Publisher homepage: www.universepg.com, ISSN: 2707-4625 (Online) & 2707-4617 (Print)
https://doi.org/10.34104/ijmms.024.05013
International Journal of Material and Mathematical Sciences
Journal homepage: www.universepg.com/journal/ijmms

Optimizing Rice Milling in Bangladesh: A Comprehensive Analysis of Semi-Automatic Processes with Modern Machinery

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ABSTRACT

This study investigates the inclusion of modern machinery into the rice milling process in Bangladesh. The investigation spanned three districts-Dinajpur, Kushtia, and Mymensingh. Data collection involved personal interviews employing semi-structured questionnaires and Focus Group Discussions, covering aspects such as mill types, ownership status, existing products, milling machinery varieties, and the total commissioning cost of mills/sections. Employing a primary descriptive statistical method, the study aimed to assess the current status of rice milling, specifically semi-automated processes utilizing modern machinery, focusing on type, capacity, and technological aspects. The research revealed milling costs for semi-automatic operations without modern equipment at Tk.2954 and those with modern equipment at Tk.3460. Whole rice recovery rates were 66.25% and 64.75%, respectively. Semi-automatic rice mills exhibited a capacity range of 1.15-1.75 t/h, with a utilization rate of 40%. The estimated benefit-cost ratios (BCRs) were higher for semi-automatic mills, both with and without modern equipment, at 1.48 and 1.64, respectively. Staff requirements for semi-automatic operations without modern equipment and those with modern equipment were reported as 9.13 and 4.50 person-hours per ton of paddy processing, respectively. These findings serve as a valuable foundation for making well-informed decisions and offering guidance to policymakers, industry stakeholders, and entrepreneurs in optimizing the benefits of automation for the sustainable and competitive rice production in Bangladesh.

Keywords: Automatic milling, Modern equipment, Capacity, BCR, Modern machinery, Rice, and Cost.

INTRODUCTION:

Rice is paramount in Bangladesh, constituting 80% of the cultivated land and yielding approximately 34.36 million metric tons of clean rice during 2013-2014 from an overall rice area of 11.37 million hectares (Ahmmed, 2014; Nath *et al*., 2016). The processing of total paddy produced in the country is predominantly carried out by various types of mechanized rice mills, including the well-known Engelberg huller (traditional and husking rice mill), Semi-automatic rice mill, and Automatic rice mill, each operating with different capacities across the nation (Nath *et al*., 2021). The Department of Food categorizes rice mills into Husking, Semi-automatic, and the Automatic types, numbering

14,239, 457, and 142, respectively, with a combined fortnight capacity of 625,000 tons (Rahman *et al.*, 2011). Additionally, the country has around 100,000 traditional Engelberg-type rice hullers (Bhuiyan *et al.*). Labor engagement in traditional rice hullers, husking, semi-automatic, and automatic rice mills involves approximately 100,000, 142,390, 13,710, and 6,248 workers, respectively. Despite its significant contribution, the rice milling sub-sector in Bangladesh is still recognized as a non-formal sector, receiving limited government facilities and incentives compared to the industrial sector. Rice milling involves processing harvested, threshed, and dried paddy to produce polished or clean white rice kernels (Paul *et al.*, 2020). It is a crucial post-harvest process that transforms paddy into whole rice, broken rice, rice bran, and husk. Approximately 90% of produced paddy in Bangladesh undergoes parboiling (Huda *et al.,* 2019b). Among these, 20% of parboiled and 10% of dry-processed paddy is treated in rice mills using rubber-roll hullers. Of the total nationally produced paddy, 30% is processed by households and does not enter the market, while the remaining 70% is processed in various medium to large rice mills (Dasgupta, 2001). Engelberg-type steel hullers dominate rice milling in Bangladesh, incurring substantial losses in whole rice recovery (Nath *et al.*, 2017). However, the establishment of more automatic and semi-automatic rice mills employing rubber-roll hullers is increasing, aiming for improved head rice and bran recovery. In husking mills, mixing bran and husk during the milling process diminishes the quality of rice bran. The conversion of Engelberg rice hullers to modern mills has the potential to save 2-4% of whole rice loss. An annual milling volume of around 27 million tons of paddy could save 0.648 million tons of milled rice, approximately a quarter of the country's total rice deficit (Kabir *et al*., 2008). Huda *et al.* (2019a) suggest that adopting modern rubber roll milling technology could lead to an average food savings of 4.5%, resulting in a yearly national average of about 1.55 million tons. Rice milling holds significant importance in Bangladesh as a sub-sector. However, there has been a limited effort to assess its current status concerning business scale, technological advancements, and the value and marketing chains of products and processing machinery. (Ahmed, 1999) identified three primary channels within the rice milling sub-sector: the imported machinery and equipment channel, the local manufacturing of rice mill machines and equipment channel, and the rice processing channel (Raha *et al.,* 2013). The landscape of the rice milling sector in Bangladesh is undergoing notable changes. Currently, there are approximately 17,000 husking mills in the country. The establishment of new semi-automatic and automatic rice mills is rising, intensifying competition for the numerous small and medium husking mills. Over the past decade, many automatic and semi-automatic rice mills have emerged in various rice-producing regions. Districts like Naogaon, Chapainawabganj, Dinajpur, Kushtia, and Jessore have particularly attracted investments to establish large automatic rice mills. In 2005, there were only 200 semi-automatic and automatic rice mills in the country. However, by 2011, this number had tripled to surpass 600 (\)

