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Head Rice Recovery, Comparative Advantage, and International Competitiveness of BRRI dhan50 Aromatic Rice in Bangladesh: Evidence from Policy Analysis Matrix

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A B S T R A C T

This study evaluates the comparative advantage and export potential of BRRI dhan50, a modern aromatic rice variety in Bangladesh, using the Policy Analysis Matrix (PAM) framework. It addresses a key empirical paradox in the rice economy, where conventional financial indicators suggest limited profitability, while efficiency-based measures reveal positive economic returns at both private and social prices. Primary data were collected from 160 randomly selected farmers in Jashore district during the 2021-22 Boro season. The results indicate that at a 56% head rice recovery (HRR), achievable through modern rubber huller milling, BRRI dhan50 demonstrates strong financial performance and a clear comparative advantage under both import and export parity conditions. However, when HRR declines to 52%, reflecting conventional milling practices, the variety retains comparative advantage only under import parity, while export competitiveness is lost, underscoring the critical role of post-harvest processing efficiency in determining international competitiveness. Sensitivity analysis further confirms that export competitiveness is highly vulnerable to reductions in milling efficiency, with DRC exceeding unity at lower HRR levels. Policy indicators (NPC = 2.38; EPC = 2.86) reveal substantial price distortions and policy-induced protection, while a positive Profitability Coefficient (PC = 5.12) indicates net transfers in favor of producers. Overall, BRRI dhan50 exhibits strong potential as a value-added aromatic rice for import substitution and conditional export competitiveness, contingent on improved milling performance and institutional support. The findings emphasize that enhancing head rice recovery, strengthening post-harvest management, and improving quality assurance systems are essential for sustaining export competitiveness. Long-term competitiveness will depend on investments in modern processing infrastructure, value-chain development, research and development, export diversification, logistics efficiency, and national branding strategies for Bangladeshi aromatic rice in global markets.

1. Introduction

Rice serves as the principal staple for more than half of the global population, providing over 20% of daily caloric intake worldwide (Tama et al., 2018). Consumption is particularly high in Asia, where per capita intake frequently exceeds 100 kg annually. While most rice is consumed domestically, international trade has grown significantly in recent years. A limited number of exporting countries now account for the majority of global supply, creating a concentrated market structure that increases

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susceptibility to supply disruptions and price volatility (Tama et al., 2018).

Aromatic rice constitutes a premium niche in the global market due to its unique fragrance and strong consumer preference. In Bangladesh, these varieties command prices that are typically two to three times higher than those of non-aromatic rice and are widely associated with cultural and religious occasions. Since the early 1990s, the country has exported small quantities of traditional aromatic varieties such as Kalijira and Chinigura mainly to Middle East and selected European markets, largely to meet the demand of expatriate communities (Rahman, 2000; Tama et al., 2018).

To enhance commercial prospects, Bangladesh has developed and released modern aromatic rice varieties through breeding programs led by the Bangladesh Rice Research Institute (Table 1). Among these improved lines, BRRI dhan50 (Banglamoti) stands out for its characteristics that are especially attractive to international consumers.

Table 1

Modern aromatic rice varieties in Bangladesh.

Variety	Year of release	Season	Gain type	Yield (ton/ha)
BR5	1976	T. Aman	Oval	3.0
BRRI dhan34	1997	T. Aman	Short bold	3.5
BRRI dhan37	1998	T. Aman	Medium slender	3.5
BRRI dhan38	1998	T. Aman	Medium slender	3.5
BRRI dhan50	2008	Boro	Long slender	6.0
BRRI dhan70	2015	T. Aman	Long slender	5.0
BRRI dhan90	2019	T. Aman	Short bold	5.0
Binadhan-9	2012	T. Aman	Long slender	3.8
Binadhan-13	2013	T. Aman	Bold	3.5
Binadhan-18	2015	Boro	Medium bold	7.3

Source: BRRI (2025) and https://bina.gov.bd.

Based on the data presented in Fig. 1, the area coverage of BRRI dhan50 in Bangladesh over a 14-year period shows a distinct lifecycle typical of an adopted particular variety. The timeline begins in the fiscal year 2011-12 with an initial introduction covering just 5.8 thousand hectares. Following this rollout, the variety experienced a rapid and steep adoption phase as farmers quickly expanded its cultivation. By 2013-14, cultivation had surged to 52.7 thousand hectares, and it continued a steady upward trajectory over the next few years, crossing the 74.0 thousand hectare mark by 2015-16.

The variety reached its absolute peak in the fiscal year 2017-18, securing a maximum coverage of 86.5 thousand hectares. Following this peak, BRRI dhan50 entered a brief plateau period, maintaining high coverage at 86.2 thousand hectares in 2018-19 and 84.8 thousand hectares in 2019-20. This period represents the height of its widespread acceptance and market stabilization across the country's rice-growing regions.

After 2019-20, the graph indicates a gradual, multi-year decline in cultivation area. The coverage dropped to 80.4 thousand hectares in 2020-21, and despite a minor, temporary rebound to 81.4 thousand hectares in 2021-22, the downward trend resumed sharply over the following two years. By 2023-24, the area had contracted to its lowest point in a decade at 65.4 thousand hectares, likely due to the introduction of newer, higher-yielding varieties or changing environmental and market dynamics. However, the final year of the dataset, 2024-25, shows a slight recovery to 67.0 thousand hectares, indicating that the variety has settled into a stable, lasting niche within Bangladesh's agricultural landscape.

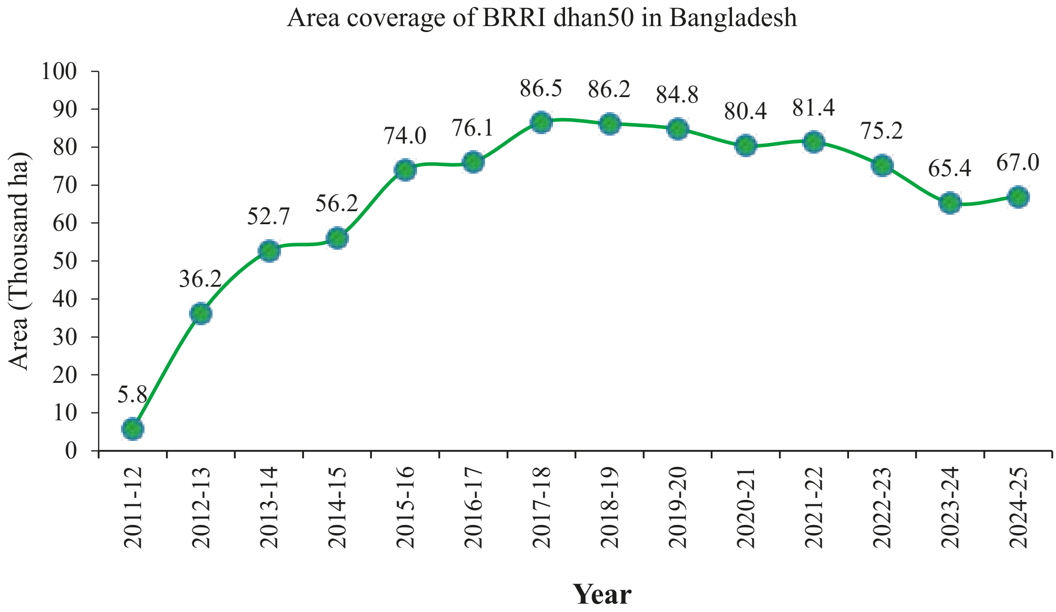

Fig. 1. Adoption of BRRI dhan50 in Bangladesh.
Note: Authors' estimation based on data from the Department of Agriculture Extension (DAE).

