Looking at gender is not enough—how diversity of farmer's marginalization relates to variety preferences

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Selected Paper prepared for presentation at the 2023 Agricultural & Applied Economics Association Annual Meeting, Washington DC; July 23-25, 2023

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Abstract

Improved varieties developed through plant breeding can help farmers adapt to climate change and meet future food demands. However, some varieties and technologies remain unadopted because they are developed without understanding different users' needs and systemic constraints. Studies are often limited to dichotomous gender-disaggregation homogenizing social conditions and preferences within gender. Household head's sex is often used to proxy gender rendering gender relations within household invisible. This paper sheds light on how variety preferences relate to diverse dimensions of marginalization, driven by intersectionality beyond gender. Using responses from both men and women farmers from household cross-sectional data in Bangladesh, cluster and regression analysis show how next to gender, other intersectionality factors including class, marital status, gender roles, and agency cast varying effects on men's and women's variety preferences. Contrary to conventional narratives about gender-specific preferences, after considering intersections, men and women demand similar variety traits when facing similar marginalizations and opportunities. Variety preferences are more similar in low-income households and diverge in richer households. Unitary models should not be assumed but rather acknowledge the individuality among members' preferences to avoid invisibility of women's priority traits. Marginalizations or social conditions a person is exposed to are more decisive of farmers' priority-setting of variety traits than gender per se. Generally, varieties that offset production constraints, food insecurity, and labor constraints benefit poorer farmers especially women, and even more especially widows. Taken together, the study's results are crucial for different actors, including breeders and extension agents to scale up varietal development and uptake.

Keywords: farmers' preferences, technology adoption, gender, intersectionality, marginalization, multivariate analysis

1. Introduction

Future production of the key global crops falls short of meeting the global food demand (Ray et al. 2013). By 2050, the food demand is reported to increase by at least 60% (Valin et al. 2014). However, the global crop yield gains are projected to drop by at least 5% by 2050 and with sharper declines in primary food crops, including rice (20-30%), maize (20-45%), and wheat (5-50%) by 2100 under business-as-usual scenario (FAO October 2016; IPCC 2014). Against this, we need quick adoption of variety improvements towards stress-tolerant varieties by farmers to sustain and improve yields amidst climate change (Dar et al. 2018).

However, low and slow adoption of new varieties poses a problem (Ahmed, A. U., Hernandez, and Naher 2016; Pandey 2012). Previous literature documents that varieties developed in the late 1970s are still widely used (Atlin, Cairns, and Das 2017). In areas subject to multiple stresses like Bangladesh, only less than one-third of the farmers were growing stress tolerant rice varieties on as low as 3.29% of rice cultivated area (Ahmed, A. U., Hernandez, and Naher 2016) despite their introduction in 2008 (Pandey 2012). In India, rice varietal age is on average 28 years despite their introduction in 2005 (Atlin, Cairns, and Das 2017). The problem is, not replacing obsolete varieties means no genetic gains can be achieved and increasing productivity is critical to meeting the food needs of the burgeoning population. Previous literature has identified gendered variety preferences important in adoption. Yet, variety preferences are assumed to be homogenous within gender. The felt needs and demands of "various men and women user groups" are not accounted for during varietal development (Orr et al. 2018). Often, farmers' demands are assumed to focus on increasing productivity and income. Hence, breeders often create value through yield increase or disease resistance traits (a prevention measure for productivity loss) (Ragot, Bonierbale, and Weltzein 2018, p.3). But, yield traits ignore the preferential needs of men and women and, in some cases, only adhere to a male-standard worldview making women's choices invisible (Goldman 2020; Manzanilla et al. 2011). This creates mismatched objectives between breeders and farmers. The latter have wide-ranging priority attributes which for them have higher utility depending on their underlying social conditions (Sanya et al. 2017). When we lack knowledge about the diversity of users and their preferences, the seed variety traits may be incongruent with the demands of the market segments targeted during seed delivery (mismatched targeting) (Orr et al. 2018, p.33). Hence, preferences and perceptions of various user groups delineated along other categories, such as class, age, marital status, inter alia, roles, and power relations need to be considered. These categories are called intersectional categories - others termed this perspective as gender+ (Bustelo et al. March 2015) -, and are not yet considered in previous research.

Our objective is to present the varietal trait demands of different farmer segments and understand how social categories and diversity of farmers' marginalization can explain when and why certain traits are preferred using an intersectional lens. Intersectionality is a framework that acknowledges that a person's marginalization results from the intersection of multiple identities rather than a single factor alone (Crenshaw 1989; Hankivsky 2014; Jost, Ferdous, and Spicer 2014). We shed light on the question "How do gender and other social categories matter for farmers' variety preferences of rice cultivars?"

We aim at highlighting to policy makers that intersectionality should be included into breeding programs for targeting yield traits and beyond. The aim is to capture diversity of farmer groups and their preferences to reduce the mismatch between breeder objectives and farmer outcomes in the long-term and increase adoption of climate-resilient varieties. Multitudes of existing analyses are limited to sex-disaggregated data. Doing so implicitly treats men and women as homogeneous. Yet, Crenshaw (1989) argues that some groups face double marginalization that is curtained in single-disaggregation. Tufan, H. A., Grando, and Meola (2018) highlight how gender intersections with wealth and social status unveil gendered needs, opportunities, and trait preferences. To address this, our analysis involves a tailored approach accounting not only for the differences between men and women but the diversity within these groups. We go beyond overly simplified, dichotomous categories and consider intersectional factors including class, age, marital status, gender roles, and power and their interactions with gender to account for the diversity of farmers' social conditions and preferences.

We make trait priorities and social conditions of intersectional groups visible to fellow scientists and policy-makers to show that there is significant individuality. This may only be seen if we use dataset and methodologies accounting for intersectionality, such as ours. Many studies employ household head's sex to proxy gender. This approach is problematic as it treats the household as an undifferentiated unit whose members have similar experiences and preferences. It renders gender relations within a household invisible (Doss 2014; Quisumbing, A. R. et al. 2014, p. 14). We contribute to this by having responses from both men and women in the same household to account for more than just household head's sex, but view the individuals within a household as separate in their preferences.

We aim to produce more reliable and targeted research in agricultural and food systems. This paper argues that intersectionality must be given more emphasis in empirical agricultural studies and policy actions because people are often differentiated and disadvantaged in many aspects beyond gender. We cannot ignore the intersections of different axes of social differentiation to avoid homogenizing the social conditions and preferences of men and women. If we do, we will disregard the fact that some individuals face multiple levels of marginalization, and curtain the social dynamics and other sources of inequalities in agri-food system.

Our approach involves segmenting the producers, developing a trait profile per segment, and performing regression analysis to show farmers' variety preferences and unpack how and why they emerge. We focus on rice for its global importance as a food staple and livelihoods (ADB 2018), but want to stretch that this research can apply to crop breeding in general.

The remainder of the paper is structured as follows: Section 2 highlights why intersectional lens is critical in framing breeding priorities. In section 3, we motivate and describe the cluster and regression analysis to identify distinct farmer segments and elicit their preferences. Section 4 presents the results of intersectional analysis. Section 5 concludes the paper and points out some limitations and implications for future breeding priorities and demand-oriented targeting.

2. Why we care about differentiated varietal traits and an intersectional lens in the analysis

2.1 Motivation for in-depth understanding of variety preferences

Some recent studies have been citing variety preferences to precondition variety adoption (Ghimire, Wen-chi, and Shrestha 2015; Hintze, Renkow, and Sain 2003; Joshi and Bauer, S. 2006; Lunduka, Fisher, and Snapp 2012) apart from demographic, social, economic, and institutional factors (Ghimire, Wen-chi, and Shrestha 2015; Pandey 2012; Gilligan et al. 2020). Trait preferences reflect the reasons to purchase or benefits that users sought. However, many variety adoption studies capture generic trait combinations, and do not offer typologies of users preferring and adopting varieties (Thiele et al. 2020). Yield, pest resistance, palatability, and acceptability (Ghimire, Wen-chi, and Shrestha 2015) as well as marketability and labor requirement (seldom) (Joshi and Bauer, S. 2006) are considered, but without understanding what these mean to farmers' daily lives. Culinary attributes are often represented by taste (Ghimire, Wen-chi, and Shrestha 2015; Waldman, Kerr, and Isaacs 2014). They, however, are diverse—e.g. cooking time and water requirement may be highly relevant for female farmers to save resources and time (Hellin, Keleman, and Bellon, M. 2010). The trait profile is expected to be diverse given the number and diversity of stakeholders (in our case, farmers). Limited and generic varietal features increase the odds of omitting important traits in the product profile, leading to their non-inclusion in breeding priorities.

This paper covers extensive variety attributes and elicit farmers' priorities per segment. We closely look at variety preferences by understanding who, when, and why they are preferred through an intersectional lens.

2.2 Motivation for intrahousehold preferences

Many studies employ household head's sex or responses from one respondent to proxy gender. This approach is problematic as it homogenizes social conditions and preferences in the household. Often, it renders women's preferences invisible (Doss 2014; Quisumbing, A. R. et al. 2014, p.14). In addition, female-headed households are a minority across Asia and Africa. Male-headed households often comprise both spouses, while a husband is usually not present in female-headed households (Doss 2014; Fafchamps and Quisumbing, A. R. 2007). While women's preferences and responses are captured in female-headed homes, they are invisible in male-headed households. Moreover, female headships are more often due to husband's death or divorce *(de jure)* than husband's temporary absence *(de facto).* Comparisons using household head's sex may mislead that preferences vary because of gender when it is best explained by other factors, in such cases, marital status. We use responses from both men and women respondents per household to unpack these intrahousehold preferences.

2.3 Motivation for viewing breeding with an intersectional lens

Although sex-disaggregated analysis contributes to assessing inequalities, it renders other sources of inequalities invisible. Analyses mainly rely on overly simplified dichotomous men/women categories (Addison, Mujawamariya, and Bam 2019; Ghimire, Wen-chi, and Shrestha 2015; Manzanilla et al. 2011; Mehar, Yamano, and Panda 2017; Vaiknoras et al. 2019) and do not look closely at other social differences (Thiele et al. 2020) and their intersections for explaining how preferences come about. Dichotomous analysis often presents contradicting results.

