INITIATIVE ON
Transforming Agrifood Systems in South Asia
CGIAR

Gendered impacts of training and factors influencing Good Agricultural Machinery Manufacturing Practices Adoption in Bangladesh

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INTRODUCTION

Agricultural mechanization is important in Bangladeshi agriculture, with over 90% of land preparation, irrigation, threshing, and pesticide application already mechanized. Meanwhile, mechanization in planting and harvesting, fertilizer application, and weeding are witnessing steady growth (Hossen, 2019; Seraj, 2020). The Agricultural-Based Light Engineering (ABLE) industry supports mechanization through its 2,000–2,500 workshops, which produce agricultural machinery and spare parts, contributing 20–25% of the country's equipment production and meeting 90% of the national demand (Inspira Advisory and Consulting Ltd., 2019; Seraj,2020).

Mechanization generates employment in both local machinery manufacturing and operational services, sectors that are predominantly men-dominated due to societal perceptions that women are physically weaker than men and unsuitable for performing difficult foundry operations (Inspira Advisory and Consulting Ltd., 2019; Husna, 2024). Gender inclusion in the ABLE sector lags behind other Light Engineering Industries (LEIs), such as electric goods and plastics, where women constitute 40–70% of production workers (BBS, 2018). LEIs have actively reduced gender inequality, facilitated by increased awareness and shifts in owner attitudes toward employing women (Majumder, 2022). In contrast, women in the ABLE sector are often restricted to manual roles such as grinding and painting, with minimal representation in highly skilled work or as entrepreneurs (Inspira Advisory & Consulting Ltd., 2019). While recent initiatives have sought to address these gender disparities, progress remains limited.

In 2023, approximately 376 women from regions including Bogura, Jashore, and Faridpur participated in skill enhancement training programs led by the Cereal Systems Initiatives for South Asia-Mechanization and Extension Activity (CSISA-MEA). Although such training initiatives represent progress, a significant knowledge gap persists regarding how gender roles influence the adoption of best manufacturing practices within the ABLE sector.

THE RESEARCH STUDY

To address the knowledge gaps in adoption of Good Agricultural Machinery Manufacturing Practices (GAMMP), a research study was conducted with the following objectives:

1. To examine gender differences in the willingness to adopt GAMMP among workers in the ABLE sector.
2. To assess GAMMP adoption levels across key dimensions among trained and untrained men and women workers in the ABLE sector.
3. To identify perceived barriers to GAMMP adoption among men and women workers in the ABLE sector.
4. To compare GAMMP adoption levels and factors influencing adoption between trained and untrained men and women workers in the ABLE sector.

METHODOLOGY

This study was conducted in Bogura district, North Bangladesh, to examine gender differences in the use and adoption of Good Agricultural Machinery Manufacturing Practices (GAMMP). Bogura was selected as the study site due to its high concentration of Agriculture-Based Light Engineering (ABLE) manufacturers, which supply approximately 90% of the national demand for agricultural machinery spare parts (Seraj, 2020). This makes the region an ideal setting for investigating GAMMP adoption.

The survey was carried out in February 2024 using a pre-tested questionnaire administered by trained enumerators who conducted the interviews in the local Bangla language to ensure clarity and accuracy.

A multi-stage sampling method was employed to select the respondents. A list of ABLEs in Bangladesh, maintained by the CSISA-MEA project of CIMMYT, served as the sampling frame. ABLE workshops were randomly selected from this list, and only those whose owners permitted employee participation were included. Among these workshops, workers who voluntarily agreed to participate were surveyed. The final sample included 747 respondents, comprising both men and women working in the ABLE sector. The sample included individuals who were either trained or untrained in GAMMP.

Respondents were asked about their willingness to adopt best practices in the workplace using a 5-point Likert scale, where 1 indicated "Not willing" and 5 indicated "Highly willing." The percentage distribution of respondents across different levels of willingness was calculated to capture variations. Adoption levels of GAMMP were assessed across six key dimensions: knowledge and awareness, skill development, productivity and efficiency, quality standards, environmental sustainability, and innovation and scaling. These dimensions align with established frameworks for evaluating technology adoption and implementation, as supported by relevant literature. For example, Diogo et al. (2022) proposed the AKAP sequence to bridge the gap between knowledge and adoption; Duckett et al. (2023) explored determinants of automation and robotics adoption; and Kumar et al. (2021) emphasized the integration of sustainability into technology innovation.

