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Agricultural Feminization in Rural West Bengal Through Gendered Working Hour Dynamics and Structural Drivers in Cooch Behar District

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ABSTRACT: Women may assume a growing share of agricultural work without gaining corresponding control over resources or decisions. This study examines gendered working-hour patterns and perceived drivers of agricultural feminization in Cooch Behar district, West Bengal. An exploratory, ex-post facto investigation covered 100 farm women, with 25 respondents from each of four purposively selected villages in Cooch Behar-II and Dinhata-II blocks. Structured interviews provided information on agricultural working hours for 2022–2023, 2023–2024, and 2024–2025, household male migration and occupational categories, daily wage rates, and agreement with nine proposed drivers. Descriptive statistics, mean-score rankings, and exploratory principal component analysis were used. Reported average annual working hours increased for women from 1668.80 to 1736.50 h, a rise of 4.06%, while men's hours declined from 1503.20 to 1328.10 h, a decrease of 11.65%. Women reported more hours than men in all three years, and the annual gender gap widened from 165.60 to 408.40 h. The number of households classified as experiencing male out-migration rose from 37 to 49. Male migration received the highest perceived-driver score (4.45 out of 5), followed by poverty (4.29) and declining agricultural profitability (4.11). The reported component structure suggested socio-economic, capacity-related, gendered labour and technological dimensions. These patterns are consistent with an increasing concentration of agricultural labour among women, but do not establish causal effects or demonstrate empowerment. The purposive sample and the exploratory

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measures limit generalization. The findings motivate attention to women's workload, remuneration, access to agricultural services, and recognition as farmers.

Keywords: Agricultural feminization; Gender dynamics; Working hours; Migration; Structural drivers; Rural livelihoods

1. Introduction

Women increasingly shoulder agricultural work while continuing to face constraints on land, income, technology, and institutional support. This structural contradiction is central to the feminization of agriculture: greater labour participation need not confer greater authority or improve well-being [1,2]. Accordingly, an assessment of feminization must distinguish women's contribution to production from their ability to control resources and make decisions [3].

Agricultural feminization can involve an increase in women's relative labour contribution, a change in management responsibilities, or both. These dimensions need not move together. Labour-hour evidence describes work allocation, whereas managerial feminization requires information on decisions and control. Seasonal migration may be associated with women taking on farm-management roles, but such changes depend on household composition and the continued presence of other adult men [4]. The present study focuses on agricultural working hours and perceived livelihood pressures, rather than treating work participation as a direct measure of empowerment.

These processes are not confined to India. Migration and changing employment opportunities link household farming to wider labour markets, but their gendered consequences vary across institutional settings [3]. In Nepal, male out-migration has increased women's agricultural and household responsibilities while producing heterogeneous changes in authority [5]. In Guatemala, gender norms and market barriers can constrain women's farming opportunities even where men migrate [6]. A contrasting institutional example is Rwanda's land-registration pilot, which improved land access for legally married women and the recording of inheritance rights, although benefits were not uniform across marital-status groups [7]. These cases establish both the international relevance of the participation-resource gap and the possibility of institutional improvement.

Indian evidence likewise cautions against equating increased work with improved agency. Pattnaik and Lahiri-Dutt (2022) [2], studying West Bengal and Gujarat, documented rising labour burdens without corresponding benefits. Research in the Eastern Gangetic Plains shows that economic necessity can alter agricultural gender norms without removing the social constraints surrounding women's participation [8]. In West Bengal, occupational diversification is also an important household livelihood strategy [9]. Together, this literature motivates a village-level examination of how reported work hours, male occupational mobility, and perceived economic pressures occur alongside one another.

Cooch Behar provides a local setting in which to examine these relationships. The selected villages contain farm households with differing reported male migration and occupational patterns. Rather than extrapolating national trends to these settlements, the study compares women's and men's reported seasonal and annual working hours and records women's assessments of possible drivers. Its contribution is the integration of local time-use summaries and perception-based evidence; it does not identify the causal effect of migration or directly measure changes in empowerment.

The study addresses three research questions:

RQ1: What is the level and distribution of women's agricultural working-hour participation in the selected villages during 2024–2025?

RQ2: How do reported agricultural working hours differ between women and men across the three reference years, and within the two selected blocks?

RQ3: Which factors do respondents perceive as contributing to agricultural feminization, and how are these perceptions grouped in the exploratory component analysis?

Section 2 explains the research design, sampling, and measurement. Section 3 presents the numerical findings. Section 4 compares them with the wider literature and discusses implications and limitations; Section 5 concludes.

