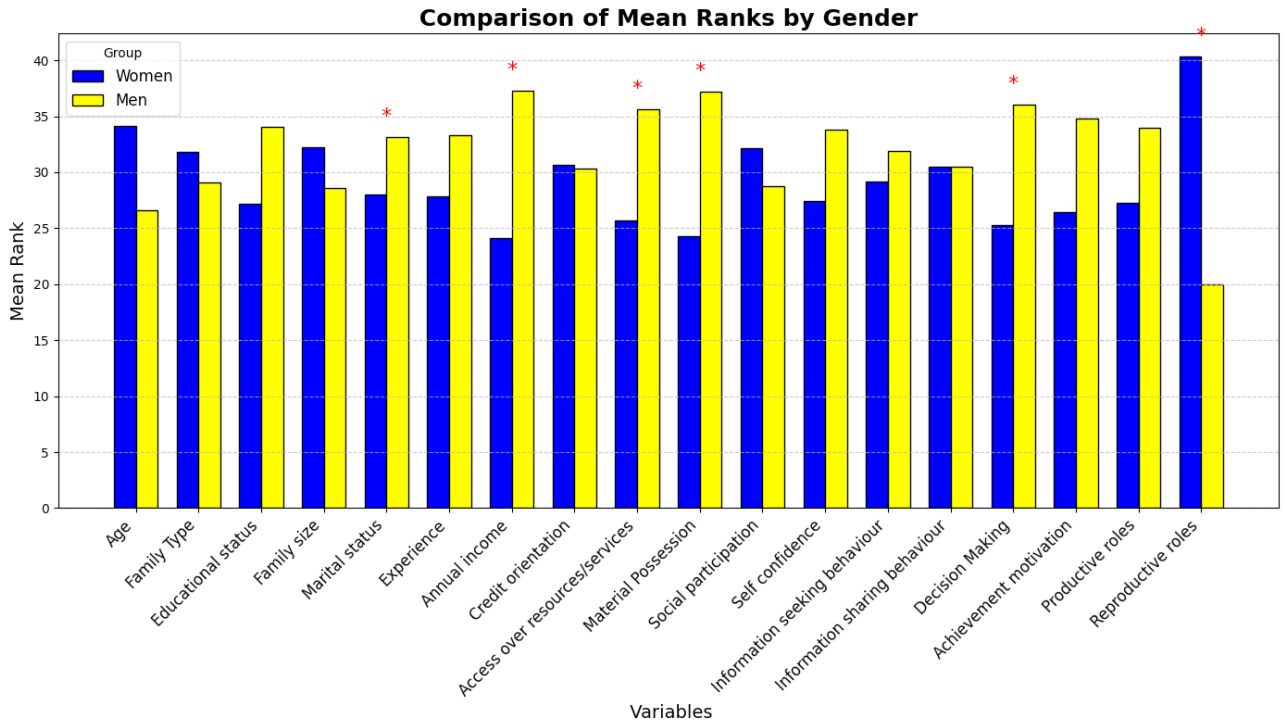


Fig. 2. Comparison of Mean ranks of Men and Women

indicating that the dataset is appropriate for PCA (Table 5). Furthermore, Bartlett's test yielded a significance level of 0.00, leading to the rejection of the null hypothesis. This result confirms significant correlations within the matrix, thereby validating the suitability of the data for PCA and subsequent interpretation of the underlying components.

3.3.2. PCA Results

Table 6 provides a comprehensive analysis of the factor loadings, communalities, eigenvalues, percentage variance, and cumulative variance explained by the extracted components. Based on the results, six components were identified, with the decision on how many components to retain guided by the criterion that eigenvalues exceed 1. The scree plot illustrating the eigenvalues for each component is presented in Figure 3. The point at which the eigenvalues begin to show a gradual, consistent decline, referred to as the "elbow," determines the total number of components to retain. Based on this examination, six principal components were selected for further analysis. Communalities represent the proportion of variance in each variable explained by the extracted factors, providing insights into shared variance and the explanatory power of the retained components.

