



## OPEN ACCESS

## EDITED BY

Hale Tufan,  
Cornell University, United States

## REVIEWED BY

John Kimani,  
Kenya Agricultural and Livestock Research  
Organization, Kenya  
Md. Hayder Khan Sujon,  
Sher-e-Bangla Agricultural University,  
Bangladesh  
Benedicta Nsiah Frimpong,  
CSIR Crops Research Institute, Ghana

## \*CORRESPONDENCE

Md Abdur Rouf Sarkar  
✉ mdrouf\_bau@yahoo.com

RECEIVED 20 August 2023

ACCEPTED 23 January 2024

PUBLISHED 12 February 2024

## CITATION

Khan MS, Sarkar MAR, Islam MR and  
Bhandari H (2024) Data-driven review on  
gender and rice varietal trait preferences in  
Bangladesh.

*Front. Sustain. Food Syst.* 8:1280597.

doi: 10.3389/fsufs.2024.1280597

## COPYRIGHT

© 2024 Khan, Sarkar, Islam and Bhandari. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Data-driven review on gender and rice varietal trait preferences in Bangladesh

Md Sahed Khan<sup>1</sup>, Md Abdur Rouf Sarkar<sup>2,3\*</sup>,  
Mohammad Rafiqul Islam<sup>4</sup> and Humnath Bhandari<sup>5</sup>

<sup>1</sup>Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh,

<sup>2</sup>Agricultural Economics Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh, <sup>3</sup>School of Economics, Zhongnan University of Economics and Law, Wuhan, China, <sup>4</sup>Rice Breeding Innovations Platform, International Rice Research Institute, Dhaka, Bangladesh, <sup>5</sup>Impact, Policy, and Foresight Department, International Rice Research Institute, Dhaka, Bangladesh

In Bangladesh, farmers adapt to changing conditions through the adoption of improved varieties containing new or combined traits. The diverse varietal adoption decisions among farmers stem from gender-based differences in trait preferences. This review synthesizes existing knowledge to assess the nature, extent, and causes of gendered disparities in rice varietal trait preferences among farmers and consumers in Bangladesh. To enhance the data-driven nature of this review, we not only scrutinized secondary articles (45 documents) and databases but also incorporated and analyzed primary data on varietal adoption and trait preferences. The analysis revealed a pronounced need for rice breeding programs in Bangladesh to integrate both market and climate-smart traits, aligning with gender-specific needs in developing optimal rice product profiles. Analysis of primary data unveiled substantial variations in women and men farmers' varietal trait preferences, influenced by factors like income, access to farming information, household size, land size, and decision-making. Consequently, addressing gender-differentiated trait preferences in the development of improved rice varieties is crucial to curtail farmers' varietal adoption lag in Bangladesh. The findings underscore the necessity of systematic identification and integration of gender-differentiated varietal trait preferences into rice breeding programs. Failure to account for such preferences may disadvantage the gender-responsiveness of developed varieties and limit the anticipated impact. Therefore, understanding the biophysical, social, and cultural dynamics of diverse farmer groups from a gender perspective is imperative for achieving gender-responsive rice variety development in the context of Bangladesh. This process involves identifying key gender concerns for integration into rice breeding programs, ensuring a comprehensive approach to sustainable agriculture.

## KEYWORDS

gender, preferences, traits, varietal development, rice variety

## 1 Introduction

Rice is the staple food for 167 million population of Bangladesh, and the ascent to a rice self-sufficient country was underpinned by a more than three-fold increase in national rice yield over the past four decades (Kabir et al., 2015; Siddique et al., 2018; Kabir et al., 2020). However, the future growth and sustainability of the rice industry are threatened by several

challenges like stagnated yields, the inability of new varieties to replace old mega varieties, low (less than 30%) seed replacement rate and varietal adoption lag (Jaim and Hossain, 2009; Hossain et al., 2012; Kabir et al., 2015; Siddique et al., 2018; Kabir et al., 2020). Bangladesh has planned and implemented numerous agricultural policies for rapid transformation of the agricultural sector through swift technological progress. The process started during the 1960s through Green Revolution by diffusing Modern Rice Varieties (MRVs) with corresponding inputs support (Hossain, 1989; Rahman, 2003) to substantially increase rice productivity (Sarkar et al., 2022). However, the diffusion of MRVs went through various cycles, picking up during its inception stage (The late 1960s and 1970s), then slowing down during the mid-1980s and then picking up again during the late 1980s and 1990s due to the policy reforms aimed at liberalization of the procurement and distribution of agricultural inputs and a reduction of import duties on agricultural equipment (Hossain et al., 1990, 1994; Hossain and Akash, 1994; Sarkar et al., 2022). The period-wise cycles of diffusing MRVs during the Green Revolution have been illustrated in Figure 1.

In order to ensure farmers' high adoption of MRVs, each generation of MRVs developed in Bangladesh had considered different varietal trait preferences, i.e., dwarfism – disease resistance – grain quality – high yield – good taste – high market price – shorter duration – stress tolerant, depending on the period and specific context (Hossain and Akash, 1994; Hossain et al., 1994; Jaim and Hossain, 2009; BRRI, 2015; Kabir et al., 2015). With the diffusion of MRVs in Bangladesh, it was projected that farmers' high adoption of MRVs may largely displace traditional varieties and, therefore, varietal diversity would decrease. However, projections were proved erroneous as considerable varietal diversity was found at the farm level (Hossain et al., 2006; Siddique et al., 2018); for instance, a survey report noted 670 rice varieties across Bangladesh – indicating substantial varietal diversity (Tiongco and Hossain, 2015).

In Bangladesh, different rice varieties respond differently to different environmental conditions with varying yields and production risk (Hossain et al., 1990; Joshi and Bauer, 2006; Hossain et al., 2007; Hossain and Barker, 2007; Hossain and Jaim, 2012; Rahman et al., 2020; Al Mamun et al., 2021; Kabir et al., 2021) and to mitigate the risks associated, farmers' adaptation to the changing conditions is made through the adoption of improved varieties with new traits or combination of traits (Kabir et al., 2015; Siddique et al., 2018;

Karmakar et al., 2021; Rahman et al., 2023). Thus, rice breeding programs in Bangladesh are designed to develop new rice varieties with traits like high yield, short duration, resistance to pests and diseases, and tolerance to other biotic and abiotic stresses to curtail farmers' adoption lag (Choudhury et al., 1992; Jaim and Hossain, 2009; BRRI, 2015; Hossain et al., 2015; Kabir et al., 2015; Tiongco and Hossain, 2015). However, genetic improvements for these specific traits alone may not be sufficient for new rice varieties to be adopted by different farmer groups as factors like gender may have considerable weight in determining if a variety will be adopted (Weltzien et al., 2020). For instance, from the 87 MRVs developed in the last five decades, only a handful of them (BRRI dhan28, BRRI dhan29, Swarna, and BR11) have become popular among farmers in Bangladesh (Jaim and Hossain, 2009; Siddique et al., 2018). Consequently, in Bangladesh, it takes 15–16 years from the release of a variety to reach its peak of adoption (Jaim and Hossain, 2009; Hossain et al., 2012; Kabir et al., 2020; Karmakar et al., 2021). Therefore, in order to develop gender-responsive varieties and to curtail the varietal adoption lag by farmers in Bangladesh, a deeper understanding on the nature and causes of differing varietal trait preferences by different farmer groups is an essential prerequisite.

Depending on farm duties, production goals and access to resources, varietal trait preferences by different groups, i.e., men, youth males, vulnerable men, women, youth women, and vulnerable women, differ largely (Ahmed, 2014; Weltzien et al., 2020). The sets of traits that men and women farmers prefer are most likely to differ based on their socio-economic status, farming conditions, and their role in the rice value chain. For instance, varietal trait preferences for men in Bangladesh are more focused on rice production and marketing, whereas, for women, the focus is mostly on production use and food security-related traits (Tiongco and Hossain, 2015). So, it is absolutely difficult to say how essential any given varietal trait is for women and men farmers of a social class and agroecology.