Some studies stipulate different preferences between men and women (Christinck et al. June 2017; Goldman 2020; Manzanilla et al. 2011), while others postulate similarities but differ in ranking (Christinck et al. June 2017; Tufan, H. A., Grando, and Meola 2018, p. 38ff). This renders difficulties in setting breeding priorities. Dichotomy boxes social realities into a binary gendered model, where reality is complex and understanding the underlying mechanisms is necessary (Colfer, Sijapati Basnett, and Ihalainen 2018; Ravera et al. 2016). Intersectionality goes beyond dichotomy and unpacks these complexities giving us the chance to explain when preferences are the same and when they are different. A feminist intersectional analysis approach presents how intersecting identities create compounding effects of exclusion or inclusion of some individuals and groups (Crenshaw 1989; UN Women 2020). The term was first introduced by Kimberle Crenshaw (1989) to explain that two different issues, racism, and sexism, are not independent but rather intersect and generate double marginalization for black women. Hankivsky (2014, p.2) and Jost, Ferdous, and Spicer (2014, p.57) regard intersecting identities as social locations or positions where an individual or group stands in comparison to others within a context of biased norms and attitudes. Put simply, social position is never a result of a single marginalization, but of the intersection of multiple dimensions of marginalization.

For this paper, intersectionality is how identities intersect and create double or multiple levels of marginalization. Three principles of intersectionality are covered: (i) intersecting categories, (ii) social justice and equity, and (iii) power adapted from Hankivsky (2014). Rather than main social categories, we focus on multiplicative or interaction effects which are considered prerequisites of intersectionality in quantitative analysis (Bowleg 2008; Brambor, Clark, and Golder 2006; Dubrow 2008). Hankivsky

(2014) views social justice and equity as a justifiable distribution of resources and relationships to equalize outcomes between marginalized and advantaged groups. We measured it using forms of gender inequalities adapted from World Bank Group (2009, p. 4ff), like assets, markets, information, risks, and institutions. Hankivsky (2014) and Colfer, Sijapati Basnett, and Ihalainen (2018) refer to power as the capacity to influence, direct, or simply have a say over events or behavior of others. We proxied power using decision-making indices for the domains of crop choice, crop management, marketing, food choice, and expenditures and investments.

We link intersectionality to rational choice theory and expected utility theory (Mongin 1998). Rational choice theory indicates that a farmer will prefer a specific trait and choose a variety giving them the highest utility. If a farmer ranks the traits as good taste > high yield > short duration, the former gives the highest expected utility among other traits. Maximizing farmers' utility depends strongly on the degree that varietal traits meet their contextual difficulties. Consequently, farmers' marginalization and utility are created based on the intersection of various identity factors like gender, age, caste, class, marital status, inter alia, and not only on a single factor.

For instance, culinary, grain quality, and time-saving traits increase women's utility as women are highly involved in food preparation, hence regarding rice for home consumption or family's food security (Beuchelt and Badstue 2013; Gilligan et al. 2020; Mehar, Yamano, and Panda 2017; Teeken et al. 2018). Women are responsible for most domestic tasks and face mobility constraints (e.g. restricted market access and participation in public spheres) (Tavenner and Crane 2019). Female preferences stem from the values and roles based on norms positioning women in the household. Conversely, men strongly prefer more agronomic and market traits as they regard rice as a commercial crop. Norms expect men as the household head and breadwinners in the family (Addison, Mujawamariya, and Bam 2019) and keep them from domestic roles.

2.4 Hypotheses

We are interested in gender interactions with intersectionality factors, gender roles, and power. Gender considerably has the most "profound consequences for a wide array of attitudes and behaviors" (DUBROW, 2008: p. 87). Thus, our intersectional analysis begins on gender first then further interacts gender with economic and institutional factors (Colfer, Sijapati Basnett, and Ihalainen 2018; McCall 2005; Ravera et al. 2016).

We hypothesize that differences and similarities in variety preferences occur depending on farmers' experiences of marginalization, which intersecting social categories influence. The interacting social categories create enabling or disabling effects on the opportunities and constraints, inclusion and exclusion for women and men. Considering gender-class interaction, for example, being richer may create an enabling effect on women reducing their marginalization while being poor may create a disabling effect where marginalization is increased. Women from high-income households typically have higher income and asset endowments which put women in similar positions and experiences as men. Consequently, richer women may hold similar variety demands as men. Men of lower economic status may consider farming for home consumption as women do due to lower marketable surplus and hence may seek similar varietal traits.

We further hypothesize that involvement in productive tasks and decisions drives preferences for productive and market traits whereas involvement in reproductive roles and food choice decisions for grain quality and culinary traits. Similar marginalization, roles, and agency would result in similar preference patterns and the other way.

Intersectionality has been established a while ago yet its application remains rare in empirical studies in agriculture, even in interventions and action plans (Tavenner and Crane 2019). In our review of the literature, it is rarely applied in preference studies. Studies adopting the concept are mostly qualitative (Teeken et al. 2018; Tufan, H. A., Grando, and Meola 2018; Schöley and Padmanabhan 2017). Quantitative applications face methodological challenges (Bauer, G. R. and Scheim 2019; Bowleg 2008; Dubrow 2008). To the best of our knowledge, this is among the first studies analyzing preferences with an intersectional lens quantitatively, particularly in a breeding and variety adoption context. We contribute to how quantitative analysis of variety preferences can embrace intersectionality.

3. Empirical Approach

3.1 Sampling and survey design

We use cross-sectional data of Bangladesh from the Stress-tolerant Rice for Africa and South Asia (STRASA) project of the International Rice Research Institute (IRRI) collected in 2018. It covers seven of Bangladesh's eight divisions (see Table 1) with 23 purposively selected districts. From its combined villages, 150 villages and 10 households per village were randomly chosen. In total, 1500 households were interviewed.

The survey questionnaire in English was designed and implemented using computer-assisted personal interview (CAPI) software SurveyBe. Before implementation, the IRRI Gender team trained the enumerators and pilot-tested the CAPI tool to ensure data quality and completeness. Relevant questions are household demographics, land ownership, rice farming and utilization, shock experiences, variety preferences and adoption, asset ownership and access, market access, food insecurity experience scale, information access, social capital (training and group membership), household income, decision-making, and time-use. The interview involved the household's main male and female member, preferably husband or wife, or if absent, their counterpart of similar age and involved in farming. Sections on variety preferences, time use, and decision-making were asked to men and women within the same household. Respondents were interviewed separately to avoid response biases. Both gender interviews capture plausible individuality and gender relations, and recognize that farming is usually a family affair involving men and women, especially in Asia and Africa (Smale et al. 2018). This collective model recognizes that men and women may have distinctive marginalization, utility functions, and choices even within the same household.

We measure variety preferences using preferential direct ranking. Per variety, farmers reported their three most preferred or priority traits which are coded 1. Unmentioned traits are coded 0. Varietal traits in the survey are extensive including agronomic, grain quality, stress tolerance, culinary, market, and cost-saving traits (Table A.2).

Representing intersecting categories principle of intersectionality, we focus on gender, age, class, and marital status as they are the commonly available factors contributing the most to differential experiences and social exclusion (Dubrow 2008; Jost, Ferdous, and Spicer 2014, p. 57).

Table 1. Data distribution within divisions.

Divisions	Rangpur	Rajshahi	Dhaka	Chittagong	Sylhet	Khulna	Barisal	Total
No. of districts	3	5	2	1	4	3	5	23
No. of villages	22	22	14	12	16	22	42	150
No. of HHs	220	220	140	120	160	220	420	1500
No. of women	220	220	138	120	160	218	420	1496
No. of men	218	218	138	120	157	217	419	1487

Remark: Both men and women per household were interviewed for variety preferences, time use, and decision-making survey sections. Four households from Dhaka and Khulna did not cultivate for unknown reasons leaving farming and variety preferences sections (the core of this research) blanks, and hence are dropped in the analysis, making n=1496. Source: Own summary using IRRI's STRASA dataset.

Representing social justice and equity, we cover the following inequality components: (i) Time use: men and women's ability to direct to different roles and opportunities. (ii) Access: the possibility of men and women accessing productive assets, including land and livestock, markets, and extension or advisory services. (iii) Risks: the exposure to different risks like climate shocks and food insecurity. Time use proxies gender roles and refers to the hours spent on productive and reproductive tasks in the previous day. Productive tasks include paid work activities including farming and purchase of household and farm supplies. Reproductive tasks involve care and domestic activities. The hours spent per task are computed and summed for all productive and reproductive tasks.

For power relations, we utilize intra-household decision-making that ranges 1-5: 1 if only the husband or male member decides, 2 if both decide and the husband/male > wife/female, 3 if both decide equally, 4 if both decide and the wife/female >husband/male, and 5 if only the wife or female decides. We take the mean score to present the degree of women's participation (i.e. solely or jointly) in cluster analysis. For regression analysis, we obtain household decision-making index (HDI) to present only women's involvement in intrahousehold decision-making for easier interpretation. Following Lombardini, Bowman, and and Garwood (May 2017), a score of 1 is given to each decision where women participate, fully or partially. The total points are summed per domain and divided by the number of answered questions in the respective domain. The HDI goes 0-1 where closer to 1 indicates women's higher agency in intrahousehold decision-making. We utilize crop management and marketing decisions for productive-related decisions while food choice decisions for reproductive decisions.

3.2 Design of the quantitative analysis

We employ a sequential multivariate analysis and a logit regression to investigate farmers' trait priority-setting as explained by intersecting social categories and their associated marginalization in terms of time use, access to assets, markets, and information, and risk exposure.