Existing empirical literature on Bangladesh's rice sector has predominantly concentrated on traditional aromatic rice varieties cultivated in the Aman season, with a particular emphasis on assessing comparative advantage and international competitiveness using the Domestic Resource Cost (DRC) ratio (Anik & Talukder, 2002; Rashid, 2009; Kazal et al., 2013). These studies have provided important foundational evidence that certain indigenous aromatic rice varieties can be economically viable under existing policy and market conditions. However, this body of work remains limited in scope, as it largely excludes modern high-yielding aromatic rice varieties that have been recently developed and introduced by national breeding programs.

In particular, the export competitiveness of modern aromatic rice varieties such as BRRI dhan50, which is predominantly cultivated in the Boro season, remains underexplored in the existing literature. This is a critical gap, given that varietal improvements, changes in seasonal production systems, and evolving market demand for premium rice types may substantially alter competitiveness outcomes compared to earlier findings based on traditional cultivars. As a result, existing evidence may not adequately reflect the current and potential future export position of Bangladesh's aromatic rice sector.

Unlike previous studies, this research incorporates the head rice recovery ratio (HRR)-a key determinant of milling yield and exportable produce quality that directly affects tradable surplus but has often been overlooked in earlier studies.

To address this gap, this study evaluates the international competitiveness of un-parboil BRRI dhan50 using the Policy Analysis Matrix (PAM) framework, which provides a more comprehensive assessment by simultaneously capturing private profitability, economic efficiency, and policy distortions. Furthermore, the analysis extends beyond conventional tradable input assumptions by incorporating a broader set of input cost structures, thereby improving the precision of economic valuation.

In addition, this study introduces a distinction between observed (actual farmer practices) and technically efficient production scenarios, allowing for a more nuanced evaluation of competitiveness under both current behavioral constraints and potential productivity improvements. This dual approach provides insights into whether farmers can remain competitive not only under existing policy distortions but also under improved efficiency conditions.

Overall, the findings are expected to generate robust empirical evidence to guide policymakers in assessing the feasibility and strategic potential of exporting modern aromatic rice from Bangladesh in an increasingly competitive global rice market.

Objectives of the study

Given the shifting dynamics in Bangladesh's aromatic rice sector, this study addresses

existing research gaps through four specific objectives:

1. to evaluate the private and social profitability of cultivating the modern aromatic Boro rice variety, BRRI dhan50, at the farm level.
2. to assess the international competitiveness and comparative advantage of BRRI dhan50 under both import-substitution and export-parity scenarios.
3. to empirically measure the impact of post-harvest milling yield-specifically comparing Head Rice Recovery (HRR) ratios of 56% and 52%, and
4. to measure macroeconomic exchange rate fluctuations on the stability of this comparative advantage using sensitivity analysis.

2. Methodology

2.1. Data and study area

The study is based on cross-sectional primary data gathered during the 2021–22 Boro season from Jashore district, a major production area for BRRI dhan50 aromatic rice. Two Upazilas (Jashore Sadar and Monirampur) were purposively selected, followed by the selection of two Unions each Upazila and two villages from each Union. From village-level farmer lists prepared with support from the Department of Agricultural Extension (DAE), a total of 160 BRRI dhan50 farmers were randomly sampled. Data were collected using a structured interview schedule and standardized procedures to ensure accuracy and consistency.

2.2. Head rice recovery ratio

Head rice recovery ratio (HRR) significantly influences the economic value of aromatic rice, particularly for export markets (Prasanna & Reddy, 2025). In Bangladesh, milling efficiency varies by technology: rubber huller mills recover up to 56% head rice, while engelberg mills recover up to 52% for BRRI dhan50 (Rahman et al., 2011). Both HRR values were incorporated into PAM calculations under import and export parity price scenarios.

2.3. Policy analysis matrix

The Policy Analysis Matrix (PAM), developed by Monke & Pearson (1989), is used to assess private and social profitability and to identify policy-induced distortions in BRRI dhan50 production. The framework distinguishes between tradable and non-tradable inputs and compares market prices with social (efficiency) prices to evaluate comparative and competitive advantage. This study extends the conventional PAM by incorporating a broader set of tradable inputs, including seed, pesticides, machinery, urea, TSP, MoP, gypsum, and ZnSO4, as well as by analyzing both observed and technically efficient production scenarios. This allows a more precise evaluation of cost efficiency, productivity gains, and long-term competitiveness under international market pressure.

Private profitability reflects actual farm-level returns based on market prices, incorporating taxes, subsidies, and policy distortions, and indicates financial viability for producers. In contrast, social profitability uses shadow prices to reflect true economic values, excluding distortions, and measures contribution to national welfare and comparative advantage.

The divergence between private and social profitability reveals policy effects and market imperfections. Higher private than social returns suggest policy protection, while higher social than private returns indicate inefficiencies or disincentives. Rooted in welfare economics and Ricardo's comparative advantage theory, PAM operationalizes these concepts through shadow pricing to evaluate efficiency and policy-induced transfers (Pearson et al., 2003; Monke & Pearson, 1989).

2.4. Sensitivity analysis

Sensitivity analysis is an essential component of Policy Analysis Matrix (PAM) analysis because it evaluates how changes in key economic variables, such as exchange rates, input prices, output prices, taxes, or subsidies, affect profitability, comparative advantage, and policy incentives. Since agricultural markets are highly sensitive to policy and market fluctuations, sensitivity analysis helps determine the stability and reliability of PAM results under alternative economic scenarios. It also identifies whether a production system remains competitive and economically efficient when economic conditions change.

In PAM studies, indicators such as Financial Profitability (FP), Social Profitability (SP), Domestic Resource Cost (DRC), and protection coefficients may vary significantly due to changes in market conditions. Therefore, sensitivity analysis is widely used to assess the robustness of comparative advantage and the effects of policy distortions on domestic production systems. For example, an increase in the exchange rate may raise the economic cost of tradable inputs, reduce social profitability, and weaken comparative advantage, even when private profitability remains stable. Thus, sensitivity analysis provides important guidance for policymakers in designing sustainable agricultural and trade policies. In this study, we set assumption: existing market exchange rate has increased from 1 US$ = 84.80 BDT (base) to 1 US$ = 100 BDT.

The PAM yields indicators that determine whether an agricultural system is competitive and has comparative advantage. The following formulations then assess comparative advantage within the PAM framework.

Table 2
The accounting structure of the Policy Analysis Matrix.

Items	Revenue	Costs		Profit
		Tradable inputs	Non-tradable inputs	
Private	A	B	C	$D_{(1)}$
Social	E	F	G	$H_{(2)}$
Divergences	$I_{(3)}$	$J_{(4)}$	$K_{(5)}$	$L_{(6)}$
(1) Private profits (D = A – B – C)			(2) Social profits (H = E –F – G)	
(3) Output transfers (I = A – E)			(4) Input transfers (J = B – F)	
(5) Factor transfers (K = C –G)			(6) Net transfers (L = I – J – K)	

Source: Monke & Pearson, 1989.

2.5. The domestic resource cost ratios (DRC)

The DRC, which would provide a measure of the level of comparative advantage to be achieved by the selected system as:

$$DRC = \frac{\text{Social costs of non tradable inputs (G)}}{\text{Social revenue (E) - Social cost of tradable inputs (F)}}$$

Decision criteria:

DRC < 1 means that economic activity is economically efficient in the use of domestic resources or that economic activity has a comparative advantage so that domestic fulfilment is more profitable with an increase in domestic production. Domestic resource investment is beneficial to agricultural production's contribution to international revenue and comparative advantage;

DRC > 1 means that economic activity is not economically efficient in the use of domestic resources or that economic activity causes comparative losses.

