

## PREFERENCES ANALYSIS FOR RICE VARIETY AND DEVELOPMENT OF PRODUCT PROFILE IN THE HILLY ECOSYSTEMS OF BANGLADESH

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### ABSTRACT

The hilly ecosystem consists of three districts in Bangladesh, namely Rangamati, Khagrachari, and Bandarban. For jhum cultivation, farmers preferred some traditional (Gelong and Binnidhan) as well as modern varieties (BRRI dhan48 and BRRI dhan55) due to ensuring higher yield and good taste. In the valley land of a hilly ecosystem, during *T. Aus* season, BRRI dhan48 and local varieties Binnidhan and Gelong were the most preferred varieties due to their good taste to eat and higher yield than other local rice varieties. Moreover, in the *T. Aman* season, the farmers most preferred varieties were BRRI dhan49, Paijam, and BR11 in the valley land due to their drought-tolerant capacity, higher yield, shorter growth duration, good taste, and medium slender grain size. In the *Boro* season, farmers preferred the varieties BRRI dhan28, BRRI dhan58, and hybrid varieties Hira, ACI, and SL-8H due to their higher yield, medium good taste to hilly people and high market demand in the local area. On the other hand hybrid rice production is popular on this area due to seed availability in the market, higher yield than other variety and production cost is not significantly different from other varieties. Overall, the hybrid and modern rice area is increasing day by day due to its higher yield potential, less disease and pest infestation, and higher market demand for local people in the hilly areas of Bangladesh. So product profile will play a significant role to fill the future demand in hilly ecosystems of Bangladesh.

**Key words:** Hilly ecosystem, preferences, variety, product profile.

### Introduction

The Chittagong Hill Tracts (CHT) comprising 70% of the hilly areas of Bangladesh and covers 13,184 km<sup>2</sup> (10% of total country area), of which 90% are sloping lands (Hossain *et al.*, 2017a). More than 35 crop species are cultivated annually in hilly areas (Ahammad and Stacey, 2016). The area is mild to very steep ranging from 15% to over 70% slope, often breaking or ending in cliffs (SRDI, 2018). Rice is the major crop component of jhum field and average yield 1.15 t ha<sup>-1</sup>, though rice grown as main crop banana provides the maximum yield of 108 t ha<sup>-1</sup> (Jamaluddin *et al.*, 2010). Moreover, jhum cultivation is one of the traditional practices in the hilly areas of Bangladesh. Jhum cultivation is very popular to tribal hill communities that govern hill agriculture. In this system land is cleared by controlled fire and then a natural fallow phase is employed long enough to be dominated by woody vegetation (Bhagawati *et al.*, 2015). Due to developing of modern rice varieties and new technologies, the hilly people shifting their agriculture for earning more profit. Crop productivity in jhum has declined due to soil erosion and associated reduction in essential soil nutrients (Karim and Mansor, 2011). Recently, many Asian countries are replacing the system with permanent agriculture due to increase population which is created pressure on land (BRRI, 2020). Even though Jhum has considerably declined in recent years but still a dominant land-use system in the hilly terrain and has been practiced by local indigenous groups of CHT for centuries (Khisa and Mohiuddin, 2015). It has been estimated that about 26,000 households practice shifting cultivation (jhum) every year, and nearly 143,000 people depend on jhum for livelihood (Shoaib, 2000). Despite declining productivity, farmers follow jhuming because they believe it is the basis of hill people's cultural identity (Ahmed, 2002). Generally, the average jhum cycle ranges from 12 to 15 years, which allows sufficient vegetation during the interval (Hossain, 2011). But due to the scarcity of land, the cycle has shortened to 2-3 years, with serious consequences for soil quality (Swapan *et al.*, 2008). To maximize the production of jhum, the quality seed for jhum crops has to be available. Bangladesh Rice Research Institute

recommended draught-tolerant rice varieties (BR24 and BRRI dhan27) for upland jhum (BRRI, 2015). Recently, Bangladesh Agricultural Development Corporation has supplied some drought-tolerant rice varieties, Narika-1 and Narika-10, to the Department of Agricultural Extension in CHTs (Chittagong hill tracts) for demonstration in jhum fields (DAE, 2016). All types of modern rice can be grown in the valleys of hilly areas. But the varietal adoption depends on the different actors along the value chain actors, such as producers, wholesalers, retailers, and consumer's preferences. This will facilitated to fill the future demand of the hilly peoples of Bangladesh. The present study therefore examines the varietal preferences of value chain actors and product profile development for the hilly ecosystem in Bangladesh for ensuring sustainability and food security in Bangladesh.