3.2.1 Principal component and cluster analysis

We seek to harness the segmentation of farmers brought about by sources of marginalization helping explain similarities or differences in their variety preferences. Following Bidogeza et al. (2009), Gebrekidan, Heckelei, and Rasch (2020), and Goswami, Chatterjee, and Prasad (2014), we segment the farmers using Principal Component Analysis (PCA) and cluster analysis, using social categories, inequality/marginalization components, and power variables, capturing intersectionality principles. Based on Kaiser's or latent root criterion, only principal components (PCs) with eigenvalues greater than 1 are retained (Bidogeza et al. 2009) for clustering. The retained factors contain only the signals giving 'stable and more precise clusters' (Gebrekidan, Heckelei, and Rasch 2020; Husson, Josse, and Pages 2010).

The sample is clustered according to similar PCs. First, the retained factors are used in agglomerative hierarchical clustering using Ward's minimum variance method (Everitt et al. 2011). Ward's values serve as starting values for k-means clustering, while the optimal number of clusters is derived from dendrogram's solution (Figure A.1). Generally, it is best to cut clusters when two stages of merging are too big, suggesting that the merged clusters are not too much alike.

Per cluster, the ranking patterns of variety preferences are examined using rank-based quotient (RBQ) scores to quantify data gathered through preferential ranking (Sabarathnam 1988). The aim is to find which segment prefers what varietal traits. RBQ trait scores are calculated as follows:

$$RBQ = \sum_{j=1}^{n} \frac{f_i(n+1-i)*100}{N*n} \quad [1]$$

Where N= total number of farmers, n= total number of ranks (3), i= rank for which RBQ is calculated (1^{st}, 2^{nd}, or 3^{rd}), and f= number of farmers reporting the rank i. Larger RBQ score represents more important varietal traits for farmers.

3.2.2 Logistic model regression

A logit model is performed to analyze how social categories, gendered time use, and agency associate with trait priority-setting and how effects vary by gender. The aim is to see whether the intersectional model specification fits better compared to the usual "just" gender division and find data evidence supporting when the preferences deviate between and within gender.

The model is specified as: $$Y_i^m = \beta_k X_{ik} + \varepsilon_{ik} \quad , \quad [2]$$

where Y_i^m represents the unobserved latent variable of variety attributes m preferred by i^{th} farmer, i=1,…,n, and is given by binary response 0 for non-prioritized attribute m, 1 for prioritized traits or those among top 3 traits. Logit estimation is performed only for the top 10 variety attributes, based on RBQ scores, out of extensive list of traits expressed by men and women (Table A.2). In this case, m=13 including (agronomic) high yield, short duration, more tillers, taller plant height, (culinary) good taste, compatible for rice products, white color of rice, (market) high market price, easy selling, (stress-tolerance) abiotic (e.g. flood tolerant), biotic stress tolerant (e.g. disease resistant), and (grain quality) grain size and shape (e.g. slender grain), high milling recovery. X_{ik} is a vector of k number of exogenous variables influencing variety preferences. It includes: gender, class, marital status, and age; time use and decision-making; rice acreage, irrigated area, and TLU; output market distance and harvest consumption share; and climate shock and food insecurity experience (see Table A.3 for variable description and descriptive statistics). β_k is the vector X_{ik} coefficient to be estimated. ε_{ik} is the model error term. From the logit coefficients, the log odds ratios are computed.

Three model specifications were tested: (1) without institutional factors—gender roles and household power or agency, (2) with institutional factors, and (3) with gender interactions with age, class, marital status, gender roles, and agency. A likelihood ratio test is performed between models to test whether the additional parameters are jointly different from zero. Rejecting this null hypothesis will suggest that gender roles and agency affect variety preferences and influence may vary within men and women.

The standard errors are clustered by village to get robust estimates as unobservables can be correlated within villages. Soil and land types, biodiversity, inter alia uncontrolled factors due to data unavailability, can be more prominent in some villages causing some preferred traits concentrated.

From a sampling standpoint, clustered standard errors are warranted because of random sample selection first by village followed by households (McKenzie 2017). Thus, there are many other villages not included in the sample. Negligence of the within-cluster error correlation causes biased estimates, i.e. "misleadingly small standard errors" and hence, "narrow confidence intervals, large t-statistics, and low p-values" (Cameron and Miller 2015, p. 2).

4. Results and Discussion

4.1 General patterns of gender-specific variety preferences

Figure 1 shows the share of men and women considering the top 10 variety attributes ranked based on RBQ scores (Table A.2). Farmers mostly seek varieties having high yield, good taste, high market price, easy-selling, and slender grain. Farmers seldom mention cost-saving traits except for women prioritizing more fodder to feed the livestock.

The conventional gender division shows that significantly more women prefer culinary traits than men. This includes good taste (10% more women), whiteness of cooked rice (7%), and compatibility with rice products (20%). Slightly more women look for high milling recovery. These are mainly associated with women's frequent involvement in food preparations and post-harvest activities especially milling. In our sample, women on average spend 6 hours doing domestic tasks while men spend less than an hour in a day. Results support the findings of Beuchelt and Badstue (2013); Mehar, Yamano, and Panda (2017); and Teeken et al. (2018) that women regard rice for home consumption due to their food preparations roles. Women are more involved in post-harvest roles. More than 400 sampled women were engaged in post-harvest tasks like drying, milling, processing, inter alia compared to only 90 men. Processing and selling rice products could be a way for women to generate income despite mobility constraints supporting Tavenner and Crane (2019).

On the other hand, more men look for varieties maximizing farm productivity and income including agronomic, market, and stress tolerance traits. About 4-6% more men seek high yielding, early-maturing, high tillering, and taller varieties. About 2-4% more men search for biotic and abiotic stress tolerance traits. While 7-11% more men seek varieties of higher demand and price. This suggests that men consider production for commercial uses and hence aim for a high marketable surplus. Many studies including Mehar, Yamano, and Panda (2017); and Teeken et al. (2018) indicate that this is due to men's easier market access and enactment of roles as household's breadwinner.

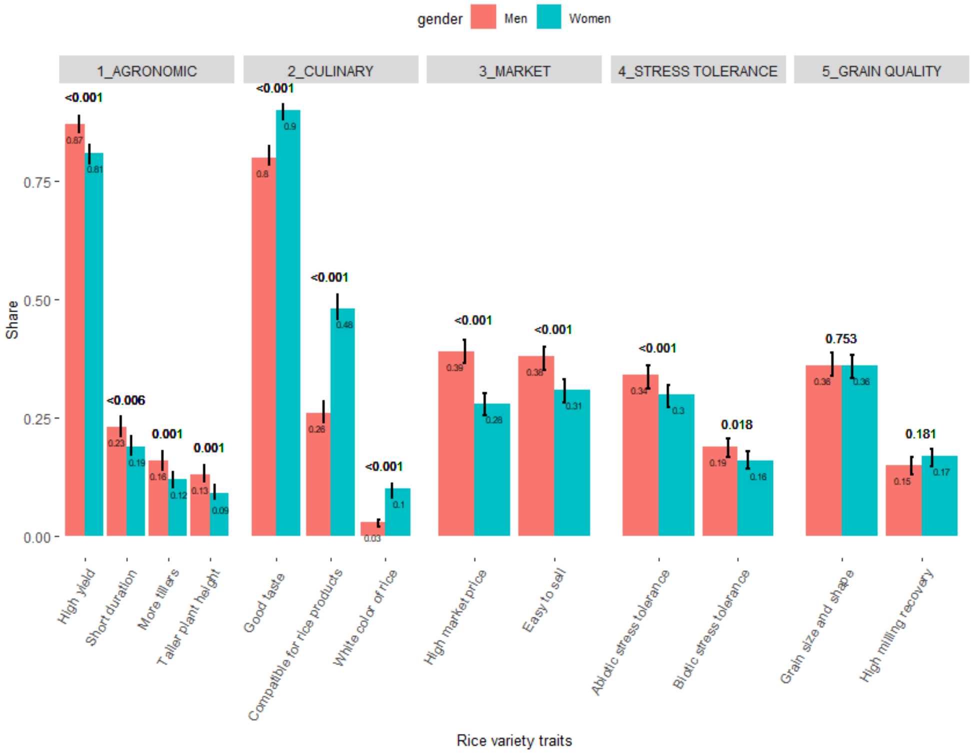

Figure 1. Share of men and women farmers considering the variety traits as one of the top three priorities.

Source: Own illustration.

But, this kind of analysis is silent about whose preferences among men and women should be prioritized and to whom should a variety be delivered. Considering only the main categories conceals plausible changes in preferences given farmers' contrasting characteristics and marginalization. Thus, we present below the variety preferences per intersectional segment capturing how trait priority-setting changes within men and women as can be explained by marginalization they are exposed to.

4.2 Farmer clusters and patterns of variety preferences under different marginalizations

It is worth emphasizing from PCA's results that gendered roles and access (PC1) and decision-making (PC2) components explain most of the variance within the data (see Table 1). This suggests that these variables are likely influencing variety adoption and trait preference outcomes, yet they are sometimes ignored.

Table 2 presents the five distinct intersectional groups. Clusters are named upon intersecting social categories as they define marginalizations a farmer is exposed to, which associate with their variety preferences. Clusters are unique based on cluster-to-cluster comparisons using Tukey-Kramer post-hoc test. Cluster 1 accounts for 31.4% of farmers and comprises oldest men having low education, and from low-income households. We classify them as "poor married old men farmers". Cluster 2 (18.1%) refers to "non-poor married less old men". Cluster 3 is the smallest cluster comprising 2.3% of farmers and is dissociated from others as the majority, 61%, are unmarried. They are mainly widows and more than half, 55%, are poor. We refer to them as "mostly poor widows." Cluster 4 (17.1%) consists of "non-poor married younger women" and cluster 5 (31.1%) of "poor married younger women".

Figure 2 presents the top variety preferences of intersectional groups. All farmer clusters seek high yield as their top priority followed by good taste. Ranking differ with other top varietal qualities. Our results reveal patterns that contradict the conventional narratives about gender-specific preferences. We find that men and women have similar preferences when faced with similar marginalization and opportunities. This is more apparent in low-income households. The diversity of farmers' marginalization can explain the underlying causes associated with preference patterns. Marginalization is activated or deactivated by the interplay of intersectionality factors. Shifting gender roles and agency may shift traditionally gender-associated traits. To show this, we present the preferences of each cluster, then show the logit results.