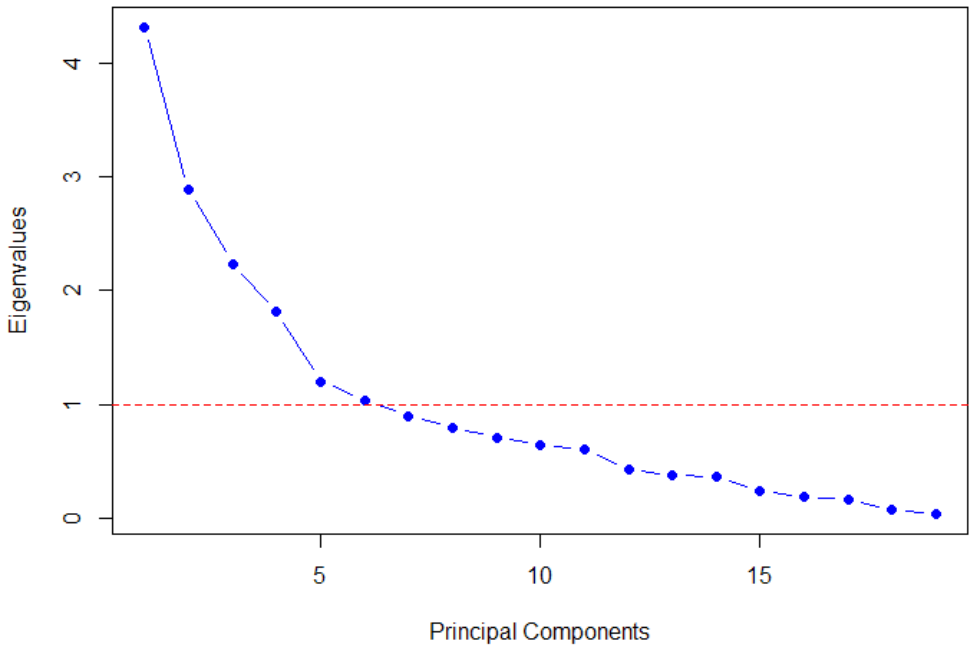


Fig. 3. Scree plot of eigenvalues of factors

Table 6. Component matrix

Code	Variables	PC1	PC2	PC3	PC4	PC5	PC6	Communality
V1	Age	0.522	0.322	-0.661	-0.071	0.135	-0.1	0.846
V2	Family type	-0.122	0.68	0.195	0.599	-0.086	-0.262	0.95
V3	Gender	-0.356	0.645	-0.203	-0.519	-0.025	0.008	0.854
V4	Educational status	0.251	-0.221	0.73	-0.186	0.081	-0.132	0.704
V5	Family size	-0.15	0.672	0.121	0.584	-0.167	-0.317	0.959
V6	Marital status	-0.28	-0.337	0.407	0.363	0.251	-0.056	0.556
V7	Experience	0.743	0.168	-0.363	0.289	0.116	0.077	0.815
V8	Annual Income	0.444	-0.522	-0.152	0.178	-0.157	-0.086	0.556
V9	Social participation	0.686	0.515	0.057	-0.053	0.108	0.108	0.765
V10	Self-confidence	0.682	0.043	0.226	-0.138	-0.243	-0.049	0.598
V11	Information seeking behavior	0.346	0.139	0.627	-0.24	0.374	-0.1	0.739
V12	Information sharing behavior	0.206	0.302	-0.04	0.021	0.654	0.21	0.607
V13	Achievement motivation	0.012	0.071	0.289	0.504	-0.121	0.693	0.837
V14	Credit orientation	0.549	0.314	0.076	-0.143	-0.07	-0.215	0.477
V15	Material Possession	0.638	-0.295	0.054	0.174	0.35	-0.208	0.693
V16	Decision Making	0.542	-0.155	0.201	-0.179	-0.431	-0.136	0.595
V17	Reproductive roles	-0.121	0.632	0.473	-0.354	-0.133	0.23	0.834
V18	Productive roles	0.635	0.001	-0.112	-0.004	-0.167	0.317	0.544
V19	Access over resources/services	0.684	-0.006	0.177	0.138	-0.167	0.099	0.557
	Eigenvalues	4.314	2.889	2.234	1.817	1.202	1.032	
	% of Variance explained	22.703	15.204	11.756	9.561	6.324	5.432	
	Cumulative % of variance explained	22.703	37.908	49.664	59.225	65.549	70.982	

The components extracted are incompatible for proper interpretation, lacking practical significance, thereby rendering the factors for retaining clear inference moot. The varimax rotation was used to gather further meaningful insights from the factor loadings (Table 7). From each component column, variables with factor loadings of 0.5 or higher were considered in identifying the specific principal components, with significance assessed at the 5% level after rotation. A detailed examination of Table 6 following the rotation reveals that the six principal components account for 19.7%, 13.4%, 11.2%, 10.9%, 8.5%, and 6.9% of the total variance, respectively. Collectively, these retained components explain 70.9% of the variance across the 19 variables. The factor loadings for each principal component are summarised in Table 8, providing a clear basis for interpretation and further analysis.

The first principal component (PC 1), which explains 19.7% of the total variance, comprises Experience (0.61), Social Participation (0.709), Self-Confidence (0.725), Credit Orientation (0.6), Decision-Making Ability (0.622), Productive Roles (0.636), and Access to Resources/ Services (0.656). Among these, Self-Confidence and Social Participation exhibit the highest factor loadings, indicating their dominant contribution to this component. This suggests that the first component primarily reflects the influence of socio-personal attributes, emphasising the importance of interpersonal engagement and self-assurance in shaping outcomes.

The second principal component (PC 2) shows a positive correlation with Annual Income (0.628) and Material Possessions (0.621), highlighting the economic dimension. In contrast, Gender (-0.829) and Reproductive Roles (-0.811) exhibit strong negative loadings. These negative associations suggest underlying disparities in traditional gender roles, underscoring the role of economic and social inequities in influencing the distribution of responsibilities and resources. PC 3 is characterised by high loadings for Age (-0.529), which shows a strong negative association, and Educational Status (0.804), reflecting a significant positive relationship. Additionally, the socio-psychological variable Information-Seeking Behaviour (0.746) also contributes positively to this component. This highlights the role of education and access to information in mitigating age-related barriers, indicating that this component explains the extent to which individuals leverage information and knowledge services based on their educational attainment.