Past literature extensively examined the preferences of consumers (Choudhury, 1991; Jaim and Hossain, 2009; Custodio, 2015; Hossain et al., 2015; Cuevas et al., 2016; Custodio et al., 2016a, 2019; Bairagi et al., 2017, 2018; Mottaleb et al., 2017), farmers (Joshi and Bauer, 2006; Hossain et al., 2015; Custodio et al., 2016b; Ynion et al., 2016; Sarkar et al., 2017; Weltzien et al., 2020; Haque et al., 2023), and other value chain actors (Custodio et al., 2016b, 2019; Sarkar et al., 2017), along with an examination of participatory varietal choices (Paris

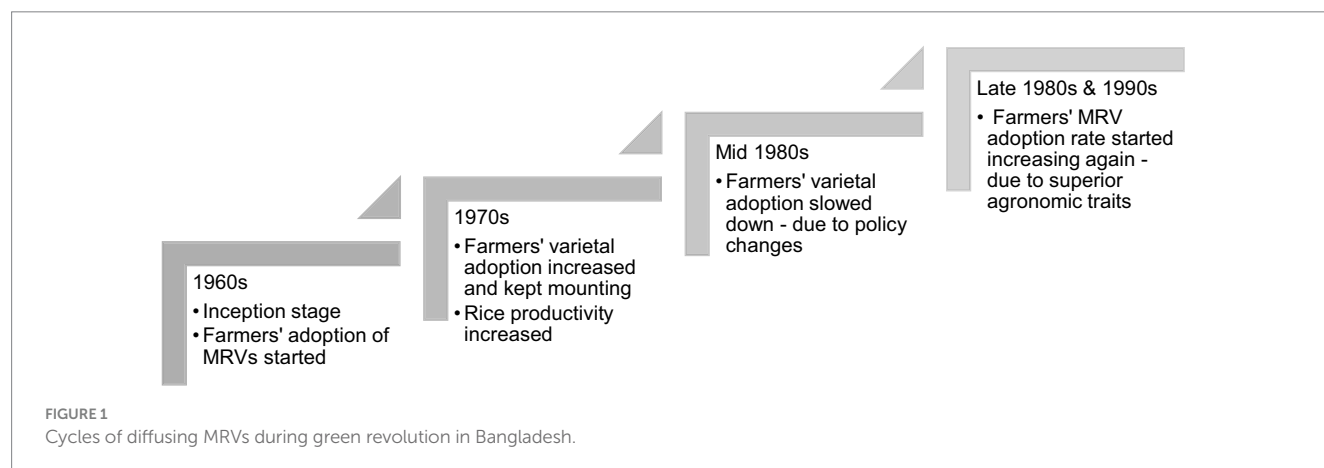


TABLE 1 Categorization of reviewed papers based on publication types and research location.

| Types of article/publication                             | Bangladesh | Partially addressed Bangladesh |
|--|------------|--------------------------------|
| Gender and varietal trait preferences                    | –          | 1                              |
| Gender dynamics in rice-based agriculture                | 10         | 1                              |
| Adoption, diffusion, and impact of modern rice varieties | 11         | 1                              |
| Preferences of rice value chain actors                   | 7          | 6                              |
| Rice vision across the globe                             | 6          | 2                              |

Source: Authors' estimation.

et al., 2005). However, the majority of these studies narrowly focused on the gender perspectives of preferences in the context of rice varietal development. This literature review underscored the absence of gender considerations in rice breeding programs in Bangladesh, emphasizing the need for a more inclusive approach. Integrating gender-differentiated trait preferences into rice varieties is identified as a crucial step to comprehensively address the intricate nuances of varietal characteristics. Therefore, the objective of this review paper is to systematically consolidate existing knowledge and information, with the aim of assessing the nature, extent, and underlying causes of gender-specific variations in rice varietal trait preferences among farmers and consumers in Bangladesh. This review pursues three specific goals: (a) to compile available knowledge documenting gender differences in varietal trait preferences; (b) to comprehensively evaluate the nature, extent, and underlying causes of gendered variations in varietal trait preferences; and (c) to identify and recognize gender-specific aspects that can be integrated into rice breeding programs in Bangladesh.

## 2 Methodology

This review addresses gender differences in varietal trait preferences through an extensive analysis of pertinent journal articles and secondary documents sourced from Scopus, Web of Science Core Collection, and Google Scholar databases. The search was conducted in February 2023 and employed four distinct categories (Sarker et al., 2023) of search items: (i) exposure keywords (e.g., "Rice," "*Oryza sativa*"); (ii) group of interest terms (e.g., "trait preference\*," "preferred trait\*," "preferred variety," "varietal preference," "varietal selection," "trait choice," "varietal characteristic"); (iii) outcome of interest terms (e.g., "plant breeding," "variety breeding," "rice breeding," "crop breeding," "crop improvement," "seed system"); and (iv) geographic specifications (e.g., "Bangladesh").

From these searches, a total of 156 articles and associated documents were initially acquired from diverse databases; however, the subsequent removal of duplicates resulted in 89 distinct documents. The criteria for inclusion encompassed original research or reviews that explicitly engaged with varietal trait preferences in the context of rice varieties, seeds, or germplasm. Articles outside the realm of plant breeding and seed systems were excluded. Moreover, geographical limitations confined the search to Bangladesh, and only English-language studies were considered. Acknowledging the potential richness of pertinent literature beyond scholarly sources, supplementary grey literature was also scrutinized.

Ultimately, 45 documents were selected for this review. The categorization of these documents based on publication types and

research locations is detailed in Table 1. Notably, a limited number of articles exclusively focused on gender and sex-disaggregated statistics concerning rice varietal trait preferences in Bangladesh. Consequently, this study meticulously curated, tabulated, and graphically presented data from a variety of published works and online resources. To facilitate this, information was collated from a diverse array of sources, spanning media outlets, blogs, research institutes, private and international organizations, policy experts, and newspapers, thereby enhancing comprehension.

In pursuit of a data-driven approach, primary data collected from farmers of different categories from 30 districts across seven divisions of Bangladesh pertaining to varietal adoption and trait preferences, accessed from the 2018 IRRI database, was also subjected to gender-based analysis (IRRI Database, 2018). Descriptive statistics were employed to analyze the primary data. The insights derived from this analysis were subsequently incorporated into the results and discussion section of the review. Notably, like any systematic review, the potential for certain research articles to be excluded due to publication and screening biases cannot be discounted. Consequently, significant effort was expended in scouring reputable databases, websites, and engaging with experts in the field via social media platforms. It is the contention of this study that its efforts substantively contribute to the generation of comprehensive evidence and the identification of key areas of inequity, thereby facilitating the formulation of gender-sensitive breeding policies.

## 3 Results and discussion

### 3.1 Nature, extent, and causes of gendered differences in varietal trait preferences

The gender-specific varietal trait preferences reviewed are summarized in this section. The extent to which varietal trait preferences related to value chain actors, gendered roles and responsibilities, and gendered access and mobility provide insights into the nature and causes of gendered differences with regard to varietal trait preferences in Bangladesh.

#### 3.1.1 Consumers' preferences

Consumer's preferences for rice grain in Bangladesh were good taste, white color, slender and fine grains, not sticky, and high-volume expansion (Custodio, 2015), and consumers' perceptions of poor-quality rice in Bangladesh are small and broken grains, rough texture, long cooking time, and too much water requirement for cooking (Custodio et al., 2019). Consumers' preferences regarding

rice grain are also varied largely within different regions of Bangladesh. Heterogeneity in rice quality perception is also evident between urban and rural consumers in Dhaka city (Custodio et al., 2019). Consumers' preference for rice according to the process of rice milled is also largely varied across Bangladesh (Jaim and Hossain, 2009). Preferences are largely varied not only among value chain actors of different socioeconomic statuses but also among women with differing empowerment attainment. Table 2 illustrates the historical trends in consumers' preferences for rice quality in Bangladesh.

Consumers' preferences regarding rice grain are also varied largely within different regions of Bangladesh. For instance, producers and producer-cum-consumers preferred rice varieties for higher yield, whereas pure consumers preferred varieties on the basis of its tastiness and fineness. The specific grain quality characteristics such as whiteness, broken, shape, amylose (%), aroma, cooking quality, hardness, and chalkiness largely influenced the preferences of both consumers and producers (Hossain et al., 2015). Another study found that 96% of the consumers in Bangladesh bought parboiled rice from the market because of consumption habit (57%), not sticky (15.7%), easily digestible (15.2%), tasty (13.2%), durability (12.2%), and expansion ratio (3.8%) (Jaim and Hossain, 2009). The same study findings noted that the foremost vital quality to consider for good quality rice in Bangladesh is slender rice (42.7%), followed by taste (24.4%) and clean rice (17.0%). Another study noted the top

five most preferred rice characteristics in urban Bangladesh as good taste, white, slender, short size, and aromatic grains (Custodio, 2015). Table 3 illustrates the perceptions of consumers on rice quality in Bangladesh.