### Materials and Methods

The study area was selected on the basis of the study's objectives and conducted within the period of 2019-2020. Based on the preliminary information received, three districts, namely Rangamati, Khagrachari, and Bandarban, were selected known as the hilly ecosystems in Bangladesh. The sample stakeholders' were identified by classifying the farmers and categorizing them on the basis of operated land: small farmers (50-249 decimals), medium farmers (250-749 decimals), and large farmers (750 and above decimals). Millers were classified as automatic rice mills, semi-automatic rice mills, and husking rice mills. A checklist was done for producer preferences. Focus group discussions (FGDs) were conducted with the assistance of sub-assistant agriculture officers (SAAOs) and local leaders to collect data, especially to capture the collective understanding of producers' preferences. Both the male and female farmers also participated in FGD. Each FGD group was consisted of 12 to 15 members. Farmers' varietal preferences have been recorded through four variety choice cards in each season. The Key Informant Interview (KII) method was implemented by the millers, wholesalers, retailers, and consumer's levels for data collection. Notably, efforts were made to ensure a fair share of women among the key informants. Both the husband and wife were jointly interviewed for consumer preferences. Semi-automatic and husking categories of rice mills were considered for processor preferences. On the other hand, rural and urban wholesalers and retailers were considered for traders preferences. The descriptive statistics technique was used to find out value chain actors preferences and product profile development.

### Results and Discussion

Value chain actors are classified in the following categories such as upstream actors (such as producer), mid-stream actors (such as faria, bepari, millers, wholesalers and retailers etc.) and downstream actors (such as consumer). Farmers with higher yield are motivated to further improve their yields in the subsequent year and this will require them to adopt improved varieties with high yield potential coupled with other factors (Asrat *et al.*, 2010). Abiotic stresses such as drought, iron toxicity, nitrogen deficiency as well as biotic stresses (pests and diseases) could have adverse effects on yield even when a variety with high yield potential is cultivated. The grain quality attributes significantly influence farmers preference for improved rice varieties (Asante *et al.*, 2011). The various grain quality attributes that were investigated included color, grain length and size, fragrance, cooking quality, grain color, absence of foreign materials, percent broken grains and grain expansion ratio and chalkiness.

**Upstream actor:** For jhum cultivation, most of the farmers cultivated their traditional varieties, namely Gelong, Merong, Binni, Rangi, Choroi, Suri, Amai, Betidhan, and the modern varieties like, BRRI dhan48, BRRI dhan43, BRRI dhan55, and Nerika in the hilly areas. According to the survey data, the most preferred traditional variety was Gelong, Binni. The most preferred modern variety was BRRI dhan48 and BRRI dhan55 due to their higher yield and good taste to eat (Table 1). In the valley land of a hilly ecosystem, the farmers cultivated the varieties BRRI dhan48, BRRI dhan55, Nerika, BR26, BRRI dhan42, hybrid Hira, and local varieties Binni and Suri, etc. during the *T. Aus* season. Among these varieties, BRRI dhan48 and the local variety Binnidhan were the most preferred varieties due to their good taste to eat and higher yield than other local varieties (Table 1).