The variables associated with PC 4 are Family Type (0.957) and Family Size (0.965), both of which show exceptionally strong positive loadings. This suggests a robust relationship between this component and family-related socio-personal factors. Given its high loadings, PC 4 can be regarded as an indicator of the structural and relational aspects of the family unit, underscoring its critical role as a personal factor influencing individual behaviour and outcomes. The fifth principal component (PC 5) includes only one variable: Information-Sharing Behaviour (0.772), which

Table 7. Varimax rotation component matrix

Code	Variables	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
V1	Age	0.479	0.069	-0.529	0.011	0.445	-0.367
V2	Family type	0.001	-0.135	-0.008	0.957	0.069	0.105
V3	Gender	-0.08	-0.829	-0.237	0.045	0.105	-0.303
V4	Educational status	0.177	0.077	0.804	-0.104	-0.099	0.012
V5	Family size	0.001	-0.136	-0.086	0.965	-0.012	0.046
V6	Marital status	-0.464	0.325	0.406	0.126	-0.028	0.229
V7	Experience	0.61	0.364	-0.312	0.112	0.446	0.033
V8	Annual Income	0.287	0.628	-0.07	-0.209	-0.176	-0.004
V9	Social participation	0.709	-0.149	0.065	0.162	0.457	0.016
V10	Self confidence	0.725	0.082	0.241	-0.041	-0.071	-0.027
V11	Information seeking behavior	0.249	-0.111	0.746	0.002	0.319	-0.082
V12	Information sharing behavior	0.026	-0.066	0.068	0.008	0.772	0.048
V13	Achievement motivation	0.047	0.005	0.005	0.141	0.057	0.901
V14	Credit orientation	0.6	-0.061	0.128	0.154	0.121	-0.243
V15	Material Possession	0.33	0.621	0.261	-0.064	0.326	-0.139
V16	Decision Making	0.622	0.139	0.207	-0.119	-0.354	-0.081
V17	Reproductive roles	0.172	-0.811	0.308	0.157	0.017	0.165
V18	Productive roles	0.636	0.134	-0.139	-0.193	0.111	0.227
V19	Access over resources/ services	0.656	0.251	0.148	0.031	0.035	0.198
	Eigen values	3.752	2.559	2.144	2.085	1.629	1.317
	% of Variance explained	19.749	13.469	11.285	10.974	8.574	6.93
	Cumulative % explained	19.749	33.218	44.503	55.478	64.052	70.982

demonstrates a strong positive loading. This component alone accounts for 8.57% of the total variance, underscoring its importance as a communication factor. The sixth and final component (PC 6) accounts for 6.93% of the total variance, with a strong positive loading for Achievement Motivation (0.901). This highlights the motivational dimension of individual behaviour. As a standalone factor, PC 6 encompasses the integral desire for achievement and self-improvement.

3.3.3. Correlation between Components 1 and 2

Together, PC1 and PC2 collectively explain 33.22% of the total variance, underscoring their effectiveness in capturing the variability within the dataset. The Correlation Circle Plot (Figure 4) provides a visual representation of the relationships and correlations among the key variables, highlighting their respective contributions to the principal components. This visualisation facilitates a deeper understanding of how variables interrelate by projecting them onto the principal components, while also identifying the most influential variables based on their factor loadings. PC1, which accounts for 19.75% of the variance, exhibits strong positive correlations with V18, V10, V19, and V14, and negative correlations with V6, V2, and V13. These contrasting patterns reflect distinct behavioural dynamics among the variables contributing to PC1. Similarly, PC2, which explains 13.47% of the variance, demonstrates strong positive loadings for V8 and V15, juxtaposed with negative loadings for V3 and V17, indicating an inverse relationship between these variable sets. Clusters of variables, such as V10 and V19, exhibit similar contributions to the components, reflecting shared trends or dimensions. In contrast, the tight grouping of variables V1, V5, and V11 near the origin, with shorter vector lengths, suggests that these variables have weaker correlations with both PC1 and PC2 and therefore play a less significant role in explaining the variance captured by these components.

Table 8. Key variables with component loadings under different principal components

Component	Variables	Loadings
Component 1	Experience (V7)	0.610
	Social participation (V9)	0.709
	Self-confidence (V10)	0.725
	Credit orientation (V14)	0.600
	Decision Making (V16)	0.622
	Productive roles (V18)	0.636
	Access over resources/services (V19)	0.656
Component 2	Gender (V3)	-0.829
	Annual Income (V8)	0.628
	Material Possession (V15)	0.621
	Reproductive roles (V17)	-0.811
Component 3	Age (V1)	-0.529
	Educational status (V4)	0.804
	Information seeking behavior (V11)	0.746
Component 4	Family type (V2)	0.957
	Family size (V5)	0.965
Component 5	Information sharing behavior (V12)	0.772
Component 6	Achievement motivation (V13)	0.901