Findings noted that relatively wealthy consumers are likely to consume more rice than relatively poor consumers, and relatively wealthy consumers tend to be sincere in selecting rice based on grain quality (Cuevas et al., 2016). On a similar note, wealthy households in Bangladesh are more likely to consume fine-grain rice than their counterparts (Mottaleb et al., 2017). However, grain quality can also be superficial and thus can be manipulated by labeling, packaging, and milling. Importantly, the visual appearance of rice grain, such as shape and size, is an important attribute of grain quality that largely affects consumers' decisions to purchase and, therefore, the market price for rice. In addition to size and shape, cooking quality, food value content, and taste also affect the price of rice by influencing consumers' repeated purchasing behavior (Cuevas et al., 2016). In Bangladesh, broken rice normally receives a lower market price, because it is treated as low-quality rice (Cuevas et al., 2016; Mottaleb et al., 2017). After yield, grain type was the second most important factor for farmers when considering the adoption of a new variety because the price of rice is largely influenced and highly associated with the grain type (Custodio et al., 2015, 2016b). Therefore, rice breeding programs must take into account the grain-type preferences of different consumer groups in developing new rice varieties. Without

TABLE 2 Historical trends in consumers' preferences on rice quality in Bangladesh.

| Decades                 |                                 |                                    |   |
|-------------------------|---------------------------------|------------------------------------|---|
| 1980 <sup>a</sup>       | 1990 <sup>b</sup>               | 2000 <sup>c</sup>                  | 2010 <sup>d</sup>                             |
| Parboiled; firm and dry | Parboiled; firm and dry         | Firm and dry                       | High amylose content                          |
| High amylose content    | High amylose content            | High amylose content               | Long slender grains; Very fine to fine grains |
| Slender                 | Short size medium shaped grains | Medium slender grains; fine grains | High head rice recovery                       |
| Short cooking time      | -                               | -                                  | Non-sticky                                    |
| High head rice recovery | -                               | -                                  | Tasty   |
| -                       | -                               | -                                  | White   |
| -                       | -                               | -                                  | Aroma; with fragrance                         |

The grain quality terms used are adopted from IRRI (2015) Rice Knowledge Bank. Source: <sup>a</sup>Choudhury (1991) and Choudhury et al. (1992); <sup>b</sup>Choudhury et al. (1992); <sup>c</sup>Hossain et al. (2015); <sup>d</sup>Custodio et al. (2016a, 2019).

TABLE 3 Consumers' perceptions of rice quality in Bangladesh.

| Attribute      | Premium quality                  | Good quality   | Low quality  |
|----------------|----------------------------------|--|--|
| Texture        | Non-sticky                       | Non-sticky   | Sticky; becomes too soft if cooked rice is soaked in water overnight |
| Size and shape | Long; Slender; Very fine to fine | Fine to medium fine; Medium size                           | Coarse; Bold   |
| Color          | White                            | White but not as white as premium; white even if parboiled | Not very white   |
| Aroma          | With fragrance                   | No bad smell   | With bad smell   |
| Purity         | -                                | With 5% impurities   | With impurities  |
| Homogeneity    | -                                | With 5% broken grains                                      | Higher % of broken grains  |
| Others         | Tasty; Longevity                 | Tasty; Longevity   | Not tasty  |

Source: Custodio et al. (2016a, 2019).

attaining desirable grain quality that matches end users' preferences, an increase in rice yield may bring less benefit to farmers. Thus, rice breeding programs should focus more on grain quality coupled with traits for high yield, as well as tolerance to biotic and abiotic stresses, that match end users' preferences. If new rice varieties incorporate end users' preferences, this might also benefit rice farmers, as they can accrue extra benefits by catering to consumers' preferences.

There has been significant variance regarding preferences for rice traits among consumers by country, by region, and by country being an importer or exporter (Bairagi et al., 2017). For instance, Bangladeshi rice consumers preferred rice that had great appearance and taste attributes. Conversely, Southeast Asian consumers' first, second, and third choice was more likely to be texture traits, aroma, and appearance, respectively. Also, geographic segmentation significantly affected consumers' decision in choosing preferred rice traits (Bairagi et al., 2017), which must be emphasized in future varietal development programs. In assessing consumers' preferences for extrinsic quality attributes, findings noted that consumers in Bangladesh whose preferred rice trait was aroma were more likely to purchase packaged rice which is consistent with the observation that aromatic rice is usually packaged and its market price is higher (Bairagi et al., 2018). One key aspect to note here is that rice breeding programs must combine both market and climate-smart traits in optimal product profiles while tailored to specific needs. Because if breeders fail to tailor rice varieties based on the demanded trait preferences, other Rice Value Chain (RVC) actors may do so and capture consumer surplus. For example, millers, wholesalers, and exporters can mix varieties to provide different "grades" of texture or double-polish grains to increase slenderness as what is currently done in Bangladesh for the so-called 'Minikit' (further polished version of BRRI dhan28 and BRRI dhan29) rice. Also, failure to incorporate agronomic and stress-tolerance traits, on the other hand, may expose farmers to higher climate and production risks. Therefore, rice breeding programs should consistently incorporate market research on the preferences of different RVC actors. In the long run, market and climate-smart rice breeding will contribute to more efficient, equitable, and sustainable RVCs as a result of better linkages between rice farmers and consumers. The RVC-based recommendations for better varietal adoption by farmers in Bangladesh are as follows;

#### Recommendations

- Targeting the bio-fortification of Swarna, BR11, BRRI dhan29, and BRRI dhan28 could result in reaching more than half of the rice consumers in Bangladesh with nutrient-dense rice.
- Farmers will accept varieties with nutritional traits only if there is no yield penalty.
- Consumers have a preference for less-parboiled rice.
- Millers, however, go for more polishing to target high-income consumers.
- Nutritional traits must be put into the endosperm for the nutrients to reach consumers.

Source: Hossain et al. (2012).

### 3.1.2 Farmers' varietal trait preferences

Varietal trait preferences are largely varied among different farmer groups depending on their roles and responsibilities in rice cultivation. Findings noted that farmers in Bangladesh opined high yield (46%), good taste (24%), and lodging resistance (23%) as the top three reasons for choosing rice variety BRRI dhan29 (Hossain et al., 2003a,b, 2006). On the other hand, high yield (28%), good taste (20%), and early maturation (13%) as the top three reasons for choosing BRRI dhan28 (Tiongco and Hossain, 2015). Regarding primary traits in new rice varieties, 96% of farmers in Bangladesh preferred high yield, and as secondary traits, they preferred grain quality, shorter maturity, lodging resistance, and higher milling recovery (Jaim and Hossain, 2009). Other findings noted farmer's rice varietal trait preferences in Bangladesh as yield, tolerance to biotic and abiotic stresses, short duration, and profitability. Farmers usually assess a new variety in terms of a range of attributes, including grain quality, straw yield, and input requirements in addition to yield (Joshi and Bauer, 2006; Haque et al., 2023). Rice grain quality largely influences the farmer's adoption decision of new rice varieties, for instance, due to poor grain quality after cooking, hybrid rice varieties are less preferred in Bangladesh (Mottaleb et al., 2015, 2017). Figure 2 illustrates the results of a varietal adoption study conducted by the International Rice Research Institute (IRRI). Findings noted that farmers' (both male and female) top preferred traits in Bangladesh are high yield, good taste, slender grain, easy to sell, and higher market price.

