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A Comprehensive Overview of Automatic Rice Milling with Modern Machinery in Bangladesh

Md. Golam Kibria Bhuiyan[1]*, Md. Monjurul Alam[2], Anisur Rahman[2], Md. Durrul Huda[1], Md. Moudud Ahmmed[3], Bidhan Chandra Nath[1], and Md. Monirul Islam[1]

[1]Farm Machinery and Postharvest Technology Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh; [2]Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh; and [3]Workshop Machinery and Maintenance Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh.

*Correspondence: kibria_1971@yahoo.com (Md. Golam Kibria Bhuiyan, Senior Scientific Officer, Farm Machinery and Postharvest Technology Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh).

ABSTRACT

This research paper thoroughly studied how modern machinery is used in milling rice in Bangladesh. The study took place in three districts: Dinajpur, Kushtia, and Mymensingh. Researchers gathered information through personal interviews, surveys, and group discussions. Data was collected from automatic mills, ownership, products, machinery used, and the cost of setting up the mill. The data analysis used a simple descriptive statistical method. The main goal of the research was to understand the current situation of rice milling in terms of automation, including the types of technology and capacities involved. For mills with modern equipment, the milling cost was Tk. 2601, while for those without modern equipment, it was Tk. 3098. The rice recovery rates were 67.5% and 66%, respectively. Automatic rice mills had a capacity of 3-3.5 tons per hour, with a utilization rate of 56%. The research also found that the estimated benefit-cost ratios (BCRs) were higher in automatic rice mills, both with and without modern equipment, at 2.64 and 2.49, respectively. Profit margins per ton of milled rice were highest in automatic mills without modern equipment (Tk. 5881) and lowest in mills with modern equipment (Tk. 7338). The staff cost per ton of paddy processing was lowest in modern automatic rice mills (Tk. 101), mainly due to their higher capacity and automation. Automatic rice mills without modern equipment had a staff cost of Tk. 173 per ton. The findings of this research provide valuable information for decision-makers, guiding policymakers, industry stakeholders, and entrepreneurs to make informed choices and optimize the benefits of automation for sustainable and competitive rice production in Bangladesh.

Keywords: Automatic milling, Modern equipment, Husking, Cost, Rice, and Profit.

INTRODUCTION:

The demand for high-quality rice has recently surged, with consumers seeking fresh and fine-quality rice. Consequently, the rice milled in husking mills is experiencing a decline in order. It has been reported that the number of automatic and semi-automatic rice mills is rapidly increasing, leading to the closure of husking mills. This shift is attributed to adopting advanced technologies in automatic and semi-automatic rice mills. Furthermore, automatic rice mills' capacity and technological advantages surpass those of husking and semi-automatic rice mills. Considering these circumstances, establishing numerous automatic and semi-automatic rice mills seems inevitable. How-

ever, there has been no significant study on the economic transition in this field, and meaningful initiatives to analyze the value chains of rice milling in Bangladesh are lacking. Therefore, this study aims to identify the status of rice milling value chains in the country, assess constraints and opportunities for improvement, and recommend technological enhancements through appropriate interventions.

Rice is pivotal as the most important crop, covering 80% of the cropped area (Nath *et al.*, 2016). In 2013-2014, the country produced approximately 34.36 million metric tons of clean rice from a total rice area of 11.37 million hectares (Kabir *et al.,* 2015). The paddy produced is predominantly processed into clean rice by various mechanized rice mills, including traditional Engelberg hullers (traditional and husking rice mills), semi-automatic rice mills, and automatic rice mills, each with different capacities and operations across the country. The rice mills under the Department of Food are typically categorized as husking, semi-automatic, and automatic rice mills, with respective numbers of 14,239, 457, and 142 and a fortnightly capacity of 625,000 tons (Kabir *et al.,* 2008). Additionally, the country has around 100,000 traditional Engelberg-type rice hullers (Alam *et al.,* 2017; Hossain *et al.,* 2022). The labor force involved in traditional rice hullers, husking rice mills, semi-automatic rice mills, and automatic rice mills numbers 100,000, 142,390, 13,710, and 6,248, respectively. Despite its significant contribution, the rice milling sub-sector in Bangladesh is still considered a non-formal sector, receiving limited government facilities and incentives compared to the industrial sector.