2. Methodology

2.1. Research Design and Analytical Framework

The study used an exploratory and ex-post facto design to describe agricultural feminization in selected villages of the Cooch Behar district. Migration, occupational choices, and household labour arrangements were observed as existing conditions; no intervention was assigned, and no explanatory variable was experimentally manipulated. The design is therefore descriptive and exploratory rather than a causal evaluation. Three agricultural reference years, 2022–2023, 2023–2024, and 2024–2025, organize the working-hour comparison.

Figure 1 shows the study setting and sampling sequence; Figure 2 links the research questions to separate evidence streams. Women's annual work-hour distributions address RQ1. Seasonal and annual gender comparisons, together with within-block contrasts, address RQ2. Agreement distributions, mean scores, and principal component analysis of the nine perceived drivers address RQ3. Household male migration and occupational categories provide descriptive context. The distinction between measured work patterns, respondents' perceptions, and literature-informed interpretation is maintained throughout.

2.2. Study Area

The study was conducted in the Cooch Behar district in northern West Bengal. The district was selected purposively because of the importance of agricultural livelihoods and women's involvement in farm operations. Two blocks, Cooch Behar-II and Dinhata-II, were selected purposively to examine local variation in agricultural participation and male occupational mobility.

The selected villages were Chat Singimari and Shooting Camp in Cooch Behar-II, and Durganagar and Kismat Dasgram in Dinhata-II. These agriculturally active settlements were chosen because farm women were directly engaged in agricultural activities, and variation in male participation and migration was observable. The selection was intended to support a localized exploratory investigation, not to provide a probability-representative district sample.

2.3. Sampling Framework and Data Collection

A multistage purposive sampling procedure was followed (Figure 1). The district, two blocks and two villages per block were selected purposively. At the respondent stage, 25 farm women were selected from each village, giving 50 respondents per block and 100 in total. Respondents were selected for their direct involvement in agricultural activities.

Primary data were collected through personal interviews using a structured interview schedule. The schedule covered women's and men's agricultural working hours, village wage rates, male household members' occupational and migration status, and perceived drivers of feminization. Working-hour information was organized by kharif, rabi, and zaid seasons for each of the three agricultural reference years. These reference years describe the period covered by the work-hour questions and are distinct from the dates and duration of the interview fieldwork.