2.6. Financial cost benefit ratio (FCB)

The FCB is the value of the domestic factors against the difference between the revenue minus tradable inputs.

$$FCB = \frac{\text{Private cost of non tradable inputs (C)}}{\text{Private revenue (A)-Private cost of tradable inputs (B)}}$$

Decision criteria:

FCB < 1 it means that the system is profitable;

FCB > 1 it means that the system utilizes more value of domestic factors than the value added, then the system is not profitable;

FCB = 1 means that the economic activity provides a normal profit or the activity is at a break-even point.

2.7. The nominal protection coefficient (NPC)

The NPC shows the level of protection for the tradable output by looking at the ratio of revenue of private prices to revenue at social prices.

$$NPC = \frac{\text{Private revenue (A)}}{\text{Social Revenue (E)}}$$

Decision criteria:

NPC > 1 it indicates that the main output is undervalued at its private price, resulting in a transfer of wealth from the production system to the economy;

NPC < 1 it indicates that the production system benefits from protection.

2.8. The effective protection coefficient (EPC)

The EPC compares the value added at private prices to the value added at social prices. This gives us a combined index of the level of trade distortion on both tradable inputs and outputs and provides a more accurate measure of the level of protection than the NPC.

$$EPC = \frac{\text{Private revenue (A)-Private cost of tradable input (B)}}{\text{Social Revenue (E)-Social cost of tradable inputs (F)}}$$

Decision criteria:

EPC < 1 it means that the system generates less value added at market prices than it would at social prices, i.e., government does not provide effective protection;

EPC > 1 it means that the selected system is protected.

3. Results

3.1. Import parity-based PAM results (HRR = 56%)

The import-parity PAM results shown in Table 3, based on a head rice recovery (HRR) of 56%, indicate that BRRI dhan50 production in Jashore is both competitive and exhibits a clear comparative advantage. At private prices, the Financial Cost-Benefit

(FCB) ratio is estimated at 0.52, which is well below unity. This suggests that farmers are able to cover production costs and generate profits under prevailing market conditions, confirming the financial competitiveness of BRRI dhan50 from the producers' perspective.

At social prices, the Domestic Resource Cost (DRC) ratio is estimated at 0.65, indicating a strong comparative advantage: the domestic resources required to produce BRRI dhan50 are valued at less than the foreign exchange saved through import substitution. The Social Cost-Benefit (SCB) ratio of 0.73 further confirms economic efficiency when inputs are priced at their opportunity cost, as it accounts for both tradable and non-tradable components of production

The Nominal Protection Coefficient (NPC) for output is 2.18, which is greater than unity, indicating that domestic farmgate market prices are substantially higher than world reference (border parity) prices. This reflects a high level of market protection, resulting in an implicit net transfer of wealth from the national economy to the production system. When both output and input policies are considered, the Effective Protection Coefficient (EPC) of 2.55 further confirms that the domestic production system benefits from strong overall policy protection, which inflates net value-added at private prices relative to social efficiency prices. The Profitability Coefficient (PC) of 3.55, along with a positive net transfer of BDT 23,855, further demonstrates that policy interventions generate substantial gains for producers, allowing private profits to significantly exceed true economic profits.

The Producer Subsidy Ratio (PSR) of 0.68 suggests substantial policy support for both outputs and production factors, while the Equivalent Producer Subsidy (EPS) of 0.31 indicates that producers receive support equivalent to 31% of social revenue, with no corresponding offsetting transfers to consumers. Therefore, under an import-parity frame-work, BRRI dhan50 production appears economically efficient and policy-supported, strengthening its potential as a competitive aromatic rice variety for import substitution in Bangladesh.

3.1.1. Sensitivity analysis

Table 3 presents the results of the Policy Analysis Matrix (PAM) indicators for the export potential rice variety, BRRI dhan50, under the existing situation and a sensitivity analysis where the exchange rate increases. The findings indicate that BRRI dhan50 production remains financially and economically viable even after the exchange rate adjustment, although some comparative advantage indicators slightly deteriorate.

The financial profitability (FP) remained unchanged at BDT 33,205 under both the base and sensitivity scenarios. This indicates that farmers' private profits were not directly affected by the increase in the exchange rate. Similarly, the financial cost-benefit ratio (FCB) also remained constant at 0.52, suggesting that the production system is financially efficient because the production costs are substantially lower than the financial returns.

In contrast, the social profitability (SP) declined from BDT 9,349 to BDT 8,082 when the exchange rate increased. This reduction implies that from the perspective of the national economy, the net social gain from producing BRRI dhan50 decreased slightly due to higher economic costs associated with tradable inputs and imported components. Nevertheless, the positive SP values in both cases confirm that the variety still contributes positively to the economy.

The domestic resource cost (DRC) increased slightly from 0.65 to 0.68 under the higher exchange rate scenario. Since the DRC values remain below one, Bangladesh still retains a comparative advantage in producing BRRI dhan50 domestically rather than importing rice. However, the increase in DRC suggests a modest reduction in international competitiveness due to the exchange rate shock. Similarly, the social cost-benefit ratio (SCB) rose from 0.73 to 0.77, indicating a slight decline in economic efficiency, although the values below one still demonstrate that the social benefits exceed the social costs.

The transfer value increased from BDT 23,855 to BDT 25,122, indicating that producers continue to receive substantial policy-induced incentives or market distortions favoring domestic production. The nominal protection coefficient (NPC) remained unchanged at 2.18, implying that domestic output prices are more than twice the corresponding world prices in both situations. This reflects significant market protection for rice producers.

The effective protection coefficient (EPC) increased from 2.55 to 2.67 after the exchange rate increase. This suggests that value-added at private prices became relatively more protected compared to social prices. Likewise, the profitability coefficient (PC) increased from 3.55 to 4.104, indicating that private profitability is substantially higher than social profitability under the distorted market conditions.

Furthermore, the producer subsidy ratio (PSR) increased from 0.68 to 0.717, while the equivalent producer subsidy (EPS) rose from 0.31 to 0.33. These increases imply that producers receive relatively greater implicit support or protection under the higher exchange rate scenario.

Table 3

Results of import parity-based PAM indicators of export potential rice variety considering 56% HRR.

Indicators	Equations	Main Analysis	Sensitivity Analysis
Financial Profitability (FP)	D = A-B-C	33205	33205
Financial Costs-Benefit Ratio (FCB)	C/(A-B)	0.52	0.52
Social Profitability (SP)	H = E-F-G	9349	8082
Domestic Resource cost (DRC)	G/(E-F)	0.65	0.68
Social Costs-Benefit Ratio (SCB)	(F + G)/E	0.73	0.77
Transfer	L = I-J-K	23855	25122
Nominal Protection Coefficient (NPC)	A/E	2.18	2.18
Effective Protection Coefficient (EPC)	(A-B)/(E-F)	2.55	2.67
Profitability Coefficient (PC)	D/H	3.55	4.104
Producers Subsidy Ratio (PSR)	L/E	0.68	0.717
Equivalent Producer Subsidy (EPS)	L/A	0.31	0.33

Note: The analysis was based on supplementary file tables S5 and S9.

3.2. Export parity-based PAM results (HRR = 56%)

Table 4 reports the export-parity PAM results based on a head rice recovery (HRR) of 56%, indicating that BRRI dhan50 production is both financially viable and economically efficient for export markets. At private prices, the Financial Cost-Benefit (FCB) ratio is estimated at 0.52, indicating that producers can profitably supply aromatic rice for export under prevailing market conditions.