Further studies, such as Thompson et al. (2022) on sustainable agricultural practices, Mishra et al. (2022) on barriers to circular economy adoption, and Islam et al. (2020) on sustainability adoption in tourism, reinforce the applicability of these dimensions. Each dimension was evaluated using specific indicators measurable on a scale of 1 (Low) to 10 (High). For instance, knowledge and awareness were measured by respondents' understanding of GAMMP principles and access to training programs.

Respondents also reported perceived barriers to GAMMP adoption, categorized as either extrinsic or intrinsic factors. These barriers were recorded using a dichotomous variable, with "Yes" indicating a perceived barrier and "No" indicating its absence. Additional questions addressed broader factors influencing adoption, including external pressures and individual motivations, providing a comprehensive understanding of the challenges faced by workers.

Descriptive statistics were employed to summarize demographic characteristics and response patterns. Aravindakshan et al. (2021) demonstrated the use of Principal Component Analysis (PCA) as a composite index-building methodology. Building on this approach, we constructed an adoption intensity index across six dimensions, disaggregated by gender and training status. Mean scores and standard deviations were calculated to identify strengths and weaknesses in adoption levels. Percentage distributions were analyzed to identify common barriers across different respondent groups, including trained and untrained men and women. Gender-disaggregated analyses provided insights into differences in perceptions, adoption levels, and barriers, highlighting the distinct challenges and opportunities experienced by men and women in the sector.

Above: Habiba Khatun, 30, working in an Agriculture-Based Light Engineering (ABLE) workshop in Jashore, Bangladesh; photo: Abdul Momin

RESULTS

SOCIOECONOMIC CHARACTERISTICS OF THE RESPONDENTS

The summary statistics (Table 1) of the sample provide insights into the socioeconomic characteristics of different respondent categories—Untrained Men, Untrained Women, Trained Women, and Trained Men. Age differences highlight significant variations across groups. Untrained Women, with an average age of 26.46 years (SD: 7.27), are younger than their counterparts. Untrained Men are older, with a mean age of 34.83 years (SD: 7.39), significantly higher ($p < 0.01$) than Untrained Women.

Similarly, Trained Women have an average age of 36.98 years (SD: 6.81), which is moderately higher ($p < 0.05$) compared to the reference group (Untrained Women).

Trained Men fall between these extremes, with an average age of 30.97 years (SD: 8.79), significantly higher (**, $p < 0.01$) than Untrained Women.

Education levels reveal notable disparities. Untrained Women report the highest mean years of education at 5.32 years (SD: 2.71), which is significantly surpassed by Trained Men, who average 5.60 years (SD: 2.91; ***, $p < 0.01$). In contrast, both Untrained Men and Trained Women have lower education levels, averaging 3.79 years (SD: 2.54; ***, $p < 0.01$) and 3.29 years (SD: 2.19; non-significant), respectively, indicating a gendered trend where men generally report less formal education unless trained.

Table 1: Sample characteristics and summary statistics.

Socioeconomic variables	Untrained Men (n=197)	Untrained Women (n=169)	Trained Women (n=170)	Trained Men (n=211)
Age of the respondent (Years)	34.83*** (7.39)	26.46 (7.27)	36.98** (6.81)	30.97*** (8.79)
Education of the respondent (Years)	3.79*** (2.54)	5.32 (2.71)	3.29 (2.19)	5.60*** (2.91)
Monthly income of the respondent (BDT)	6240.24*** (1636.03)	5643.79 (783.22)	6661.08* (1579.34)	15639.35*** (3275.79)
Work hours of the respondent (hrs day^{-1})	8.17 (0.57)	8.11 (0.63)	8.11 (0.36)	8.27 (0.94)
Work weeks of the respondent (wk $month^{-1}$)	5.98 (0.23)	6.00 (0.25)	6.00 (0.00)	5.99 (0.15)
ABLE work experience for the respondent (Years)	4.25*** (4.00)	7.28 (4.95)	7.65*** (4.75)	11.45*** (7.18)

Notes: Values are presented as means with standard deviations in parentheses. Mean differences marked with, *, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, using "Untrained Women" as the reference group. BDT = Bangladeshi Taka."