Table 1. Varietal choice among the farmers in the Aus season in the hilly ecosystem of Bangladesh

Ranks	Jhum cultivation in the hilly ecosystem			Valley land in the hilly ecosystem ( <i>T. Aus</i> )		
	Rangamati	Khagrachari	Bandarban	Rangamati	Khagrachari	Bandarban
1	Gelong	Gelong	Gelong	BRRRI dhan48	BRRRI dhan48	BRRRI dhan48
2	Merong	BRRRI dhan48	Merong	Nerika	Nerika	BRRRI dhan55
3	Binni	Binni	Mongthong	BRRRI dhan55	BR26	Nerika
4	Betidhan	Choroi	Suri	BRRRI dhan42	Brri dhan42	Hira dhan
5	Rangi	BRRRI dhan43	Baradhan	Binni	BRRRI dhan43	Baradhan
6	Amari	Nerika	Binni	Amari	BR3	Binni
7	Suri	Company	BRRRI dhan48	Suri	BRRRI dhan28	BRRRI dhan43
8	Sonalichikan	Kamarang	Chakma chikan	Sonalichikan	Kamarang	Chakma chikan
9	Nerika	BRRRI dhan55	BRRRI dhan33	Merong	BRRRI dhan55	BRRRI dhan33
10	Kamarang	Sonamukhi	ACI	Kamarang	suri	ACI

Source: Prepared by authors' based on data from field survey, 2019-20.

During *T. Aman* season, most farmers cultivated the varieties were BRRRI dhan49, BR11, Pajjam, BRRRI dhan39, BRRRI dhan33, Sakkapanja, BRRRI dhan46, BRRRI dhan52 and aromatic rice Kali Zira etc in the valley land of the hilly ecosystem. Among these varieties, the farmers most preferred varieties were BRRRI dhan49, Pajjam and BR11 due to their higher yield, shorter growth duration and, good taste to eat, medium slender grain size (Table 2). In the *Boro* season, the hilly farmers cultivated the varieties BRRRI dhan28, BRRRI dhan29, BRRRI dhan58, and the hybrid varieties Hira, Ispahani, ACI, SL-8H, Aloran, Dhanigold, Janakraj, Sinjenta-1203, and Lalteer, etc. on the valley or plain land. Among these varieties, the farmers preferred BRRRI dhan28, BRRRI dhan58, and the hybrid varieties Hira, ACI, and SL-8H due to their higher yield, medium good taste, and high market demand. The hybrid rice area is increasing day by day due to higher yield potential, less disease and pest infestation, and higher market demand for local people in the hilly areas of Bangladesh (Table 2).

Table 2. Varietal choice among the farmers in the hilly ecosystem of the *T. Aman* and *Boro* season of Bangladesh

Ranks	Valley land in the hilly ecosystem ( <i>T. Aman</i> )			Valley land in the hilly ecosystem ( <i>Boro</i> )		
	Rangamati	Khagrachari	Bandarban	Rangamati	Khagrachari	Bandarban
1	Pajjam	BRRRI dhan49	BRRRI dhan49	BRRRI dhan28	BRRRI dhan28	BRRRI dhan58
2	BRRRI dhan49	BR11	BR11	Hira	BRRRI dhan58	Hira
3	BR11	BRRRI dhan39	BRRRI dhan33	BRRRI dhan58	Hira	BRRRI dhan28
4	BRRRI dhan39	pajjam	Soma dhan	BRRRI dhan29	Bina dhan-12	BRRRI dhan74
5	BR25	BRRRI dhan33	Hori dhan	BRRRI dhan74	BRRRI dhan29	ACI
6	BRRRI dhan40	Sakkapanja	BR10	ACI	Ispahani	BRRRI dhan33
7	BRRRI dhan32	BRRRI dhan40	BRRRI dhan39	Ispahani	ACI	SL-8H
8	BRRRI dhan41	BRRRI dhan52	BRRRI dhan46	Sinjenta-1203	BRRRI dhan74	BRRRI dhan55
9	BRRRI dhan71	Binni	BRRRI dhan52	Agmoni	Aloran	Dhani gold
10	BR3	Kali zira	BR25	Janakraj	Janakraj	Lalteer

Source: Prepared by authors' based on data from field survey, 2019-20.

