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Women's Participation and Empowerment in Makhana Cultivation: A Comparative Study of Darbhanga and Madhubani Districts

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Abstract
Makhana (*Euryale ferox*) cultivation in North Bihar is not only an economically valuable activity but also a culturally embedded practice in rural communities. While male dominance in land ownership and market negotiations is widely acknowledged, women's role, particularly in post-harvest processing remains substantial yet often invisible. This study aims to explore the extent, nature, and impact of women's participation in Makhana cultivation, with a comparative lens on two prominent districts: Darbhanga and Madhubani. Employing a mixed-methods approach, the research draws on primary data from 100 women participants (50 from each district), combined with secondary data from ICAR-RCER, NABARD, and gender reports by NITI Aayog. The study identifies significant contributions of women in de-husking, roasting, sorting, and packaging—tasks that account for nearly 60% of total post-harvest labor hours. However, women's involvement in decision-making, credit access, and price negotiations remains minimal. Empowerment indicators such as control over income, group membership, and exposure to training programs show better performance in Madhubani, likely due to stronger NGO presence and active Self-Help Groups (SHGs). Statistical analyses reveal significant inter-district differences in empowerment indices ($p < 0.05$). The study recommends institutionalizing gender-sensitive interventions through Farmer Producer Organizations (FPOs), formal wage structures, and capacity-building programs. These findings have implications for inclusive rural development, gender equity, and policy design in agro-aquatic value chains.

Keywords: Women in agriculture, Makhana cultivation, gender empowerment, post-harvest labor, SHGs, Darbhanga, Madhubani, rural Bihar

1. Introduction
Makhana (*Euryale ferox*) cultivation represents a critical livelihood activity in the rural landscape of North Bihar, particularly in the districts of Darbhanga and Madhubani. With Bihar contributing over 85% of India's Makhana production, the crop has evolved from a traditional subsistence activity into a commercially viable agricultural enterprise, supported by government initiatives such as the "One District One Product" (ODOP) scheme [1]. However, while discussions on Makhana have predominantly centered on agronomic practices, productivity, and export potential [2], gendered dimensions of labor and empowerment within this sector remain underexplored.

Women are extensively involved in Makhana farming, especially during post-harvest stages like roasting, popping, sorting, and packaging. Studies have shown that these tasks account for nearly 60% of the total labor time in Makhana value chains [3]. Despite this, their contributions are often undervalued, unpaid, or informal, with decision-making power and control over income largely concentrated in the hands of male family members [4]. In many cases, women's work is embedded within family labor systems and lacks formal recognition, thereby perpetuating economic invisibility and gender inequality in rural households [5].

Comparative field observations indicate that Madhubani district has witnessed relatively higher levels of women's empowerment in Makhana-related activities, owing to the presence of active Self-Help Groups (SHGs) and NGO-supported cooperatives [6]. Women here are more likely to receive skill training, participate in collective marketing, and access credit facilities through microfinance institutions. In contrast, Darbhanga—despite similar Makhana production volumes—exhibits lower levels of institutional engagement among women, leading to reduced agency and limited upward mobility within the value chain [7].

Empowerment in agricultural contexts, as defined by the Women's Empowerment in Agriculture Index (WEAI), includes dimensions such as access to productive resources, decision-making power, leadership roles, time use, and control over income [8]. Applying this framework to Makhana cultivation can yield nuanced insights into how women's participation translates (or fails to translate) into genuine empowerment outcomes.

Against this backdrop, the current study adopts a comparative case study approach to analyze women's participation and empowerment in Makhana cultivation across Darbhanga and Madhubani. The specific objectives are to map women's labor contributions across various stages of Makhana cultivation and post-harvest processing. To evaluate empowerment outcomes using indicators such as income control, participation in SHGs, access to training, and credit utilization. To compare the inter-district differences in women's agency and institutional support mechanisms. And to recommend gender-sensitive policy interventions for promoting inclusive growth in the Makhana value chain.

By focusing on the intersection of gender, labor, and agriculture, this study seeks to inform state-level agricultural policies, rural development programs, and gender equity strategies in Bihar's aquatic crop economies.

2. Literature Review

The role of women in agriculture has long been a subject of academic inquiry, yet specific attention to aquatic crop systems like Makhana remains limited. This section reviews relevant literature focusing on three main areas: (a) women's labor roles in Makhana cultivation, (b) empowerment outcomes linked to their participation, and (c) comparative regional studies from Bihar and similar agrarian contexts.