4.2.1 Gender-class intersection reveals more similar trait preferences of men and women in poorer households while individuality in high-income households

In line with our hypothesis, farmers of similar economic class face similar marginalized situations and consequently have similar preferences. Men and women from poorer families prioritize short duration or early-maturing, taller, slender grain, flood-tolerant, and easy-selling varieties. They show the lowest preference for market price and milling recovery. In contrast, high income men and women rank market trait, milling recovery, and disease-resistance traits highest relative to other clusters.

Poor growing conditions (e.g. land, irrigation constraints) and market remoteness may explain why poorer farmers prefer short duration and more tillers alongside high yield. Low-income farmers are often smallholders (<0.5 ha) cultivating less than half of high-income farmers' rice area (0.88 ha) (Table 2). Consequently, they produce low marketable surplus. Moreover, they have poor institutional and technical farm characteristics. Braun and Gatzweiler (2014) emphasize economic seclusion as a primary reason preventing access to productive resources and opportunities resulting in low production quantities. Men and women in poorer households prefer early-maturing varieties to maximize land and labor use by increasing cropping times of rice or growing other crops to increase cropping intensity. They prefer high tillering varieties to ensure a higher grain yield given their smallest production and low surplus.

Low-income farmers view farming as for household's subsistence and food security because their production is mostly just sufficient for home consumption. A major share, 70%, of their harvest goes to home consumption while only 10% is sold. Food insecurity is more evident in low-income farmers where 14% more are food insecure than high-income farmers. This may explain their preference for high tillering and early-maturing varieties alongside high yield. Bellon, M. R. et al. (October 2003) and McElhinny et al. (2007) recorded that early-maturing varieties are frequently preferred by women due to their food provision roles. Upon interaction, results suggest it is not solely or frequently women who prefer earliness in a variety. Men and women value the crop the same way if both have similar class and marginalization.

Subsistence farming, low marketable surplus, and market remoteness can explain why farmers expressed fewer market traits. Contrary to many studies citing market traits being more attached to men, we find that market price is less prioritized by some men from low-income households and increasingly sought by high-income women. Low-income farmers rank milling recovery, an attribute important in deriving milled rice for selling, lowest probably due to low marketable surplus and sales. Low-income farmers market less given low degree of commercialization and even if they do, they cannot bargain about the price. Moreover, poorer farmers are generally situated farther from output and input markets. This is in line with the findings of (Alene et al. 2008; Fischer and Qaim 2012; Ouma et al. 2010) confirming that market remoteness drives down marketing decisions. Thus, remoteness coupled with a low marketable surplus may resort to selling just to make ends meet for the household.

Table 2. Characteristics of the farmer clusters based on intersecting social categories and marginalization in Bangladesh.

Variables (Bangladesh)	C1 (Poor married old men)	C2 (Non-poor married less old men)	C3 (Poor widows)	C4 (Non-poor married younger women)	C5 (Poor married younger women)
Intersectional factors					
Gender (1-female)	0.01[a-d]	0.03[a,e,f,g]	0.57[b,e,h,i]	0.99[c,f,h]	1.00[d,g,i]
Age (in years)	47.52[a-d]	44.75[a,e,f,g]	36.31[b,e]	38.33[c,f]	38.62[d,g]
Class (1-poor)	0.73[a,b,c]	0.33[a,d,e]	0.55[b,d,f,g]	0.33[c,f,h]	0.74[e,g,h]
Education (in years)	4.56[a,b]	6.71[a,c,d,e]	4.21[c,f]	5.84[b,d,f,g]	4.68[e,g]
Marital status (1-married)	0.99[a,b]	0.96[a,c,d]	0.39[b,c,e,f]	0.98[d,e]	0.97[f]
Primary occupation	1.23[a-d]	1.16[a,e,f,g]	1.99[b,e,h,i]	2.95[c,f,h]	2.93[d,g,i]
Household assets and access					
Rice acreage (in ha)	0.43[a,b,c]	0.87[a,d,e]	0.25[b,d,f,g]	0.89[c,f,h]	0.43[e,g,h]
Total livestock unit (TLU)	1.88[a,b,c]	2.71[a,d,e]	1.00[b,d,f,g]	2.69[c,f,h]	1.88[e,g,h]
Irrigation (in ha)	0.21[a,b]	0.70[a,c,d]	0.19[c,e]	0.71[b,e,f]	0.21[d,f]
Market access					
Formal seed sources	0.46[a,b]	0.74[a,c,d]	0.37[c,e]	0.73[b,e,f]	0.46[d,f]
Output market distance (km)	2.07[a,b]	1.63[a,c]	1.86	1.58[b,d]	2.06[c,d]
Input market distance (km)	2.22[a,b]	1.63[a,c]	1.80	1.57[b,d]	2.21[c,d]
Harvest consumption share (%)	75.24[a,b]	26.30[a,c,d]	68.00[c,e]	26.03[b,e,f]	75.47[d,f]
Harvest sold share (%)	10.36[a,b]	60.81[a,c,d]	16.72[c,e]	61.15[b,e,f]	9.87[d,f]
Total rice production (kg)	1342.07 [a,b]	6030.15[a,c]	904.94	3906.99[b,d]	1335.02[c,d]
Information access					
Seed information recipient (1-yes)	0.77[a,b,c,d]	0.94[a,e,f,g]	0.60[b,e,h,i]	0.05[c,f,h,j]	0.12[d,g,i,j]
Training attendance (1-yes)	0.11[a,b,c]	0.42[a,d,e,f]	0.07[d]	0.01[b,e]	0.01[c,f]
Social group membership (1-yes)	0.25[a,b]	0.40[a,c,d,e]	0.16[c]	0.16[b,d,f]	0.23[e,f]
Risks					
Climate shock experience (1-yes)	0.68[a,b]	0.41[a,c,d]	0.64[c,e]	0.38[b,e,f]	0.68[d,f]
Food insecurity experience (1-yes)	0.38[a,b,c]	0.26[a,d,e]	0.75[b,d,f,g]	0.22[c,f,h]	0.38[e,g,h]
Institutions					
Time use productive tasks (hours)	8.09[a,b,c]	7.81[d,e,f]	5.21[a,d,g,h]	1.94[b,e,g]	2.11[c,f,h]
Time use reprod tasks (hours)	0.45[a,b,c]	0.65[d,e,f]	3.12[a,d,g,h]	7.37[b,e,g]	7.31[c,f,h]
Land ownership (1-own)	0.66[a-d]	0.57[a,e,f,g]	0.15[b,e,h,i]	0.02[c,f,h]	0.02[d,g,i]
Crop choice decision (1-5)	1.67[a,b,c]	1.42[a,d,e]	4.46[b,d,f,g]	1.39[c,f,h]	1.67[e,g,h]
Crop management decision (1-5)	1.34[a,b,c]	1.26[a,d,e]	4.25[b,d,f,g]	1.24[c,f,h]	1.34[e,g,h]
Food choice decision (1-5)	2.52[a,b]	2.62[c]	4.49[a,c,d,e]	2.65[b,d]	2.54[e]
Marketing decision (1-5)	1.37[a,b,c]	1.29[a,d]	4.35[b,d,e,f]	1.26[c,e,g]	1.36[f,g]
Exp. and invest. Decision (1-5)	2.03[a]	1.94[b]	4.50[a,b,c,d]	1.93[c]	2.03[d]
Land type and adoption					
STRV adoption rate (%)	0.19[a,b]	0.36[a,c,d]	0.13[c,e]	0.37[b,e,f]	0.18[d,f]
Average STRV cultivated area(in ha)	0.05[a,b]	0.19[a,c,d]	0.05[c,e]	0.18[b,e,f]	0.05[d,f]
n	937	540	67	510	929
Cluster size (%)	31.41	18.10	2.25	17.10	31.14

Remarks: [a,b,c,] letters are Tukey-Kramer post-hoc test results indicating cluster-to-cluster statistical difference.

Variable description and summary statistics (mean and sd) are in Table A.3.

Source: Own estimation using IRRI's STRASA dataset.

Men and women in high-income households are often attached to productivity- including agronomic and stress-tolerance, and market-oriented traits. Conventional gender disaggregation shows, market and disease tolerance are generally preferred by men. The intersectional results suggest that women of higher income similarly prefer those traits as men, especially disease tolerance traits, presumably because of their less to non-marginalized situations. Richer households have larger landholdings and irrigated area, hence produce more marketable surplus. They might be producing for commercial purposes and prioritize traits augmenting market surplus. Moreover, more high-income women prefer high milling recovery than men and low-income women as they are selling more to millers and for millers, milling recovery is a critical trait. More high-income women prefer biotic stress tolerance presumably because of their households' larger landholdings making pest and disease management more time-consuming and costly. Teeken et al. (2018) find that women seek these traits to save time on crop management to which they are often assigned.

Gatzweiler and Braun (2016) recognize that smallholders are more vulnerable to shocks because of lower income and fewer assets (e.g. land and livestock in our case) lowering their ability to bounce back after shocks. Exposure and vulnerability to climate shocks may rationalize preference towards abiotic stress-tolerant and taller varieties, which help farmers cope with deepwater situations (Kuroha et al. 2018). Nearly 30% more low-income households than high-income experienced climate shocks. Richer households have less exposure, because one-third of them are in districts less exposed to climate stresses. Even when they experience shocks, they have higher adaptive capacity given better resource endowments. Consequently, poorer farmers are more likely seeking both flood-tolerant and taller varieties relative to others. Although not among top 10 preferences, it is noteworthy that high-income farmers are more likely seeking varieties producing more fodder as they own more livestock relative to other clusters.

Further, we observe that while preferences of men and women within low-income households are more similar, those from high-income households diverge. High tillering potential and market price are placed among men's priority traits but not for women. Milling recovery, good taste, and compatibility with rice products are among women's priority traits but not for men. High-income women uniquely prefer whiteness of rice. This suggests that men and women from better-off households have more diverging preferences.