From an efficiency perspective, the Domestic Resource Cost (DRC) is estimated at 0.91, which remains below unity and confirms a comparative advantage in export production. This indicates that the domestic resources used to produce BRRI dhan50 are valued at less than the foreign exchange earned from exports. The Social Cost-Benefit (SCB) ratio of 0.94 further supports this finding, demonstrating economic efficiency when both inputs and outputs are valued at distorted social prices. As the SCB incorporates the full opportunity cost of both tradable and non-tradable inputs, it offers a more comprehensive assessment of comparative advantage than the DRC alone.

Policy indicators highlight significant distortions in the production system. The Nominal Protection Coefficient (NPC) for output is 2.79, which exceeds unity and indicates a substantial divergence between private and social output prices. This suggests that producers receive prices above the social value of output, implying an implicit transfer from the production system to the broader economy. When policies affecting both outputs and tradable inputs are considered jointly, the Effective Protection Coefficient (EPC) of 3.55 indicates that the system benefits from overall protection, thereby increasing private value added. The Profitability Coefficient (PC) of 19.42, along with a positive net transfer of BDT 31,494, further suggests substantial transfers from the economy to BRRI dhan50 producers. In addition, the Producer Subsidy Ratio (PSR) of 1.15 confirms real support to both outputs and production factors, while the Equivalent Producer Subsidy (EPS) of 0.41 indicates considerable support. However, the structure of these interventions suggests that policy measures may favor consumers more than they directly protect producers. The export-parity PAM results indicate that BRRI dhan50 has a modest but positive comparative advantage in export markets, with profitability and competitiveness strongly shaped by existing policy measures.

3.2.1. Sensitivity analysis

Table 4 presents the results of the Policy Analysis Matrix (PAM) indicators for the export potential rice variety BRRI dhan50 under the export parity condition and a sensitivity analysis where the exchange rate increased. The results show that BRRI dhan50 remains financially profitable and economically viable despite changes in the exchange rate, although some indicators suggest a reduction in comparative advantage and social efficiency.

The financial profitability (FP) remained unchanged at BDT 33,205 under both the base and sensitivity scenarios, indicating that farmers' private profits were not directly affected by the increase in the exchange rate. Similarly, the financial cost-benefit ratio (FCB) also remained constant at 0.52, implying that production costs are substantially lower than financial returns and that the variety continues to be financially attractive for producers.

In contrast, the social profitability (SP) declined sharply from BDT 1,710 to BDT 443 when the exchange rate increased. This decrease suggests that higher exchange rates raised the economic cost of tradable inputs and reduced the net social benefit from BRRI dhan50 production. Although the SP value remained positive, the significant decline indicates that the economic gains to the national economy became relatively smaller under the sensitivity scenario.

The domestic resource cost (DRC) increased from 0.91 to 0.98 following the exchange rate increase. Since the DRC values remained slightly below one, Bangladesh still maintained a comparative advantage in exporting BRRI dhan50. However, the movement of DRC closer to unity indicates that the comparative advantage weakened considerably under higher exchange rate conditions. Similarly, the social cost-benefit ratio (SCB) increased from 0.94 to 0.983, reflecting a decline in economic efficiency, although the values below one still confirm that social benefits marginally exceeded social costs.

The transfer value increased from BDT 31,494 to BDT 32,761, indicating greater divergence between private and social profitability due to policy interventions and market distortions. The nominal protection coefficient (NPC) remained unchanged at 2.79, implying that domestic output prices were nearly three times higher than world reference prices, which reflects strong market protection for rice producers.

Moreover, the effective protection coefficient (EPC) increased from 3.55 to 3.80, indicating that domestic value-added received stronger protection under the increased exchange rate scenario. The profitability coefficient (PC) rose substantially from 19.42 to 74.95 because social profitability declined sharply while private profitability remained unchanged. This finding suggests that private profits were much higher than social profits due to policy protection and market distortions. Furthermore, the producer subsidy ratio (PSR) increased from 1.15 to 1.20, while the equivalent producer subsidy (EPS) increased from 0.41 to 0.43. These increases indicate that producers received relatively greater implicit subsidies and policy support after the exchange rate increase.

Table 4

Results of export parity-based PAM indicators of export potential rice variety considering 56% HRR.

Indicators	Equations	Main Analysis	Sensitivity Analysis
Financial Profitability (FP)	D = A-B-C	33205	33205
Financial Costs-Benefit Ratio (FCB)	C/(A-B)	0.52	0.52
Social Profitability (SP)	H = E-F-G	1710	443
Domestic Resource cost (DRC)	G/(E-F)	0.91	0.980
Social Costs-Benefit Ratio (SCB)	(F + G)/E	0.94	0.983
Transfer	L = I-J-K	31494	32761
Nominal Protection Coefficient (NPC)	A/E	2.79	2.79
Effective Protection Coefficient (EPC)	(A-B)/(E-F)	3.55	3.80
Profitability Coefficient (PC)	D/H	19.42	74.95
Producers Subsidy Ratio (PSR)	L/E	1.15	1.20
Equivalent Producer Subsidy (EPS)	L/A	0.41	0.43

Note: The analysis was based on supplementary file tables S6 and S10.

3.3. Import parity-based PAM results (HRR = 52%)

Table 5 presents a Financial Cost–Benefit (FCB) ratio at private prices of 0.51, which is below unity and indicates that BRRI dhan50 production in Jashore is financially competitive. The Domestic Resource Cost (DRC) ratio of 0.73 also confirms a comparative advantage, implying that the domestic resources used in production generate value exceeding their economic cost. The Social Cost–Benefit (SCB) ratio of 0.80 further strengthens this conclusion, demonstrating economic efficiency when evaluated at social prices. As the SCB accounts for the full opportunity cost of both tradable and non-tradable inputs, it provides a more comprehensive measure of comparative advantage than the DRC alone.

Policy indicators point to both substantial distortions and strong policy support within the system. The Nominal Protection Coefficient (NPC) of 2.38, which exceeds unity, indicates that domestic market prices for the output are significantly higher than world market prices, resulting in a positive transfer of resources to the production system. The Effective Protection Coefficient (EPC) of 2.86 indicates that the system benefits from strong overall policy protection, reflecting the combined effects of government interventions on both tradable outputs and inputs. A Profitability Coefficient (PC) of 5.12, together with a positive net transfer of BDT 27,109, indicates substantial net financial gains in favor of producers over social returns. Moreover, the Producer Subsidy Ratio (PSR) of 0.84 confirms real support to both output and production factors, while the Equivalent Producer Subsidy (EPS) of 0.35 implies that producers receive support equivalent to 35% of social revenue, with no corresponding transfer to consumers.

3.3.1. Sensitivity analysis

Table 5 presents the results of the Policy Analysis Matrix (PAM) indicators for the export potential rice variety BRRI dhan50 under import parity conditions, along with a sensitivity analysis where the exchange rate is increased. The results show that the variety remains financially profitable and economically efficient, although some indicators reflect a decline in social efficiency and comparative advantage under the higher exchange rate scenario.

The financial profitability (FP) remains constant at BDT 33,690 in both the base and sensitivity cases, indicating that farmers' private profits are not affected by the exchange rate change. Similarly, the financial cost-benefit ratio (FCB) remains stable at 0.51, confirming that production is financially efficient, as costs are significantly lower than financial returns.