**Midstream actors:** Market actors who perform such functions are needed to ensure the secure, smooth, and sequential flow of goods and services from producers to consumers. The midstream actors in rice marketing are millers and processors for paddy, wholesalers, and retailers for rice. In the paddy marketing system, paddy traders and processors considered the following elementary appearances to purchase the best quality of paddy: purity of variety, absence or minimal impurities or foreign materials, higher percentages of filled grain, lower moisture content, absence of black spots, and good color grain. The most preferred varieties were BRRRI dhan28, BRRRI dhan29, BRRRI dhan58, and BRRRI dhan49 at millers' level in the study areas. They usually offer hybrids and other types of coarse rice in the government food warehouses. For the quality of rice, wholesalers and retailers considered the absence of dead rice, no bad smell, and no black

spot; minimal or no broken grains and impurities; white and translucent grains; as well as aroma for aromatic rice. While purchasing the best quality of rice, wholesalers and retailers also consider the consumers' feedback on taste, non-stickiness, soft texture, and the longevity of rice after cooking. Among wholesalers and retailers, the brand name is more important than the original name of the rice variety. Sometimes the same variety is sold under different brand names, such as Najir, Pajam, and BRRI dhan49, based on different milling processes. The most demandable brands and varieties were *Najir*, *Miniket*, *Pajam*, *Zira*, BRRI dhan28, BRRI dhan29, BRRI dhan49, and *BR11* at wholesale and retail markets.

**Downstream actors:** Different income groups of consumers' exist in the market, and they are the downstream actors in the rice supply chain. The study interviewed three types of respondents: high-income, middle-income, and low-income consumers. Most consumers who purchase rice year-round prefer coarse rice due to its lower price. On the other hand, coarse types of rice (such as BR11) were mostly purchased by the low and medium income group of consumers for their cheaper price. In addition, some of the tribal people preferred sticky rice in the hilly region. High-income farmers prefer to consume higher-quality rice produced in hilly areas, such as Pajam, SakkaPanja, and others. The people who are ethnic minorities in the hilly areas preferred traditional rice varieties as well as Gelong, Binni, Rangi, and Merong to celebrate their religious festivals by making different types of special cakes, sometimes for local consumption. From the above discussion, we conclude that every actor in the value chain has preferences that play a significant role in the market. But the current situation is that most of the miller controls the rice market in Bangladesh. They can provide the product according to current market demand.

**Product profile development in hilly ecosystem:** Ideal product profile is important tools for varietal replacement plans that reflect the preferences of producers, millers, wholesalers, retailers, and consumers. A *product profile* is understood as a written description of the traits being targeted in a new product (variety) that will achieve the goals of the breeding program. A product replacement strategy involves the deployment of a *product profile* to develop a variety with superior characteristics to one already available on the market that is dominant within a particular breeding or agro-ecological zone within a restricted period of five to eight years, depending on the breeding cycle. To achieve this goal, the *product profile* describes a mix of *basic traits* essential to the success of the market variety that the new product should at least meet and *value-added traits* where the breeding program will seek to improve on the market product, therefore creating a more successful and impactful variety ([www.excellenceinbreeding.org](http://www.excellenceinbreeding.org)). Therefore, the following product profile has been developed for future breeding programs to address the hilly ecosystems of Bangladesh. The preferences were classified into four trait groups, namely, basic, range, value-added, and future value-added traits. Benchmark varieties were selected according to the farmer's preferences and the variety's adoption rate in this area. Gellong (the local variety) was the benchmark variety for jhum cultivation in the hilly area, and this variety was the most preferred cultivar in these areas due to its good taste. But due to some constraints, the farmers want to improve this variety. From the survey, we found that the existing traits of the benchmark variety were 2.2 t/ha yield, medium bold grain, >24% amylose, 100days growth duration, 100-110 cm plant height, 6-8 numbers per hill tiller, <60 percent head rice recovery, and no pest resistance capacity.