Monthly income presents a stark differentiation. Untrained Women earn an average of 5643.79 BDT (SD: 783.22), which is significantly lower than the earnings of all other groups. Untrained Men earn 6240.24 BDT (SD: 1636.03), significantly higher (*, p < 0.01). Trained Women show slightly higher earnings at 6661.08 BDT (SD: 1579.34; , p < *0.05), while Trained Men report the highest income at 15639.35 BDT (SD: 3275.79), with a highly significant difference (*, p < 0.01) compared to Untrained Women. This suggests that training substantially enhances earning potential, particularly for men.

Work hours and work weeks display minimal variation across groups. Untrained Women work an average of 8.11 hours per day (SD: 0.63) and 6 weeks per month (SD: 0.25). Similar figures are reported by Untrained Men (8.17 hours/day, 5.98 weeks/month) and Trained Women (8.11 hours/day, 6 weeks/month). Trained Men show a slightly higher average of 8.27 hours per day (SD: 0.94), but none of these differences are statistically significant, indicating consistent work patterns across categories.

Work experience reflects substantial disparities. Untrained Women report 7.28 years (SD: 4.95) of experience, which is significantly lower than Trained Men, who exhibit the most experience at 11.45 years (SD: 7.18; , p < 0.01). Untrained Men, with 4.25 years (SD: 4.00), show the least experience, significantly lower than Untrained Women (, p < 0.01). Trained Women average 7.65 years (SD: 4.75), significantly higher (***, p < 0.01) than the reference group, indicating that training may correlate with enhanced experience in certain contexts.

WILLINGNESS TO EMBRACE BEST MANUFACTURING PRACTICES AT WORKPLACE

The willingness of men and women to adopt best manufacturing practices at the workplace reveals notable gender-based trends and varying levels of motivation (Fig.1). The analysis indicates a limited proportion of respondents expressing strong enthusiasm toward adoption, with only 1.7% of men reporting being "highly willing" and no women falling into this category. This highlights a general lack of strong commitment among both groups, particularly women.

In the "very much willing" category, the proportions of men (26.0%) and women (27.7%) are relatively similar, reflecting comparable levels of strong willingness. However, the majority of respondents expressed moderate willingness. Specifically, 31.9% of men and 28.9% of women reported being "moderately willing," while the largest share of both groups—34.3% of men and 31.9% of women—indicated they were "slightly willing." These results suggest that while respondents are open to adopting these practices, stronger motivation is lacking.

Above: Worker practicing grinding in Bangladesh; photo: Abdul Momin

A higher proportion of women (11.5%) reported being "not willing" compared to men (6.1%), pointing to potential barriers faced by women in adopting these practices. These barriers could include limited access to training, workplace constraints, or other structural challenges. This discrepancy underscores the need for targeted efforts to address these issues and enhance women's willingness to participate.

Overall, the findings suggest that both men and women exhibit relatively moderate levels of willingness, with most respondents falling into the "slightly willing" and "moderately willing" categories. Addressing this requires a focus on improving perceived benefits and providing supportive workplace environments. Tailored interventions, particularly for women, could help address specific barriers and increase adoption levels. Practical steps may include targeted training, incentives, and organizational support to encourage stronger willingness and engagement with best manufacturing practices.