In contrast, social profitability (SP) declines from BDT 6,580 to BDT 5,313 after the exchange rate increase. This reduction indicates that higher exchange rates raise the economic cost of tradable inputs, thereby reducing the net social benefit from rice production. Although SP remains positive, the decline suggests a weakening contribution to national economic welfare.

The domestic resource cost (DRC) increases from 0.73 to 0.77, indicating a slight reduction in comparative advantage. However, since the DRC remains below one, BRRI dhan50 still maintains an economic advantage in domestic production compared to imports. The increase toward unity suggests that the competitiveness of the variety is gradually weakening under the higher exchange rate condition. Similarly, the social cost-benefit ratio (SCB) increases from 0.80 to 0.84, reflecting a decline in economic efficiency, although the values below one confirms that social benefits still exceed social costs.

The transfer value increases from BDT 27,109 to BDT 28,376, indicating that producers receive higher implicit support due to policy distortions and price differences between domestic and world markets. The nominal protection coefficient (NPC) remains unchanged at 2.38, suggesting that domestic output prices are more than twice the world reference prices, reflecting a strong level of price protection.

The effective protection coefficient (EPC) increases from 2.86 to 3.02, indicating that value-added in domestic production becomes more protected under the increased exchange rate scenario. The profitability coefficient (PC) also increases from 5.12 to 6.34, showing that private profitability is substantially higher than social profitability, mainly due to policy-induced distortions. Furthermore, the producer subsidy ratio (PSR) rises from 0.84 to 0.88, while the equivalent producer subsidy (EPS) increases from 0.35 to 0.37. These increases suggest that producers receive greater implicit subsidies or protection when the exchange rate rises.

Table 5

Results of import parity-based PAM indicators of export potential rice variety considering 52% HRR.

Indicators	Equations	Main Analysis	Sensitivity Analysis
Financial Profitability (FP)	D = A-B-C	33690	33690
Financial Costs-Benefit Ratio (FCB)	C/(A-B)	0.51	0.51
Social Profitability (SP)	H = E-F-G	6580	5313
Domestic Resource cost (DRC)	G/(E-F)	0.73	0.77
Social Costs-Benefit Ratio (SCB)	(F + G)/E	0.80	0.84
Transfer	L = I-J-K	27109	28376
Nominal Protection Coefficient (NPC)	A/E	2.38	2.38
Effective Protection Coefficient (EPC)	(A-B)/(E-F)	2.86	3.02
Profitability Coefficient (PC)	D/H	5.12	6.34
Producers Subsidy Ratio (PSR)	L/E	0.84	0.88
Equivalent Producer Subsidy (EPS)	L/A	0.35	0.37

Note: The analysis was based on supplementary file tables S7 and S11.

3.4. Export parity-based PAM results (HRR = 52%)

Table 6 presents a Financial Cost–Benefit (FCB) ratio of 0.51 at private prices, which is below unity and indicates that BRRI dhan50 production in Jashore remains financially profitable for export. However, the Domestic Resource Cost (DRC) of 1.06 which exceeds one, suggests the absence of a comparative advantage in export production, as domestic resources are used less efficiently than the foreign exchange earned, leading to comparative losses. Similarly, the Social Cost-Benefit (SCB) ratio of 1.04 is greater than one, reinforcing the lack of comparative advantage when inputs and outputs are valued at distortion-free social prices. As the SCB incorporates the full opportunity costs of both tradable and non-tradable inputs, it is considered a more comprehensive and reliable indicator than the DRC alone.

Policy indicators reveal significant distortions alongside elements of policy support. The Nominal Protection Coefficient (NPC) of 3.12, which exceeds unity, suggests that the main output is overvalued at private prices, leading to a transfer of resources from the broader economy to production system. The Effective Protection Coefficient (EPC) of 4.18 indicates strong policy-induced protection affecting both tradable outputs and inputs, thereby inflating private value added. In contrast, the Profitability Coefficient (PC) of − 31.78 points to net transfers from the production system to the economy (BRRI dhan50 production remains financially attractive for farmers because of strong protection and support policies, but it is not socially efficient under export parity conditions, as the economy incurs higher resource costs than the value generated at world prices.), although the reported positive net transfer of BDT 34,749 indicates that there are also simultaneous transfers benefiting producers. Furthermore, the Producer Subsidy Ratio (PSR) of 1.41 confirms substantial support to outputs and production factors, while the Equivalent Producer Subsidy (EPS) of 0.45 implies that producers receive significant net support without corresponding protection for consumers.

3.4.1. Sensitivity analysis

Table 6 presents the Policy Analysis Matrix (PAM) results for the export potential rice variety BRRI dhan50 under export parity conditions with a sensitivity analysis where the exchange rate is increased. The results indicate that while financial profitability remains stable, the variety becomes economically inefficient under social pricing after the exchange rate shock.

The financial profitability (FP) remains unchanged at BDT 33,690 in both the base and sensitivity scenarios, indicating that farmers' private profits are not affected by the increase in exchange rate. Similarly, the financial cost-benefit ratio (FCB) remains constant at 0.51, confirming that production is financially efficient from the farmers' perspective, as revenues exceed costs.

In contrast, the social profitability (SP) is negative in both cases and declines further from BDT –1,060 to BDT –2,327. This indicates that, from the viewpoint of the national economy, BRRI dhan50 production generates a net economic loss, and the loss increases when the exchange rate rises. The increase in exchange rate raises the economic cost of tradable inputs, worsening the inefficiency in resource allocation.

The domestic resource cost (DRC) increases from 1.06 to 1.15, indicating that BRRI dhan50 loses its comparative advantage under both scenarios. Since the DRC is greater than one, it implies that domestic production is less efficient (export) than importing rice. The rise in DRC further confirms a deterioration in competitiveness when the exchange rate increases. Similarly, the social cost-benefit ratio (SCB) rises from 1.04 to 1.09, reinforcing the conclusion that social costs exceed social benefits and economic efficiency declines further under the sensitivity scenario.

The transfer value increases from BDT 34,749 to BDT 36,016, indicating a widening gap between private and social values due to policy distortions and market interventions. The nominal protection coefficient (NPC) remains constant at 3.12, showing that domestic rice prices are more than three times the world price level, reflecting strong price protection for producers.

The effective protection coefficient (EPC) increases from 4.18 to 4.53, indicating greater protection of value-added in domestic production under the higher exchange rate scenario. The profitability coefficient (PC) remains negative but improves from –31.78 to –14.48, showing that although private profitability remains positive, social losses are large relative to private gains. Furthermore, the producer subsidy ratio (PSR) increases from 1.41 to 1.47, and the equivalent producer subsidy (EPS) rises from 0.45 to 0.70. These results indicate stronger implicit subsidies and policy support to producers, even though the underlying economic efficiency is weak.

Table 6

Results of export parity-based PAM indicators of export potential rice variety considering 52% HRR.

Indicators	Equations	Main Value	Sensitivity Analysis
Financial Profitability (FP)	D = A-B-C	33690	33690
Financial Costs-Benefit Ratio (FCB)	C/(A-B)	0.51	0.51
Social Profitability (SP)	H = E-F-G	-1060	-2327
Domestic Resource cost (DRC)	G/(E-F)	1.06	1.15
Social Costs-Benefit Ratio (SCB)	(F + G)/E	1.04	1.09
Transfer	L = I-J-K	34749	36016
Nominal Protection Coefficient (NPC)	A/E	3.12	3.12
Effective Protection Coefficient (EPC)	(A-B)/(E-F)	4.18	4.53
Profitability Coefficient (PC)	D/H	-31.78	-14.48
Producers Subsidy Ratio (PSR)	L/E	1.41	1.47
Equivalent Producer Subsidy (EPS)	L/A	0.45	0.70

Note: The analysis was based on supplementary file tables S8 and S12.