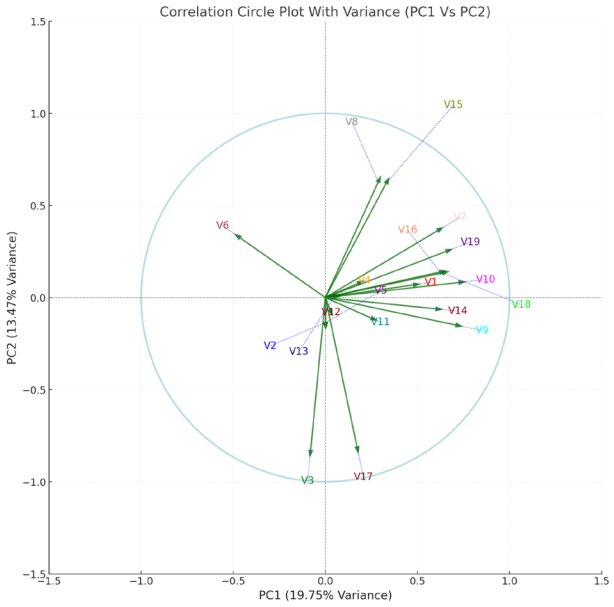


Fig. 4. Correlation circle plot depicting PC1 and PC2

Table 9. Tests of Equality of Group Means

Variables	Wilks' Lambda	F	df1	df2	Sig.
Age	0.943	3.498	1	58	0.066
Family type	0.984	0.937	1	58	0.337
Educational status	0.942	3.586	1	58	0.063
Family size	0.973	1.604	1	58	0.21
Marital status	0.903	6.243	1	58	0.015
Experience	0.957	2.586	1	58	0.113
Annual income	0.771	17.184	1	58	0.000
Credit orientation	1	0.006	1	58	0.939
Access over resources/services	0.862	9.306	1	58	0.003
Material Possession	0.829	11.963	1	58	0.001
Social participation	0.988	0.706	1	58	0.404
Self confidence	0.966	2.058	1	58	0.157
Information seeking behavior	0.995	0.293	1	58	0.59
Information sharing behavior	1	0.007	1	58	0.933
Decision Making behavior	0.93	4.363	1	58	0.041
Achievement motivation	0.949	3.104	1	58	0.083
Reproductive roles	0.642	32.315	1	58	0.000
Productive roles	0.964	2.176	1	58	0.146

3.4. Discriminant Function Analysis

Table 9 reveals that both male and female groups exhibited significantly high mean scores for key predictor variables, including Marital Status ($F = 6.243$, $p = 0.015$), Annual Income ($F = 17.184$, $p = 0.000$), Access to Resources and Services ($F = 9.306$, $p = 0.003$), Material Possession ($F = 11.963$, $p = 0.001$), Decision-Making Behavior ($F = 4.363$, $p = 0.041$), and Reproductive Roles ($F = 32.315$, $p = 0.000$). Variables such as Age ($p = 0.066$) and Educational Status ($p = 0.063$) showed marginal significance, suggesting potential relevance despite not meeting the conventional threshold for statistical significance ($p > 0.05$). In contrast, all other variables showed no statistically significant differences between genders and contributed minimally to group discrimination. These findings underscore the influence of socio-economic and gender-specific roles in distinguishing the groups, with Reproductive Roles emerging as the most significant discriminator. The discriminative capability of the function in separating the groups was further assessed using metrics such as the Eigenvalue, percentage of explained variance, canonical correlation, and Wilks' lambda (Table 10). An eigenvalue of 5.744 indicates strong discriminative power, explaining 100% of the variance. The results demonstrate that the overall test, incorporating all functions, is statistically significant (Wilks' lambda = 0.148, Chi-square = 93.524, $p = 0.000$), effectively distinguishing between male and female groups. The canonical correlation coefficient of 0.923 indicates a strong relationship between the discriminant function and the analysed groups, confirming that the set of predictor variables used in the analysis has substantial discriminatory power with minimal overlap. When expressed as a percentage, the canonical correlation indicates that approximately 85% of the variance between men and women is attributable to these predictors.

Table 11 presents the standardised canonical discriminant function coefficients and unstandardized coefficients, which illustrate the relative significance of each predictor variable in defining the discriminant function. Upon examining the coefficient values, it becomes evident that key predictor variables, including Reproductive Roles (-1.494), Age (-0.99), Access to Resources and Services (0.795), Marital Status (0.698), Experience (0.624), and Decision-Making Behavior (0.542), play a pivotal role in explaining group variances and exhibit a strong association with the discriminant function. In contrast, the remaining variables have a negligible impact on the discriminant function, highlighting their limited relevance in distinguishing between the groups. The directionality of the coefficients, whether positive or negative, provides valuable insights into how each variable influences group membership, offering a clearer understanding of their respective roles in explaining the disparities. These findings underscore the critical importance of socio-economic and psychological variables in shaping the observed differences between the groups. Furthermore, the unstandardized discriminant function coefficients can be employed to construct a predictive model, which can be represented as follows:

Table 10. Eigenvalue and Wilk's lambda

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	5.744	100	100	0.923
Wilks' Lambda				
Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	0.148	93.524	18	0

Table 11. Standardised and unstandardised canonical discriminant function coefficients

Variables	Standardized canonical discriminant function coefficients	Unstandardized coefficients
Age (X_1)	-0.99	-1.315
Family type (X_2)	0.166	0.461
Educational status (X_3)	0.158	0.148
Family size (X_4)	-0.158	-0.422
Marital status (X_5)	0.698	2.613
Experience (X_6)	0.624	0.482
Annual income (X_7)	0.192	0.364
Credit orientation (X_8)	0.27	0.13
Access over resources/services (X_9)	0.795	0.404
Material Possession (X_{10})	-0.197	-0.199
Social participation (X_{11})	-0.256	-0.221
Self-confidence (X_{12})	-0.032	-0.005
Information seeking behaviour (X_{13})	0.302	0.11
Information sharing behaviour (X_{14})	0.231	0.096
Decision Making behavior (X_{15})	0.542	0.218
Achievement motivation (X_{16})	0.484	0.342
Reproductive roles (X_{17})	-1.494	-0.432
Productive roles (X_{18})	0.005	0.003

$D= -1.315\ X_1 + 0.461\ X_2 + 0.148\ X_3 - 0.422\ X_4 + 2.613\ X_5 + 0.482\ X_6 + 0.364\ X_7 + 0.13\ X_8 + 0.404\ X_9 - 0.199\ X_{10} - 0.221\ X_{11} - 0.005\ X_{12} + 0.11\ X_{13} + 0.096\ X_{14} + 0.218\ X_{15} + 0.342\ X_{16} - 0.432\ X_{17} + 0.003\ X_{18}$

Table 12 presents the classification results from the discriminant function analysis, demonstrating a high degree of accuracy in predicting group membership by gender. The model correctly classified approximately 96.7% of the cases in the original analysis, highlighting its effectiveness. Specifically, 96.6% of individuals in the men's group were accurately predicted, while 96.8% of the women's group were correctly classified. The cross-validation results, which provide a more robust evaluation by classifying each case using functions derived from all other cases, yielded an overall accuracy of 91.7%. Within the cross-validation analysis, the men's group (Group 1) maintained an accuracy of 96.6%, whereas the women's group (Group 2) showed a reduced accuracy of 87.1%. These findings indicate the model's overall reliability and its potential to effectively distinguish between gender-based groups.