Figure 3 illustrates that men and women farmers in Bangladesh prefer the same traits, but they rank them differently. To elaborate,

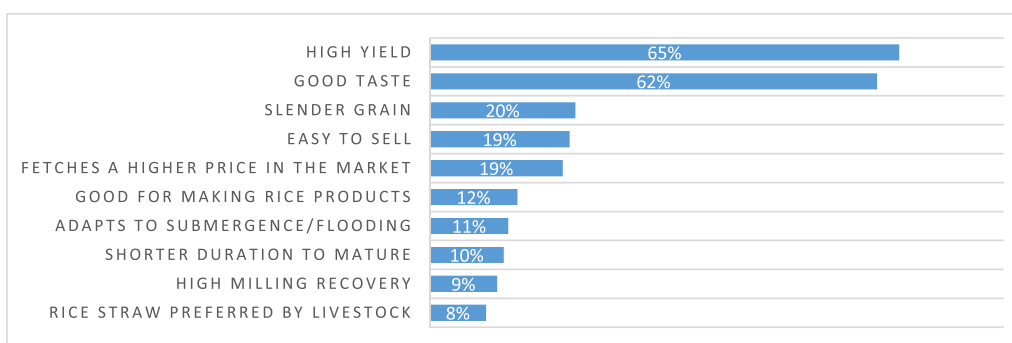
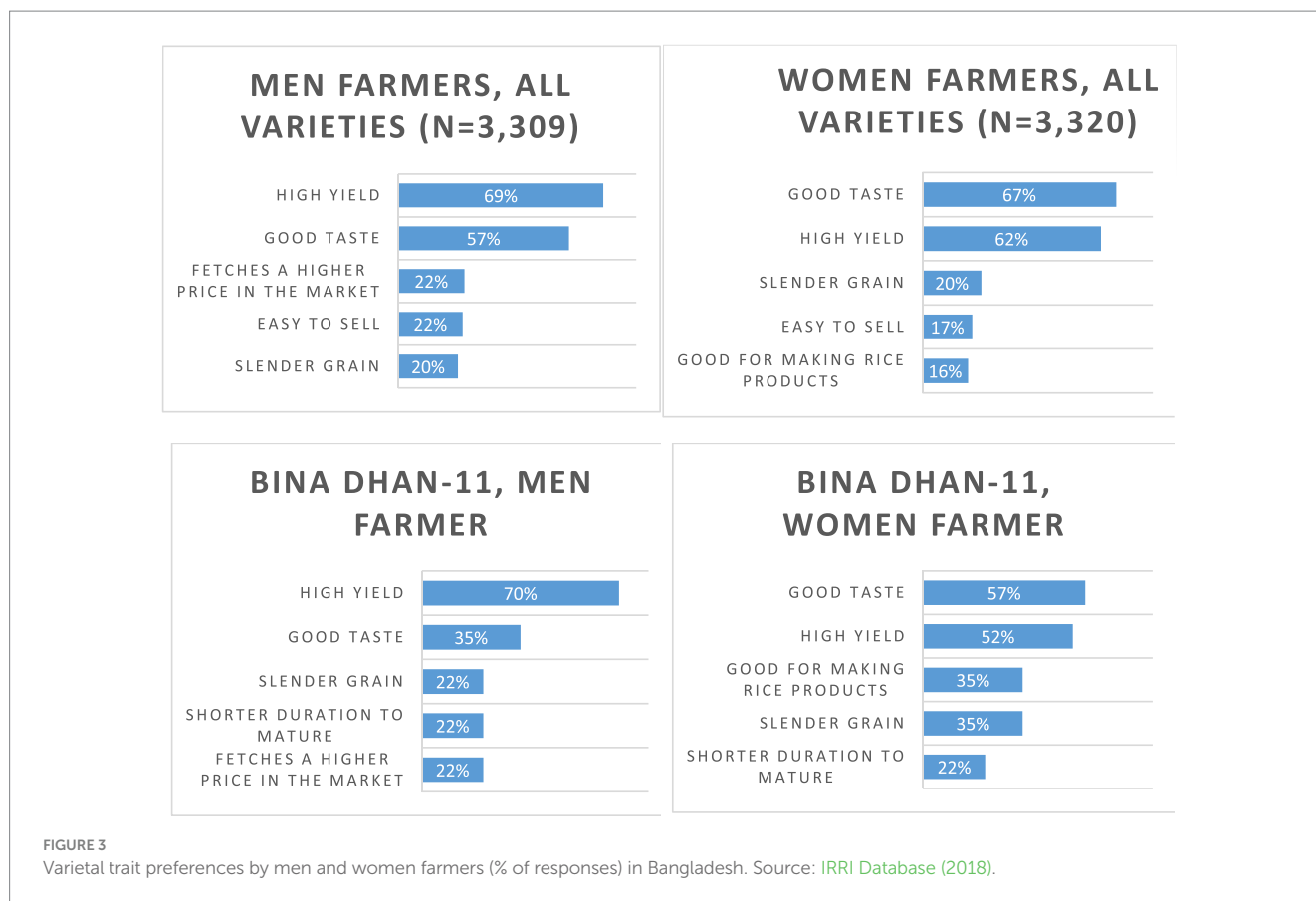


FIGURE 2

Farmer preferred traits (% of responses) in Bangladesh – combined men and women (all varieties). Source: IRRI Database (2018).

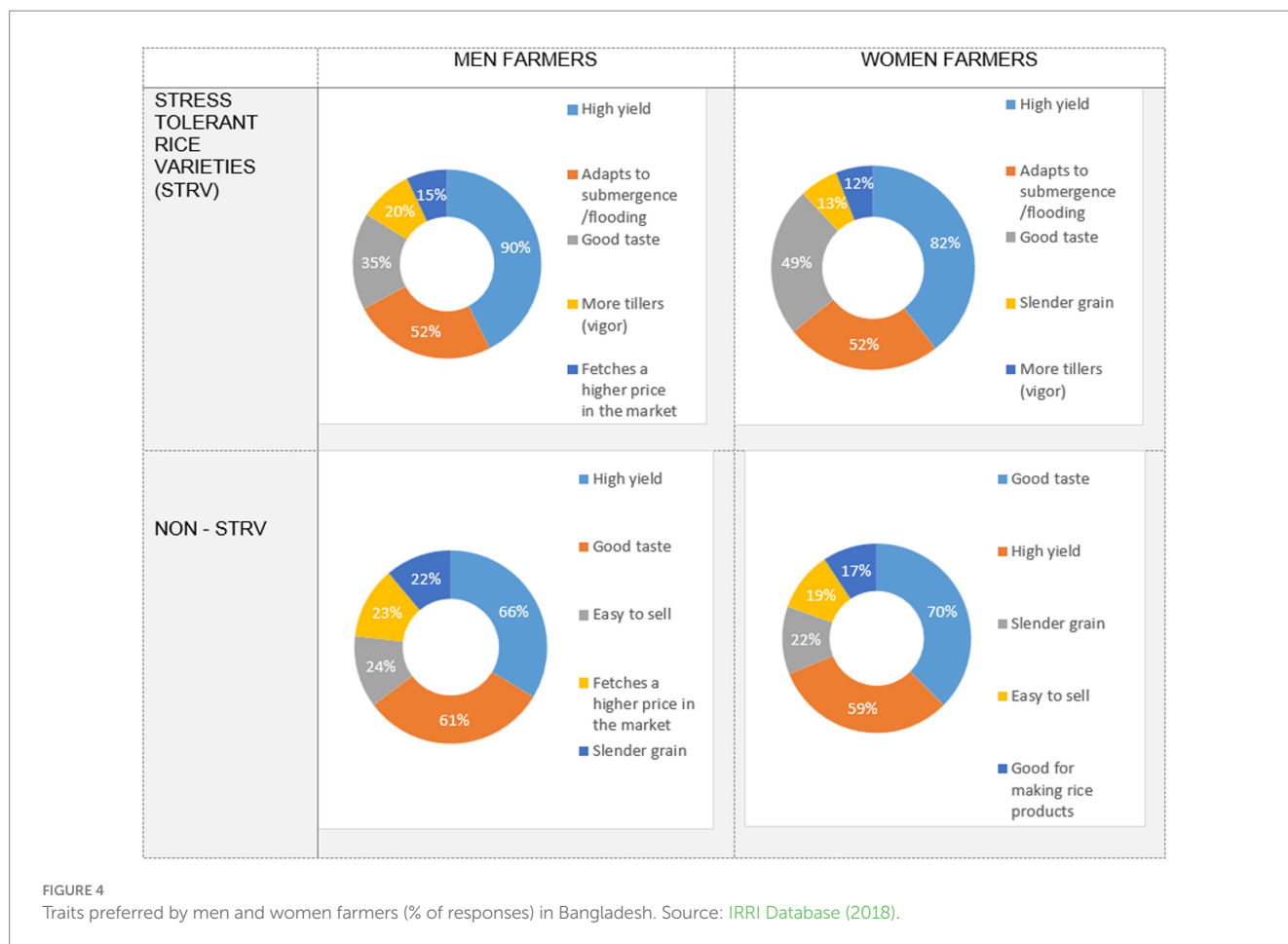


varietal traits preferred by men farmers seem to be mostly production and market-oriented, whereas traits preferred by women farmers seem to be both production and consumption (good for making rice products) oriented. Similar findings have also been noted for non-stress tolerant rice variety (non-STRV) trait preferences (Figure 4). From Figure 4, traits by both men and women farmers in Bangladesh preferred similar traits for stress tolerant rice varieties (Chowdhury, 2014), and both ranked flood tolerance highly. However, for non-stress-tolerant rice varieties, the findings distinctly reveal significant variations in varietal traits preferred by men and women farmers in Bangladesh. This observation underscores that, in stress ecosystems, farmers, irrespective of gender, prioritize production. Conversely, in favorable ecosystems, male farmers exhibit a stronger emphasis on agronomic traits, while female farmers prioritize traits related to grain quality.