4. Discussion

The PAM results indicate that the competitiveness of BRRI dhan50 is highly sensitive to both market orientation (import versus export parity) and milling performance. Under import parity conditions, BRRI dhan50 exhibits a strong comparative advantage at both milling recovery levels, with DRC values of 0.65 and 0.73 at 56% and 52% HRR, respectively. In contrast, under export parity conditions, the DRC increases from 0.91 at 56% HRR to 1.06 at 52% HRR, indicating the loss of comparative advantage when milling efficiency declines. These findings suggest that competitiveness is not solely determined by production efficiency at the farm level but also by post-harvest performance and the structure of domestic and international markets.

The stronger competitiveness under import parity arises because domestic production is compared against the cost of imported rice, which includes international freight, insurance, handling, and transaction costs. These additional costs raise the import parity price and improve the relative competitiveness of domestic production. Consequently, the DRC and SCB values remain comfortably below unity under import parity, indicating that BRRI dhan50 can efficiently substitute for imports. Similar findings have been reported for rice production systems in Bangladesh and other Asian countries, where domestic rice production demonstrates stronger competitiveness in import-substitution markets than in export-oriented markets because domestic prices are generally higher than border-equivalent prices (Monke & Pearson, 1989; Yao, 1997; Gullati & Minot, 2007; Islam et al., 2016; Hossain & Deb, 2020).

The results further demonstrate the critical role of head rice recovery in determining competitiveness. A reduction in HRR from 56% to 52% causes DRC values to increase under both parity conditions and pushes export parity DRC above unity. Milling recovery directly affects the quantity of marketable rice obtained from a given volume of paddy. Higher HRR increases output without proportionally increasing production costs, thereby reducing unit costs and improving economic efficiency. Conversely, lower HRR reduces the volume of saleable whole grains while production costs remain largely unchanged, leading to higher DRC and SCB ratios. This relationship is particularly important for aromatic rice because export markets reward whole-grain quality and impose discounts on broken rice. Therefore, even a small decline in milling recovery can substantially reduce export earnings and weaken international competitiveness. Previous studies on aromatic rice value chains have similarly highlighted milling yield as a key determinant of profitability, value addition, and export performance (Bhattacharya, 2011; Tama et al., 2018; Roy et al., 2023).

The divergence between import and export competitiveness can also be explained by differences in market structure and quality requirements. Although BRRI dhan50 remains competitive under import parity at both HRR levels, export competitiveness weakens considerably and disappears at 52% HRR. Export markets require compliance with strict standards related to grain length, aroma, appearance, moisture content, and milling quality. Exporters therefore face additional costs associated with quality control, grading, packaging, certification, transportation, and international marketing. These costs reduce net export returns and lower social profitability. Furthermore, Bangladesh competes in international aromatic rice markets with established exporters such as India and Thailand, which benefit from larger production scales, more advanced milling technologies, and stronger export networks. As a result, the export parity price available to Bangladeshi producers is relatively lower, causing DRC and SCB values to increase under export-oriented scenarios (Miyata, 2011; Mohanty et al., 2017; Kannan et al., 2017; Tama et al., 2018).

The policy indicators further suggest that observed private competitiveness is strongly influenced by policy interventions and market distortions. Across all scenarios, NPC, EPC, PSR, and EPS values exceed unity, indicating significant protection and support to producers. Under import parity, NPC values ranging from 2.18 to 2.38 suggest that domestic output prices are more than double their social prices. Similarly, export parity NPC values ranging from 2.79 to 3.12 indicate a substantial divergence between domestic and world prices. These findings imply that private profitability is enhanced by policy-induced transfers, allowing producers to earn profits considerably higher than economic profits measured at social prices. Similar results have been reported in PAM studies of rice production in developing countries, where subsidies, trade restrictions, and market interventions create significant differences between private and social profitability (Monke & Pearson, 1989; Yao, 1997; Alam et al., 2011; Kassali & Jimoh, 2018).

The sensitivity analysis reveals that exchange-rate depreciation weakens comparative advantage under both import and export parity conditions. Although financial profitability remains unchanged because private prices were assumed constant, social profitability declines and both DRC and SCB increase. Under import parity, DRC rises from 0.65 to 0.68 at 56% HRR and from 0.73 to 0.77 at 52% HRR. Under export parity, DRC increases from 0.91 to 0.98 at 56% HRR and from 1.06 to 1.15 at 52% HRR. The deterioration occurs because exchange-rate depreciation raises the economic cost of tradable inputs, including different chemical fertilizers, fuel, machinery, and processing equipment. The effect is particularly severe under export parity because export competitiveness depends heavily on maintaining low production and processing costs relative to international competitors. Similar exchange-rate effects on agricultural competitiveness have been documented in rice-producing countries where imported inputs constitute a substantial share of production costs (Anderson & Martin, 2009; Anderson et al., 2013; Mohanty et al., 2017).

Overall, the findings indicate that BRRI dhan50 possesses a strong comparative advantage for import substitution but a relatively fragile comparative advantage for export promotion. The transition from export competitiveness at 56% HRR (DRC = 0.91) to export inefficiency at 52% HRR (DRC = 1.06) demonstrates that milling efficiency is a critical threshold variable for international competitiveness. Therefore, investments in modern milling technologies, improved drying and storage facilities, quality control systems, and post-harvest management practices are likely to generate larger gains in export competitiveness than farm-level productivity improvements alone. These results support previous studies emphasizing that sustaining competitiveness in aromatic rice exports requires simultaneous improvements in production efficiency, milling recovery, product quality, and market integration (Rahman et al., 2018; Tama et al., 2018; Rahman & Hasan, 2019; Roy et al., 2023).

5. Conclusion and policy recommendations

The Policy Analysis Matrix (PAM) results demonstrate that BRRI dhan50 possesses substantial potential as a competitive aromatic rice variety in Bangladesh, although its competitiveness varies considerably across market scenarios and milling recovery levels. Under import parity conditions, BRRI dhan50 consistently exhibits strong financial profitability and comparative advantage at both 56% and 52% head rice recovery (HRR) levels, as reflected by DRC and SCB values below unity. These findings indicate that domestic production can efficiently substitute for imports and contribute positively to national resource use and foreign exchange savings.

In contrast, export competitiveness is more sensitive to milling performance. At 56% HRR, BRRI dhan50 maintains a modest comparative advantage under export parity conditions (DRC = 0.91; SCB = 0.94), suggesting that exports are economically viable. However, when HRR declines to 52%, export competitiveness disappears (DRC = 1.06; SCB = 1.04), indicating that social costs exceed social benefits. This finding highlights the critical importance of milling efficiency and grain quality in determining export performance. The results further show that exchange-rate depreciation weakens social profitability and comparative advantage by increasing the economic cost of tradable inputs, although private profitability remains protected through existing policy support mechanisms.

The consistently high values of NPC, EPC, PSR, and EPS suggest that producer profitability is strongly influenced by policy interventions and market protection. While these measures enhance private returns, long-term competitiveness will depend less on policy support and more on improvements in productivity, milling efficiency, quality assurance, and export-market integration. Overall, BRRI dhan50 has stronger potential as an import-substituting aromatic rice variety than as an export commodity, although improvements in post-harvest management and milling technology could substantially strengthen its export competitiveness.