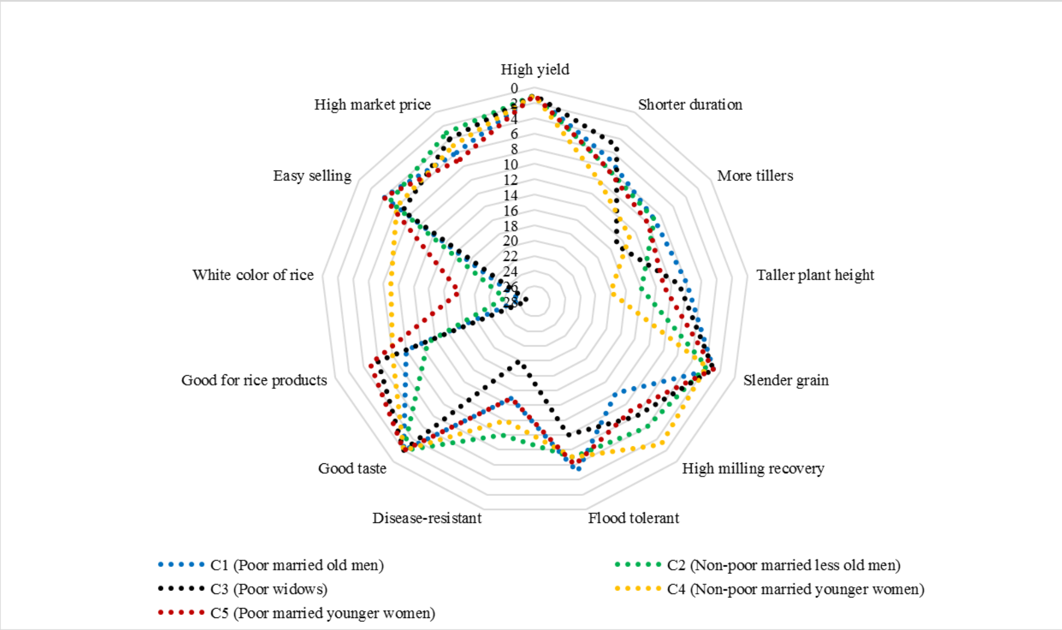

Figure 2. Variety preferences of the farmer clusters.

Remark: The further the line is outside, the more farmers prefer the trait on the respective axis. The ranking is based on RBQ scores. Full ranking is in Table A.4. Source: Own illustration and estimation using IRRI's STRASA dataset.

4.2.2 Gender-marital status reveals compounding marginalization of women and their changing preferences

Similar marginalization of widows and poor farmers can explain the similarities in their varietal trait demands. Widows rank short duration highest to more optimally use available land and family labor and ensure sufficient production amidst poor growing conditions, as observed in low-income men and women (Table 2). Widows have the smallest rice acreage and irrigated area amongst poor farmers despite being better-off in terms of income, wherein the cluster has on average 19% less poor people. Ravera et al. (2016) and Teeken et al. (2018) indicate that early-maturing varieties are favored as a response to labor shortages, which is a primary challenge for widows.

Widows take over some productive roles previously assigned to men, their husbands especially. They have similar productive hours to that of men and substantially higher than those of other women. However, widows are challenged accessing labor, both on- and off-farm, for they have statistically significantly the least household members. 54% of farmers in the widow cluster are from households with 1-3 members while it is only about 15% and 19-21% in low- and high-income segments, respectively (Figure 3). Yotopoulos and Lau (1973) and Binswanger and Rosenzweig (1986) indicate household members as crucial for farm labor and small farms' efficiency. Traits responding to labor shortages, such as short duration, may provide widows a higher utility by saving time and balancing productive and reproductive workloads.

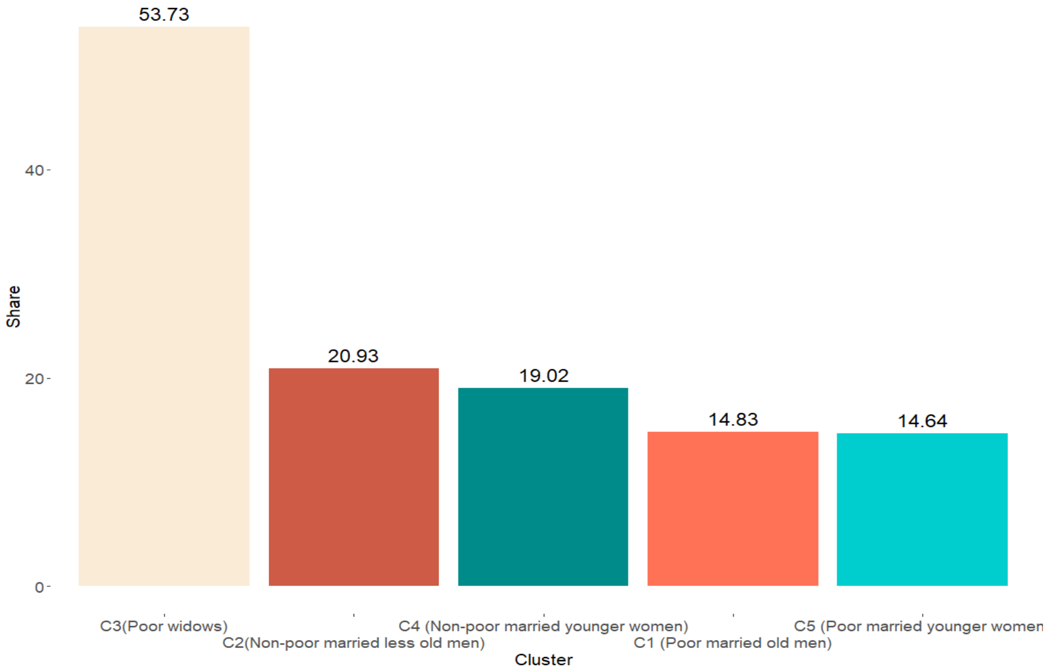

Figure 3. Share of farmers with only 1-3 members in a household, by farmer clusters.

Source: Own illustration and estimation using IRRI's STRASA dataset.

Associated with worst growing conditions and labor constraints, widows have the smallest production. They are the most food insecure. Widows prefer short duration possibly to ensure family's consumption, as poorer farmers. They are next to poorer women to rank compatibility for rice products the highest as they may engage in processing rice products for household consumption and additional remuneration. Widows uniquely prefer non-glutinous rice and are the least to prefer more fodder due to limited to no possession of livestock.

Thus, women's marginalization is not solely defined by gender and class but also by interaction with marital status. Our results suggest that women's marginalization is compounded for being widowed, preventing them from hiring farm laborers (often comprising men) and expanding production.

This supports findings of Braun and Gatzweiler (2014) that being widowed challenges access to productive resources and opportunities due to their seclusion. Kumar, M. and Bharadwaj (2016) indicate that widows are restricted from engaging, managing, and communicating with off-farm laborers. While men can effortlessly claim women's labor, women, especially widows whose households often lack men, have no similar claim over men's labor supporting Doss and Morris (2001).

4.2.3 Men's and women's preferences change with shifting gender roles and agency

There is a consensus that women, no matter the class, pay close attention to cooking attributes, particularly compatibility for rice products, wherein widows exhibit the highest rank. Many studies (Beuchelt and Badstue 2013; Mehar, Yamano, and Panda 2017; Teeken et al. 2018) attribute this to food preparation responsibilities which are often regarded as women's expertise. In our sample, women dominate the reproductive roles spending as much as 10 times of men's reproductive hours while concurrently doing some productive roles, primarily post-harvest activities (Table 2). Time use results support the findings of Levien (2017) and Ravera et al. (2016) that women face a greater workload than men balancing productive and reproductive roles. Time-saving attributes including short duration provide widows a greater utility given their household labor shortages. This supports Hellin, Keleman, and Bellon, M. (2010) and Teeken et al. (2018) indicating that women dislike varieties that aggravate their workload. Moreover, women regardless of household income status are more attached to grain quality (seed size and shape) and compatibility for rice products to respond to their processing post-harvest roles. Poor and widowed farmers may seek taller varieties for multiple functions including more rice straw for livestock and cooking fuel source helping them save time from fodder and fuelwood collection being often women's domains.

Men in poorer households exhibit women-associated preferences possibly because of shifting roles and responsibilities. Contrary to frequent results that seed size and shape and cooking features are for women, findings suggest that poorer men rank these traits higher. As trade-offs, they move away from some agronomic (e.g. disease tolerance) and market traits. This indicates their low market engagement, presumably due to low marketable surplus and production predominantly used for home consumption. Similarly, women show preferences towards men-associated agronomic and market traits upon changes in roles and agency. Men generally prefer traits augmenting surplus probably due to easier market access and marketing roles. Yet we find that widows favor market price, short duration, and milling recovery. This is probably attributed to women's takeover of some men-dominated tasks and decisions during the absence of men. Widows have remarkably higher productive hours and agency than that of other women and closer to that of men. Levien (2017) stipulate, women contest mobility restrictions, e.g. *purdah*, to contribute to household income.

4.3. Intersectional model results

Logistic regression results show how social dimensions affect men and women's trait priority-setting, and support results of farmers' segmentation. The significant likelihood ratio (LR) test suggests that inclusion of gender roles and agency, which are commonly ignored in preference and adoption models, improves model fit and better explains the variation within the data for all varietal traits. This supports PCA's results where gender roles and decision-making components capture the most variation in the original dataset (see Table A.1). We next include gender interactions with other social categories and institutional factors. They appear jointly different from zero but only for rice tillering, high milling recovery, good taste, and high market price. For that reason, we capture gender intersections using a subsample of men and women. Results suggest that social positions, gender roles, and agency affect variety preferences and this varies across groups of men and women (Figure 4).