Farmers in the study areas want to replace the weakness of the benchmark variety with the following traits: 10% higher yield than 2.2 t/ha; medium slender type grain; moderate growth duration (<100 days); higher numbers of tillers (10-12 no. /hill); greater than 65 percent head rice recovery; disease resistance (BLB and Tungro); and insect resistance such as BPH and Rice Bug (Table 3). BRRI dhan48 was the benchmark variety for the *T. Aus* season due to its higher yield for valley land. From the survey, we found that the existing traits of the benchmark variety were 5.5 t/ha yield, medium bold grain, >26.8% amylose, no heat tolerant at seedling and reproductive stages, growth duration of 110 days, 105 cm plant height, 8-10 numbers per hill tiller, <60 percent head rice, and no pest resistance capacity. Farmers in the study areas want to replace the weakness of the benchmark variety with the following traits: 10% higher yield than 5.5 t/ha, medium slender type grain, moderate growth duration (<110 days), higher numbers of tillers (10-12 no./hill), greater than 65 percent head rice, disease resistance (BLB ) and insect resistance (Rice bug, BPH) (Table 4).

Table 3. Product profile for Jhum cultivation in hilly ecosystem of Bangladesh in *Aus* season

Target environment: Upland Rice (Jhum cultivation) in hilly ecosystem		Benchmark variety: Gellong (Local variety) (adoption rate 21% in hilly areas)	
Season : <i>B. Aus</i>			
Traits	Trait specification	Existing traits	Expected traits
Basic	Yield (ton/ha)	2.2	>10%
	Grain size and shape	MB	MS
	Amylose (%)	>24	>24
Range	Growth duration (days)	100	90-100
	Plant height (cm)	100-110	>110
	Tillering (no./hill)	6-8	12-15
	Head Rice (%)	<60	>65
Value added	Disease resistance	None	BLB
	Disease resistance	None	Tungro
Future value added	Insect resistance	None	BPH & Rice bug

Note: MS, Medium slender, BLB, Bacterial leaf blight; BPH, Brown plant hopper; Source: Prepared by authors' based on data from field survey, 2019-20.

Table 4. Product profile for Valley land in the hilly ecosystem of Bangladesh in the *T. Aus* season

Target environment: Valley land in the hilly ecosystem		Benchmark variety: BRRI dhan48 (adoption rate 8% in hilly areas)	
Season : <i>T. Aus</i>			
Traits	Trait specification	Existing traits	Expected traits
Basic	Yield (ton/ha)	5.5	>10%
	Grain size and shape	MB	MS
	Amylose (%)	26.8	26.8
	Heat tolerant at flowering stage	None	Yes
Range	Growth duration (days)	110	100-110
	Plant height (cm)	105	105-110
	Tillering (no./hill)	8-10	12-14
	Head Rice (%)	<60	>65
Value added	Disease resistance	None	BLB
	Insect resistance	None	Rice bug
Future value added	Insect resistance	None	BPH and GLH

Note: MS, Medium slender, BLB, Bacterial leaf blight; BPH, Brown plant hopper; GLH, Green leafhopper. Source: Prepared by authors' based on data from field survey, 2019-20.

During *T. Aman* season, for valley land in hilly areas (actually high to medium-high land), BRRI dhan49 was the benchmark variety in *T. Aman* season. From the survey, we found that the existing traits of the benchmark variety were 5.5 t/ha yield, medium-bold grain, 25% amylose, 135-day growth duration, 100 cm plant height, 8–9 numbers per hill tiller, 60 percent head rice, and highly susceptible to false smut. However, farmers in the study areas want to replace the weakness of the benchmark variety with the following traits: 10% higher yield than 5.5 t/ha, medium slender type grain, higher numbers of tillers (12-15 no./hill), greater than 65 percent head rice, disease resistance (false smut) and insect resistance (SHB, BPH, and leaf roller) (Table 5).