Figure 5 illustrates the differences in varietal trait preferences for men and women farmers by divisions in Bangladesh. Results noted that both men and women farmers have a higher preference for yield and good taste in most divisions. Also, men farmers are more market-oriented in Rajshahi, Dhaka, Khulna, and Barisal divisions, while women are more market-oriented in Rangpur, Dhaka, and Barisal divisions. Both men and women farmers have more focus on the submergence trait in the Barisal division and on the home consumption trait (higher milling recovery) in the Rajshahi division. These results clearly indicate that varietal trait preferences differ not only between men and women but also among farmers of different divisions in Bangladesh.

In addition to these, the study results noted that, using different factors like income groups, farmers' access to farming information, household size, land size, and decision-making on varietal choice, both men and women farmers preferred similar traits with different rankings. The only exception was found in the case of varietal trait preference by religion, where similar traits were preferred by Hindu and Muslim farmers but ranked differently. However, women farmers preferred similar traits and ranked similarly regardless of their religious status. All these results elucidate quite a lot on the nature, extent, and causes of gendered varietal trait preferences in Bangladesh.

Table 4 illustrates the gendered varietal trait preferences in Bangladesh. From Table 4, varietal trait preferences ranked higher by women or men farmers give indications of strong gender specificity. For instance, traditionally, women in Bangladesh are responsible for post-harvest processing and food preparation, which leads to varietal traits related to these activities being preferred more by women than men farmers (Ynion et al., 2016). That's why; women farmers noted trait preferences for a variety, i.e., post-harvest, processing, and consumption aspects that were not mentioned by their counterparts. One key aspect to note here is that women and men farmers in Bangladesh, even within the same agroecology and village, may require different improved traits for cultivating rice under complementary conditions and thus may express different trait preferences for varieties. Hence, attention to incorporating gender-differentiated trait preferences in developing improved varieties can curtail farmers' varietal adoption lag in Bangladesh.



### 3.2 Gender and rice breeding programs in Bangladesh

The influence of gender differences on rice farming in Bangladesh is fundamental because men and women have unequal control over and access to productive resources on which rice farming depends largely (Ahmed, 2014; Weltzien et al., 2020). This is particularly the case for smallholder farmers in Bangladesh, where women and men have different roles and responsibilities and where rights and access to productive resources differ significantly (Al-amin et al., 2004). Systematic identification and integration of gender-differentiated varietal trait preferences in designing rice breeding programs in Bangladesh remains unreciprocated. Lack of sensitivity towards gender-differentiated trait preferences by the rice breeding programs can be a disadvantage for gender-responsiveness of the variety developed and can also limit the anticipated impact of newly developed varieties (Weltzien et al., 2020). Hence, understanding the biophysical, social, and cultural environment of different farmer groups from a gender perspective is quintessential to gender-responsive variety development in Bangladesh.

Rice breeding programs in Bangladesh aim to develop new rice varieties incorporating farmer-preferred traits to curtail varietal adoption lag (Choudhury, 1991; Jaim and Hossain, 2009; BRRI, 2015; Hossain et al., 2015; Kabir et al., 2015; Tiongco and Hossain, 2015;

Karmakar et al., 2021). However, in Bangladesh, it usually takes 15–16 years from the release of a variety to reach its peak of adoption (Jaim and Hossain, 2009; Kabir et al., 2020). For instance, stress-tolerant along with high market-value rice varieties were promoted in Bangladesh by the Cereal Systems Initiative for South Asia (CSISA) project; however, when monitored, the adoption of such varieties appeared to be very low (Ahmed, 2014). One of the reasons behind such a slow varietal adoption rate can be the conventional varietal development approach (supply-driven) followed by the rice breeders in Bangladesh, in which breeders mostly prefer traits that do not always match the needs of different farmer groups, i.e., men and women (Hossain et al., 2003a,b; Sarkar et al., 2017). In Bangladesh, women farmers' engagement in agriculture has been ever-increasing (Haque et al., 2017; Khan et al., 2017, 2023; Khan, 2019), and their thoughts and perceptions are equally important in developing improved rice varieties. Also, women's knowledge of post-harvest management and cooking quality (Paris et al., 2005; Gurung et al., 2013) are important considerations in developing rice varieties for different agroecologies suffering from both biotic and abiotic stresses. Therefore, the use of the participatory varietal selection (PVS) process may address this issue to a great extent as it involves different farmer groups in the selection of desired breeding lines. Also, the participation of women in the PVS process increases women's decision-making authority in varietal choice, seed acquirement, and crop management (Paris et al., 2005; Gurung et al., 2013).

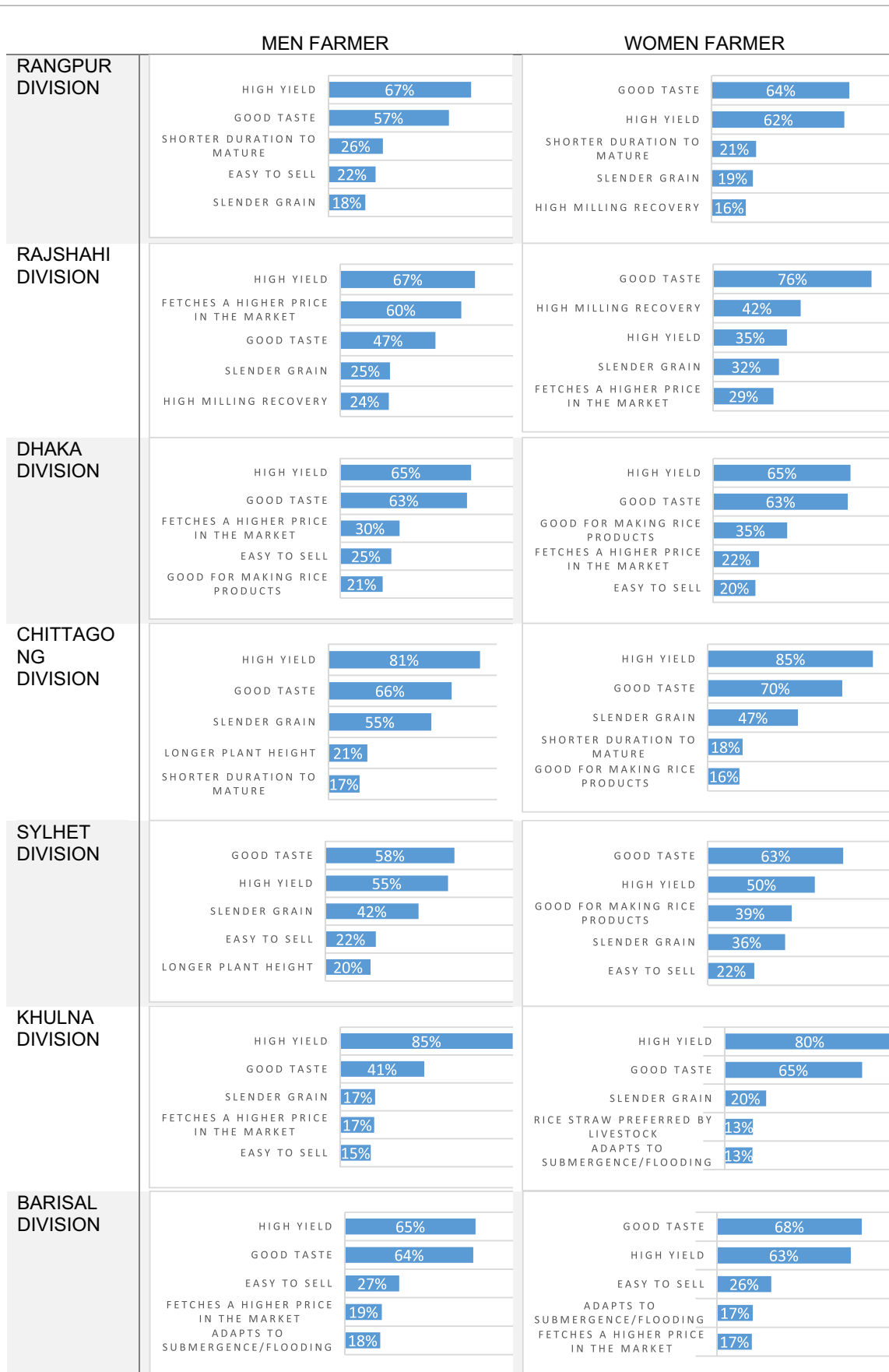


FIGURE 5 Preferred traits by men and women farmers (% of responses) in Bangladesh (by Division). Source: IRRI Database (2018).