Above: Jannatul Ferdaus, a female trainee student from Kushtia Polytechnic Institute, demonstrates welding techniques during her training at Kushtia Engineering Works in Kushtia, Bangladesh; photo: CIMMYT

DIMENSIONS OF DEFINING ADOPTION LEVELS AMONG THE RESPONDENTS

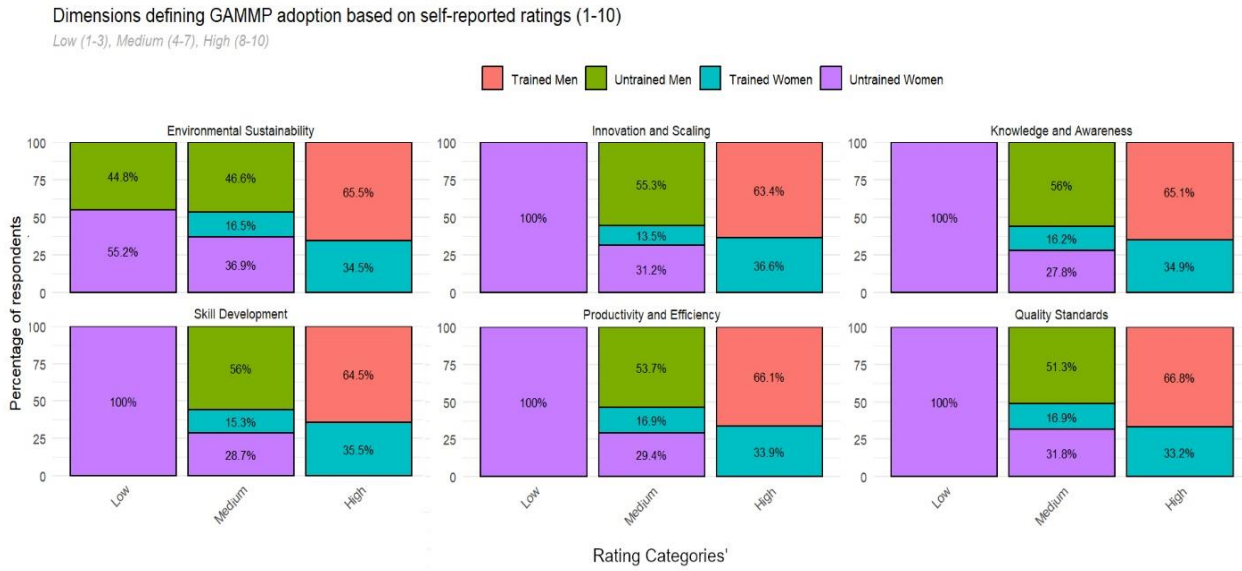

Figure 1: Dimensions defining GAMMP adoption. The x-axis of the plots represents 'Rating Categories': Low (1–3), Medium (4–7), and High (8–10). The percentage values within each stack of the bar plot indicate the share of responses from each respondent group within these rating categories.

The plotted dimensions of GAMMP adoption (Fig. 1) reveal stark differences across respondent groups based on training and gender, emphasizing the critical role of training in fostering higher adoption levels. Trained Men consistently exhibit the highest proportions in the "High" category across all dimensions, ranging from 63.4% in Innovation and Scaling to 66.8% in Quality Standards, showcasing their significant advantage in adopting GAMMP practices. Trained Women also perform better than untrained groups, with notable improvements such as 36.6% in the "High" category for Innovation and Scaling and 33.9% for Productivity and Efficiency; however, their scores remain lower than those of Trained Men, highlighting the presence of structural or societal barriers.

Conversely, Untrained Women overwhelmingly dominate the "Low" category in nearly all dimensions, particularly Skill Development and Productivity and Efficiency, where 100% of their responses fall in the lowest range, underscoring their significant disadvantages in adoption. Untrained Men, while slightly better than Untrained Women, also demonstrate limited representation in the "High" category, with percentages like 29.4% for Productivity and Efficiency and 31.2% for Innovation and Scaling. These findings underscore the transformative impact of training on improving adoption levels, particularly for men, while simultaneously highlighting the urgent need for gender-sensitive interventions to address the persistent gaps experienced by women in both trained and untrained groups.

GENDER-DIFFERENTIATED ADOPTION INTENSITY LEVELS

The violin plot (Fig. 2) and summary statistics of adoption intensity (Table 2) provide a detailed overview of the scaled Adoption Intensity Index across four groups categorized by training status and gender: Trained Men, Trained Women, Untrained Men, and Untrained Women. The adoption intensity is divided into three levels—Low (0–0.33), Medium (0.34–0.66), and High (0.67–1.00)—with clear thresholds visually demarcated by dashed red lines in the plot. Together, these findings underscore the critical interplay of training and gender in influencing the adoption of GAMMP practices.