There has been a growing demand for high-quality rice in the market, with consumers seeking fresh and superior-grade rice. Consequently, rice milled in husking mills is experiencing a decline in order. Reports indicate a swift rise in automatic and semi-automatic rice mills, coinciding with the closure of husking mills. This shift is attributed to the adoption of advanced technologies in automatic and semi-automatic rice mills, offering higher capacity and techno-logical advantages compared to husking and semi-automatic rice mills. Given these circumstances, establishing many automatic and semi-automatic rice mills seems inevitable. However, there has been a lack of substantial studies addressing the economic transition in this domain. To address this gap, the current study aims to assess the status of semi-automatic rice milling in Bangladesh, identifying constraints and opportunities for improvement. The study also explores interventions that can enhance technology in this sector. To determine the present status of semi-automatic rice milling in terms of type, capacity, and technology.

METHODOLOGY:

Based on the growth and concentration of rice and rice mills (clusters), the study was conducted in 3 districts of Bangladesh. The districts were Dinajpur, Kushtia, and Mymensingh. Besides, Mymensingh and Dinajpur are rice surplus areas, and Kushtia has a big rice milling hub. Based on these rice milling hubs/clusters,

three districts (**Table 1**) are considered research areas in this study. An auto rice mill was also selected in the Panchagargh district for additional information on the machinery value chain. This study employed a comprehensive methodology to investigate the present status of rice milling in Bangladesh, focusing on critical aspects such as demand and supply of Business Development Services (BDS), operational costs of rice mills, and the performance of the supply chain. The survey questionnaire, developed through collaboration with key informants and experts, consisted of two sets addressing both the demand and supply sides of BDSs alongside a checklist for Key Informants (KIs). Rigorous pre-testing ensured the refinement of these instruments. Data collection involved personal interviews using semi-structured questionnaires and participatory Focus Group Discussions (FGDs). The interview process prioritized clarity, with each question explained thoroughly to respondents to ensure accurate information retrieval. FGDs incorporated appropriate participatory tools and techniques, enhancing the depth and richness of insights. The analytical approach employed a simple descriptive statistical method, with data calculated in Excel format for the computation of operational costs of rice mills. This format allowed for easy modification or refinement of data, facilitating the automatic calculation of operating expenses. Additionally, a mathematical model was developed and simulated using STELLA software to assess the performance of the rice milling supply chain in Bangladesh. The data collection on the present status of rice milling covered a wide range of variables, including mill types, ownership status, existing products, types of milling machinery, total commissioning costs, and details of various processes such as cleaning, soaking, steaming, drying milling, capacity utilization, and rice recovery.

Table 1: Semi-automatic Rice mill.

Rice mill	Covered			Total
	Dinajpur	Kushtia	Mymensingh	
Semi-automatic Rice mill	14	9	15	38

Table 2: Sample distribution for the leading actor in the survey.