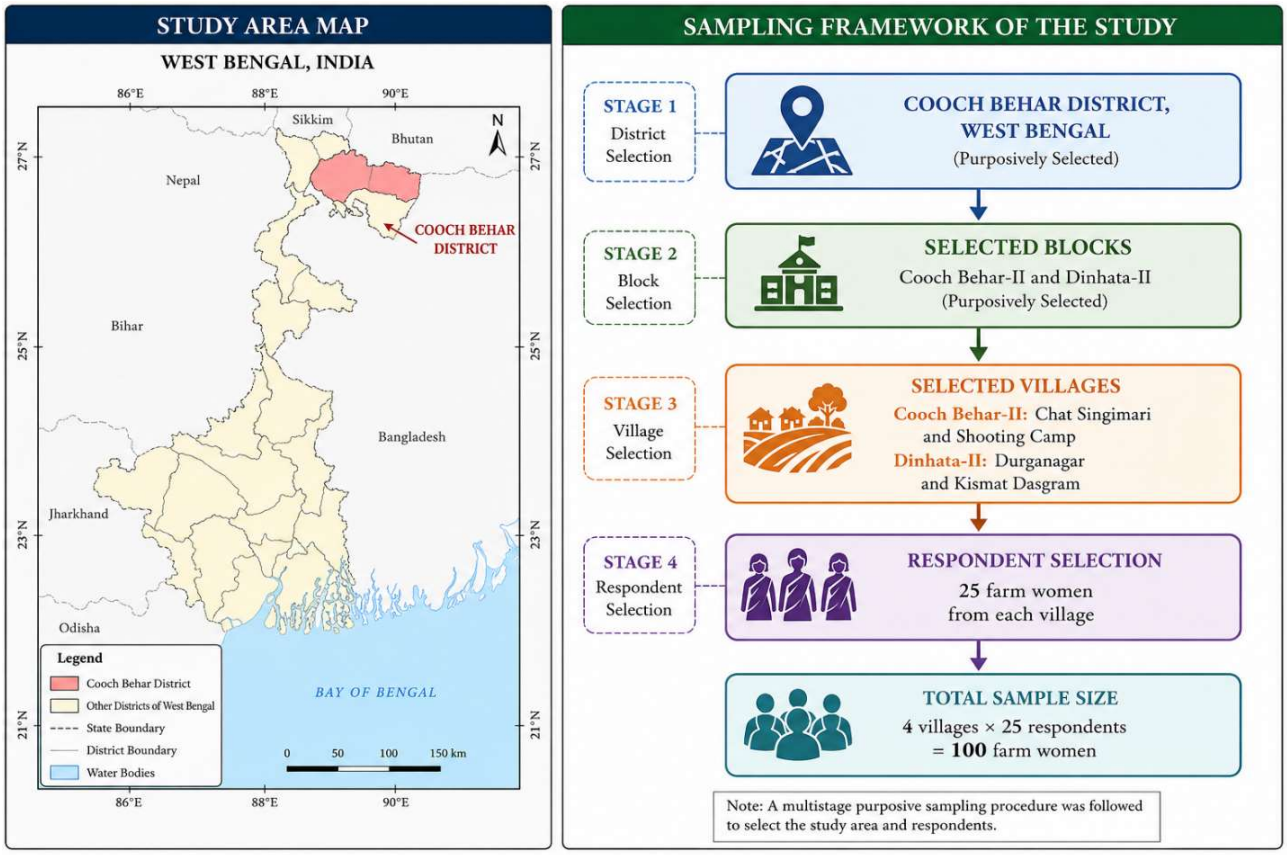


Figure 1. Geographic location of the study area and multistage sampling procedure.

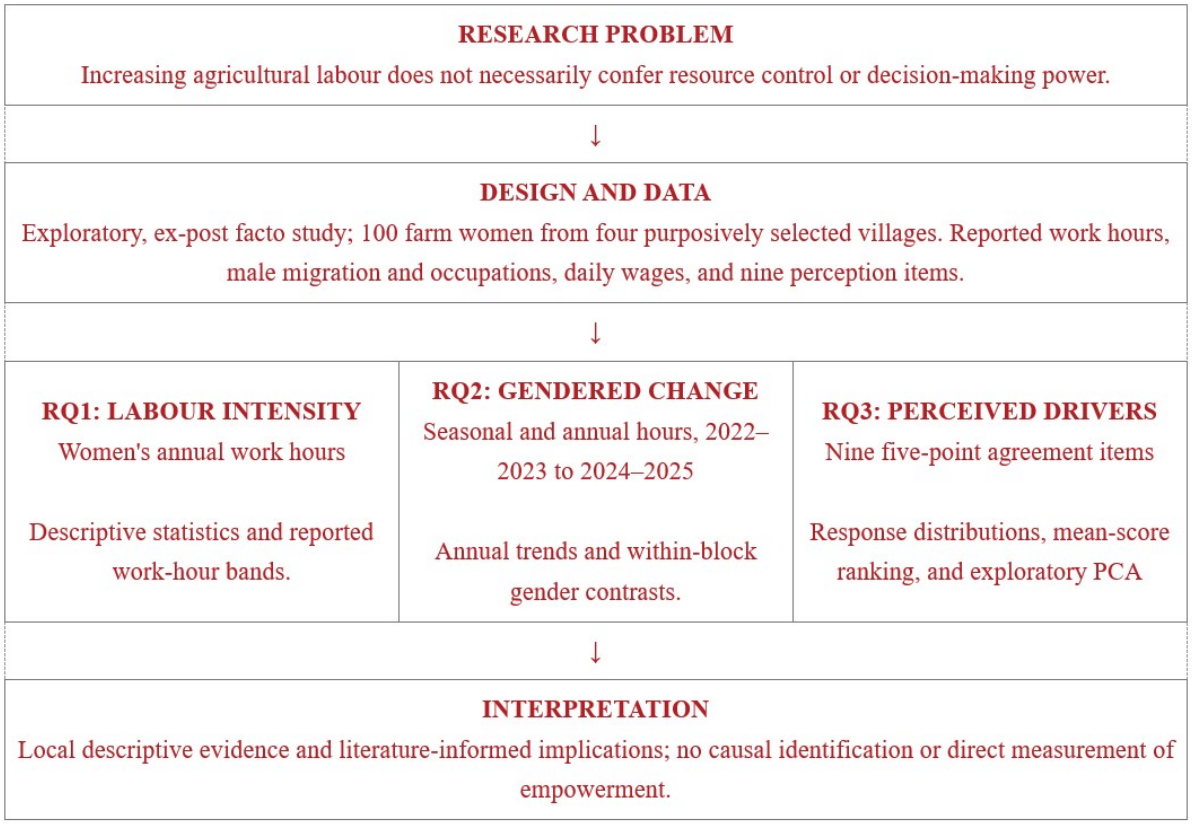


Figure 2. Research framework linking the study questions, measurements, and analysis. PCA = principal component analysis. Arrows show the analytical sequence, not estimated causal relationships.

2.4. Variables and Measurement

The principal outcome was women's reported annual agricultural working time, with men's reported hours used as a comparator. Annual hours were the sum of the three seasonal values. Agricultural feminization is interpreted here as a pattern of gendered labour allocation, not as a validated empowerment index. For descriptive presentation, the reported work-hour bands are labelled low, medium, and high labour intensity.