The sensitivity analysis shows that exchange-rate depreciation reduces the comparative advantage of BRRI dhan50 by increasing the economic cost of tradable inputs, resulting in higher DRC and SCB values. Although financial profitability remains unchanged, social profitability declines under both import and export parity conditions. The adverse effect is more severe for exports, where competitiveness becomes marginal at 56% HRR and disappears at 52% HRR. Therefore, sustaining competitiveness requires higher milling recovery, improved processing efficiency, and reduced dependence on imported inputs.

Based on these empirical findings, the following targeted policy interventions are recommended:

5.1. Short-term policy recommendations (1-3 years)

1. Improve milling yield and head rice recovery

Since export competitiveness is highly sensitive to HRR, immediate efforts should focus on improving milling yield through the adoption of modern milling equipment, proper paddy drying, and improved grain handling practices. Training programs should be implemented to improve harvesting, drying, storage, and post-harvest management practices. Reducing grain breakage during harvesting and processing can significantly increase HRR and improve marketable output.

2. Enhance quality control and certification

Bangladesh should strengthen quality inspection, grading, and certification systems for aromatic rice exports. Standardized quality assurance mechanisms would improve buyer confidence and help BRRI dhan50 compete in premium international markets.

3. Maintain stable input supply and market support

Policies ensuring timely access to quality seed, fertilizers, irrigation services, and extension support should continue to reduce production risks and maintain farm profitability. Temporary support measures may be necessary during periods of exchange-rate volatility and rising input costs.

4. Promote market information systems

Establishing digital platforms and export-market information systems can help farmers, traders, and exporters access real-time information on prices, quality requirements, and international demand conditions, thereby reducing market inefficiencies.

5.2. Long-term policy recommendations (4-10 years)

1. Invest in modern rice processing infrastructure

Long-term competitiveness requires substantial investment in modern milling complexes, automated grading systems, color sorting technologies, and advanced storage facilities. Improving processing efficiency would increase HRR, reduce post-harvest losses, and enhance export quality.

2. Develop an export-oriented aromatic rice value chain

Bangladesh should establish a coordinated aromatic rice value chain linking farmers, millers, exporters, research institutions, and government agencies. Contract farming and traceability systems could improve quality consistency and strengthen export market access.

3. Strengthen research and development

Public investment in rice research should prioritize the development of aromatic and premium quality rice varieties with higher milling recovery, improved grain quality, climate resilience, and export-oriented characteristics. Research on reducing post-harvest losses should also receive greater attention.

4. Improve logistics and trade facilitation

High transportation and transaction costs reduce export competitiveness. Investments in transportation infrastructure, port facilities, cold-chain logistics, and customs modernization would lower export costs and improve the competitiveness of Bangladeshi aromatic rice in global markets.

Limitation

This study is based on primary data collected from a single district (Jashore), which may not fully capture the heterogeneity of production practices, market conditions, and policy environments across Bangladesh. As a result, the findings should be interpreted with caution when generalizing to other regions. Future research should expand the scope to multiple districts and diverse agro ecological zones to provide a more comprehensive assessment of comparative advantage, export potential, and policy impacts. Incorporating broader geographic coverage would strengthen external validity and allow for more robust sensitivity analyses across varying production systems and market contexts.

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Declaration of interests

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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Supplementary files

Data requirement for calculating PAM

A comprehensive data set is needed to estimate the Policy Analysis Metrics (PAM). The desired information required for constructing the PAM includes inputs, outputs, and market and social prices. For this study, we used cross-sectional data on the dry (Boro) seasons' costs and return of BRRI dhan50, and also published and unpublished secondary data from different pertinent sources. Inputs are divided into two categories: (1) traded intermediate inputs and (2) non-traded intermediate inputs.

Traded intermediate inputs

In Bangladesh, rice production typically involves the use of various fertilizers (such as urea, TSP, MoP, gypsum and ZnSO4), seeds, insecticides/pesticides, and machinery (power tiller/tractor), which are treated as traded intermediate inputs. The costs of tradable inputs are estimated using social or border parity prices. A conversion factor of 0.914 is applied for pesticides to construct the social budget (Shahabuddin and Dorosh, 2002). Although machinery is also considered a tradable input, a comprehensive dataset to estimate its social or border parity price at the farm level is not available. Therefore, market prices are used proxies for border parity prices for machinery in this study.

Seed Shadow Pricing

The shadow price of seed is calculated by applying a well-adopted formula that has been used in the relevant analysis by Antriyandarti, (2015); and Islam, (2016); Islam et. al., (2021a); Islam et. al., (2021b). The formula is as follows:

Shadow seed price = {(Actual seed cost/Actual output) × Shadow output price}

The detailed calculations of the import-parity border price of fertilizers and rice are presented in Appendix Table S1 to S4.

Non-traded intermediate inputs

Unskilled agricultural labor, manure, land rent, and interest on operating capital are considered as non-traded intermediate inputs and domestic resources because these components of the factors of production do not usually enter the international market. Irrigation equipment is regarded as a non-traded intermediate input because detailed costs for irrigation equipment are unavailable. The fees of these inputs were collected from secondary sources (such as FPMU, 2022). The specific conversion factors are used for the social valuation of these costs and prices of non-tradable inputs. We use particular conversion factors of 0.85, 0.91 and 0.79 for human labor, manure and irrigation charges respectively to construct a social budget (Shahabuddin and Dorosh, 2002). However, manure and land rental costs are used as full social costs in this study (Shahabuddin and Dorosh, 2002; BRF, 2005; Kazal et al., 2013). The opportunity cost of operating capital is calculated at 9% interest for five months of the rice production period in the Boro season. The payments for non-traded intermediate inputs and domestic resources are converted from a measurement of “per unit of the land” to “per unit of output”. Methodologically, these items are valued considering their opportunity costs. In Bangladesh, factor markets are reasonably competitive, and thus, payment for non-traded intermediate inputs and domestic resources represent the opportunity costs of these resources.

Table S1

Selected FOB and CIF price and source.

Commodity	FOB/ CIF	Source
Thai Jashmin rice (aromatic) (2% broken)	FOB	Thai Rice Exporter Association, 2021; Food Outlook, 2021
Urea (Black Sea)	FOB	https://ycharts.com/indicators/black_sea_urea_bulk_spot_price
TSP (US Gulf port)	FOB	https://ycharts.com/indicators/triple_superphosphate_price
MoP (Morocco)	FOB	https://ycharts.com/indicators/potassium_chloride_muriate_of_potash_spot_price
DAP (Gulf port)	FOB	https://ycharts.com/indicators/us_diammonium_phosphate_spot_price_gulf
Gypsum (Gulf port)	FOB	https://www.statista.com/statistics/219363/wallboard-products-crude-price-in-the-us/
ZnSo4 (Gulf port)	FOB	https://www.made-in-china.com/products-search/hot-china-products/zinc_sulphate_monohydrate_price.html

Table S2

Calculation of import-parity border price of aromatic rice (BRRI dhan50), 2021-22.