3.5. Gender-based occupational participation in various post-harvest operations

Our study revealed that both men and women are significantly engaged in various secondary occupations within the fisheries value chain. These include retail and wholesale marketing, bulk wholesale trading, drying and salting of fish for commercial distribution, sorting and grading in processing plants, and fish cutting in specialized processing units. Additionally, their roles extend to labor-intensive tasks such as loading and unloading within the harbor premises, working as ice plant operators responsible for ice production, crushing, and logistics, as well as engaging in the technical work of net fabrication and repair. Figure 5 illustrates the distinct participation levels of men and women, highlighting significant disparities in the gendered division of labor within the post-harvest fisheries sector. Both men (13.79%) and women (12.9%) demonstrated near-equal engagement in retail and wholesale fish marketing, suggesting a relatively balanced contribution to the overall marketing enterprise. In contrast, fish auctioning at the landing site remains predominantly male-dominated, with 20.68% of men involved compared to only 6.45% of women. This disparity underscores men's pronounced role in exerting greater control over financial transactions and decision-making processes within the harbor. The study revealed that drying, salting, and marketing of dried fish products is exclusively dominated by women, with 22.58% of the female workforce engaged in this activity, while men have no recorded participation.

Table 12. Classification results using DFA.

		Gender	Predicted Group Membership		Total
			Men	Women	
Original	Count	Men	28	1	29
		Women	1	30	31
	%	Men	96.6	3.4	100
		Women	3.2	96.8	100
Predicted	Count	Men	28	1	29
		Women	4	27	31
	%	Men	96.6	3.4	100
		Women	12.9	87.1	100

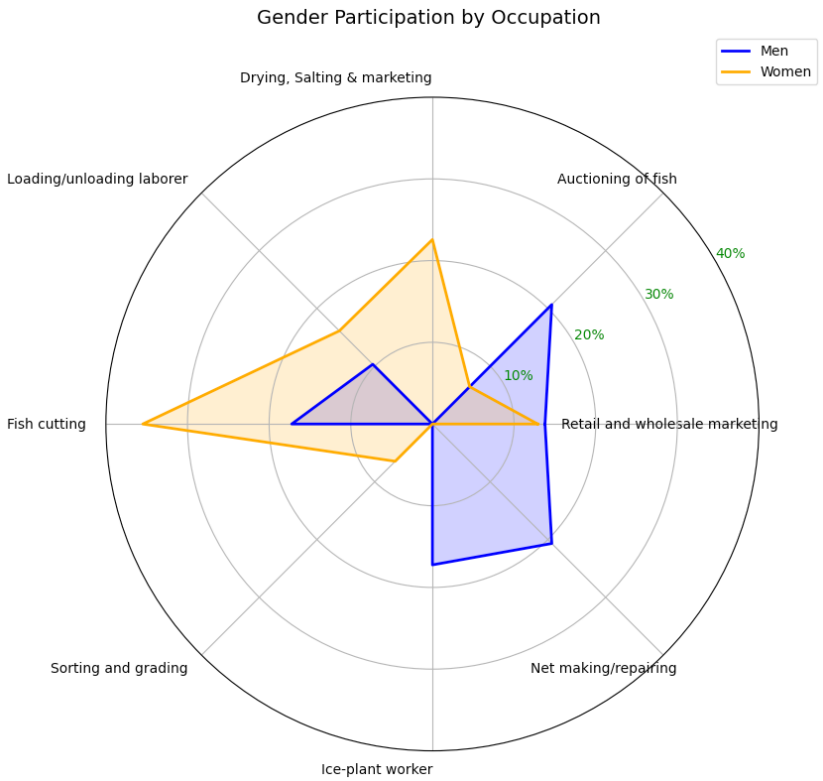


Fig. 5. Gender wise Participation by occupational roles

Interestingly, in contrast to traditional gender norms, women were more involved in loading and unloading tasks (16.12%) compared to men (10.34%), highlighting their significant contribution to physically demanding roles traditionally perceived as male-dominated. Similarly, sorting and grading in processing plants is managed solely by women (6.45%), underscoring their indispensable role in quality control and value addition, particularly for export purposes. The dominance of women becomes evident in fish cutting within processing units, with 35.48% of women engaged compared to 17.24% of men, highlighting their significant role in labor-intensive tasks essential for value addition. On the other hand, men dominate highly technical and resource-intensive roles, such as those of ice-plant workers, responsible for ice production, crushing, and transportation. These tasks are exclusively performed by men (17.24%), with no female involvement. Additionally, net making and repair for fishing operations is entirely undertaken by men (20.68%), reflecting their technical expertise in gear and craft maintenance. Despite their substantial contributions to post-harvest activities, women are largely confined to roles requiring lower technical skills and yielding comparatively lower income, perpetuating entrenched gender disparities within the fisheries sector.