Household male migration and occupational categories were recorded separately from respondents' agreement with statements about possible drivers. Poverty, education, technology, and other proposed causes were measured as perceptions, not as independently estimated causal effects. Village wages were recorded in Indian rupees (INR) per day. Work hours and daily wages are presented separately; neither hours of family farm work nor their notional wage value is treated as realized income. Table 1 summarizes the variables.

Table 1. Variables used in the study and their measurement.

Variable	Analytical Role	Measurement
Women's annual agricultural working hours	Outcome	Reported total agricultural hours across kharif, rabi, and zaid.
Men's annual agricultural working hours	Comparator	Reported annual agricultural hours used for gender comparisons.
Women's work-hour category	Derived descriptor	Low, medium, and high bands as reported; a labour-intensity classification, not an empowerment scale.
Male migration status	Household descriptor	Counts of households classified as permanent or seasonal male out-migration.
Male occupational category	Household descriptor	Agriculture with marginal work, business, or service employment.
Male migration as a perceived driver	Perception item	Five-point agreement score, from 1 to 5.
Poverty	Perception item	Five-point agreement score, from 1 to 5.
Lack of off-farm income opportunities	Perception item	Five-point agreement score, from 1 to 5.
Technological advancement	Perception item	Five-point agreement score, from 1 to 5.
Declining agricultural profitability	Perception item	Five-point agreement score, from 1 to 5.
Lack of education	Perception item	Five-point agreement score, from 1 to 5.
Economic transition	Perception item	Five-point agreement score, from 1 to 5.
Traditionality in farm practices	Perception item	Five-point agreement score, from 1 to 5.
Gender difference in wage rates	Perception item	Five-point agreement score, from 1 to 5.
Village market wage rate	Economic descriptor	Reported male and female agricultural wage rates, INR per day.

The nine perception items are statements about proposed drivers. Agreement is not a measure of the size of a causal effect.

2.5. Measurement of Perception-Based Variables

Respondents indicated their agreement with each proposed driver on a five-point Likert scale (Table 2). Each item was analysed separately. Higher mean scores indicate stronger agreement that the item contributes to agricultural feminization. The full response distribution accompanies the mean ranking so that disagreement, neutrality, and heterogeneous responses remain visible.

For item j, the mean score was calculated as $M(j) = [5f(SA) + 4f(A) + 3f(N) + 2f(D) + f(SD)]/n(j)$, where f denotes the response frequency and n(j) is the number of responses to the item. SA, A, N, D, and SD denote strongly agree, agree, neutral, disagree, and strongly disagree, respectively.

Table 2. Likert response categories and scoring.

Response Category	Score
Strongly agree	5
Agree	4
Neutral	3
Disagree	2
Strongly disagree	1

2.6. Statistical Tools and Data Analysis

2.6.1. Descriptive Summaries and Work-Hour Comparisons

Means, standard deviations, and coefficients of variation describe working-hour distributions. The coefficient of variation is CV = 100 × SD/mean. Annual hours for each gender and reference year are the sum of the seasonal hours. Changes are expressed in hours and as a percentage of the earlier-year value. Within-block gender gaps are calculated as women's mean annual hours minus men's mean annual hours.

The reported within-block male-female mean contrasts and associated Z statistics concern gender differences within each block, not a comparison of women's hours between the two blocks. Statistical inference depends on the sampling unit, the variance estimator, and whether observations are paired within households. A sample exceeding 30 observations does not by itself establish that an independent-samples Z test is appropriate; linked observations require treatment of their dependence (NIST/SEMATECH, n.d.) [10]. The substantive comparison in this study, therefore, emphasizes the descriptive mean gaps.

2.6.2. Exploratory Principal Component Analysis

Principal component analysis (PCA) was used to summarize covariation among the nine perceived-driver items. PCA constructs linear combinations of the original variables to summarize variation; its components are data-dependent summaries rather than demonstrated causal mechanisms [11]. The rotated loading matrix presents the relationships between the perceived-driver items and the extracted components. Component labels follow the items with displayed loadings. A large loading indicates a strong relationship with a component, not a high average level of agreement, a technology-adoption rate, or evidence of empowerment.

2.7. Measurement Quality and Interpretive Scope

The work-hour measures and perception statements serve different purposes and should not be combined into a single empowerment score. The nine statements represent distinct proposed drivers; their item means are descriptive summaries of ordered responses. They are not treated as a validated unidimensional scale. Reliability and construct validity of the instrument, together with the accuracy of seasonal work-hour reporting, require separate assessment. The exploratory component structure does not substitute for such assessment.