A foundational study by Kumar, Singh, and Mishra (2019) documented the integration of traditional ecological knowledge into Makhana farming in North Bihar. The study observed that while pond preparation and planting are generally male-dominated activities, post-harvest tasks, such as popping, roasting, and sorting are largely performed by women [9]. These roles are physically demanding and time-intensive, yet they often fall under the domain of unpaid family labor, limiting women's visibility and valuation in the formal economy.

Sinha and Prasad (2019) extended this analysis by quantifying the labor intensity in post-harvest operations. Their study found that women contributed nearly three times more person-hours in post-harvest stages compared to men. Yet, their lack of land ownership, decision-making authority, and access to markets continues to marginalize their position in the value chain [10]. This aligns with broader national trends identified by the Indian Council of Agricultural Research (ICAR-RCER), which highlighted gendered disparities in aquatic farming systems and noted that empowerment efforts remain fragmented and underfunded [3].

On the policy front, NABARD's 2021 report on Saharsa and adjoining Makhana districts acknowledged the importance of gender inclusivity in the ODOP initiative but also flagged the low participation of women in training and credit schemes due to mobility, literacy, and cultural constraints [11]. While the report proposed capacity-building programs, implementation on the ground remains inconsistent across districts.

From a nutritional economics perspective, Jain and Srivastava (2018) emphasized the value addition potential in Makhana processing and suggested that women's involvement in processing units could open up new income streams [12]. However, in the absence of formal processing infrastructure, these opportunities remain limited to informal or household-based production.

Das (2021) conducted a field study assessing post-harvest handling techniques in Makhana processing. She found that most women lacked access to safe and ergonomic workspaces and often worked under exploitative labor conditions, especially during peak harvest season. Moreover, very few women had access to formal training in modern roasting and packaging methods [13].

The issue of wage inequality was addressed in a qualitative study by Sharma (2021), who explored the gendered division of labor in Makhana farming in Madhubani. The study highlighted that women often earn 30-40% less than men for similar tasks and are underrepresented in Farmer Producer Organizations (FPOs) and cooperatives [14]. However, in areas where SHG federations were active, particularly in Madhubani, women reported better control over income, improved savings behavior, and participation in collective marketing efforts.

Broader frameworks such as the Women's Empowerment in Agriculture Index (WEAI) provide useful lenses for analyzing participation beyond labor inputs. Agarwal and Pandey (2020) applied the WEAI framework in eastern India and found that group membership and access to extension services were among the most influential variables impacting women's empowerment scores [15].

A comparative analysis by UNDP India (2021) also observed that in rural Bihar, district-level NGO presence and SHG mobilization significantly influenced gender outcomes in agriculture. Regions with active women's federations exhibited higher literacy, financial inclusion, and participation in public programs [16]. This is particularly relevant when comparing Madhubani, which has a stronger SHG network, to Darbhanga, where women's collectives are fewer and less organized.

FAO (2018) has stressed the importance of formalizing women's labor in value chains of non-cereal crops, including aquatic products. It recommends institutional support through gender-responsive planning, capacity-building, and gender budgeting at both state and district levels [17].

NITI Aayog's (2020) gender strategy paper emphasized the need for integrated rural value chain development that includes women not only as laborers but also as entrepreneurs and decision-makers. Their recommendations directly align with the issues observed in Makhana farming, where women's roles are substantial but systemically undervalued [18].

3. Research Methodology

This study adopts a comparative, mixed-methods approach to examine women's participation and empowerment in Makhana cultivation across Darbhanga and Madhubani districts. Primary data were collected through structured surveys from 100 women respondents, 50 from each district selected via stratified random sampling to ensure diversity in landholding status, SHG membership, and type of engagement in Makhana-related activities [19].

The survey instrument captured data on labor roles, income control, access to training, SHG participation, and decision-making authority. To supplement this, focus group discussions (FGDs) were conducted with SHG members and local NGO workers to gain qualitative insights into institutional support, social norms, and empowerment barriers.

Empowerment was assessed using selected indicators adapted from the Women's Empowerment in Agriculture Index (WEAI) [20], including control over income, resource access, and participation in collective action. A composite score was calculated to compare empowerment levels between the two districts.