Rice milling encompasses various operations in treating harvested, threshed, and dried paddy to produce clean white or "polished" rice kernels. It is a crucial post-harvest processing operation. This process transforms paddy into whole rice, broken rice, rice bran, and husk, with losses often attributed to the poor technical performance of milling machinery, leading to suboptimal yields. In Bangladesh, approximately 90% of the paddy produced is parboiled, and rubber-roll hullers are utilized in rice mills for processing around 20% of parboiled and 10% of dry-processed paddy. Of the total paddy produced nationally, 30% is processed by households and does not enter the market, while the remaining 70% undergoes processing in medium to large rice mills (Kadan *et al.*, 2001). The predominant method of rice milling in Bangladesh involves using an Engelberg-type steel huller, resulting in significant losses in the recovery of whole rice. However, the country is witnessing an increasing number of automatic and semi-automatic rice mills utilizing rubber-roll hullers to enhance the recovery of head rice and bran.

In husking mills, mixing bran and husk during the milling process reduces the quality of rice bran. Converting Engelberg rice hullers to modern mills could save 2-4% of whole rice loss (Raha, 2018). Considering the annual milling of about 27 million tons of paddy, this conversion could save approximately 0.648 million tons of milled rice, nearly a quarter of the country's total rice deficit (RAHMAN, 2013). Nagothu *et al*. (2014) reported that modern rubber roll milling technology could save an average of 4.5% of food, leading to a total national savings of about 1.55 million tons annually (Kabir *et al.*, 2018). While rice milling is a crucial sub-sector in Bangladesh, there is a dearth of studies assessing its present status regarding business size, technology levels, and value chains of products and marketing chains for processing machinery (Nath *et al.*, 2022). Ahmed, (1999) identified three major channels in the rice milling sub-sector: the imported machinery and equipment channel, the local manufacturing of rice mill machines and equipment, and the rice processing channel. The sector is transforming, with 17,000 husking mills in the country (MIA, 2022). Establishing new semi-automatic and automatic rice mills is growing, posing increased competition for thousands of small and medium husking mills. Over the past decade, several hundred automatic and semi-automatic rice mills have been established, particularly in rice-producing zones like Naogaon, Chapainawabganj, Dinajpur, Kushtia, and Jessore. In 2005, there were only 200 semi-automatic and automatic rice mills, which tripled to over 600 by 2011 (Hasjim *et al.*, 2013). This research aims to identify the present status of automated rice milling with modern machinery, focusing on types, capacity, and technology. The article highlights the shift towards automation and modernization in the rice milling sector in Bangladesh.

MATERIALS AND METHODS:

Selection of the Study Site

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 this rice milling hub/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.

Table 1: Sample distribution of rice mill for survey.

Rice mill	Covered			Total
	Dinajpur	Kushtia	Mymensingh	
Automatic rice mill	16	12	7	35

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

Survey Questionnaire

Semi-structured questionnaires were prepared according to the study's objectives with active consultation with key informants, experts from the relevant fields, and secondary information. Two sets of semi-structured questionnaires were also developed to assess the status (services required, service providers, etc.) of the demand and supply side of Business Development Services (BDS). Furthermore, a check-list was developed for KIs. The draft questionnaires and checklist were pre-tested and necessary corrections, modifications, and alterations were made accordingly.

Data Collection Method

Personal interviews collected data through semi-structured questionnaires and Focus Group Discussions (FGDs). During the interview, each question was explained to the respondents clearly, and they tried to find the facts as much as possible. Appropriate participatory tools and techniques were used in FGDs.