TABLE 4 Gendered varietal trait preferences in Bangladesh.

| Men  |                        | Women |                        |
|------|------------------------|-------|------------------------|
| Rank | Traits                 | Rank  | Traits                 |
| 1    | High yield             | 1     | Good taste             |
| 2    | Good taste             | 2     | High yield             |
| 3    | High market price      | 3     | Slender grain          |
| 4    | Easy to sell           | 4     | Easy to sell           |
| 5    | Slender grain          | 5     | Good for rice products |
| 6    | Shorter duration       | 6     | High market price      |
| 7    | Adapts to flooding     | 7     | High milling recovery  |
| 8    | Good for rice products | 8     | Adapts to flooding     |
| 9    | More tillers (vigor)   | 9     | Shorter duration       |
| 10   | High milling recovery  | 10    | Fodder for livestock   |

The ranking was determined by considering the frequency of responses from the participants. The highest frequency is allocated the first rank, followed by sequential rankings for the remaining frequencies. Authors' estimation based on data from [IRRI Database \(2018\)](#).

TABLE 5 Key gender aspects for integration with rice breeding programs in Bangladesh.

| Domains  | Determinations  | Gender integration  |
|--|---|---|
| Figure out farmers' criteria for selecting varieties         | Modify selection strategies to improve chances for the adoption of newly bred varieties                     | Women and men can have specific expertise for evaluating certain varietal traits, and their trait priorities can vary   |
| Understand farmers' varietal adoption decisions              | Target gender-responsive breeding priorities and assess benefits that different farmer groups may derive    | Women farmers can derive benefits from or be negatively impacted by specific types of varietal traits   |
| Characterize consumer demand for specific types of varieties | Based on the developed gender strategy, predict future market opportunities for specific types of varieties | Families with different geography and resource levels can have specific demands; i.e., urban vs. rural consumers [men and women], poor vs. rich, etc.               |
| Recognize patterns of genetic diversity                      | Gender-focused maintenance of the germplasms  | Both women and men farmers can use specific varieties for specific purposes   |
| Identify customers for newly developed varieties             | Target gender-focused seed dissemination approach and develop seed marketing strategies accordingly         | Target women farmers as customers for specific varieties due to their unique trait preferences or family roles, i.e., bio-fortified crops targeting child nutrition |

Source: Adopted from [Weltzien et al. \(2020\)](#).

In addition to gender considerations, it is crucial to recognize the diverse preferences within other demographic groups involved in rice farming. The varietal trait preferences of youth, both male and female, as well as senior citizens and persons with disabilities, constitute significant aspects that merit attention within the rice breeding framework. Understanding their distinct criteria regarding factors such as production ownership, control, and access is essential for a comprehensive analysis of decision-making processes in the rice value chain. Additionally incorporating such trait preference parameters within the rice breeding mechanism is likely to generate new thinking avenues in curtailing farmers' rice varietal adoption lag in the context of Bangladesh. Therefore, rice breeding programs in Bangladesh need to be more mindful in soliciting gender-responsive criteria for developing improved rice varieties. Identified domains and determinations for proper gender integration with rice breeding programs in Bangladesh are illustrated in [Table 5](#).

Gendered differences in production environments may go undetected in typical analyses focusing solely on geographic and biophysical aspects. Thus, rice breeding programs in Bangladesh need to analyze and target different farmer groups, considering sociocultural factors like gender as well as economic and ecological factors. In addition, rice breeding programs in Bangladesh can benefit

substantially from gender-focused market analysis, concepts and tools for describing and prioritizing consumer needs, and market demands as a basis for gender-responsive targeting.

## 4 Concluding insights and recommendations

Many of previous researches were associated with ongoing rice breeding programs, indicating that gendered differentiation with regard to varietal trait preferences has been a concern for rice breeding programs. However, explaining the gender differences in varietal trait preferences for a specific context in Bangladesh was not the primary goal of any research identified for this review. However, few researchers ([Al-amin et al., 2004](#); [Haque and Chowdhury, 2006](#); [Jaim and Hossain, 2011](#); [Rahman et al., 2016](#); [Haque et al., 2017](#); [Khan et al., 2017](#); [Khan, 2019](#)) had a primary objective to explain differences in gender relations in the different farming context of Bangladesh. Only one research, [Gurung et al. \(2013\)](#), tried exploring the gender dynamics in changing rice-based agriculture in Bangladesh. In another research, [Ahmed \(2014\)](#), reviewed the gender-related activities under different projects of IRRI since 2000. Consequently,

the underlying causes for contrasting gendered varietal trait preferences are not well identified in previous research. In the context of Bangladesh, detailed discussions to understand the varietal trait preferences of women and men for future varietal development programs were rarely used among the articles reviewed. Therefore, analyzing the differences among varieties preferred by women and men, and the specific traits those varieties possess can provide a basis for identifying gender differences. Hence, specifically designed research dedicated to understanding the gender differences in varietal trait preferences is recommended so that the gender-responsive rice breeding program becomes a reality in Bangladesh.

Previous studies on rice grain quality preference in Bangladesh have focused mainly on consumers (Jaim and Hossain, 2009; Bairagi et al., 2017, 2018). However, little has been done to assess grain quality in relation to both farmer and consumer preferences (Hossain et al., 2012, 2015; Sarkar et al., 2017; Haque et al., 2023) in order to infer how grain quality could influence farmers' preference for improved rice varieties and consumers' preference for quality rice grain. In Bangladesh, more research (both qualitative and quantitative) is required to assess the influence of grain quality and other factors affecting farmers, both in men, women and youth, varietal trait preferences for improved rice varieties. It is striking, however, that there is rather scant literature on gender and varietal trait preferences in Bangladesh. Therefore, further research using an interdisciplinary research approach (both qualitative and quantitative) on gendered differences in varietal trait preferences for different farmer groups in Bangladesh will fill a major gap in the literature. More analysis, similar to the analysis done by Tiengco and Hossain (2015), is required in major rice growing regions of Bangladesh to aid the development of improved rice varieties that are more responsive to the needs and preferences of both men and women farmers in Bangladesh.

#### 4.1 Key aspects for gender-responsive rice breeding in Bangladesh

- Develop gender-responsive product profiles: Understanding the differences in women and men farmers' varietal trait preferences can help defining the specific type of variety to be bred by the rice breeding programs in Bangladesh. Developing context-specific gender-responsive rice product profile, with a defined set of targeted attributes that a new variety is expected to meet in order to be successful in the market (Ynion et al., 2016; Sarkar et al., 2017; Ragot et al., 2018) is helpful in this respect. Critical aspects here include recognizing the combination of "must have" traits that need to be above a threshold for acceptability and prioritizing the key varietal traits to be improved. Consumer-preferred quality traits such as processing and cooking attributes are a major group of "must have" traits that women in Bangladesh frequently highlight, and insufficient attention to ensure acceptable levels of these traits risks a lack of farmers' adoption of newly developed varieties. Therefore, gender-responsive product profile development will define the combination of varietal traits needed to respond to the targeted demand of different farmer groups and of different ecologies across Bangladesh.
- Gender-responsive breeding strategy for enhanced genetic gains: One of the most important questions of modern times

is whether it is really worth developing a gender-specific variety that meets demand and has benefits for a certain farmer group. The answer is quite simple. We do not need to develop separate varieties, given the fact that in Bangladesh, varietal trait preferences of women and men farmers are based on their differentiated farming and household roles and responsibilities. For instance, men's focus on agronomic traits and women's preferences for qualities for post-harvest processing, cooking, and food security are complementary. The inclusion of such complementary varietal traits that satisfy both women and men farmers' trait preferences in a given variety could be a pre-condition for responding to the full range of varietal desires and needs. Breeding separate varieties for women and men could be necessary only when the traits for their respective objectives differ significantly and involve tradeoffs.