The purposive selection limits inference to the participating respondents and villages. Comparisons across reference years describe reported work patterns and cannot, on their own, distinguish a migration effect from differences in landholding, crop choice, household composition, or other conditions. No direct measure of women's land ownership, control over income, or decision-making authority is used to establish empowerment.

3. Results

3.1. Status of Feminization in Agriculture

In 2024–2025, women's reported average annual agricultural working time was 1736.50 h (SD = 196.75; CV = 11.33%). Using the reported work-hour bands, 12 respondents were in the low category, 73

in the medium category, and 15 in the high category (Table 3). These categories describe variation in women's labour intensity within the sample, rather than degrees of empowerment.

Table 3. Distribution of respondents by reported annual agricultural work-hour bands, 2024–2025.

Category	Hours per Woman per Year	Number	Percentage
Low	<1540	12	12.00
Medium	1540 to <1900	73	73.00
High	1900 or more	15	15.00

n = 100. Mean = 1736.50 h; SD = 196.75 h; CV = 11.33%. The labels refer to reported work-hour bands.

3.2. Gender-Wise Trends in Agricultural Working Hours

Women's reported annual agricultural working time increased from 1668.80 h in 2022–2023 to 1705.30 in 2023–2024 and 1736.50 in 2024–2025 (Table 4). The corresponding annual increases were 2.19% and 1.83%, giving a total increase of 67.70 h (4.06%) over the period. Men's annual hours declined from 1503.20 to 1410.50 and then to 1328.10, a total decrease of 175.10 h (11.65%).

Women reported more hours than men in every year and each of the three seasons. The annual female-minus-male gap widened from 165.60 h in 2022–2023 to 294.80 in 2023–2024 and 408.40 in 2024–2025. Thus, the result is a widening of an existing gender difference, not a reversal, first occurring in 2024–2025.

Table 4. Reported seasonal and annual agricultural working hours by gender and reference year.

Reference Year	Gender	Kharif (h)	Rabi (h)	Zaid (h)	Annual (h)
2022–2023	Male	529.10	467.50	506.60	1503.20
2022–2023	Female	577.20	516.90	574.70	1668.80
2023–2024	Male	487.20	441.00	482.30	1410.50
2023–2024	Female	594.60	527.60	583.10	1705.30
2024–2025	Male	462.60	410.70	454.80	1328.10
2024–2025	Female	601.50	540.30	594.70	1736.50

3.3. Male Migration and Occupational Diversification

The number of households classified as experiencing male out-migration increased from 37 in 2022–2023 to 43 in 2023–2024 and 49 in 2024–2025 (Tables 5–7). Seasonal migration accounted for most of these cases, increasing from 36 to 41, then to 46 households; permanent migration increased from 1 to 2, then to 3. The category combining agriculture with marginal work declined from 53 to 47, then to 41 households, while the business and service categories remained at 7 and 3, respectively.

In 2024–2025, Cooch Behar-II recorded 18 seasonal and 1 permanent migration cases, compared with 28 seasonal and 2 permanent cases in Dinhata-II. These distributions describe the household context of the reported labour-hour patterns. They do not identify individual transitions between occupations or establish that migration caused the change in women's hours.

Table 5. Reported household male migration and occupational categories, 2024–2025.

Category	Chat Singimari	Shooting Camp	Durganagar	Kismat Dasgram	Total
Permanent migration	0	1	1	1	3
Seasonal migration	10	8	15	13	46
Agriculture with marginal work	12	13	7	9	41
Business	2	2	1	2	7
Service	1	1	1	0	3

Chat Singimari and Shooting Camp belong to Cooch Behar-II; Durganagar and Kismat Dasgram belong to Dinhata-II. Each village has 25 respondents. Counts sum to 100 within each reference year. The same to Tables 6 and 7.

Table 6. Reported household male migration and occupational categories, 2023–2024.

Category	Chat Singimari	Shooting Camp	Durganagar	Kismat Dasgram	Total
Permanent migration	0	0	1	1	2
Seasonal migration	6	9	14	12	41
Agriculture with marginal work	16	13	8	10	47
Business	2	2	1	2	7
Service	1	1	1	0	3

Table 7. Reported household male migration and occupational categories, 2022–2023.

Category	Chat Singimari	Shooting Camp	Durganagar	Kismat Dasgram	Total
Permanent migration	0	0	0	1	1
Seasonal migration	4	7	14	11	36
Agriculture with marginal work	18	15	9	11	53
Business	2	2	1	2	7
Service	1	1	1	0	3

3.4. Wage Rates of Male and Female Agricultural Workers

Reported male daily agricultural wages ranged from INR 400 to INR 500 across the villages, while female wages ranged from INR 300 to INR 400 (Table 8). The unweighted village averages were INR 462.50 for men and INR 350.00 for women. The difference was INR 112.50 per day, with the female average 24.32% below the male average. These are village-level wage summaries, not an adjusted estimate of pay differences for identical tasks and hours.