Techniques Applied

A simple descriptive statistical method was used for analyzing data. Data was calculated in Excel format separately to compute the operational cost of rice mills from primary and secondary sources. Excel format automatically permits easy change or refinement of data and the subsequent calculation of operating costs for changed or refined data in the designed Excel computation mode. The mathematical model for simulating the performance of the Supply chain of the rice milling system in Bangladesh was simulated using STELLA software.

Data Collection on the Present Status of Rice Milling in Bangladesh

The data on the present status of rice milling was collected through a semi-structured questionnaire. Data was collected on types of mills, ownership status, existing products, types of milling machinery used in the mill section, and total cost of commissioning of the mill/mill section. Data was also collected on cleaning, soaking, steaming, drying, milling, capacity utilize-ation, and milling recovery of rice.

Automatic Rice Mill

Automatic rice mills perform all operations mechanically, such as cleaning, steaming, drying, shelling, polishing, and grading. Unlike other rice mills, these mills do not require any drying floor. The process involves cleaning paddy, steaming, and parboiling, mechanical drying, milling with a rubber-roll sheller, separating, polishing, sieving for broken rice, aerating, bagging, and weighing. Automatic rice mills produce the best quality, adequately graded rice. Semi-automatic rice mill husk and bran are obtained separately

and have better use in briquette rice husk and edible oil extraction from the bran. The flow chart of an automatic rice mill is shown in **Fig. 1**.

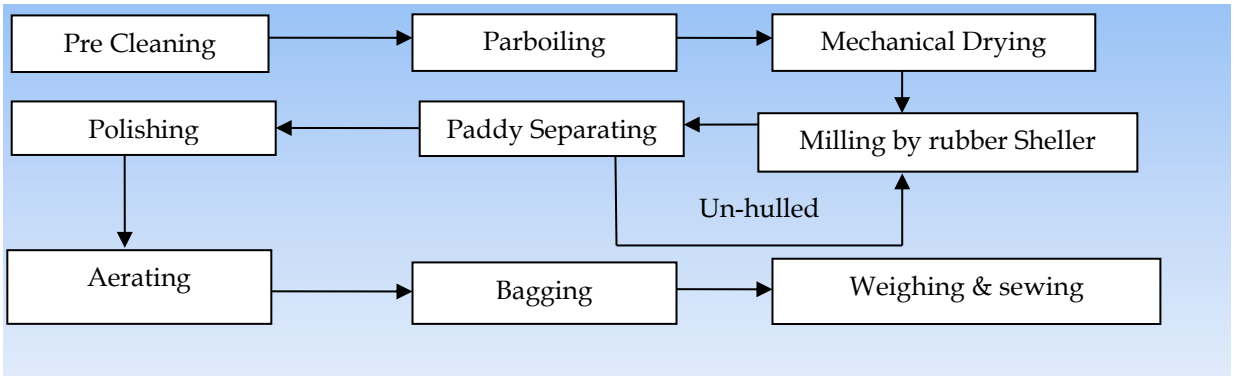

Fig. 1: Flowchart of an automatic rice mill.

Automatic rice mill owners have recently used modern equipment to improve rice quality. The equipment is a de-stoner, rotary separator/plain shifter, fine (silky) polisher, color sorter, etc. This modern equipment adds value to the processed rice due to less broken rice and stone and free from black rice. Market demand for this processed rice has increased.

Present Status of Rice Milling

The rice milling sector in Bangladesh is changing. New semi-automatic and automatic rice mills are being set up growing, raising competition for thousands of small and medium-sized husking mills. Over the last decade, several hundred automatic and semi-automatic rice mills have been established in various rice-producing zones. Naogaon, Chapainawabganj, Dinajpur, Kushtia, Jessore, and Mymensingh are some districts that have attracted investment to set up large-capacity automatic rice mills. According to the Rice Mills Owners' Association, there are about 17000 rice mills in the country. In 2005, there were only 200 semi-automatic and automatic rice mills. The number tripled to approximately 600 in 2011. The field survey of this research and the Rice Mill Owners' Association reveals that there are 15,500 husking mills, and the number of semi-automatic and automatic rice mills in 2015 was estimated to be more than 950. The trend of establishment of semi-automatic and automatic rice mills in the country is shown in **Fig. 2**.