4. Discussion

This gendered analysis delves into specific roles and responsibilities, providing valuable insights into significant gender disparities within the Malpe fisheries harbor community, with an emphasis on socio-economic, socio-psychological, and sociological dimensions. Although both men and women share equal labor in the post-harvest sector, our findings revealed the dominance of men in productive roles whereas women shoulder the burden of several reproductive roles. It is also inferred that men exhibited higher annual incomes, material possessions, and decision-making autonomy, exemplifying enhanced access to basic resources and opportunities. Conversely, women are more occupied with both domestic and labor roles showcasing higher levels of social participation and household responsibilities. The study underlined that women in the secondary sector are made to face major challenges due to their limited authority to decision-making opportunities, access to basic education, early marriages, and child care, which curbs their potential to fulfill economic and financial independence with increased mobility. These structural impediments greatly pitch in to widen the probability of the gender gap in achieving sustainable development goals (SDG 5). The study reinforces Williams' (2012) assertion that significant gender-based disparities persist in access to capital, education, essential resources, and information, particularly within the secondary fisheries sector.

Women empowerment greatly focuses on enhancing their social and economic welfare by accelerating social status, job and wage adequacy, and favorable income, promising parity with their male counterparts in key areas like access to basic education, decision-making autonomy, and access to basic resources and services (Ragsdale *et al.*, 2022). Gender roles are often delimited when they penetrate women's participation, access to resources, and opportunities since these roles are constructed traditionally by society. Gender analysis studies and research proceedings in the fisheries sector are traversing beyond the traditional gender roles and societal norms to investigate the actual capabilities of men and women in small-scale fisheries development. The study

presented strong evidence supporting significant gender disparities prevalent in the post-harvest fisheries sector. The study predominantly highlighted notable differences across gender where almost every beneficial attribute favored men in terms of education, income, decision-making authority, access to resources, and opportunities. While men greatly outperform in more productive roles, women, on the other hand, often shoulder the disproportionate load of undervalued and unpaid reproductive roles along with their proactive involvement in various post-harvest operations including Loading/unloading, drying of fish, value-addition in processing units. The study critically underlines women's contributions in the post-harvest fisheries operations alongside deeply rooted gender roles and inequities. These findings aligned with the statements put forward by Harper *et al*. (2013) and Kleiber *et al.* (2015), who evaluated and documented the unrecognized and undervalued role of women's contribution to small-scale fisheries.

Specifically, the study highlights the importance of comprehensive gender-disaggregated data as it facilitates the evaluation of how men and women exclusively contribute to the fisheries sector. Poor sex-disaggregated data and certain gender-blind policies limit women's participation and entrepreneurial prospects in this growing sector (Brugere and Williams, 2017). The lack of gender-disaggregated data could hinder the details regarding the contributions of women and other marginalized groups in sustainable fisheries management and economic empowerment in small-scale fisheries (Rice *et al*., 2024). It can be inferred from the research that the contribution of women in domestic households is gathering magnified prominence in the upliftment of the family's livelihood thus offering protection from poverty and poor social status. This was supported by Ibbara (2021), who put forward a statement confirming that women's income from fishery-related activities has tremendously increased their socio-economic conditions such as access to education, and resources and thereby ensuring food security. Similarly, Weeratunge *et al*. (2010) highlighted that women's participation in fishery-related activities, particularly in value addition and marketing, has enhanced their social and economic standing, thereby strengthening resilience in small-scale fisheries.

The socio-personal attributes opened a path to determine the community dynamics where women contribute a lot more than men in maintaining family structures, although they are undervalued and unrecognized. These variables reflect the dual roles of women in small-scale fisheries. The findings suggested that a significant proportion of women belong to the middle and older age groups, whereas men are primarily younger. It was observed that although most women are older than their male counterparts, they often lack economic power and decision-making autonomy comparable to that of men. Instead, decision-making authority remains under the control of other family members, reflecting entrenched gender dynamics. This finding aligns with the observations of Prieto-Carolino (2021), who noted similar patterns of exclusion in the processing sector of tuna fisheries. This distribution of age indicates the fluctuating career timelines and life stages of the respondents, provided, the older women perform a central role in domestic responsibilities. While looking into family type and family size, it clearly emphasizes the extra burden of reproductive roles on women, with the prevalence of nuclear family settings. It is apparent from the study that women often maintain these family structures, counterbalancing their dual roles in society, while men greatly concentrate on income-generating activities.

Another interesting outcome from the study is the stark difference in educational attainment between men and women where men are observed to have secondary or graduate degrees. Women, on the other side, exhibit high illiteracy (25.8%) or only have a basic primary level of education. Limited access to education among women can be a hindrance limiting their ability to seek opportunities in higher-paying roles and decision-making authorities. These findings are reinforced by Matsubara and Makino (2023), who identified comparable educational barriers faced by women in Japanese coastal fisheries, where entrenched social norms hinder their access to basic education and limit their opportunities for professional growth. Additionally, Gopal *et al.* (2020) emphasized that limited access to basic education significantly hinders women's ability to enhance their socio-economic profiles, thereby restricting their capacity to assume equitable roles within the global aquaculture and fisheries sector. Access to higher education for women could fill this gap to ensure their engagement in various socio-economic activities like their male equals. While almost every woman (100%) is married, reflecting their strong ties in family-centric roles, men deviate significantly exhibiting a distinct marital status. Our findings resonate with the observation by Swathilekshmi *et al*. (2022), emphasizing that a greater proportion of women were married and older than their male counterparts.