Table 8. Reported market wage rates for agricultural work by village.

Block	Village	Male (INR/Day)	Female (INR/Day)
Cooch Behar-II	Chat Singimari	500	300
Cooch Behar-II	Shooting Camp	450	350
Dinhata-II	Durganagar	400	350
Dinhata-II	Kismat Dasgram	500	400
All four villages	Unweighted mean	462.50	350.00

Daily wage rates cannot be multiplied directly by annual hours to obtain annual earnings. Such a calculation requires the duration of a paid working day and the allocation of hours between paid and unpaid work. The higher reported agricultural hours of women, therefore, do not demonstrate higher annual income.

3.5. Women's Working Hours by Household Type

The household-type tabulation reports the highest average annual female working time in households classified as experiencing male out-migration: 1871.02 h among 49 respondents (Table 9). The averages calculated from the displayed totals were 1514.15 h for agriculture with marginal work, 1524.29 h for business with occasional farming, and 1426.67 h for service employment with farming. These descriptive subgroup contrasts do not isolate a migration effect from other household differences.

Table 9. Reported women's annual agricultural work hours by household male occupational type, 2024–2025.

Household Type	Total Female Hours	Number of Women	Mean Hours per Woman
Male out-migration	91,680	49	1871.02
Agriculture with marginal work	62,080	41	1514.15
Business with occasional farming	10,670	7	1524.29
Service employment with farming	4280	3	1426.67

Subgroup means are the displayed total hours divided by the displayed number of women, rounded to two decimal places.

3.6. Gender Differences within the Selected Blocks

In Cooch Behar-II, women reported 1714.00 annual agricultural hours and men 1386.80, a female-minus-male gap of 327.20 h (Table 10). In Dinhata-II, the corresponding values were 1759.00 and 1269.40, giving a gap of 489.60 h. The descriptive gender gap was therefore larger in Dinhata-II. The two reported Z statistics refer to these within-block contrasts and do not test whether women's mean hours differ significantly between blocks.

Table 10. Reported within-block gender contrasts in annual agricultural hours, 2024–2025.

Block	Male Mean (h)	Female Mean (h)	Female − Male (h)	Reported Z
Cooch Behar-II	1386.80	1714.00	327.20	−7.2
Dinhata-II	1269.40	1759.00	489.60	−9.2

There were 50 female respondents per block. The Z sign follows the male-minus-female comparison. The table does not contain a between-block significance test.

3.7. Perceived Causes of Feminization in Agriculture

Male migration had the highest reported mean agreement score (4.45), followed by poverty (4.29), declining agricultural profitability (4.11), economic transition (3.93), and lack of off-farm income opportunities (3.88) (Table 11). Technological advancement had the lowest mean score (1.61). These scores summarize perceived contributions to feminization, not estimated causal effects.

Table 11. Reported ranking of perceived drivers of agricultural feminization.

Perceived Driver	Reported Mean	Reported Rank
Male migration	4.45	I
Poverty	4.29	II
Lack of off-farm income opportunities	3.88	V
Technological advancement	1.61	IX
Declining agricultural profitability	4.11	III
Lack of education	3.40	VI
Economic transition	3.93	IV
Traditionality in farm practices	2.91	VII
Gender difference in wage rates	2.52	VIII

Scores range from 1 (strongly disagree) to 5 (strongly agree). A higher score indicates stronger perceived contribution.

The response distributions show agreement or strong agreement from 89% of respondents for migration, 88% each for poverty and declining profitability, 77% for economic transition, and 73% for lack of off-farm opportunities (Table 12). For technology, 97% disagreed or strongly disagreed. Agreement was 61% for lack of education, 29% for traditionality, and 56% for wage differences. Low agreement with a proposed driver does not establish the absence of that condition in the villages.

Table 12. Respondents' agreement with the proposed drivers of agricultural feminization.

Perceived Driver	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Male migration	62 (62%)	27 (27%)	7 (7%)	2 (2%)	2 (2%)
Poverty	47 (47%)	41 (41%)	7 (7%)	4 (4%)	1 (1%)
Lack of off-farm income opportunities	36 (36%)	37 (37%)	12 (12%)	9 (9%)	6 (6%)
Technological advancement	0 (0%)	0 (0%)	3 (3%)	55 (55%)	42 (42%)
Declining agricultural profitability	29 (29%)	59 (59%)	8 (8%)	2 (2%)	2 (2%)
Lack of education	8 (8%)	53 (53%)	20 (20%)	9 (9%)	10 (10%)
Economic transition	25 (25%)	52 (52%)	15 (15%)	7 (7%)	1 (1%)
Traditionality in farm practices	4 (4%)	25 (25%)	35 (35%)	30 (30%)	6 (6%)
Gender difference in wage rates	46 (46%)	10 (10%)	27 (27%)	16 (16%)	1 (1%)

Values are the number of respondents (percentage); $n = 100$ for each item. Counts and percentages have been combined in each cell to avoid duplicate columns.