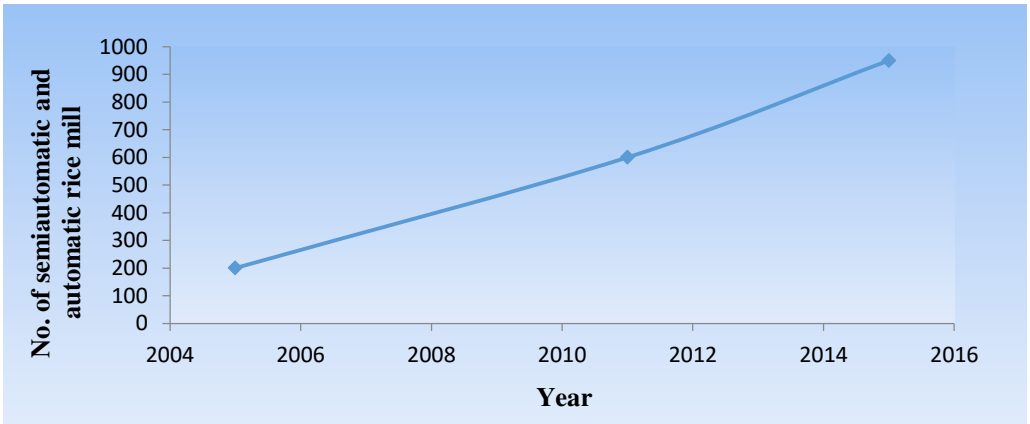

Fig. 2: The trend of automatic rice mill establishment in Bangladesh.

Industry insiders link the growth of automatic rice mills with the change in consumers' preferences. End users want better quality rice, a longer shelf life, less broken quantities, and rice that is almost free from stone. Other factors for raising automatic and semi-automatic mills are an increase in production due to a decline in broken grains, the scope to produce rice cooking oil by using rice bran, and higher market prices. Husking mill owners say this mill currently controls two-thirds of the market. Because of the in-

creasing demand for automatic rice mill processed rice, the share is projected to be half of the total processed rice within a couple of years.

Value addition in fine rice processing in an automatic rice mill with modern equipment

Parboiled fine rice processed by an automatic rice mill with modern equipment, the value chain analysis indicated that miller (73.52%), retailing (13.17%), and wholesaling (9.83%) constituted major value additions. Value addition at the commission agent's level was 3.02% (**Fig. 3**). The initial value of 1515 kg paddy, equivalent to one ton of clean rice, was Tk.37410, while the retail price was Tk.49600. Value addition at Miller's level included Tk.8125 in processing and Tk.3163 by selling husk, bran, broken rice, and black rice. Value addition at this level included 0.5% in soaking, 1.81% in parboiling, 7.27% in boiling, 1.04% in drying, 3.79% in milling, 0.087% in rotary separating, 1.1% in silky polishing, 0.17 in de-stoning, 0.68% in color sorting, 2.51% in weighing, bagging, and sewing, 1.0% in stuff cost, 0.04% in opportunity cost and 0.165% in lubrication cost. Value addition at the wholesale level consisted of 3.90% in transport, 0.98% for unloading, and 0.98% in storage. The retailer value additions included 3.25% in the vehicle, 0.97% in storage, and 0.19% in other costs.