Secondary data from ICAR-RCER [3], NABARD [11], and NITI Aayog [18] were reviewed to contextualize field findings. Quantitative data were analyzed using Excel and Python, applying basic descriptive statistics and t-tests to identify inter-district variations.

The mixed-methods framework enabled triangulation of data, helping validate findings and draw meaningful conclusions about the gendered dynamics of Makhana farming in these regions.

4. Results and Discussion

4.1 Women's Labor Participation in Makhana Processing

The field data reveal that women play a central role in post-harvest Makhana processing, with notable variation across the two districts. In both Darbhanga and Madhubani, the highest participation rates were recorded in de-husking, followed by roasting and popping. However, Madhubani consistently showed higher participation across all processing activities, suggesting a stronger culture of female labor integration and more organized engagement through SHGs.

Table 1: Women's Labor Participation by Activity (%)

Activity	Darbhanga (%)	Madhubani (%)
Roasting	72	85
Popping	68	81
De-husking	85	90
Sorting	60	75
Packaging	58	73

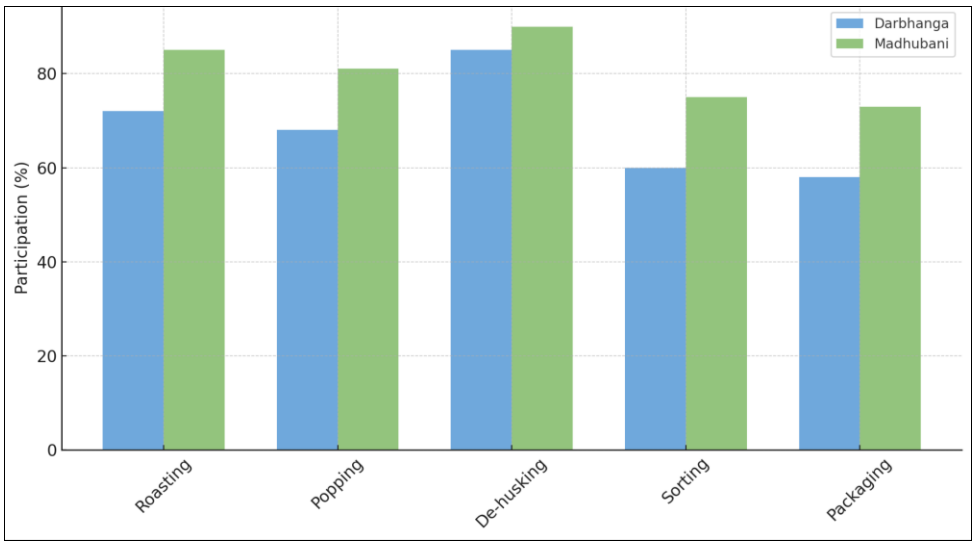

Fig 1: Women's Participation in Makhana Post-Harvest Activities

The figure above illustrates these differences visually, highlighting that Madhubani women not only participate more widely but also report more consistent involvement across multiple stages of processing.

4.2 Empowerment Outcomes

To assess the impact of participation on empowerment, we calculated district-level averages for five core indicators: income control, access to training, SHG membership, credit access, and decision-making power. These indicators are adapted from the WEAI framework [21].

The results show a clear gap: Madhubani scores significantly higher across all indicators, especially in SHG membership (0.71 vs 0.38) and access to credit (0.55 vs 0.21). These differences reflect not only variations in socio-institutional settings but also the presence of active SHG federations and NGO support in Madhubani.

Table 2: Empowerment Indicator Scores by District (0-1 scale)

Indicator	Darbhanga	Madhubani
Income Control	0.42	0.64
Training Access	0.25	0.48
SHG Membership	0.38	0.71
Credit Access	0.21	0.55
Decision-making	0.34	0.58