Being low-income significantly increases men's and women's preference for easy-selling varieties by 1.4 times. Supporting results from cluster analysis, poorer farmers may sell their produce only to meet cash needs given their small production and low market engagement. Moreover, there is 2 times statistically significant increase in the odds that poorer men prefer some culinary traits, particularly good taste and whiteness of rice. While there is 0.8 times decrease for poorer men to seek high market price. In contrast, poorer women are 1.5 times more likely seeking some agronomic traits particularly taller plant height and 0.9 times less likely preferring grain quality traits than richer women. This confirms our earlier observation that men and women from poorer households shift in some of their traditionally-associated variety preferences due to economic seclusion.

Reproductive roles pose sizeable changes in men's variety preferences. Men spending 10 hours on reproductive tasks are nearly 3 times more likely to prefer good taste and cooking features than men spending only about 2 hours per day. They are 5 times and 4 times more likely to prefer biotic stress tolerance and more tillers, respectively, to save time from crop management practices, and for more rice straw for fuel and/or livestock fodder which are often regarded women's roles. Men's preference for market price, taller plant height, and grain quality significantly declines. Shifting roles to women-dominated domains lead men to often women-associated traits and lower preference for some men-associated traits like market traits. Moreover, men's increasing productive hours significantly lowers preference for grain size and shape and increases easy-selling.

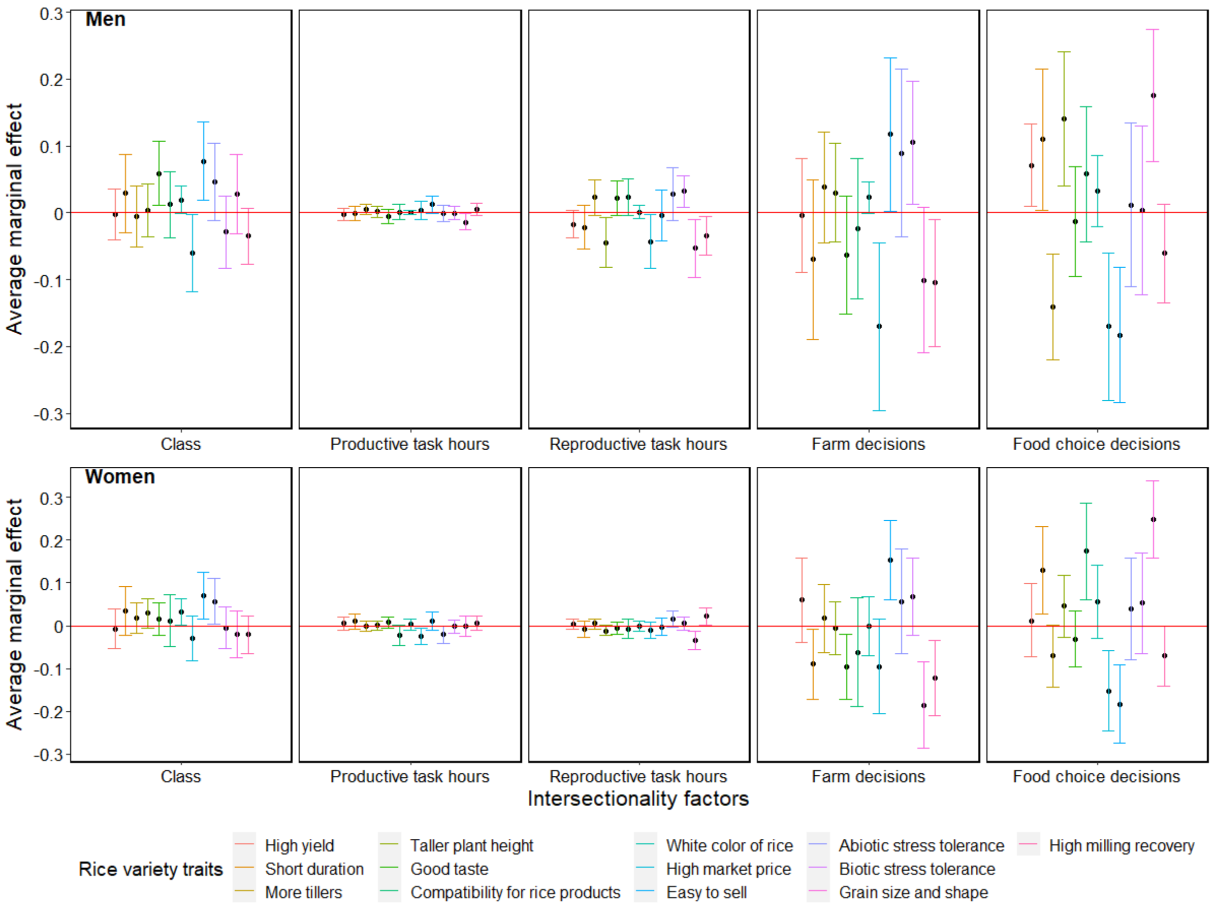

Figure 4. Average marginal effects of class and institutional factors on men's and women's variety preferences at 95% CI. Source: Own estimation using IRRI's STRASA dataset.

Increasing women's agency in intrahousehold decisions significantly lowers men's preference for market price by 0.5 times. Men whose wives or women in their household have the primary say in food choice decisions are about 4 times more likely to seek taller varieties and twice more likely to prefer grain size and shape and short duration, than men in households where decisions are men-dominated. While the odds that they seek high tillering, easy-selling, and high market price significantly decline. Higher women's agency in farm decisions augments men's preference for whiteness of rice, biotic stress tolerance, and easy-selling by 2 times. While men's preference towards high market price, high milling recovery, and grain size and shape significantly declines. This suggests that decisions on preferred varieties are not solely determined by a single individual in the household. Rather, it is a family affair often between husband and wife.

Similarly, gender roles and agency significantly change women's preferences. Women spending 10 hours in productive tasks per day are 0.5 times less likely to prioritize compatibility with rice products, compared to those performing 2 hours. Increasing women's reproductive hours, surprisingly, significantly reduce their preference towards grain size and shape and culinary traits though only small declines and insignificant. Rather, preference towards milling recovery increased substantially by about 4 times. As seen from the clusters where milling recovery remains in women's top 10 priority traits, this may be attributed to women's prime involvement in milling and processing and in ensuring higher grain yield for family's food security. We assume that milling and processing for family's consumption might have been reported as a reproductive role under food preparations. This mirrors the preferences of millers, who prefer to buy varieties with higher milling recovery. Women with a greater say in farm decisions, particularly crop management and marketing, are twice more likely to seek easy-selling varieties than women who poorly participate. Women with a higher agency in food choice decisions are three times more likely to prefer grain size and shape, and nearly twice more likely to seek short duration and compatibility for rice products. While women's agency poses the highest reduction in the likelihood to seek market traits.

Marital status and age do not show much significant changes in farmers' variety preferences. But worth noting, being unmarried, mostly widows, increases women's probability to search for grain quality, market price, cooking attributes, short duration, and taller varieties. This suggests widows' priority for both productive- and reproductive-associated traits as seen from cluster analysis. No significant changes are found between married and unmarried men suggesting that being widows is a more relevant issue for women.

5. Conclusions and Policy Implications

Some varieties and technologies remain unadopted not because they are bad in themselves, but rather due to lack of understanding of farmers' needs and systemic constraints leading to user ignorance and mismatched targeting by technology producers, e.g. breeders, and extensionists. Studies on users' preferences are often limited to dichotomous gender-disaggregation usually looking at the household head's sex. There is however no single gender experience but rather intersects with other axes of social differentiation. This paper sheds light on how variety preferences of different farmer segments relate to various levels of marginalization that multiple intersectionality dimensions beyond gender (class, age, marital status, gender roles, and power) influence. Our analysis goes beyond overly simplified men and women categories and recognizes the plausible individuality among men and women within household. This paper offers the following conclusions contributing to demand-led and socially-inclusive breeding.

First, contrary to gender-specific preferences, we find that men and women demand similar preferences when faced with identical marginalization and opportunities. Variety preferences are more similar between men and women in low-income households and diverge in richer households. This brings two important implications: (i) While unitary models (e.g. household-level analysis) can work in poorer households because men and women therein have more similar preferences due to more similar marginalization, it is not true for richer households. Individuality in preferences seems to occur more within richer households. Thus, unitary models should not be assumed, but rather acknowledge the individuality among members' preferences to avoid invisibility of women's priority traits. Methodologies capturing different interests within a household must be devised when both gender interviews are unavailable or impossible to perform given the survey time and resources required; (ii) More similar preferences can imply that men and women from poorer households withdraw from their traditional gender-associated traits. This reveals patterns that contradict the conventional narratives along gendered variety preferences.

Second, future preference and adoption studies, varietal development as well as segmentation and targeting of the seed markets should consider incorporating gender interactions with other intersectionality dimensions. Men and women are not universal, hence cannot be expected to react similarly towards a variety. Variety and technology upscaling to farmers' contexts requires knowing what dimensions are important. From cluster and logit results, class and marital status are social positions next to gender that drive more visible contrasts in farmers' marginalization and trait priority-setting. Age did not present evident variations at least for our sample. Gender roles and power or agency do shape farmers' preferences. Location comes into play as types and intensities of stresses vary across sites and resources may be distributed differently.

If breeders will develop and deliver rice varieties to farmers in Bangladesh in locations we studied, we recommend they integrate high yield, good taste, and slender grain as these seem to be must-have traits for all farmer types. Men and women in poorer households and widow seek similar variety attributes. They should be the focus for targeting early-maturing, taller, flood-tolerant, easy-selling, and suitable for rice products varieties because of their multiple production constraints and more exposure and vulnerability to food insecurity and climate shocks. But widows also show preference towards men-associated features like market price and milling recovery upon takeover of some men's roles. Targeting the needs of poorer farmers can be investment-worthy as they comprise the majority in Bangladesh and that is true in many developing countries. However, widows may not be so attractive for breeding as the segment is small to warrant large breeding investments. But knowing that widows establish similar preferences as poorer farmers, can mean that similar varieties can be delivered and designed for them. Our recommended trait profile for breeding and seed sector, however, may not be universal to all crops nor all locations. Results we present maybe context specific and for rice only. Generally, varieties offseting production constraints, food insecurity, and labor constraints will highly benefit poorer farmers especially women, and more so widows. Variety design and delivery must not assume unitary decisions, especially for high-income households, to avoid invisibility of women's choices.