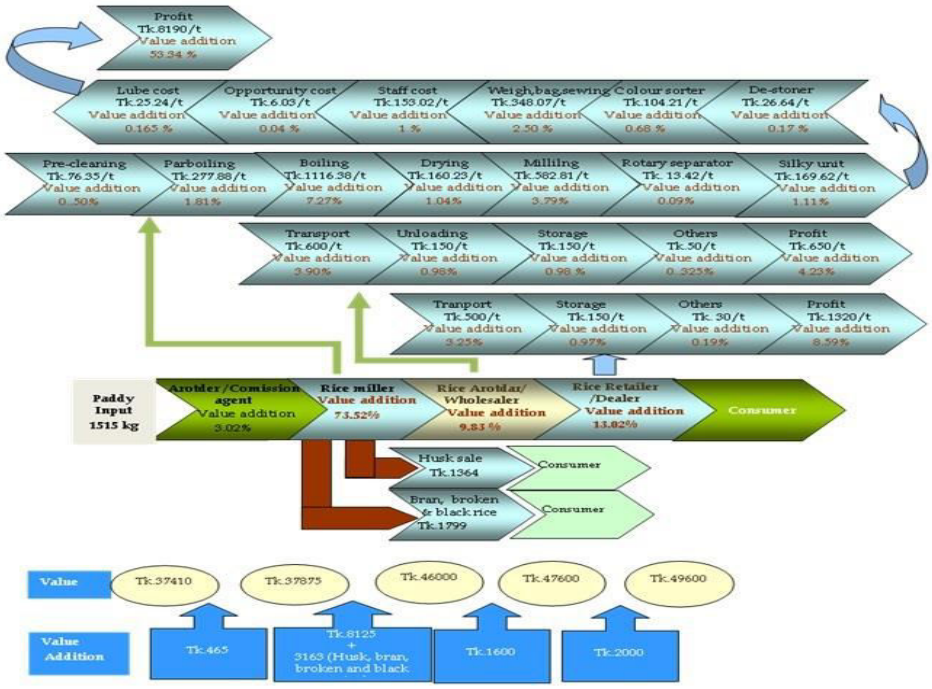

Fig. 3: Value addition of parboiled fine rice in an automatic rice mill with modern equipment.

Value Addition of Coarse Rice Processing in Automatic Mill with Modern Equipment

Value chain analysis of parboiled coarse rice processed by automatic rice mills with modern equipment indicated that miller (73.4%), retailing (12%), and wholesaling (11.35%) constituted the major value additions. Value addition at the commission agent's level was 3.18% (**Fig. 4**). The 1460 kg paddy, equivalent to one ton of clean rice, was Tk.28752, while the retail price was Tk.39800.

Value additions at the miller's level were Tk.7300 in processing and Tk.3048 by selling husk, bran, broken rice, and black rice. Value additions at this level consisted of 0.52% in pre-cleaning, 1.9% in parboiling, 7.63% in boiling, 1.1% in drying, 3.98% in milling, 0.09% in rotary separating, 1.2% in silky polishing, 0.18% in de-stoning, 0.739% in color sorting, 2.73% in weighing, bagging and sewing, 1.05% in stuff cost, 0.04% in opportunity cost and 0.17% in lubrication cost. Value addition at the wholesale level consisted of 4.26% in transport, 1.42% for unloading, and 1.11% in storage. The retailer value addition included 3.53% in the vehicle, 1.1% in storage, and 0.35% in other costs. In local machinery and the equipment channel for automatic rice mill, the primary value additions were

platform, tanks, cyclones, elevators, pipes & rice silos cost Tk.4131000, ducting plumbing pipe Tk.4050000, accessories Tk.2025000, electrical & other equipment Tk.8910000, air compressor with piping Tk.1215000 (**Fig. 5**). The total cost for local machinery & the equipment was estimated as Tk.20331000, which were collected from the local market.