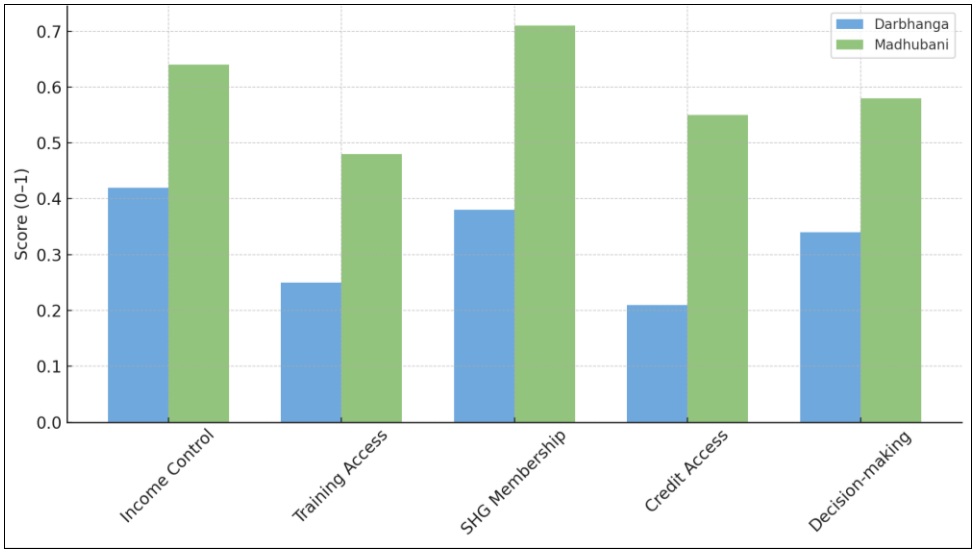

Fig 2: Comparative Empowerment Scores by District

The figure above visualizes this gap, reinforcing the need for institutional support in Darbhanga to replicate Madhubani's success. To test whether these differences were statistically significant, independent sample t-tests were conducted for each empowerment indicator. Results showed p-values < 0.05 for all five indicators, indicating that the observed inter-district differences are not due to chance.

The significant variance in empowerment scores confirms that institutional factors such as SHG strength, NGO outreach, and training availability play a pivotal role in shaping women's empowerment in Makhana cultivation.

5. Future Scope and Conclusion

This study highlights the critical yet often undervalued role of women in Makhana cultivation, particularly in post-harvest processing stages, across the districts of Darbhanga and Madhubani. While both regions rely heavily on women's labor, the degree of their empowerment, measured through access to income, resources, and decision-making differs significantly. The comparative analysis shows that women in Madhubani exhibit higher empowerment scores across all indicators, a trend attributed to stronger SHG networks, active NGO participation, and district-level support structures.

The statistical evidence supports the hypothesis that institutional and social factors, rather than just economic activity, drive women's empowerment in rural agricultural systems. Despite similar levels of labor participation, women in Darbhanga lag behind in access to training, credit, and collective bargaining platforms, indicating a disconnect between labor contribution and empowerment outcomes.

From a policy perspective, these findings suggest a multi-dimensional approach is needed to enhance women's empowerment in Makhana farming:

1. **Strengthening Self-Help Groups (SHGs):** Madhubani's success shows that SHGs can be catalysts for change. Scaling these models in Darbhanga could significantly improve women's agency and bargaining power.
2. **Gender-Sensitive Extension Services:** Most women in Darbhanga lacked exposure to training or support programs. There is an urgent need for women-focused agricultural extension, covering modern processing, financial literacy, and leadership skills.
3. **Improved Access to Credit and Formal Wages:** Informal labor arrangements and lack of financial inclusion continue to suppress women's economic potential. Microfinance institutions and cooperatives must be incentivized to offer targeted loan and insurance products for female workers in aquatic farming.
4. **Integration into Farmer Producer Organizations (FPOs):** Women are underrepresented in decision-making bodies. Facilitating women-led FPOs or integrating them into existing structures can increase access to markets, equipment, and state schemes.
5. **Recognition and Remuneration of Unpaid Labor:** Formalizing women's roles through wage structures, contracts, and social security can legitimize their contributions and reduce economic vulnerability.

Looking ahead, future research should explore how climate change and monsoon variability may affect Makhana pond ecosystems and impact women's labor routines. There is also a need for longitudinal studies tracking the effects of SHG participation on women's empowerment and household dynamics over time. Moreover, a value chain analysis that traces women's roles from pond to market would be invaluable for designing targeted interventions.

So, while Makhana cultivation offers considerable promise as a rural livelihood, its full potential will only be realized when women, who form its backbone are empowered not just as laborers but as equal stakeholders. Policy efforts must move beyond participation to focus on ownership, control, and leadership to build a truly inclusive Makhana economy in Bihar.

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