3.8. Principal Component Analysis of Perceived Causes

The reported rotated matrix grouped the nine items into four components (Table 13). Component 1 included migration (0.834), poverty (0.765), declining profitability (0.870), and economic transition (0.764). Component 2 included lack of off-farm opportunities (0.951) and lack of education (0.963). Component 3 included traditionality in farm practices (0.892) and gender wage differences (0.907). Component 4 was represented by technological advancement (0.961). The four-component solution accounted for 81.928% of the total variance.

Table 13. Reported rotated principal component loadings for the nine perceived-driver items.

Perceived Driver	Component 1	Component 2	Component 3	Component 4
Male migration	0.834	—	—	—
Poverty	0.765	—	—	—
Lack of off-farm income opportunities	—	0.951	—	—
Technological advancement	—	—	—	0.961
Declining agricultural profitability	0.870	—	—	—
Lack of education	—	0.963	—	—
Economic transition	0.764	—	—	—
Traditionality in farm practices	—	—	0.892	—
Gender difference in wage rates	—	—	0.907	—

A dash denotes a loading not displayed in the reported matrix, not a zero loading. Component labels are interpretive summaries of the displayed item groupings.

4. Discussion

The findings show a widening female-male difference in reported agricultural working time alongside increasing household male migration. The interpretation below distinguishes these descriptive patterns from possible explanations and separates the local findings from evidence reported in other settings.

4.1. Labour Feminization, Migration and Household Livelihoods

The simultaneous increase in women's reported hours and the decline in men's hours is consistent with a growing concentration of agricultural labour among women. The higher female hours reported for migration households, and the larger gender gap in Dinhata-II, are also compatible with labour substitution within households. However, aggregate work-hour and migration summaries do not establish whether migration preceded the change in hours, whether the same households moved between categories, or how

landholding and crop choice influenced the pattern. Migration should therefore be discussed as a plausible explanation supported by respondents' perceptions, rather than as a causally identified determinant.

This distinction helps position the findings within Indian research. Chandrasekhar et al. (2022) [4] show that seasonal migration can be associated with women's farm-management responsibilities, whereas the present study documents labour-time contrasts without measuring management directly. Pattnaik and Lahiri-Dutt (2022) [2] highlight how more agricultural work can coexist with limited gains in autonomy. The prominence of poverty and declining profitability in respondents' rankings is consistent with a necessity-based interpretation, but it does not prove that all participants experienced feminization as distress. Timsina et al. (2023) [8] similarly emphasize that changes in agricultural gender roles can occur within persistent social constraints. The local evidence is therefore better understood as an indication of changing work allocation than as a uniform empowerment or disempowerment trajectory.

4.2. International Comparisons and Institutional Alternatives

The Nepal comparison illustrates a common pattern but also an important limit. Spangler and Christie (2020) [5] describe women taking on additional farm and household responsibilities following male out-migration, with managerial changes varying across households. Cooch Behar's work-hour results are consistent with the workload aspect of that account. Unlike the Nepal study's qualitative investigation, however, this survey does not establish how authority was renegotiated. Similar labour patterns should not be assumed to imply identical changes in power.

Guatemala offers a contrasting outcome. Hernandez et al. (2023) [6] found that restrictive gender norms, market access, and women's aspirations could limit their assumption of crop-production roles even in high-emigration settings. Thus, men's absence need not automatically lead to the same form of agricultural feminization everywhere. Relative to that case, the Cooch Behar respondents report substantial agricultural work and perceive migration as important. The comparison points to the need to examine local tasks, alternative livelihoods, and household arrangements rather than generalizing one migration response across countries.

Rwanda's land-registration pilot provides an example of institutional improvement rather than simply increased labour participation. Ali et al. (2014) [7] reported better land access for legally married women, clearer inheritance recording, and increased soil-conservation investment, while identifying risks for women outside legally recognized marriages. This is not a direct test of agricultural feminization, but it demonstrates why resource rights and implementation design matter when seeking benefits for women farmers. For Cooch Behar, it motivates measuring control over resources alongside hours worked; it does not establish that the same intervention would produce identical outcomes locally.