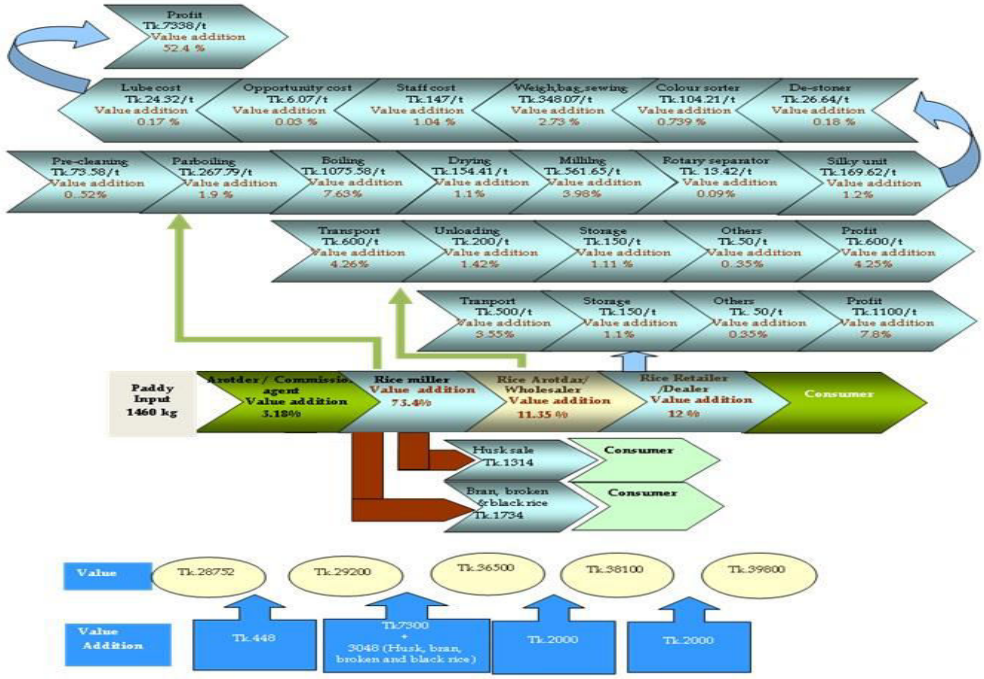

Fig. 4: Value addition of parboiled coarse rice in an automatic rice mill with modern equipment.

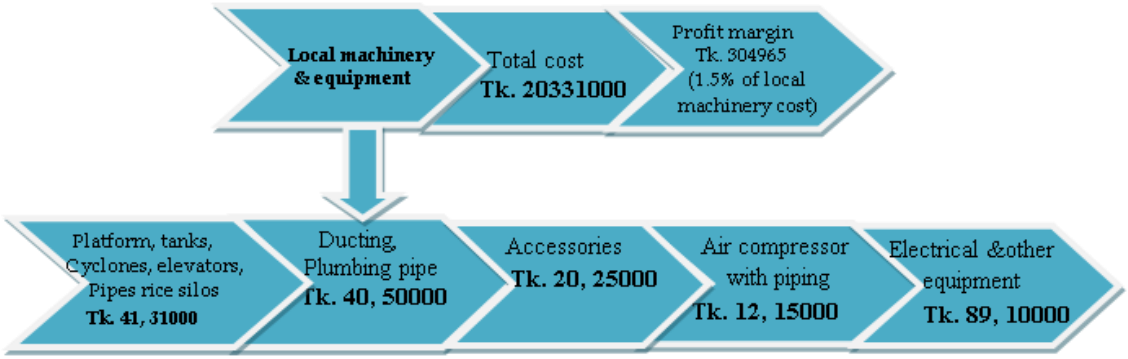

Fig. 5: Cost of local machinery and equipment for the automatic rice mill.