Trained Men exhibit the highest adoption intensity, with a mean score of 0.87 and a median of 0.87.

The narrow range of scores (0.76 to 1.0) and low standard deviation (0.05) reflect a highly consistent and concentrated distribution in the "High" adoption level. This suggests that targeted training interventions effectively enhance adoption intensity for this group, likely by providing improved access to knowledge, skills, and awareness. These findings highlight the strong impact of training on achieving uniformly high adoption outcomes among men.

In comparison, Trained Women demonstrate a slightly lower adoption intensity, with a mean of 0.75 and a median of 0.76. While the scores are concentrated in the "Medium" to "High" levels, the range (0.61 to 0.91) and standard deviation (0.06) indicate greater variability compared to their male counterparts.

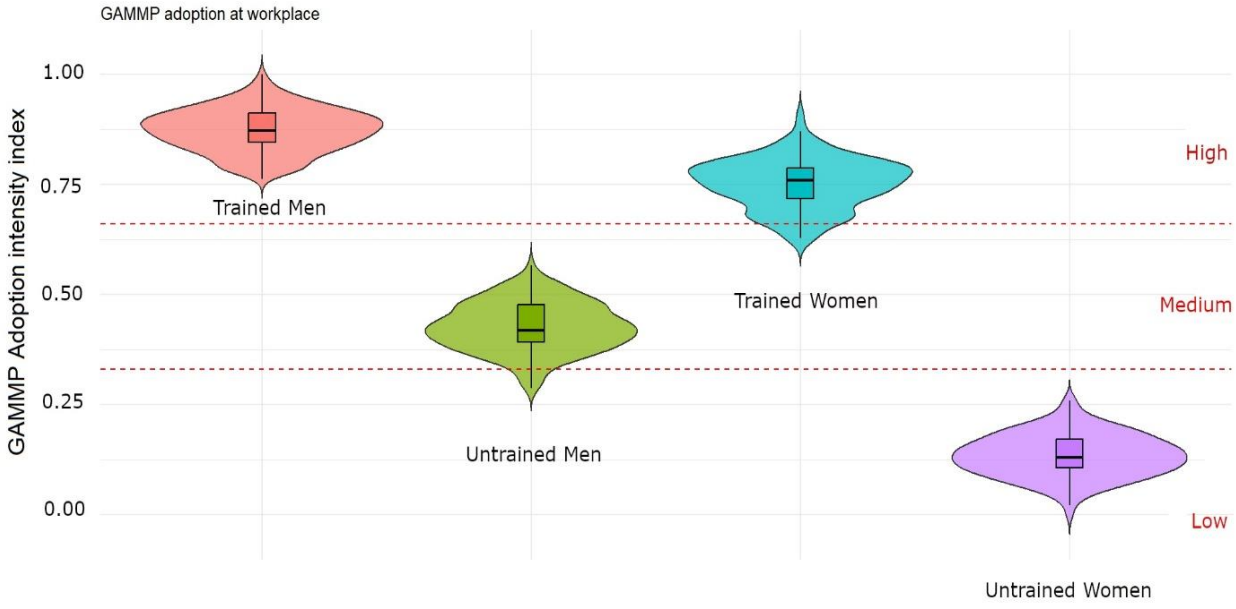

Figure 2: Violin plot illustrating the distribution and relative positions of trained and untrained men and women regarding GAMMP adoption at the workplace.

This suggests that training positively influences women's adoption intensity but does not fully eliminate systemic challenges such as societal constraints, resource access, or decision-making limitations. Tailored interventions addressing these barriers are essential to help women achieve adoption levels comparable to men.

Untrained Men show considerably lower adoption intensity, with a mean of 0.43 and a median of 0.42. The scores are concentrated in the "Low" to "Medium" adoption levels, with a range of 0.29 to 0.57 and a standard deviation of 0.06. While some individuals in this group exhibit moderate adoption levels, the overall low mean and median highlight the limited engagement with GAMMP practices without training. This finding underscores the importance of formal training in fostering behavioral change and enhancing adoption levels.