Items	Base Analysis		Sensitivity Analysis	
	Engelberg (Head Rice = 52%)	Rubber huller (Head Rice = 56%)	Engelberg (Head Rice = 52%)	Rubber huller (Head Rice = 56%)
F.O.B. price at port of exit (US$/mt)	723.25	723.25	723.25	723.25
Freight charge (US$/mt)	90.07	90.07	90.07	90.07
Off. Exchange rate (1 US$ = Tk.)	**84.80**	**84.80**	**100.00**	**100.00**
A. C.I.F. price at Chattogram US$/mt	813.32	813.32	813.32	813.32
B. C.I.F. price at port of entry (Tk./mt)	68969.54	68969.54	81332.00	81332.00
C. Marketing margin from the port of entry to wholesale market (Tk./mt)	3862.68	3862.68	3862.68	3862.68
Import handling cost (Tk./mt)	1790.74	1790.74	1790.74	1790.74
Transport cost (Tk./mt)	1828.95	1828.95	1828.95	1828.95
Domestic trading cost (Tk/mt)	242.99	242.99	242.99	242.99
D. Border price at wholesale (Tk./mt) (B + C)	72832.22	72832.22	85194.68	85194.68
E. Component of marketing spread between the wholesale market to the product level (Tk./mt)	40613.54	37842.54	40613.54	37842.54
Cost from mill gate to wholesale (Tk./mt)	1588.95	1588.95	1588.95	1588.95
Milling cost (Tk./mt)	3805.60	3805.60	3805.60	3805.60
Adjustment at 52 or 56 % of milling cost (Tk/mt)	32640.00	29920.00	32640.00	29920.00
Interest cost (Tk/mt)	747.49	696.49	747.49	696.49
Cost from farm gate to mill gate (Tk/mt)	1831.50	1831.50	1831.50	1831.50
F. Border price at farmgate (Tk./mt) (D-E)	32218.68	34989.68	44581.14	47352.14
Clean rice price (Tk./kg)	32.22	34.99	44.58	47.35

Table S3

Calculation of export-parity border price of aromatic rice (BRRI dhan50), 2021-22.

Items	Base Analysis		Sensitivity Analysis	
	Engelberg (Head Rice = 52%)	Head Rice = 56%	Head Rice = 52%	Head Rice = 56%
F.O.B. price at port of exit (US$/mt)	723.25	723.25	723.25	723.25
Freight charge (US$/mt)	0	0	0	0
Off. Exchange rate (1 US$ = Tk.)	**84.8**	**84.8**	**100**	**100**
A. C.I.F. price at Chattogram US$/mt	723.25	723.25	723.25	723.25
B. C.I.F. price at port of entry (Tk./mt)	61331.60	61331.60	72325	72325
C. Marketing margin from the port of entry to wholesale market (Tk./mt)	3862.68	3862.68	3862.68	3862.68
Export handling cost (Tk./mt)	1790.74	1790.74	1790.74	1790.74
Transport cost (Tk./mt)	1828.95	1828.95	1828.95	1828.95
Trading cost (Tk/mt)	242.99	242.99	242.99	242.99
D. Border price at wholesale (Tk./mt) (B + C)	65194.28	65194.28	76187.68	76187.68
E. Component of marketing spread between the wholesale market to the product level (Tk./mt)	40613.54	37842.54	40613.54	37842.54
Cost from mill gate to wholesale (Tk./mt)	1588.95	1588.95	1588.95	1588.95
Milling cost (Tk./mt)	3805.6	3805.6	3805.60	3805.6
Adjustment at 52 of 56 % of milling cost (Tk/mt)	32640	29920	32640	29920
Interest cost (Tk/mt)	747.49	696.49	747.49	696.49
Cost from farm gate to mill gate (Tk/mt)	1831.5	1831.5	1831.50	1831.5
F. Border price at farmgate (Tk./mt) (D-E)	24580.74	27351.74	35574.14	38345.14
Clean rice price (Tk./kg)	24.58	27.35	**35.57**	**38.35**

Table S4

Border price of different chemical fertilizer (Base and sensitivity Analysis).

Items	2021-22											
	Urea	Urea (Sensitivity analysis)	TSP	TSP (Sensitivity analysis)	MoP	MoP (Sensitivity analysis)	DAP	DAP (Sensitivity analysis)	Gypsum	Gypsum (Sensitivity analysis)	ZnSo4	ZnSo4 (Sensitivity analysis)
A. F.O.B. price at port of exit (US$/mt)	361.63	361.63	527.5	527.50	202.5	202.50	574.63	574.63	75.00	75.00	575.00	575.00
B. Freight charge (US$/mt)	90.07	90.07	90.07	90.07	90.07	90.07	90.07	90.07	90.07	90.07	90.07	90.07
C. Off. Exchange rate (1 US$ = Tk.)	84.80	100.00	84.80	100.00	84.8	100.00	84.80	100.00	84.80	100.00	84.80	100.00
D. C.I.F. price at port of entry (Tk./mt)	38304	45170.00	52370	61757.00	24810	29257.00	56366	66469.54	13998	16506.54	56398	66506.54
E. Domestic handling cost (from port to wholesale) (Tk./mt)	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43	4500.43
F. Border price at wholesale (Tk./mt) (D+E)	42805	49670.43	56870	66257.43	29310	33757.43	60867	70969.97	18498	21006.97	60898	71006.97
G. Domestic handling cost (Cost from farmgate to wholesale) (Tk./mt)	895.42	895.42	1040	1040.00	1040	1040.00	1040.00	1040.00	1040.00	1040.00	1040.00	1040.00
H. Border price at farmgate (Tk./mt) (F+G)	43700	50565.85	57910	67297.43	30350	34797.43	61907	72009.97	19538	22046.97	61938	72046.97
I. Border price at farmgate (Tk./kg)	43.70	50.57	57.91	67.30	30.35	34.80	61.91	72.01	19.54	22.05	61.94	72.05

Table S5

Results of export parity-based PAM indicators of export potential rice variety considering 52% HRR.

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76307	7796	35306	33205
Social	34989	8078	17562	9349
Divergences	41318	-281	17744	23855

Source: Field survey, 2021-22
Note: Import parity: Head rice recovery ratio considered 56%

Table S6

Results of PAM of export potential rice variety (BRRI dhan50).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76307	7796	35306	33205
Social	27350	8078	17562	1710
Divergences	48957	-281	17744	31494

Source: Field survey, 2021-22
Note: Export parity: Head rice recovery ratio considered 56%

Table S7

Results of PAM of export potential rice variety (BRRI dhan50).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76792	7796	35306	33690
Social	32220	8078	17562	6580
Divergences	44572	-281	17744	27109

Source: Field survey, 2021-22
Note: Import parity: Head rice recovery ratio considered 52%

Table S8

Results of PAM of export potential rice variety (BRRI dhan50).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76792	7796	35306	33690
Social	24580	8078	17562	-1060
Divergences	52212	-281	17744	34749

Source: Field survey, 2021-22;
Note: Export parity: Head rice recovery ratio considered 52%

Table S9

Results of PAM of export potential rice variety (BRRI dhan50) (Sensitivity analysis).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76307	7796	35306	33205
Social	34989	9345	17562	8082
Divergences	41318	-1548	17744	25122

Source: Field survey, 2021-22
Note: Import parity: Head rice recovery ratio considered 56%

Table S10

Results of PAM of export potential rice variety (BRRI dhan50) (Sensitivity analysis).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76307	7796	35306	33205
Social	27350	9345	17562	443
Divergences	48957	-1548	17744	32761

Source: Field survey, 2021-22
Note: Export parity: Head rice recovery ratio considered 56%

Table S11

Results of PAM of export potential rice variety (BRRI dhan50) (Sensitivity analysis).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76792	7796	35306	33690
Social	32220	9345	17562	5313
Divergences	44572	-1548	17744	28376

Source: Field survey, 2021-22
Note: Import parity: Head rice recovery ratio considered 52%

Table S12

Results of PAM of export potential rice variety (BRRI dhan50) (Sensitivity analysis).

Items	Revenue	Tradable inputs	Non-tradable inputs	Profit
Private	76792	7796	35306	33690
Social	24580	9345	17562	-2327
Divergences	52212	-1548	17744	36016

Source: Field survey, 2021-22;
Note: Export parity: Head rice recovery ratio considered 52%