Actor	Dinajpur	Kushtia	Mymensingh	Total
Paddy aratdar	10	08	10	28
Rice wholesaler	12	10	08	30
Rice retailer	20	12	10	42
Rice mill machinery manufacturer	04	02	01	07
Rice mill Machinery Importer, Dhaka	-	-	-	01

Semi-automatic Rice Mill

Semi-automatic rice mills are those in which rice processing operations are done with either an improved or modern boiler, drying in a threshing floor/dryer and milling with a rubber roll huller. The process involves cleaning paddy, steaming, sun drying/mechanical drying, milling with a rubber-roll sheller, polishing, aerating, bagging, and weighing. Rice produced in a semi-automatic rice mill is well-polished and less broken. Husk and bran are obtained separately and are better used in briquette and edible oil extraction. The flow chart of a semi-automatic rice mill is shown in **Fig. 1**.

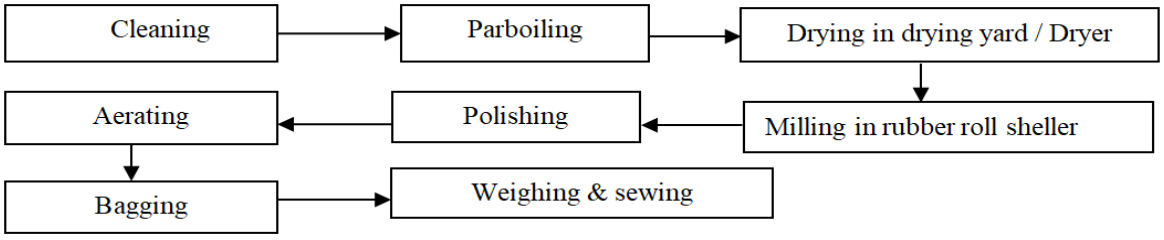

Fig. 1: Flowchart of a semi-automatic rice mill.

Value addition of fine rice processing in the semi-automatic mill with modern equipment

Value chain analysis of parboiled fine rice processed by semi-automatic rice mills with modern equipment indicated that miller (71.81%), retailing (12.17%), and wholesaling (12.17%) constituted the major value additions (**Fig. 2**).

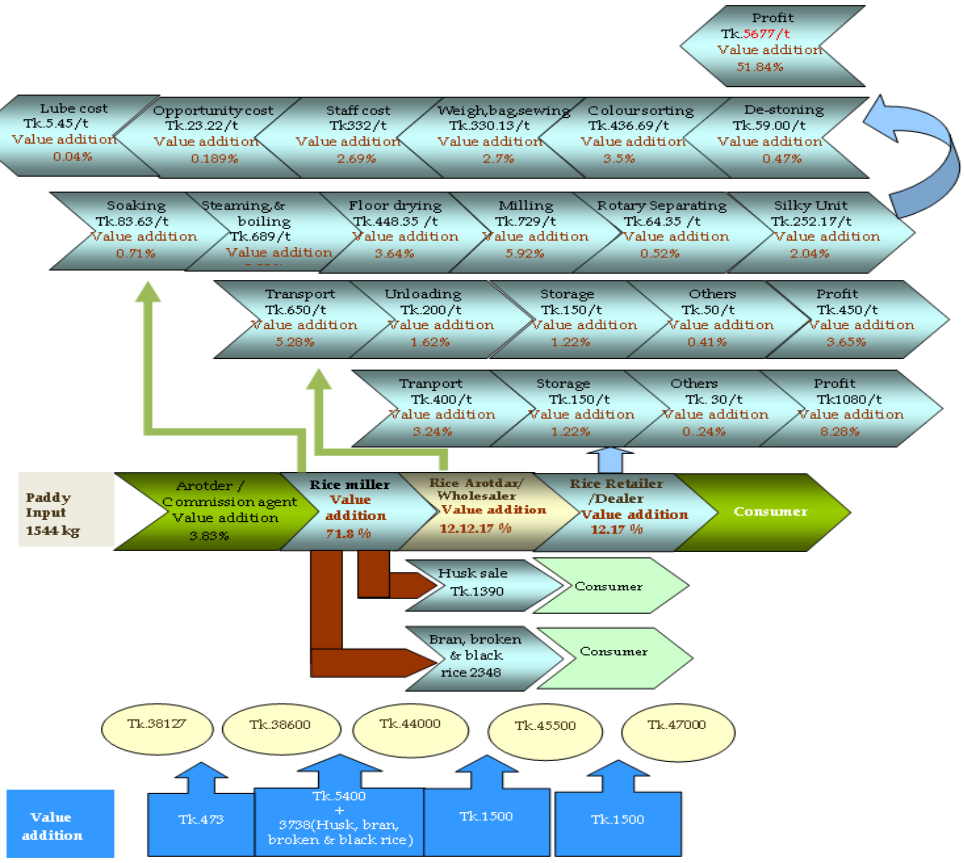

Fig. 2: Value addition of parboiled fine rice in a semi-automatic rice mill with modern equipment.