The socio-economic variables revealed pronounced gender disparities that are deeply perpetuated as structural inequalities displaying its effect in various aspects such as income levels, possession of certain items, and access/control over critical resources/services. While observing these socio-economic attributes, men and women were engaged in all aspects of pre and post-harvest operations for a fixed income. Our study's findings reveal that men's annual revenue is twice that of women involved in the same operations within the harbor. This agrees with Swathilekshmi *et al.* (2022) who reported that men earn more than women in the fisheries sector of Andhra Pradesh. This disparity highlights the gendered division of labor, with men predominantly occupying roles such as wholesaling, retailing, gear-making & repairing, and auctioneering which offer higher earning potential.

In contrast, women are often confined to unskilled labor positions in processing plants and tasks like loading and unloading at the harbor, sorting and grading at processing units with more working hours, typically undervalued and poorly compensated. These trends align with the observations of Benson *et al*. (2018), who highlighted the gendered division of labor in the coastal regions of the Lagos state of Nigeria, where women predominantly

occupy roles in the post-harvest sector but earn significantly less than men. Similarly, Mutia *et al*. (2020) reported economic disparities in the fisheries sector of Lake Taal, Philippines, where men dominate high-paying jobs, while women are confined to unskilled, low-paying positions, further perpetuating gender inequities across regions. This visible economic gap not only undermines women's financial freedom but also forces them to depend on their male counterparts for a living.

Women show significantly higher participation in activities such as drying, salting, and smoking fish compared to men, making these tasks an area predominantly managed by women within the harbor community. While men play a minor role in marketing dried fish, often earning commissions for their efforts, the drying process remains a vital income source for women. This activity not only provides seasonal earnings but also represents one of the most lucrative opportunities for women in the area, thus improving their entrepreneurial capacity. This observation aligns with the findings of Tanuja *et al.* (2022), who proposed an entrepreneurship model for rural women focused on value addition in fishery products, demonstrating significant improvements in their livelihoods in Odisha. However, women play crucial roles in value addition, marketing, packing, and retailing, which are essential for ensuring the timely distribution of catch in local markets (De Silva *et al*., 2012).

The study highlights socio-economic disparities, with men dominating ownership of essential income-generating assets, while women possess minimal or no household and professional assets, limiting their economic contributions. This finding is consistent with the observations of Prieto-Carolino *et al*. (2021), who emphasized the critical contributions of both genders to the processing sector of the tuna value chain in General Santos City, Philippines. However, they highlighted that power dynamics within the sector disproportionately favor men, marginalizing women and limiting their participation in key decision-making and frontline roles. The challenges women face in accessing formal credit facilities often stem from factors such as a lack of collateral security, limited financial literacy, and systemic biases within financial institutions that prioritize men, as highlighted by Brugere *et al*. (2022). Mutia *et al*. (2020) observed that women who secure credit for their families often lack control over its utilization, as the funds are absorbed into the family's common pool and allocated for various household purposes. These limitations are deeply rooted in societal norms that favor men, systematically excluding women from financial decision-making autonomy. This aligns with the findings of Kusakabe and Thongprasert (2022), who highlighted similar barriers in small-scale fisheries in Asia, where gendered norms restrict women's participation in financial decision-making processes.

Women demonstrated significantly higher levels of social participation and engagement in reproductive roles than productive ones, emphasizing their critical contribution to maintaining familial and social cohesion. Our findings highlight the critical role of women as primary caregivers in the secondary sector of small-scale fishing communities. Their contributions are predominantly focused on ensuring food security and managing household finances, a dynamic also emphasized by Lentisco and Lee (2015). Conversely, men exhibited greater self-confidence, decision-making autonomy, and involvement in productive roles, reflecting entrenched traditional gender hierarchies that reinforce male dominance in resource management. Our observation aligns with the findings of Frangoudes and Gerrard (2019), who noted that women's contributions to the fisheries sector are often undervalued and unrecognized, despite their crucial role in sustaining households through essential domestic responsibilities. Unfortunately, women's roles in households are often viewed as an extension of their reproductive responsibilities, which restricts their participation in professional domains. This not only highlights their invisibility in fisheries resource management practices but also perpetuates gendered power dynamics (Szymkowiak and Rhodes-Reese, 2020).

Traditionally, men are perceived as household breadwinners, often encouraged to take risks and assert their viewpoints. This societal favoritism has allowed men to develop decision-making skills over time. The analysis of decision-making dynamics revealed a consensus among both men and women that final decisions in practice are predominantly made by men, aligning with the findings of Lawless *et al*. (2019). Meanwhile, cultural norms frequently confine women to dual roles, balancing domestic and economic responsibilities. This imbalance limits women's ability to assert themselves in decision-making processes, thereby reinforcing existing gender disparities. This disparity reflects the gender norms and relations observed in the Solomon Islands, where men are encouraged to undertake physically demanding and skilled jobs, while women are often marginalized into less lucrative roles, perpetuating a structural imbalance (Lawless *et al*., 2019). Notably, both genders displayed comparable behavior in information-sharing and seeking, suggesting a promising avenue for fostering collaborative efforts in knowledge exchange and addressing broader gender disparities. The study reveals that women frequently express a desire to seek innovative processing technologies within the secondary sector, which could enable them to secure higher-paying positions. However, their current roles often lack opportunities for skill development and technological training wholly agreeing with the assertions of Prieto-Carolino *et al.* (2021), who highlighted similar barriers that prevent women from advancing in professional roles within the fisheries sector.

Leadership roles within the community were predominantly held by men, emphasizing male perspectives in decision-making platforms, while women's participation was largely confined to informal roles in community interactions. The organizational structures of the fisher community seldom include women in fisheries resource management and formal decision-making processes, reflecting persistent gender imbalances (Immanuel & Rao, 2012). The challenges identified in the present study underscore the critical need to move beyond gender-blind policies and adopt transformative approaches to address systemic constraints.