Third, variety preferences change with shifting gender roles and agency. We find women in poorer households and widows contest mobility restrictions and traditional gender roles and participate in similar roles as men, leading their demands for some agronomic and market traits such as tillering potential and market price. Women's visibility in decision-making may drive changes in men's preferences as well as their own. The decision on varietal uptake is a family affair rather than individual.

For more targeted dissemination, it is recommended to explore who decides the variety or technology adoption in the household and what preferences they have.

Fourth, farmers' trait priority-setting depends on marginalization rather than on gender per se. Human and agro-ecological capacities explain the possible underlying causes associated with variety preferences--e.g. in terms of growing conditions and production, food insecurity and perceived uses of crop, labor constraints, market access, climate shocks, gender roles, and power relations.

Finally, while we offer distinctive demands of farmer segments, not all those can be answered considering the budget and time requirements of varietal development. Breeding and seed sector cannot provide one-size-fits-all solutions. Complementary innovations catering farmers' marginalized situations will promote adoption. Farmers' segmentation herein is a way to view who the marginalized are, how they are marginalized, and what complementary innovations can fit their needs.

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Appendices

Table A.1. Retained principal components after PCA with factor loadings for each variable, eigenvalues, and percent cumulative variance explained after varimax rotation.

Variables (Bangladesh)	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Intersectional factors									
Gender	**0.4474**	0.0226	0.0094	0.0102	0.0064	0.0115	0.0132	0.0251	-0.0036
Age	-0.1257	-0.0050	-0.0485	0.2227	-0.0716	-0.0099	**0.5698**	-0.0101	0.0265
Class	0.0195	-0.0215	-0.2328	-0.1182	0.1668	0.0917	0.0539	0.1937	0.1773
Education	-0.0561	-0.0048	-0.0049	0.0847	-0.0091	0.0079	**-0.7273**	0.0637	0.0277
Marital status	0.0185	-0.1702	0.0238	0.1099	0.0094	0.0015	0.1133	0.0318	**0.4635**
Primary occupation	**0.4125**	-0.0035	-0.0093	-0.0134	-0.0065	0.0031	-0.0416	-0.0067	0.0123
Household assets and access									
Rice acreage	0.0170	0.0274	0.1046	**0.5004**	0.0350	0.0779	0.0490	0.0345	-0.1263
Total livestock unit (TLU)	0.0364	0.0392	-0.0313	**0.4562**	0.0677	-0.0036	0.1169	0.2722	0.2465
Irrigation	0.0107	-0.0525	0.2604	**0.3474**	0.0509	0.0333	0.0135	-0.0329	-0.1852
Market access									
Formal seed sources	0.0196	-0.0337	**0.3341**	-0.2969	0.0034	0.2631	0.0779	0.1514	0.2221
Output market distance	-0.0054	-0.0298	0.0358	0.0134	**0.6415**	-0.0393	-0.0391	-0.0534	-0.0635
Input market distance	-0.0030	0.0290	0.0033	0.0457	**0.6334**	-0.0282	-0.0057	-0.0185	0.0203
Rice harvest consumption share	-0.0037	-0.0253	**-0.5618**	-0.0710	-0.0365	0.0411	-0.0035	0.0158	-0.0134
Rice harvest sold share	-0.0038	-0.0195	**0.5946**	-0.0288	0.0081	-0.0232	-0.0349	-0.0513	0.0359
Total rice production	0.0154	-0.0552	-0.0337	0.0155	0.0284	0.0335	0.0693	0.1011	**-0.6765**
Information access									
Seed information recipient	**-0.3579**	-0.0010	0.0614	-0.0617	0.0460	0.0228	-0.0379	0.0810	-0.0215
Training attendance	-0.1368	-0.0022	0.1335	-0.0589	-0.0368	0.0313	-0.0311	**0.3948**	-0.1409
Social group membership	0.0195	-0.0013	-0.0324	0.0253	-0.0287	-0.0373	-0.0477	**0.8036**	-0.0390
Risks									
Climate shock experience	0.0065	0.0315	-0.0530	-0.1660	**0.3536**	0.1106	0.0694	0.0781	0.0950
Food insecurity experience	0.0272	0.0407	0.1312	**-0.4257**	0.0376	-0.0500	0.2903	0.0985	-0.1844
Institutions (Gender roles and power)									
Time use productive tasks	**-0.3963**	0.0216	0.0005	-0.0215	0.0038	-0.0201	-0.0207	0.0065	0.0576
Time use reproductive tasks	**0.4363**	0.0023	0.0101	0.0006	0.0106	0.0258	-0.0275	0.0435	0.0209
Land ownership	**-0.3345**	0.0089	-0.0630	0.0497	0.0183	0.0678	-0.0272	-0.0623	0.0550
Crop choice decision	-0.0020	**0.4594**	-0.1012	0.0624	0.0142	0.0324	0.0082	-0.0020	-0.0128
Crop management decision	0.0092	**0.4496**	-0.0178	0.0119	0.0292	0.0076	0.0117	0.0046	-0.0686
Food choice decision	0.0020	**0.3714**	0.1411	-0.0201	-0.0912	-0.0797	-0.0447	0.0245	0.1644
Marketing decision	-0.0110	**0.4485**	-0.0034	-0.0276	0.0273	0.0534	0.0040	-0.0717	-0.0514
Expenditure and investments decision	0.0078	**0.4495**	0.0422	-0.0064	-0.0135	-0.0229	0.0254	0.0523	0.0865
Adoption									
STRV adoption rate	0.0005	-0.0063	-0.0247	-0.0497	-0.0435	**0.6895**	-0.0109	-0.0212	0.0480
Average STRV cultivated area	0.0022	0.0207	-0.0032	0.1174	0.0054	**0.6322**	-0.0155	-0.0475	-0.1107
Eigenvalues	4.64	3.46	2.43	1.83	1.79	1.75	1.35	1.17	1.16
Cumulative variance explained [%]	15.48%	27.01%	35.11%	41.22%	47.20%	53.05%	57.56%	61.45%	65.30%

Remarks: KMO statistic for Bangladesh is 0.7889 which validates sampling adequacy with factoring and cluster analysis. PC1 (gender roles and access) and PC2 (decision-making) explain most of the variance within the data suggesting that these variables likely influence variety preferences and adoption, yet are sometimes ignored. Source: Own estimation using IRRI's STRASA dataset.

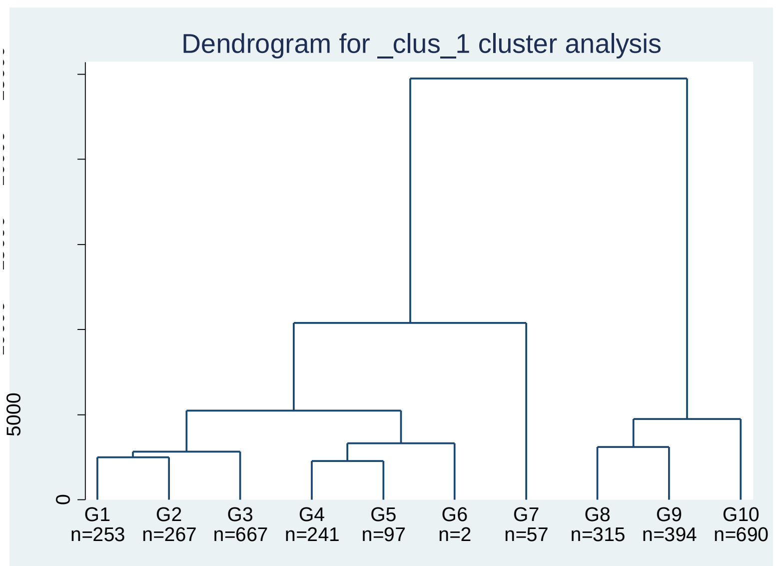

Figure A.1. Dendrogram analysis for number of farmer clusters.

Table A.2. Detailed list of farmers' variety preferences.

Trait preferences	Rank-based quotient score				Rank		
	All	Men	Women	P-value	All	Men	Women
Agronomic							
High yield	56.65	60.45	52.89	0.000	**1**	**1**	**1**
Short duration	6.99	7.88	6.11	0.003	**7**	**7**	**9**
More tillers	4.39	4.94	3.84	0.019	**10**	**8**	**10**
Taller plant height	3.57	4.23	2.93	0.003	11	**10**	13
Shorter plant height	0.69	0.89	0.48	0.019	27	23	28
Long duration	0.25	0.17	0.34	0.100	30	32	29
Grain quality							
Slender grain	14.13	14.50	13.77	0.421	**3**	**3**	**3**
Longer grain	1.88	2.04	1.71	0.352	18	17	18
High milling recovery	6.06	4.76	7.36	0.000	**8**	**9**	**8**
Shorter grain	1.10	1.18	1.03	0.510	21	20	22
Rounded grain	1.08	1.17	1.00	0.513	23	21	23
Stress tolerance							
Flood tolerant	8.40	8.94	7.86	0.109	**6**	**6**	**6**
Disease resistant	3.14	3.39	2.90	0.209	13	12	15
Insect-pest resistant	2.77	2.88	2.65	0.555	14	14	17
Lodging resistant	2.15	2.61	1.69	0.010	16	15	19
Weed resistant	0.05	0.05	0.05	0.893	38	38	37
Drought tolerant	1.40	1.53	1.28	0.328	20	18	21
Saline tolerant	0.65	0.60	0.71	0.545	28	27	27
Culinary							
Good taste	43.93	38.97	48.86	0.000	**2**	**2**	**2**
Good for rice products	5.76	3.80	7.71	0.000	**9**	11	**7**
Aromatic	0.93	0.87	0.99	0.545	25	25	24
White color of rice	1.80	0.61	2.99	0.000	19	26	12
Non-glutinous rice	1.09	0.56	1.61	0.000	22	28	20
Short cooking time	0.17	0.08	0.26	0.035	34	37	33
Glutinous rice	0.20	0.18	0.23	0.709	32	30	34
Less water use	0.15	0.08	0.21	0.073	35	36	35
No aroma	0.20	0.13	0.27	0.120	33	35	32
Softness of cooked rice	1.98	1.09	2.86	0.000	17	22	16
Marketability							
Easy selling	9.82	10.70	8.95	0.005	**5**	**5**	**4**
High market price	10.14	12.30	7.99	0.000	**4**	**4**	**5**
Cost-saving							
More fodder	3.23	3.14	3.33	0.574	12	13	11
Adaptability to land levels	0.84	0.87	0.81	0.778	26	24	25
Adaptability to any crop establishment	0.23	0.16	0.31	0.221	31	33	30
Low seed price	0.29	0.30	0.28	0.888	29	29	31
Others	1.02	1.33	0.72	0.010	24	19	26
Less fertilizer and pesticide usage	0.14	0.16	0.11	0.442	36	34	36
Less cost	0.09	0.18	0.00	0.005	37	31	38

Remarks: Ranking of trait preferences are based on RBQ scores. Source: Own summary using IRRI's STRASA dataset.