Value addition at the commission agent's level was 3.83%. The initial value of 1544 kg paddy, equivalent to one ton of clean rice, was Tk.38600, while the retailing price was Tk.47000. Value addition at Miller's level constituted Tk.5400 in processing and Tk.3700 by selling husk bran, and broken rice. Value addition in processing included 0.7% in soaking, 5.59 % in steaming and parboiling, 3.64 % in floor drying, 5.92% in milling, 0.52% in rotary separating, 2.04% in silky polishing, 0.47 in de-stoning, 3.5% in color sorting, 2.7% in weighing, bagging and sewing, 2.69% in stuff cost, 0.189% in opportunity cost and 0.04% in lubrication cost.

Value addition of coarse rice processing in a semi-automatic rice mill with modern equipment

Value addition estimation at this chain indicated that miller (70.7%), retailing (13.17%), and wholesaling (12.55%) constituted the significant value addition. Value addition at the commission agent's level was 3.75% (**Fig. 2**). To produce a ton of milled rice required 1487 kg paddy, which costs about Tk.29284, and the retail price was Tk. 38100. The value addition for milling was Tk. 5260, and additional value addition was estimated at Tk. 3329 was found by selling husk, bran, and broken rice, and at the millers' level value addition consisted of 0.69% in soaking, 5.47% in steaming and parboiling, 3.56% in drying on floor, 5.78% in milling, 0.53% in rotary separating, 2.07% in silky polishing, 0.49 in de-stoning, 3.6% in color sorting, 2.72% in weighing, bagging and sewing, 2.63% in stuff cost, 0.18% in opportunity cost of land and 0.0005% in lubrication cost. Value addition at the wholesale level consisted of 4.94% in transport, 1.65% for unloading, and 1.65% in storage. The retailer value addition included 3.71% in the vehicle, 1.65% in storage, and 0.24% in other costs.

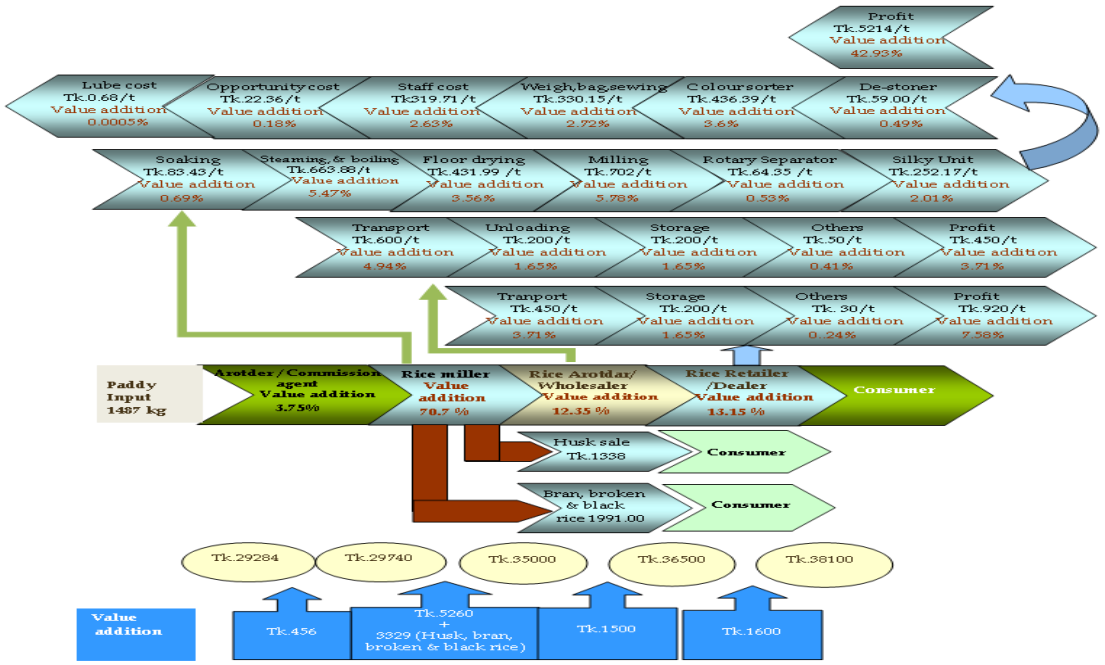

Fig. 3: Value addition of parboiled coarse rice in a semi-automatic rice mill with modern equipment.