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 %
Auto rice mill*	2601	67.5
Auto rice mill**	3098	66

*Without modern equipment and **With modern equipment

In **Table 3**, it was found that fine rice processed in a husking mill required Tk.2601 to produce 1 ton of rice, and the whole rice recovery was 67.5 %. For automatic rice mills with modern and without modern

equipment, the milling costs were Tk.2601 and Tk.3098, respectively, and whole rice recovery was 67.5% and 66%, respectively. Similar milling recovery (66%) was found in air blow-type Engelberg hullers (Zubair *et al.,* 2015). Milling recovery (65%) was also found in the automatic rice mills without modern equipment. 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 will have better profit margins than others. Similar results were found in the whole rice recovery. The operating cost of the husking mills and automatic rice mills 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 mills while the automatic mill with modern equipment processes large amounts 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 %
Auto rice mill*	2522	70
Auto rice mill**	3010	68.5

*Without modern equipment and **With modern equipment

In **Table 4**, it was found that the milling cost of auto-matic without modern equipment and automatic with modern equipment rice mills were Tk.2552 and Tk.3010, respectively, and whole rice recoveries were found to be 70% and 68.5%, 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 the graded rice is found to be higher. Similar results were found for whole rice recovery in automatic and automatic rice mills with modern equipment. The automatic rice mill (Tk. 2522) is almost identical because the capacity of the husking mill is low compared to the automatic rice mill.

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)
Automatic rice mill	3-3.5

Results showed that the capacity of automatic rice mills was 3-3.5 t/h. Baqui (2010) found that the power 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 feeding rate of materials; thus, in these cases, the capacities of semi–automatic rice mills may vary.

Capacity Utilization

The 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 ton)	Ability utilized (metric ton)	Capacity utilization (%)
Automatic	16	2,08,000	1,16,480	56

The capacity utilization of automatic rice mills was 56% (**Table 6**). Nagothu *et al.* (2014) found that the capacity utilization of husking, semi-automatic, and automatic mills were 54%, 52%, and 56%, respectively; a similar result was observed for automatic rice mills. In the case of husking and semi-automatic rice mills, they operate with a limited amount of paddy and do not operate a whole year; technology varies from mill to mill, 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	
Auto rice mill*	2601	3374	3092	6466	2.49
Auto rice mill**	3098	5027	3163	8190	2.64

*Without modern equipment and **With modern equipment

Milling costs per ton were found to be Tk. 2601 and Tk. 3098 for automatic rice mills without modern equipment and with modern equipment, respectively. Comparatively lower milling costs per ton of fine rice were found in automatic rice mills without and with modern equipment such as Tk.2601 and Tk. 3098, respectively (**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 biofuel, poultry, and dairy feed. The estimated BCRs were higher in automatic rice mills for both with and without modern equipment at 2.64 and 2.49, 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	
Auto rice mill*	2522	2898	2983	5881	2.33
Auto rice mill**	3010	4290	3048	7338	2.44

*Without modern equipment and **With modern equipment

Lower milling costs per ton of fine rice were found in automatic rice mills without and with modern equipment such as Tk.2522 and Tk. 3010, respectively (**Table 8**). The profit margins per ton of milled rice were estimated to be highest in automatic rice mills without modern equipment and lowest in automatic rice mills with modern equipment mills, such as Tk. 5881 and Tk. 7338 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. The estimated BCRs were higher in automatic rice mills for both with and without modern equipment at 2.44 and 2.33, respectively (**Table 8**).

Employment Distribution

In 1986, the BBS enumerated the total number of agents involved in rice trading and processing, which was 107,657. Of these, 59,067 were paddy-processing establishments of various capacities and technologies. According to 1992 estimates, 11,948 bears and 2,200 avatars dominated the terminal markets (Chowdhury, 1992).