Cole *et al.* (2020) highlighted the effectiveness of engaging both men and women in reshaping traditional gender norms to reduce disparities in the informal fisheries sector. This aligns closely with our findings, which emphasize the importance of collecting and analyzing gender-disaggregated data as a foundational step to addressing entrenched inequalities. Given that women constitute much of the workforce in the secondary sector, their inclusion in policy formulation and decision-making processes should be actively promoted to ensure equitable representation and empowerment (Benson *et al.*, 2018). Certain national policies aimed at promoting the marine fisheries sector specifically target women engaged in small-scale fisheries, particularly in retail and wholesale marketing as well as value addition of fishery byproducts with export potential. These policies provide women with access to resources such as credit schemes, self-help groups, and cooperative societies, to enhance their socio-economic status and empowerment. This approach can serve as a foundation for implementing gender-transformative strategies, where social and economic dimensions are systematically assessed through a gender lens.

5. Conclusion

The engagement and involvement of women and men in the secondary/post-harvest sector of the Malpe fisheries harbor underscore pronounced gender disparities, ranging from access to fundamental education to the specific roles they assume within the community. Women are frequently compelled by societal norms or household expectations to undertake dual roles, managing both domestic responsibilities and professional obligations. This often involves balancing caregiving duties with active participation in labor-intensive tasks within the fishing community. Women are disproportionately affected by traditionally imposed practices that confine individuals to societally constructed roles, limiting their autonomy and opportunities (Williams, 2019). Our study, conducted within a small-scale fishing community in the southwest region of India, provides a comprehensive analysis of gendered activity and access profiles. The findings underscore the significant challenges faced by women in attaining an equitable socio-economic standing and advancing their livelihoods, highlighting systemic barriers and persistent gender disparities within the community. The study highlights two critical dimensions: first, it examines the evolution of gender roles over the past few years, analyzing whether instances of role reversal have emerged within the community. Second, it evaluates the degree to which both men and women rely on essential resources and services, exploring how these are accessed and utilized to foster their socio-economic advancement.

This study employed Principal Component Analysis (PCA), Mann-Whitney U tests, and Discriminant Function Analysis (DFA) to systematically examine gendered patterns within the post-harvest sector of Malpe harbor. The analyses identified two dominant dimensions, 'socio-economic empowerment' and 'economic capital', in which women consistently scored lower than men, underscoring persistent disparities in access to resources and services, decision-making autonomy, and the recognition of labor contributions. Furthermore, DFA results emphasized the influence of intersectional variables such as age, gender roles, and resource entitlements in shaping participation profiles. Together, these findings illuminate the complex and layered nature of gender inequities in coastal livelihoods and underscore the need for targeted, intersectionality-informed interventions in policy and practice. The empirical insights generated through this study underscore the imperative to translate evidence into transformative policy frameworks. However, doing so necessitates a critical engagement with existing gaps in data systems, financial mechanisms, governance structures, and other multidimensional factors that constrain effective implementation. The collective action of women engaged across various nodes of the post-harvest value chains can catalyze addressing systemic and organizational barriers that frequently restrict their progression into frontline roles. There is a heightened imperative to formulate, implement, and rigorously monitor gender-responsive policies at both national and international levels. Considering these challenges, the study puts forward a set of context-specific, actionable policy recommendations with strong potential for practical adoption and impact.

The marginalization experienced by both men and women in the post-harvest fisheries sector can be systematically addressed through globally coordinated and gender-responsive policy interventions. A foundational step involves mandating gender-disaggregated data collection and reporting across all post-harvest activities, integrated within state and national fisheries data systems. The routine publication of gender-specific indicators will enhance visibility and inform more equitable decision-making. To mitigate entrenched disparities, it is recommended that at least 40% of total fisheries development funding be allocated specifically to post-harvest sub-sectors and related domains where women constitute the majority workforce. However, meaningful progress remains hindered by a critical lack of training opportunities and systemic neglect of individuals employed in the lower tiers of the value chain. For marginalized populations, particularly women, barriers to accessing labor-saving and income-enhancing technologies remain significant. Establishing targeted capacity-building initiatives through agencies such as the Marine Products Export Development Authority (MPEDA) and other state-level programs is essential. These programs should prioritize leadership development, technological training, and entrepreneurship support specifically tailored to women in the secondary sector. Enhancing women's ability to influence fisheries governance requires their active and collective engagement in decision-making and resource management structures.

Further, the introduction of collateral-free microfinance schemes and accessible credit facilities, with affordable interest rates and guaranteed capital for women-led enterprises, can significantly enhance financial inclusion. Leveraging existing cooperative society networks may facilitate this process. In addition, embedding gender mainstreaming modules within fisheries extension services

will ensure that advisory support is responsive to the specific needs of women. Promoting equitable access to resources, services, and opportunities should be central to all policy frameworks. This can be operationalized through the implementation of biennial gender audits at major landing centers and across post-harvest operations, providing an evidence-based tool to assess progress in equity and inclusion. Finally, improving digital literacy through the establishment of low-cost internet access points at harbors can empower women with real-time market information, price data, and networking opportunities. Aligning these policy measures with international frameworks, such as the FAO's Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (2018) and the UN 2030 Agenda, particularly SDG 5.5 (gender equality) and SDG 14.b (access for small-scale artisanal fishers), can facilitate a more inclusive, resilient, and sustainable fisheries sector in which women's contributions are both recognized and supported. Regular monitoring of these policies' impact along with regular feedbacks will be essential to ensure progress towards gender equity in fisheries sector.

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