Milling Cost and Recovery of Rice for Different Types of Rice Mills

The milling cost and recovery per ton of whole rice (fine and coarse) are shown in **Table 3**.

Table 3: Milling cost and recovery of fine rice for different types of rice mills.

Type of rice mill	Milling cost, Tk./ton of rice	Whole rice recovery %
Semi-Auto*	2954	66.25
Semi-Auto**	3460	64.75

*Without modern equipment **With modern equipment

In **Table 3**, the milling costs were found to be Tk for semi-automatic without modern equipment and semi-automatic with modern equipment.2954, Tk.3460, and whole rice recovery was 66.25% and 64.75%, respectively. Similar milling recovery (66%) was found in air blow-type Engelberg hullers (Baqui *et al.*). Milling recovery (65%) was also seen in automatic rice mills without modern equipment (Baqui *et al.*). The whole rice recovery of the semi-automatic rice mill (66.25%) was slightly higher than that of the semi-automatic rice mill with modern equipment (64.75%). This happens because some modern equipment, such as fine (silky) polisher and color sorter, is used. A fine polisher polishes the remaining bran in the rice, and a color sorter sorts the black and discolored grain from the rice. However, the market price of rice processed in rice mills with modern equipment is higher than that of other rice mills. Eventually, the rice mills with modern equipment have better profit margins than others. Similar results were found in the whole rice recovery. The operating cost of an automatic rice mill without modern equipment was found to be the same (Tk.2601); this happened due to the small amount of paddy being processed by the husking mill, while the automatic mill with modern equipment processes a large amount of paddy.

Table 4: Milling cost and recovery of coarse rice for different types of rice mill.

Type of rice mill	Milling cost, Tk. /ton of rice	Whole rice recovery %
Semi-Auto*	2859	68.25
Semi-Auto**	3375	67.25

*Without modern equipment **With modern equipment

In **Table 4**, rice mills were Tk for The milling cost of semi-automatic without modern machinery and semi-automatic with modern equipment.2859, Tk.3375, and whole rice recoveries were found at 68.28% and 67.25%, respectively. Whole rice recovery was found to be higher in semi-automatic rice mills (68.25%) than in semi-automatic with modern equipment rice mills (67.25%); this is because semi-automatic rice mills use some modern equipment like a fine polisher and color sorter. A fine polisher polishes the remaining rice bran, and the color sorter sorted the black and color rice. For this, the rice mill has lower whole rice recovery than another semi-automatic rice mill. However, the selling price of properly polished and graded rice is found to be higher. A similar result was found for whole rice recovery in automatic and automatic rice mills with modern equipment. The milling costs for the husking mills (Tk. 2519) and the automatic rice mills (Tk. 2522) are found to be almost the same because the capacity of the husking mills is low compared to the automatic rice mills.

Milling Capacity of Different Types of Rice Mills

Milling capacity indicates the amount of rice processed in a specified time. The capacity of mills is expressed in terms of clean rice. The milling capacity of husking, semi-automatic, and automatic rice mills is shown in **Table 5**.

Table 5: Milling capacity of different types of rice mill.

Types of rice mill	Capacity (t/h)
Semi-automatic rice mill	1.5 -1.75

Results showed that the capacity of semi-automatic rice mills was 1.15-1.75 t/h. Baqui, (2010) found that the capacity of husking of semi-automatic and automatic rice mills was less than 1.0 t/h, 2-2.5 t/h, and 4.0 t/h, respectively. Similar results for husking and automatic mills in BRRI (2013-14). Capacity depends on operator efficiency, machine efficiency, and the feeding rate of materials; thus, the capacities of semi-automatic rice mills may vary in these cases.

Capacity Utilization

Processing capacity utilization of rice mills was computed based on average use, 280 working days (automatic rice mill) in a year, and the results are shown in **Table 6**.

Table 6: Capacity utilization of rice mills.