4.3. Interpreting the Perception Rankings and Component Structure

The first two component groupings are consistent with a distinction between perceived economic pressures and constraints on alternative livelihood opportunities. The third combines traditional farm practices with wage differences and is better described as a gendered labour dimension than as a direct measure of household composition. The single-item technological component requires particular caution. Its high loading can coexist with the low technology mean because loadings describe response variation, whereas means describe agreement levels. It neither demonstrates widespread mechanization nor shows that technology increased women's participation. More generally, these exploratory groupings organize perceptions; they do not establish validated latent causes [11].

4.4. Implications for Agricultural Support

The combination of substantial reported female work hours and lower village daily wages motivates support that addresses both workload and opportunities. Extension activities could be scheduled around women's availability and include practical training suited to the farm operations they undertake. Recognition of women as farm operators, accessible service delivery, and opportunities to participate in producer organizations would address the participation-resource gap discussed in the wider agrifood literature [1]. These are literature-informed implications, not interventions evaluated by this study.

The importance respondents attach to migration and limited off-farm opportunities also argues against assuming that every woman should undertake more agricultural work. Support could include viable non-farm options, information on credit and market access, and services that help households manage seasonal labour constraints. The village wage differences justify closer examination of task allocation, workday length, and actual payments before attributing the entire difference to unequal pay for identical work. Technology support should begin with identifying women's tasks and preferences rather than assuming that mechanization is already a major local driver. Future programme assessment should measure workload, income control, and decision-making together, so that rising participation is not mistaken for improved well-being.

4.5. Limitations and Future Research

Several limitations qualify the findings. First, 100 respondents were purposively selected from four villages in two blocks. The results describe these respondents and cannot be treated as district-wide prevalence estimates. The selection of women already active in agriculture also excludes the experiences of women outside farming. Second, agricultural work hours are respondent-reported rather than independently observed time-use records. Earlier-year estimates may be particularly vulnerable to recall error if obtained retrospectively; the reference-year comparison should not be interpreted as evidence from a prospective panel without a documented repeated-observation design.

Third, the study does not control for landholding, crop mix, household composition, remittances, weather, or other factors that may shape labour allocation. It cannot isolate a causal effect of migration. Fourth, agreement with proposed drivers is distinct from direct measurement of poverty, resource access, or empowerment. The perception instrument's reliability and construct validity are not established by the descriptive rankings, and the exploratory PCA is not an independent validation exercise. Household dependence also matters for gender comparisons, so descriptive mean gaps and formal statistical inference must be distinguished.

Finally, reported village wages do not measure actual annual earnings, and agricultural hours do not capture the full burden of unpaid domestic and care work. Work-hour categories are sensitive to their chosen boundaries, while small household subgroups limit precision. Future research should use a larger probability-based sample, prospectively collected seasonal time-use data, and clearly linked household observations. A documented, piloted questionnaire and transparent component diagnostics would strengthen measurement. Direct indicators of land rights, income control, and decision-making, together with qualitative interviews, would help distinguish increased responsibility from improved agency.

5. Conclusions

The study documents an increase in women's reported agricultural working hours and a decline in men's hours across three reference years in the selected Cooch Behar villages. Women reported more agricultural work than men throughout the period, with a widening annual gap. Migration, poverty, and declining agricultural profitability were the most strongly endorsed perceived drivers. The findings are consistent with labor feminization occurring alongside changes in household livelihoods, but the design does not establish whether migration caused the changes or whether additional work improved women's empowerment.

The central implication is that women's growing agricultural contribution should be considered together with workload, remuneration, and access to resources. Agricultural support should recognize women as active farmers without assuming that greater participation alone is a desirable outcome. Stronger evidence on decision-making, income control, and alternative livelihood preferences is needed to guide such support. The present results provide a localized exploratory basis for that investigation rather than a district-wide or causal account of agricultural feminization.

Statement of the Use of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors used Grammarly to improve readability, grammar, and language clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Author Contributions

S.B.: Conceptualization, Literature search and review, Writing—original draft; L.D.: Conceptualization, Literature search and review, Writing—section; S.P.: Conceptualization, Literature search and review, Writing—section; K.K.D.: Literature search and review, Writing—section; P.B.: Literature search and review, Mapping; S.G.: Literature search and review, Writing—original draft, Editing and formatting, Supervision, Resources; S.C.: Conceptualization, Literature search and review, Writing—section; K.M.: Literature search and review, Writing—section; S.D.: Editing and writing; S.M.: Literature search and review, Writing—section. All co-authors read, commented, and approved the final manuscript.

Ethics Statement

The study was reviewed and approved by the Research Advisory Committee (RAC), Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya (Reference No. UBKV/Agril. Extn./180/25; approved on 19 August 2025). The study was conducted in accordance with the ethical guidelines and regulations of the Research Advisory Committee.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data may be made available upon reasonable request from the corresponding author.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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