Employment distribution in rice mill

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

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
Auto rice mill*	100	173	3.20	3120	5.99	5840
Auto rice mill**	116	101	3.95	5925	4.14	6205

*Without modern equipment and **With modern equipment

The labor cost for automatic rice mills without and with modern equipment was Tk. 100 and Tk. 116, respectively. This difference in the price of labor per ton of paddy is due to the higher capacity of the automatic rice mills and a more minor labor requirement for automation in drying and milling sections. The lowest staff cost was found in the case of modern automatic rice mills (Tk. 101 per ton of paddy processing) mainly because of their higher capacity and automation (**Table 9**). The staff costs of automatic rice mills without modern equipment were found to be Tk173 per ton of paddy processing. Regarding employment opportunities, an automatic rice mill with modern equipment utilized about 5925 person-days per year compared to other rice mills (ranging between 2232 to 3120 person-days per year) because of its higher capacity utilization. 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, labor requirements of automatic and automatic with modern equipment rice mills were found to be far less (3.20 and 3.95 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 similar trend was visible for staff employment. Staff employment opportunities were found to be highest in automatic rice mills with modern equipment (6205 person-days per year) followed by automatic rice mills without modern equipment (5840 person-days per year). However, the staff requirement of automatic and semi-automatic rice mills with modern equipment was found to be lower (4.14 and 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 deliveries are absorbed in automatic mills, followed by semi-automatic, and the lowest number in husking mills. The automatic mills use more paddy than husking and semi-automatic mills. It works for a more extended period 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
Automatic	49	11	60

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 Mill Owner Association, 2012), the number of labor 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 are operating in the country, where more than 1,00,000 laborers are working there.

CONCLUSION AND RECOMMENDATION:

The rice milling sub-sector faces inadequate skill at rice mill and rice mill equipment manufacturing workshop; training on operation, maintenance, and repair of rice mill equipment to operators and technicians; design, drawing, and manufacturing training to rice mill equipment manufacturer and management training to rice mill management are necessary. The findings reveal crucial insights into the present status of automated rice milling with modern machinery. Specifically, analyzing milling costs and the recovery rates for fine and coarse rice in auto rice mills highlights the economic advantages of employing modern equipment. The study underscores the financial benefits associated with automation. The estimated highest profit margins per ton of milled rice, reaching Tk. 8190, emphasize the economic viability of automatic rice mills. The lowest staff costs (Tk. 101 per ton of paddy processing) and significantly reduced labor requirements (3.20 to 3.95 person-hours per ton of paddy processing) further illustrate the advantages of automation, mainly attributed to higher capacity and streamlined processes. These findings offer a solid foundation for informed decision-making, providing actionable insights for policymakers, industry stakeholders, and entrepreneurs. The potential for optimizing the advantages of automation in rice production is evident, fostering sustainability and competetiveness in Bangladesh's crucial agricultural sector. As the nation strives for modernization, the embracing automated rice milling with modern machinery emerges as a strategic pathway for enhancing efficiency, profitability, and overall resilience in the dynamic landscape of rice production.

Upgrading husking rice mills to automatic and semi-automatic rice mills is an urgent issue of national interest. On the other hand, traditional husking mills operating all over rural Bangladesh must be upgraded to improved air-blow type husking mills with a small polisher or by rubber roll de-husker and a small polisher unless the milling sub-sector is fully automated. Older-generation is semi-automatic and automatic rice mills must be upgraded with modern equipment such as de-stoners, friction-type vertical polishers, plain shifters/rotary separators, fine polishers, color sorters, etc. Public sector policy support, soft credit, and the private sector business development support are necessary to upgrade this sub-sector. The rice milling sub-sector faces inadequate skill at rice mill and rice mill equipment manufacturing workshop; training on operation, maintenance, and repair of rice mill equipment to operators and technicians; design, drawing, and manufacturing training to rice mill equipment manufacturer and management training to rice mill management are necessary. Inadequate knowledge and skill development services are available only at the tertiary level of educational institutions; however, rice millers have limited access to these services. Policy support for having business service provisions at Poly-technique, Vocational training institutes, and universities would be strengthened along with soft credit provisions from commercial banks.

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CONFLICTS OF INTEREST:

The authors declare no conflicts of interest.

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