Type of mill	No. of mills	Actual capacity (metric tonne)	Ability utilized (metric tonne)	Capacity utilization (%)
Semi-automatic	15	31752	12705	40

The capacity utilization of semi-automatic rice mills was 40% (**Table 6**). Raha *et al.* (2012) discovered that the capacity utilization of husking, semi-automatic, and automatic mills was 54%, 52%, and 56%, respectively; a similar result was observed for automatic rice mills. Husking and semi-automatic rice mills operate with a limited amount of paddy and do not operate for a whole year; technology varies from mill to mill, and the use of older technology and inefficient operators may have influenced the capacity utilization.

Milling cost, by product selling cost and benefit-cost ratio of parboiled fine rice processing

Comparative milling cost, by-product selling price, and benefit-cost ratio of parboiled fine are shown in **Table 7**.

Table 7: Comparative milling cost, by product selling price and benefit-cost ratio for parboiled fine rice.

Type of rice mill	Milling cost, Tk/ton of rice	Profit, Tk/ton of rice			BCR
		Rice milling	Byproducts (husk, bran, and broken rice)	Total	
Semi-Auto*	2954	1321	3056	4376	1.48
Semi-Auto**	3460	1940	3738	5677	1.64

*Without modern equipment **With modern equipment

Milling costs per ton were found to be Tk. 2954 and Tk. 3460 for a semi-automatic rice mill with modern equipment (**Table 7**). Interestingly, by-products such as husk, bran, and broken rice contribute significantly

to the profit margin of all rice mills. The bran from semi-automatic and automatic rice mills is in good demand in edible oil mills, and oil mill cakes are used for poultry and fish meal production. The husk is used as fuel for boilers and dryers in the rice mills, making briquette as bio-fuel, poultry, and dairy feed. The estimated BCRs were higher in semi-automatic rice mills for both with and without modern equipment at 1.48 and 1.64, respectively (**Table 7**). This indicates that automatic rice mills are doing good business compared to semi-automatic rice mills (BCR ranges from 1.48 to 1.64 without and with modern equipment) and husking rice mills (BCR 1.40).

Milling cost, by product selling cost and benefit-cost ratio of parboiled coarse rice processing

Comparative milling cost, by-product selling price, and benefit-cost ratio of parboiled coarse rice are shown in **Table 8**.

Table 8: Comparative milling cost, by product selling price and benefit-cost ratio for parboiled coarse rice.

Type of rice mill	Milling cost, Tk/ton of rice	Profit, Tk/ton of rice			BCR
		Rice milling	Byproducts (husk, bran, and broken rice)	Total	
Semi-Auto*	2859	1061	3035	4097	1.43
Semi-Auto**	3375	1885	3329	5215	1.55

*Without modern equipment **With modern equipment

Milling costs per ton were found in semi-automatic rice mills with modern equipment such as Tk. 2859 and Tk.3375, respectively (**Table 8**). Interestingly, byproducts such as husk, bran, and broken rice contribute significantly to the profit margin of all rice mills. The bran from semi-automatic and automatic rice mills is in good demand in edible oil mills, and oil mill cakes are used for poultry and fish meal production. The husk is used as fuel for boilers and dryers in the rice mills, making briquette as biofuel, poultry, and dairy feed. This indicates that automatic rice mills are doing good business compared to semi-automatic rice mills (BCR ranges from 1.43 to 1.55 without and with modern equipment.

Employment distribution in rice mill

The employment distribution in husking mills, semi-automatic rice mills without modern equipment, semi-automatic rice mills with the modern equipment, automatic rice mills without modern equipment, and automatic rice mills with modern equipment is shown in **Table 9**.

Table 9: Employment distribution in different rice mills.

Type of rice mill	Employment					
	Labor, Tk/ ton of paddy	Staff cost, Tk/ ton of paddy	Labor, man-hr/ ton of paddy	Labor, person-days/yr	Staff, man-hr/ ton of paddy	Staff, person-days/yr
Semi-Auto*	403	168	14.17	2274	9.13	1095
Semi-Auto**	483	216	15.67	3015	4.50	1460