- Complexity of gendered trait prioritization: Based on the evidences of previous discussions, it is clear that varietal trait preferences are quite different for women and men and are equally important for guiding future rice breeding programs in Bangladesh in a gender-responsive manner. However, it is often difficult to generalize or quantify the gendered differences unfailingly. For instance, if breeding programs in Bangladesh opt for the gender-focused comparison of varietal trait preferences, it is more likely to generate a contradictory picture due to numerous socioeconomic characteristics influencing gender roles and responsibilities, shaping their preferences. Generalizations about gender-differentiated varietal trait preferences requires an explanation of how preferences reflect underlying gender differences in assets, markets, information, and risk. This requires reference to a social profile that includes but is not limited to analysis of varietal preference differences between women and men in Bangladesh.
- Ways forward: To learn effectively about the gender differences in farmers' varietal trait preferences, rice breeding programs in Bangladesh must use multiple methods (On-station trial, on-farm trial, participatory varietal selection, individual interviews, focus group discussions, and case studies). In addition, breeders must have joint annual feedback and planning meetings with both women and men farmers to improve knowledge and awareness of overall goals and specific breeding objectives of rice variety development. Breeding programs must also set quotas for variety trials to be conducted by women in their fields, which in turn will give them a direct opportunity to propose their priority traits to use for varietal evaluations. Effective implementation of all these is expected to support gender-responsive trait prioritization by the future rice breeding programs in Bangladesh.

#### Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

## Author contributions

MSK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft. MARS: Investigation, Methodology, Supervision, Visualization, Writing – original draft. MRI: Funding acquisition, Investigation, Supervision, Writing – review & editing. HB: Supervision, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Acknowledgments

The authors express gratitude to Ranjitha Puskur, Country Representative for India and Research Leader – Gender & Livelihoods at International Rice Research Institute (IRRI), for her scholarly

## References

- Ahmed, S. (2014). *An overview of gender-related activities in IRRI-PETTRA, IRRI-FoSHoL and CSISA-India Projects*, International Rice Research Institute (IRRI): Bangladesh
- Al Mamun, M. A., Nihad, S. A. I., Sarkar, M. A. R., Aziz, M. A., Qayum, M. A., Ahmed, R., et al. (2021). Growth and trend analysis of area, production and yield of rice: a scenario of rice security in Bangladesh. *PLoS One* 16:e0261128. doi: 10.1371/journal.pone.0261128
- Al-amin, S., Miah, M. M., and Chowdhury, A. H. (2004). Role of women in the improvement of livelihoods of resource poor household. *Bangladesh journal of extension. Education* 16, 25–33.
- Bairagi, S., Gustafson, C.R., Custodio, M.C., Ynion, J., and Demont, M. (2018). Drivers of consumers' revealed preferences for extrinsic quality attributes: evidence from the Rice sector in south and Southeast Asia. In Poster prepared for presentation at the Agricultural and Applied Economics Association annual meeting, Washington, DC 5–7
- Bairagi, S., Mohanty, S., Ynion, J., and Demont, M. (2017). Determinants of consumer preferences for Rice attributes: Evidence from south and Southeast Asia. In Paper prepared for presentation at the Agricultural and Applied Economics Association annual meeting, Chicago, IL
- BRRI. (2015). Annual report 2014–15. Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.
- Choudhury, N.H. (1991). *Parboiling and consumer demand for parboiled rice in South Asia*, Rice Grain Marketing and Quality Issues. International Rice Research Institute., Manila, Philippines, 47–54.
- Choudhury, N., Kabir, K. A., Biswas, S. K., and Islam, R. (1992). "Influence of rice grain properties on market price in Bangladesh" in *Consumer demand for Rice grain quality*. eds. L. J. Unnevehr, B. Duff and B. O. Juliano (Manila, Philippines: International Rice Research Institute), 117–133.
- Chowdhury, A. (2014). *Stress-tolerant rice varieties in Bangladesh*. BRRI: Bangladesh.
- Cuevas, R. P., Pede, V. O., McKinley, J., Velarde, O., and Demont, M. (2016). Rice grain quality and consumer preferences: a case study of two rural towns in the Philippines. *PLoS One* 11:e0150345. doi: 10.1371/journal.pone.0150345
- Custodio, M.C. (2015). Preferences of urban rice consumers in south and Southeast Asia. In Proceeding of International seminar on consumer preference in rice, Kasetsart University, Bangkok campus, Thailand.
- Custodio, M. C., Cuevas, R. P., Ynion, J., Laborte, A. G., Velasco, M. L., and Demont, M. (2019). Rice quality: how is it defined by consumers, industry, food scientists, and geneticists? *Trends Food Sci. Technol.* 92, 122–137. doi: 10.1016/j.tifs.2019.07.039
- Custodio, M.C., Demont, M., Laborte, A.G., Diaz, C., Ynion, J., and Islam, R. (2016b). *Rapid value chain assessment and rice preferences of consumers, farmers and other rice value chain actors in Bangladesh*. Los Baños: International Rice Research Institute
- Custodio, M. C., Demont, M., Laborte, A., and Ynion, J. (2016a). Improving food security in Asia through consumer-focused rice breeding. *Glob. Food Sec.* 9, 19–28. doi: 10.1016/j.gfs.2016.05.005
- guidance and insightful suggestions during the conceptualization phase of the literature review. Additionally, the authors extend their appreciation to IRRI for granting permission to utilize primary data sourced from the [IRRI Database \(2018\)](#), thereby enhancing the data-driven nature of the study.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Custodio, M. C., Paguirigan, N. C., Laborte, A. G., Ynion, J., and Demont, M. (2015). What kind of rice do consumers want? *Rice Today* 14, 38–39. Available at: <https://ricetoday.irri.org/whatkind-of-rice-do-consumers-want/>

Gurung, K., Bhandari, H., Paris, T., and Mohanty, S. (2013). Gender dynamics in changing Rice-based agricultural Systems in Bangladesh. Village dynamics in South Asia (VDSA), Policy brief, IRRI.

Haque, M. M., and Chowdhury, A. H. (2006). "Role of women as clients and change agents in selected areas of development: reflection from empirical evidence" in *Gender and human resources for health in South Asia: Challenges and constraints: University Grants Commission (UGC)*. eds. M. M. Ullah and A. Islam (Canada: Dhaka and Canadian International Development Agency (CIDA)), 131–150.

Haque, S., Khan, M.S., and Joshi, D. (2017). Poverty-gender-agriculture nexus in the northern region of Bangladesh: challenges and opportunities. Policy Brief. WLE Briefing Series No. 20. Available at: <https://hdl.handle.net/10568/91686>

Haque, M. E., Sarkar, M. A. R., Islam, M. A., Omar, M. I., and Islam, M. S. (2023). Preferences analysis for rice variety and development of product profile in the hilly ecosystems of Bangladesh. *Bangladesh J. Environ. Sci.* 44, 49–56.

Hossain, M. (1989). *Green revolution in Bangladesh: Impact on growth and distribution of income*. Dhaka: University Press Limited.

Hossain, M., and Akash, M.M. (1994). *Public rural works for relief and development*. Washington, DC: IFPRI.

Hossain, M., and Barker, R. (2007). Current status and challenges in rice production in south and Southeast Asia. In Proceeding of the Paper presented at the convening on Rice. Held June 5–7, at the Bill and Melinda Gates Foundation, Seattle, USA.

Hossain, M., Bose, M. L., and Mustafi, B. A. A. (2006). Adoption and productivity impact of modern Rice varieties in Bangladesh. *Dev. Econ.* 44, 149–166. doi: 10.1111/j.1746-1049.2006.00011.x

Hossain, M., and Jaim, W. M. H. (2012). "Diversity, spatial distribution and the process of adoption of improved Rice varieties in Bangladesh" in *Adoption and diffusion of modern Rice varieties in Bangladesh and eastern India*. eds. M. Hossain, W. M. H. Jaim, T. R. Paris and B. Hardy (Los Baños, Philippines: International Rice Research Institute)

Hossain, M., Jaim, W.M.H., Paris, T.R., and Hardy, B. (2012). *Adoption and diffusion of modern rice varieties in Bangladesh and eastern India*. Los Baños (Philippines): International Rice Research Institute, 251

Hossain, M., Janaiah, M., and Husain, M. (2003a). Hybrid rice in Bangladesh: farm level performance. *Econ. Polit. Wkly.* 38, 2517–2522. Available at: <https://www.jstor.org/stable/4413709>

Hossain, M., Lewis, D., Bose, L.M., and Chowdhury, A. (2003b). Rice research, technological progress, and impacts on the poor: the Bangladesh case (summary report). EPTD discussion paper no. 110, environment and production technology division, international food policy research institute (IFPRI).