Table A.3. Descriptive statistics (mean and standard deviation) of the selected variables for farmer typologies and characterizations and logit model.

Variable name	Variable code	Description and unit	Pooled (n=2983)	
			Mean	SD
Intersectional factors				
Gender	sex	1 if female, 0 if male	0.50	0.50
Age	age	In years	42.42	12.35
Class[1]	povp	Proxied by wealth or poverty status; 1 if poor, 0 otherwise	0.59	0.49
Education	educ	In years	5.20	4.24
Marital status	marstat	1 if married, 0 otherwise	0.96	0.19
Primary occupation	occup	1 if the member is employed in on-farm activities, 2 off- and non-farm activities except for domestic labor, 3 domestic non-farm labor, 4 no job	2.06	0.98
Household assets and access				
Rice acreage	riceHa_aman	Acreage cultivated with rice in ha	0.59	0.53
Total livestock unit (TLU)	tluhh	Livestock value owned by the household in TLU	2.15	2.22
Irrigation	riceIrrigHa	Rice acreage irrigated in ha	0.38	0.47
Household size	hhsize	Number of members of all ages in a household	4.93	1.71
Market access				
Formal seed sources	seedsourceFormal	1 if accessing seeds from agri input shops, departments, NGOs, research institutions, weekly market, rice millers, traders, cooperatives; 0 if from own saved or own produced seed or from informal seed sources e.g. neighbours	0.55	0.50
Output market distance	outputmarket_access	Distance to the nearest market to sell their products in km	1.90	1.77
Input market distance	inputmarket_access	Distance to the nearest input dealer in km	1.99	1.77
Rice harvest consumption share	prodConsShare	% share of harvested rice for household's consumption	57.88	32.27
Rice harvest sold share	prodSoldShare	% share of harvested rice for market selling	28.17	31.40
Total rice production	totprodhh	Total harvested rice in kg	2617.24	15688.96
Information access				
Seed information recipient	inforecipient	1 if the member received information about seeds through extension services, other farmers, or media, 0 if did not receive any information on seeds	0.47	0.50
Training attendance	trainingattend	1 if the member has attended any agricultural training in last 5 years, 0 otherwise	0.12	0.32
Social group membership	grp	1 if the member is a member of any social group, 0 otherwise	0.26	0.44
Risks				
Climate shock experience	climShock	1 if experienced drought, submergence, or salinity during the cropping season; 0 otherwise	0.58	0.49
Food insecurity experience	foodins	1 if experienced situations of both mild and severe symptoms of food insecurity, 0 otherwise	0.34	0.47
Institutions (Gender roles[2] and power)				
Time use productive tasks	timetot_prodTask	Total hours rendered for productive tasks in the previous day, in hours/ day	5.06	3.66
Time use reproductive tasks	timetot_reprodTask	Total hours rendered for reproductive tasks in the previous day, in hours/ day	3.87	3.70
Land ownership	landowner	1 if the member has the land rights, 0 otherwise	0.32	0.47
Crop choice decision	cropChoice	Decision-making index in different domains; 1-5 where 1- husband or men only, 2- husband dominates, 3- both equally, 4- wife dominates, 5- wife or women only	1.64	0.79
Crop management decision	cropMgt		1.37	0.66
Food choice decision	foodChoice		2.61	0.82
Marketing decision	marketing		1.40	0.67
Expenditure and investments decision	expInv		2.05	0.79
Land type and adoption				
Adoption rate	adopt_ind	1 if currently cultivating STRV, 0 otherwise	0.25	0.43
Average STRV cultivated area	strvArea	Acreage cultivated with STRV in ha, including 0s	0.10	0.24

[1]Bangladesh poverty status is based on World Bank's USD 1.90/day per capita international poverty line or ~61.6 Bangladesh thaka per day.

[2]Productive tasks include agricultural activities and paid work activities like market selling, construction, etc. Reproductive tasks include care work, community, and religious activities.

Table A.4. Farmers' variety preferences by cluster

Trait preferences	Rank-based quotient score: C1 (Poor married old men)	C2 (Non-poor married less old men)	C3 (Poor widows)	C4 (Non-poor married younger women)	C5 (Poor married younger women)	Rank: C1	C2	C3	C4	C5
Agronomic										
High yield	55.70[1]	69.37[1,2,3]	58.62	52.78[2]	52.21[3]	**1**	**1**	**1**	**1**	**1**
Short duration	7.86[1]	7.37	9.95	5.00[1]	6.77	**7**	**8**	**5**	**10**	**8**
More tillers	4.50	6.29[1,2]	1.91	2.71[1]	4.27[2]	**9**	**9**	15	13	**10**
Taller plant height	5.23[1,2,3]	2.39[1]	4.56	1.83[2]	3.48[3]	**8**	14	**9**	18	11
Shorter plant height	0.83	0.95	0.50	0.31	0.61	24	19	24	27	26
Long duration	0.23	0.04	0.50	0.33	0.35	31	36	25	26	30
Grain quality										
Slender grain	16.23[1]	10.64[1,2]	16.75	12.96	14.49[2]	**3**	**4**	**3**	**4**	**3**
Longer grain	1.94	2.08	1.24	1.30	2.05	17	15	19	19	16
High milling recovery	2.92[1,2]	7.92[1,3,4]	5.72[5]	13.10[2,3,5,6]	4.31[4,6]	12	**6**	**8**	**3**	**9**
Shorter grain	1.48	0.69	1.49	0.67	1.18	21	21	18	23	21
Rounded grain	1.66[1,2]	0.22[1,3]	0.25	0.30[2,4]	1.49[3,4]	19	27	30	29	19
Stress tolerance										
Flood tolerant	9.95[1]	7.38	4.56	6.97[1]	8.49	**5**	**7**	**10**	**7**	**6**
Disease resistant	2.49[1]	5.31[1,2,3]	1.24[2]	3.88[4]	2.27[3,4]	15	**10**	20	12	15
Insect-pest resistant	2.33[1]	4.06[1]	0.91	2.44	2.76	16	11	22	15	14
Lodging resistant	2.94[1]	2.06	2.74	1.10[1]	1.93	11	16	12	22	17
Weed resistant	0.04	0.07	0.00	0.04	0.06	38	34	31	36	36
Drought tolerant	1.39	1.74	2.74	2.08[1]	0.76[1]	22	17	13	17	25
Saline tolerant	0.50	0.79	0.83	1.12	0.46	27	20	23	21	27
Culinary										
Good taste	44.07[1,2]	30.21[1,3,4,5]	43.62[3]	48.05[4]	49.53[2,5]	**2**	**2**	**2**	**2**	**2**
Good for rice products	4.00[1,2]	3.10[3,4]	7.21	6.42[1,3,5]	8.63[2,4,5]	**10**	13	**6**	**8**	**5**
Aromatic	0.78	0.96	1.00	1.23	0.90	25	18	21	20	24
White color of rice	0.67[1,2]	0.50[3,4]	0.50[5]	5.53[1,3,5,6]	1.75[2,4,6]	26	24	27	**9**	18
Non-glutinous rice	0.49[1,2,3]	0.46[4,5]	4.23[1,4,6,7]	2.18[2,5,6,8]	1.23[3,7,8]	28	25	11	16	20
Short cooking time	0.14	0.00	0.00	0.12	0.34	35	37	34	33	31
Glutinous rice	0.26	0.04	0.00	0.28	0.21	30	35	35	30	34
Less water use	0.07	0.10	0.00	0.20	0.23	37	33	33	31	32
No aroma	0.10	0.12	0.50	0.39	0.22	36	30	26	25	33
Softness of cooked rice	1.63[1,2]	0.36[3,4]	0.50	2.57[3]	3.05[2,4]	20	26	28	14	12
Marketability										
Easy selling	10.99[1]	10.44	7.21	7.63[1]	9.69	**4**	**5**	**7**	**6**	**4**
High market price	9.54[1]	16.65[1,2,3]	12.94	8.81[2]	7.48[3]	**6**	**3**	**4**	**5**	**7**
Cost-saving										
More fodder	2.83	3.82	1.74	3.93	3.03	13	12	17	11	13
Adaptability to land levels	1.03	0.58	1.82	0.53	0.92	23	22	16	24	22
Adaptability to any crop establishment	0.16	0.16	0.00	0.15	0.41	34	28	32	32	28
Low seed price	0.36	0.14	0.50	0.08	0.41	29	29	29	34	29
Others	1.74[1,2,3]	0.54[1]	1.99	0.30[2]	0.91[3]	18	23	14	28	23
Less fertilizer and pesticide usage	0.19	0.11	0.00	0.05	0.15	33	32	36	35	35
Less cost	0.21	0.12	0.00	0.00	0.00	32	31	37	37	37

Remarks: [1,2,3,…,n] are Tukey-Kramer post-hoc test results. Source: Own estimation using IRRI's STRASA dataset.