*Without modern equipment **With modern equipment

The labor cost per ton of paddy for a semi-automatic rice mill without modern equipment was estimated as Tk. 403. However, a semi-automatic rice mill with modern equipment required Tk. 483 to mill a ton of paddy (**Table 9**). Meanwhile, the labor cost for automatic rice mills without and with modern equipment was Tk. 100 and Tk. 116, respectively. This difference in labor cost per ton of paddy is due to the automatic rice mills' higher capacity and less labor requirement for automation in drying and milling sections. The staff costs of semi-automatic without and with modern equipment were found to be Tk. 168, Tk. 216 per ton of paddy processing, respectively. This higher capacity utilization is because of the higher demand for quality rice (in terms of physical size and shape and glassy looking) in the market. However, Staff requirements of semi-automatic without modern equipment and semi-automatic with modern equipment rice mills were found (9.13 and 4.50 man-hr per ton of paddy processing) compared to husking and semi-automatic rice mills, which were in the range of 14.17-15.67 man-hr per ton of paddy processing (**Table 9**). A simi-

lar trend was visible for staff employment. The employment opportunities of staff were found in semi-automatic rice mills with modern equipment (3015 person-days per year) and semi-automatic rice mills without modern equipment and husking mills (2274 person-days per year) (**Table 9**). However, staff requirements of semi-automatic rice mills with modern equipment were found to be lower (4.50 man-hr per ton of paddy processing) compared to automatic and semi-automatic rice mills without modern equipment (5.99 and 9.13 man-hr per ton of paddy processing) and husking mill (6.95 man-hr per ton of paddy processing).

Employment scenario of the rice mill sector

There is a belief that technological changes displace labor. Still, **Table 10** shows that the most significant delivery numbers are absorbed in automatic mills, followed by semi-automatic mills, and the lowest number is in husking mills. The automatic mills use more paddy than husking and semi-automatic mills. It works for more extended periods than other categories of the mill moreover, the intensity of work increases along with the use of by-products.

Table 10: Distribution of mills by number of employees.

Type of mills	No. of employees		
	Male	Female	Total
Semi-automatic	16	12	38

Considering the above table and the number of rice mills in Bangladesh (15,550 husking mills, 650 semi-automatic mills, and 350 automatic rice mills; Rice *et al.* Association, 2012), the number of laborers employed in husking mills, semi-automatic mills, and automatic mills were estimated 4,03,000, 24700 and 21000, respectively. Besides these, about 1,00,000 traditional husking mills operate in the country, where more than 1,00,000 laborers are working there.

CONCLUSION AND RECOMMENDATIONS:

The findings of this research paper shed light on the status of semi-automated rice milling with modern machinery in three districts of Bangladesh. The study highlights variations in milling costs, whole rice recovery rates, and capacity utilization among semi-automatic mills with and without modern equipment. The higher estimated Benefit-Cost Ratios (BCRs) for semi-automatic rice mills, both with and without modern equipment, underscore the potential economic advantages of automation in the industry.

However, policy-makers, industry stakeholders, and entrepreneurs must address the identified challenges and leverage the recommendations provided to fully optimize the advantages of automation for sustainable and the competitive rice production in Bangladesh. By implementing these measures, the rice milling industry can contribute significantly to the country's economic development and food security.

1) Encourage rice mill owners to adopt modern machinery by providing financial support, subsidies, or tax incentives. This will facilitate the widespread integration of advanced technologies.
2) Develop and implement training programs for mill operators to ensure proper usage, maintenance, and troubleshooting of modern milling equipment. This will optimize the benefits of automation and reduce the risk of downtime.
3) Allocate resources for ongoing research and development initiatives to stay abreast of emerging technologies in rice milling. This will enable the industry to improve its processes and maintain a competitive edge continually.
4) Work towards increasing the capacity utilization of semi-automatic rice mills, potentially through awareness campaigns or collaborative efforts with industry associations, to maximize production efficiency.
5) Facilitate the transfer of technology from more advanced regions or mills to those that may lack access, thereby promoting uniform modernization across various areas of Bangladesh.

ACKNOWLEDGEMENT:

The Program on Agricultural and Rural Transformation for Nutrition, Entrepreneurship and Resilience in Bangladesh (PARTNER), BRRI Part, Bangladesh financially supported this work.

CONFLICTS OF INTEREST:

No conflict of interest.

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Citation: Bhuiyan GK, Alam MM, Rahman A, Huda MD, Ahmmed MM, Nath BC, and Rahaman H. (2024). Optimizing rice milling in Bangladesh: a comprehensive analysis of semi-automatic processes with modern machinery, *Int. J. Mat. Math. Sci.*, **6**(1), 5-13. https://doi.org/10.34104/ijmms.024.05013