Hossain, M., Lewis, D., Bose, M. L., and Chowdhury, A. (2007). "Rice research, technological progress, and poverty: the Bangladesh case" in *Agricultural research,*

- livelihoods, and poverty: Studies of economic and social impacts in six countries. eds. M. Adato and R. Meinzen-Dick (Washington, D.C.: IFPRI)
- Hossain, M., Quasem, M.A., Akash, M.M., and Jabber, M.A. (1990). *Differential impact of modern Rice technology: The Bangladesh case. Working paper*. Dhaka: Bangladesh Institute of Development Studies (BIDS)/Bangladesh Rice Research Institute (BRRI)
- Hossain, M., Quasem, M. A., Jabbar, M. A., and Mokaddem, M. (1994). "Production environments, MV adoption, and income distribution in Bangladesh" in *Modern Rice technology and income distribution in Asia*. eds. C. C. David and K. Otsuka (Boulder, CO, USA: Lynne Rienner Publishers Inc)
- Hossain, M. I., Rahman, N. M. F., Kabir, M. S., and Tareq, M. (2015). Development and validation of producer and consumer preference models for Rice varieties in Bangladesh. *Bangladesh Rice J.* 19, 63–71. doi: 10.3329/brj.v19i1.25223
- IRRI. (2015). *Rice knowledge Bank*. International Rice Research Institute: Philippines
- IRRI Database, (2018). Farm household survey database. Social Sciences Division, International Rice Research Institute. Available at: <https://ricestat.irri.org/thsd/>
- Jaim, W.M.H., and Hossain, M. (2009). Rice milling processes, consumers' preferences and cooking practices in Bangladesh: Implications for nutritional value. Final workshop on adoption and diffusion of modern rice varieties in Bangladesh and eastern India, held 3–4, Oct. 2009 at BRAC Center Inn, Dhaka, Bangladesh. Organized by the International Rice Research Institute (IRRI), International Food Policy Research Institute (IFPRI), and International Center for Tropical Agriculture (CIAT).
- Jaim, W.M.H., and Hossain, M. (2011). Women's participation in agriculture in Bangladesh 1988–2008: changes and determinants. In *Proceeding of the 7th International Asian Society of Agricultural Economists Conference 12 October, Hanoi, Vietnam*. 12.
- Joshi, G., and Bauer, S. (2006). Farmers' choice of the modern rice varieties in the rainfed ecosystem of Nepal. *J. Agric. Rural. Dev. Trop. Subtrop.* 107, 129–138.
- Kabir, M. S., Salam, M. U., Chowdhury, A., Rahman, N. M. F., Iftekharuddaula, K. M., Rahman, M. S., et al. (2015). Rice vision for Bangladesh: 2050 and beyond. *Bangladesh Rice J.* 19, 1–18. doi: 10.3329/brj.v19i2.28160
- Kabir, M. S., Salam, M. U., Islam, A. K. M. S., Sarkar, M. A. R., Mamun, M. A. A., Rahman, M. C., et al. (2020). Doubling rice productivity in Bangladesh: a way to achieving SDG 2 and moving forward. *Bangladesh Rice J.* 24, 1–47. doi: 10.3329/brj.v24i2.53447
- Kabir, M. J., Sarkar, M. A. R., Rahman, M. C., Rahman, N. M. F., Mamun, M. A. A., Chowdhury, A., et al. (2021). Risk of rice cultivation under current and future environment and market. *Bangladesh Rice J.* 25, 101–110. doi: 10.3329/brj.v25i1.55182
- Karmakar, B., Rahman, M. M., Sarkar, M. A. R., Mamun, M. A. A., Rahman, M. C., Nessa, B., et al. (2021). Adoption lag minimization for increasing Rice yield. *Bangladesh Rice J.* 25, 75–88. doi: 10.3329/brj.v25i1.55180
- Khan, M. S. (2019). Women empowerment in agriculture: empirical evidence from Lalmonirhat district. *EBAUB J.* 1, 82–91.
- Khan, M. S., Begum, F., and Islam, M. M. (2017). A review on feminization of agriculture and women empowerment in Bangladesh. *Fundamental Appl. Agricult.* 2, 183–188.
- Khan, M. S., Haque, S., Sarkar, M. A. R., Hoque, M. N., Noman, S. M. H., and Wahid, T. (2023). Thinking out of the 'man box': an intersectional exploration of gender dynamics in northern Bangladesh via gender tracking framework. *World Develop. Sustain.* 3:100100. doi: 10.1016/j.wds.2023.100100
- Mottaleb, K. A., Mohanty, S., and Nelson, A. (2015). Factors influencing hybrid Rice adoption: a Bangladesh case. *Aust. J. Agric. Resour. Econ.* 59, 258–274. doi: 10.1111/1467-8489.12060
- Mottaleb, K. A., Rahut, D. A., and Mishra, A. K. (2017). Modeling rice grain-type preferences in Bangladesh. *British Food J.* 119, 2049–2061. doi: 10.1108/BJF-10-2016-0485
- Paris, T., Singh, A., Cueno, A., and Singh, V. (2005). Assessing the impact of participatory research in rice breeding on women farmers: A case study in eastern Uttar Pradesh, India. In Paper presented in the impact assessment workshop held in Mexico: Forthcoming proceedings in experimental agriculture
- Ragot, M., Bonierbale, M., and Weltzein, E. (2018). *From market demand to breeding decisions: a framework. Working paper no. 2*. CGIAR Gender and Breeding Initiative, International Potato Center (CIP): Lima.
- Rahman, S. (2003). Environmental impacts of modern agricultural technology diffusion in Bangladesh: an analysis of farmers' perceptions and their determinants. *J. Environ. Manag.* 68, 183–191. doi: 10.1016/S0301-4797(03)00066-5
- Rahman, M. S., Haque, M. M., Kabir, M. J., Islam, A. K. M. S., Sarkar, M. A. R., Mamun, M. A. A., et al. (2020). Enhancing rice productivity in the unfavourable ecosystems of Bangladesh. *Bangladesh Rice J.* 24, 83–102. doi: 10.3329/brj.v24i2.53450
- Rahman, M. C., Rahaman, M. S., Biswas, J. C., Rahman, N. M. F., Islam, M. A., Sarkar, M. A. R., et al. (2023). Climate change and risk scenario in Bangladesh. *Asia Pac. J. Reg. Sci.* 7, 381–404. doi: 10.1007/s41685-022-00252-9
- Rahman, F., Shammi, S. A., Parvin, M. T., Akter, N., Khan, M. S., and Haque, S. (2016). Contribution of rural women to rice production activities in two different areas of Bangladesh. *Progress. Agric.* 27, 180–188. doi: 10.3329/pa.v27i2.29329
- Sarkar, M.A.R., Haque, M.E., Siddique, M.A.E., and Bhandari, H. (2017). Priorities in Rice breeding in Bangladesh: A market demand approach for developing an ideal product profile. In *Proceeding of the transforming Rice breeding: Cutting edge breeding approaches*, International Rice Research Institute (IRRI), Los Baños, Philippines, 1–10.
- Sarkar, M. A. R., Rahman, M. C., Rahaman, M. S., Sarker, M. R., Islam, M. A., Balie, J., et al. (2022). Adoption determinants of exotic rice cultivars in Bangladesh. *Front. Sustain. Food Syst.* 6:813933. doi: 10.3389/fsufs.2022.813933
- Sarker, M. R., Sarkar, M. A. R., Alam, M. J., Begum, I. A., and Bhandari, H. (2023). Systems thinking on the gendered impacts of COVID-19 in Bangladesh: a systematic review. *Heliyon* 9:E13773. doi: 10.1016/j.heliyon.2023.e13773
- Siddique, M.A.B., Islam, M.S., Kabir, M.J., Salam, M.A., Islam, M.A., Omar, M.I., et al. (2018). Farm level adoption and evaluation of modern Rice cultivation in Bangladesh. Annual research review workshop 2017–18. Agricultural Economics Division, Bangladesh Rice Research Institute.
- Tiongco, M., and Hossain, M. (2015). Adoption of modern varieties and Rice varietal diversity on household farms in Bangladesh. *Harvest Plus* 22, 1–25. Available at: <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130123>
- Weltzien, E., Rattunde, F., Christinck, A., Isaacs, K., and Ashby, J. (2020). *Gender and farmer preferences for varietal traits: Evidence and issues for crop improvement*. 1st Edn John Wiley & Sons Inc.
- Ynion, J., Demont, M., Custodio, M.C., and Sarkar, M.A.R. (2016). *The investment game application (IGA): A tool for prioritizing Rice farmers' preferences for varietal trait improvements*. International Rice Research Institute: Philippines, 1–23