Untrained Women represent the lowest-performing group, with a mean adoption intensity of 0.13 and a median of 0.13. The narrow range (0.0 to 0.26) and low standard deviation (0.05) reflect a consistently low level of adoption intensity concentrated in the "Low" range.

The flat and narrow distribution seen in the violin plot further emphasizes the compounded challenges faced by untrained women. These findings highlight the urgent need for gender-specific training programs and interventions to address structural and social barriers that limit adoption for this group.

Comparison Across Groups reveals the critical role of training in elevating adoption intensity, as both trained men and women significantly outperform their untrained counterparts. However, the effect of training is more pronounced among men, who achieve higher mean scores, and narrower distributions compared to women. This disparity suggests systemic gendered challenges, such as cultural norms, resource inequities, and decision-making constraints, that limit the full impact of training for women. Untrained groups, particularly untrained women, exhibit the lowest adoption intensities, further reinforcing the necessity of targeted training programs.

Table 2: Adoption intensity across trained and untrained men and women in the study sample

Respondent group	Count	Mean	Median	Std_Dev	Min	Max
Trained Men	211.00	0.87	0.87	0.05	0.76	1.00
Trained Women	170.00	0.75	0.76	0.06	0.61	0.91
Untrained Men	197.00	0.43	0.42	0.06	0.29	0.57
Untrained Women	169.00	0.13	0.13	0.05	0.00	0.26

BARRIERS TO GAMMP ADOPTION

Perceived barriers to GAMMP adoption (Table 3) vary across gender and training status, highlighting key challenges faced by different respondent groups. Lack of awareness emerged as the most significant barrier, particularly for trained women (86.55%) and untrained women (84.95%), underscoring a persistent need for targeted communication and outreach efforts. Insufficient training was another notable constraint, affecting 63.74% of trained women and 70.87% of untrained women, suggesting gaps in the depth or accessibility of training programs. Time constraints were more pronounced among men, with 36.27% of untrained men and 33.53% of trained men citing this issue, compared to 27.48% and 19.90% of trained and untrained women, respectively.

High implementation costs were less commonly reported but remained a concern, particularly among trained men (19.16%) and untrained men (17.16%).

Resistance from management or colleagues was the least frequently mentioned barrier, affecting only a small proportion of respondents, with trained men (10.78%) reporting it slightly more than other groups. These findings emphasize the importance of addressing both gender-specific and general barriers to foster equitable and widespread adoption of GAMMP practices.

Above: Workers receiving training in an ABLE workshop; photo: Fazlul Karim, CIMMYT

Table 3: Perceived barriers to GAMMP adoption by gender and training status, showing the percentage of respondents identifying key challenges

Perceived barriers to GAMMP	Trained Men (%)	Trained Women (%)	Untrained Men (%)	Untrained Women (%)
Lack of Awareness	73.05	86.55	58.33	84.95
Insufficient Training	60.48	63.74	62.25	70.87
Time Constraints	33.53	27.48	36.27	19.90
High Implementation Costs	19.16	14.61	17.16	12.13
Resistance from Management/Colleagues	10.78	9.94	4.41	9.70

FACTORS INFLUENCING GAMMP ADOPTION

The factors influencing GAMMP adoption (Table 4) among men and women reveal notable similarities and differences in their perceived importance. Intrinsic factors, such as perceived benefits and self-satisfaction, are ranked as the top motivators for both genders, with 60% of men and 55% of women identifying perceived benefits as the most significant driver. Self-satisfaction and motivation follow as the second most important intrinsic factor, with slightly higher emphasis among women (45%) compared to men (40%). This highlights the critical role of personal motivation and perceived advantages in shaping adoption behavior across genders.

Extrinsic factors demonstrate more variation in perceived importance. Training and education emerge as the leading extrinsic motivators for both men (32%) and women (30%), underscoring the value of skill-building initiatives in facilitating adoption. However, peer influence and social norms hold greater significance for women (25%) than men (15%), suggesting a stronger reliance on social dynamics among female respondents. In contrast, men place higher importance on incentives and recognition (23%) compared to women (18%). Other factors, such as management support, workplace environment, and organizational culture, rank consistently lower for both genders, indicating that broader organizational aspects may play a less critical role in influencing GAMMP adoption.