In *Boro* season, BRRI dhan28 was the benchmark variety for good taste. From the survey, we found that the existing traits of the benchmark variety were 6.0 t/ha yield, medium slender grain, 28% amylose, none lodging tolerance, growth duration of 140–145 days, 90 cm plant height, 8-10 numbers per hill tiller, 60 percent head rice, and highly susceptible to blast. Farmers in the study areas want to replace the

weakness of the benchmark variety with the following traits: 10% higher yield than 6.0 t/ha; higher numbers of tillers (12-15 no. /hill); greater than 65 percent head rice; disease resistance (Blast and BLB days, 90 cm plant height, 8–10 numbers per hill tiller, 60-65 percent head rice recovery ratio, and highly susceptible to blast. Farmers in the study areas want to replace the weakness of the benchmark variety with the following traits: 10% higher yield than 6.0 t/ha; higher numbers of tillers (12–15 no. /hill); greater than 60 percent head rice; disease resistance (Blast and BLB); and insect resistance (stem borer and Rice hispa) (Table 6).

Table 5. Product profile for Valley land in the hilly ecosystem of Bangladesh in *Aman* season

Target environment: Valley land in hilly ecosystem		Benchmark variety: BRRI dhan49 (adoption rate 18% in hilly areas)	
Season : <i>T. Aman</i> (High to medium high land)			
Traits	Trait specification	Existing traits	Expected traits
Basic	Yield (ton/ha)	5.5	>10%
	Grain size and shape	MB	MS
	Amylose (%)	25.0	>25.0
Range	Growth duration (days)	135	135
	Plant height (cm)	100	110-115
	Tillering (no./hill)	8-9	12-15
	Head Rice (%)	60-62	>65
Value added	Disease resistance	Highly susceptible to False smut	False smut resistance
	Insect resistance	None	BPH
Future value added	Disease resistance	None	ShB
	Insect resistance	None	Leaf roller

Note: MS, Medium slender, BPH, Brown plant hopper; ShB, Sheath blight; Source: Prepared by authors' based on data from field survey, 2019-20.

Table 6. Product profile for Valley land in the hilly ecosystem of Bangladesh in the *Boro* season

Target environment: Valley land in hilly ecosystem		Benchmark variety: BRRI dhan28 (adoption rate 19% in hilly areas)	
Season : <i>Boro</i>			
Traits	Trait specification	Existing traits	Expected traits
Basic	Yield (ton/ha)	6.0	>10%
	Grain size and shape	MS	MS
	Amylose (%)	28	28
	Lodging tolerant	None	Yes
Range	Growth duration (days)	140-145	<140
	Plant height (cm)	90	>90
	Tillering (no./hill)	8-10	12-15
	Head Rice (%)	60-65	>65
Value added	Disease resistance	Highly susceptible to blast	Blast resistance
Future value added	Disease resistance	None	BLB
	Insect resistance	None	Stem borer and Rice hispa

Note: MS, Medium slender, BLB, Bacterial leaf blight; Source: Prepared by authors' based on data from field survey, 2019-20.

In *Boro* season, BRRI Dhan28 was the benchmark variety for good taste. From the survey, we found that the existing traits of the benchmark variety were 6.0 t/ha yield, medium slender grain, 28% amylose, none lodging tolerance, growth duration of 140-145 days, 90 cm plant height, 8-10 numbers per hill tiller, 60 percent head rice, and highly susceptible to blast. Farmers in the study areas want to replace the

weakness of the benchmark variety with the following traits: 10% higher yield than 6.0 t/ha; higher numbers of tillers (12-15 no. /hill); greater than 65 percent head rice; disease resistance (Blast and BLB); and insect resistance (stem borer and Rice hispa) (Table 6).

### Conclusion and recommendations

In hilly areas of Bangladesh, agriculture is the prime source of livelihood, and the rice area coverage also increases day by day due to the addition of new land after burning the forest. So we have to develop a high-yielding variety for hilly areas of Bangladesh that will fill the current rice production demand in Bangladesh. So, if we follow the product profile in the hilly ecosystem, the varietal adoption and total yield will be increased in the hilly areas of Bangladesh, and food will be secured.

- Therefore, breeders must consider the preferences of the actors in the rice value chain in the hilly areas and the agro-climatic conditions of the regions in the process of variety development.
- In this regard, short to medium growth duration, higher yield potential, biotic and abiotic stress resistance, and a good market demand for the variety should be under due considerations.

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