Table 4: Factors influencing GAMMP adoption, ranked by perceived importance among men and women, with corresponding percentage of respondents.

Factors affecting GAMMP adoption	Perceived Ranking (Men)	% Respondents (Men)	Perceived Ranking (Women)	% Respondents (Women)
A. Intrinsic				
Perceived Benefits	1	60%	1	55%
Self-Satisfaction and Motivation	2	40%	2	45%
B. Extrinsic				
Training and Education	1	32%	1	30%
Incentives and Recognition	2	23%	3	18%
Peer Influence and Social Norms	3	15%	2	25%
Management Support and Supervision	4	13%	4	11%
Workplace Environment	5	10%	5	10%
Organizational Culture and Leadership	6	7%	6	6%

CONCLUSIONS

This study examined the gendered impact of training and the factors influencing the adoption of Good Agricultural Machinery Manufacturing Practices (GAMMP) in Bangladesh, with a focus on understanding adoption levels, barriers, and enabling factors among trained and untrained men and women. The research aimed to provide evidence-based insights to enhance adoption rates and address gender disparities in agricultural machinery manufacturing in the ABLE sector.

A structured survey was conducted among a sample of trained and untrained men and women, encompassing both adopters and non-adopters of GAMMP. Quantitative data on socioeconomic characteristics, perceived barriers, and willingness to adopt were analyzed. Statistical techniques, including descriptive and inferential analyses, were employed to identify key factors affecting adoption and assess the impact of training across gender categories.

The findings reveal that willingness to adopt GAMMP is notably higher among trained respondents compared to their untrained counterparts, indicating the pivotal role of training in driving adoption. However, the current adoption level remains moderate, with men exhibiting a slightly higher adoption rate than women, highlighting persisting gender disparities. Trained individuals, irrespective of gender, showed greater self-efficacy and awareness of GAMMP benefits, but adoption gaps persist due to structural and societal constraints.

Barriers to GAMMP adoption include lack of awareness, insufficient training, time constraints, and resistance from colleagues or management, with women perceiving these barriers more acutely. Key factors influencing adoption were intrinsic motivations, such as perceived benefits and self-satisfaction, alongside extrinsic factors like training, incentives, and peer influence. Gender-specific differences in these factors were evident, with men ranking workplace environment and management support higher, while women emphasized peer norms and incentives.

Policy interventions must prioritize gender-responsive training programs to address the unique challenges faced by women in adopting GAMMP. Efforts should focus on enhancing awareness and capacity-building initiatives, coupled with targeted incentives and recognition mechanisms to promote adoption across all groups. Addressing structural barriers through organizational reforms and fostering supportive workplace environments will be crucial for achieving equitable and sustainable adoption of GAMMP practices.

Above: A woman worker in an ABLE workshop skillfully preparing molds in Jashore, Bangladesh; photo: Sahib Nihal, CIMMYT

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Above: Workers participate in specialized foundry training in Bogura, Bangladesh; photo: Abdul Momin

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ABOUT TAFSSA

TAFSSA (Transforming Agrifood Systems in South Asia) is a CGIAR Regional Integrated Initiative that supports actions improving equitable access to sustainable healthy diets, boosts farmers' livelihoods and resilience, and conserves land, air, and water resources in a climate crisis.

ABOUT CGIAR

CGIAR is a global research partnership for a food-secure future. Visit https://www.cgiar.org/research/cgiar-portfolio to learn more about the initiatives in the CGIAR research portfolio

ABOUT CSISA-MEA

USAID-funded project CSISA-MEA aims to support the growth and expansion of agricultural mechanization in Bangladesh by making it affordable for smallholder farmers to access cost and resource-saving machinery for sowing, irrigation, harvesting, and other agricultural activities. CSISA-MEA assists various market actors across the value chain, including machinery manufacturers, importers, retailers, dealers, mechanics, spare parts vendors, and local service providers who deliver services directly to farmers.

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