**Women’s empowerment and trait preferences among cereal and legume growers in Bangladesh[[1]](#footnote-1)**

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**Abstract**

*Evidence from studies on women's empowerment suggests that when women have a larger role in decision-making on crop selection and adoption, household well-being improves. However , the relation between women’s empowerment and crop decision-making is seldomly investigated in the literature. We integrate women studies and economics methods to explore links between crop trait preferences and women’s empowerment among agricultural primary decision makers in Bangladesh. We use disaggregated survey data from the Bangladesh Integrated Household Survey, covering three waves in 2011, 2015 and 2018. Focusing on cereals and legumes, we compute the women’s empowerment in agriculture index (WEAI) in each survey round and we regress the index on primary decision makers’ first and second top – ranked crop attributes. We find links between trait preferences and women’s empowerment, the gender of the primary decision maker and the hours worked by women on cereal and legume plots. Higher levels of women empowerment at the district level are associated with a shift in top-ranked trait preferences: from agronomic traits to quality traits, with market demand gaining momentum. Findings are enforced with the increase of hours worked by women on the plots, while the sex of the primary decision maker seems to play a marginal role. The present study is the first to relate indices of women’s empowerment to considerations of trait preferences. Our results call for developing gender-informed breeding methods which prioritize intra-household as well as intra-community gender dynamics.*

**Keywords:** gender empowerment gap, trait preferences, WEAI, BIHS

1. **Introduction**

Women play a key role in agriculture (Sell and Minot 2018, Doss et al. 2018) as they make essential contributions to the agricultural and rural economies in all developing countries (Doss et al. 2018). Rural women often manage complex households and pursue multiple livelihood strategies. Their activities typically include producing agricultural crops, tending animals, processing, and preparing food, working for wages in agricultural or other rural enterprises, collecting fuel and water, engaging in trade and marketing, caring for family members, and maintaining their homes (Doss et al. 2018; Palacios-Lopez et al. 2016). In this perspective, numerous studies argue that gender has significant impacts on farming and agricultural activities. Notwithstanding, men and women have unequal access to and control over key productive resources upon which agriculture depends. For example, gender differences affect how crops are utilized in production, postharvest, food processing and marketing (Weltzien et al. 2020).

Looking at crop choices and adoption, a blossoming literature has shown that farmers’ preferences for traits differ across gender (Ashby et al. 1994; Laborte et al. 2015; Tegbaru et al. 2020). Women and men diverge in trait preferences when they face different constraints, different roles and responsibilities in production and consumption systems, and different crop production goals (Weltzien and Christinck 2017; Weltzien et al. 2020). Women’s varietal trait preferences appear more frequently related to food security traits such as early maturity, postharvest processing and food preparation traits including storability, grain colour and texture (Weltzien et al. 2020). Productivity under sub-optimal soil fertility and multiple harvests are frequently ranked top priorities by women as well (Weltzien and Christinck 2017).

Gendered crop choices set for gender-responsiveness as a foundation for the effectiveness of public sector breeding (McDougall et al. 2022). For some time now, breeding programs have recognized the need to consider gender differences in trait preferences and incorporate them in programs (Grando 2017). Yet, despite growing agreement, understanding and approaching gendered trait differences remain frequently an uncharted territory. A well-known rationale behind gender-responsive breeding is higher varietal adoption. However, recent evidence maps the contribution of gender-responsive breeding to the expansion of women’s choice in the rural technological domain and thus, to women’s empowerment (McDougall et al. 2022).

Despite its potential in advancing gender equality (i.e., SDG5) (Polar et al. 2021a), the relation between women’s empowerment and gendered trait preferences is largely unexplored. Individual preferences are an important dimension of choice and gender-related disparities often restrict the set of choices. For breeding technology users, gender inequality accrues when the set of options does not include traits that women value positively or it includes traits which are detrimental to women (Polar et al. 2021a). It follows that a foundation for making progress along the pathway from gender-responsive breeding to gender equality is the study of women’s and men’s trait preferences and how they evolve with women’s empowerment in the community. To the best of authors’ knowledge, this study is one of the few to relate indices of women’s empowerment to the evolution of trait preferences over time.

Building on the work of Polar et al. 2021b on the meaningfulness of choices as a pre-condition for empowerment in agricultural technologies, we investigate how district-level women’s empowerment relate to top-ranked trait choices among cereals and legumes growers in Bangladesh. The analysis utilizes three rounds of the Bangladesh Integrated Household Survey (BIHS), which were administered in 2011, 2015 and 2018 under the guidance of the International Food Policy Research Institute (IFPRI). We focus on two crop groups: cereals and legumes. Both groups retain a key role in the production and dietary intake of Bangladesh rural areas, but they vary for women’s engagement and role: the share of women in cereal production ranges between 11-18%, while it reaches up to 48% in legume cultivation (Rahman 2000). The study investigates two research questions: are changes in top-ranked trait choices by primary decision makers related to changes in women’s empowerment at the district level? Is the relationship accrued by the sex of the primary decision maker and the number of hours female workers spend on the plot?

Through a multivariate matching technique, we construct a pool of 2108 plot-level observations, whose primary decision maker of reference is a female (treatment group) to match those plots whose primary decision maker is a male (control group). This corresponds to 364 treatment households and as many control households. For each plot-level observation, we have information on the crop cultivated and the first and second top – ranked crop characteristics by the primary decision-maker. Our empirical specification links women’s empowerment to top – ranked crop characteristics through a fixed-effect pooled cross section model. Because empowerment itself is likely to be endogenous, we test the relation using two instrumental variable specifications: one that employs women’s empowerment in its lagged form (Blundell and Bond, 2000) and one that uses the number of community activities the woman participated in during the previous year, following Sraboni et al. 2014.

Our results show that higher levels of women empowerment at the district level are associated with a shift in top-ranked trait preferences: from agronomic traits to quality traits, with a surge in market demand as top-ranked characteristic. Findings are enforced with the increase of hours worked by women on the plots, while the sex of the primary decision maker seems to play a marginal role. We conclude the study discussing the implications of intra-household and intra-community gender dynamics for gender-responsive breeding.

1. **Background** 
   1. **Linking women’s empowerment and trait preferences**

The rationale for studying mechanisms around gender inequality in agriculture is rooted in a body of empirical evidence that demonstrates the ways in which women are essential to improvements in household agricultural productivity, food security, and nutrition security (for a review on the subject, see Sraboni et al. 2014). It is now well-established that rural households do not act in a unitary manner when making decisions and this is reflected in different preferences and choices (Alderman et al. 1995; Haddad et al. 1997), which are the result of different roles and powers at play. Nonetheless, the study of trait choices and crops adoption is one domain where gendered preferences have been long overlooked, with disappointing results in terms of varietal uptake and productivity (Walker and Alwang 2015; McDougall et al. 2022). Gender-responsive breeding is a breeding paradigm which understands and equitably considers the preferences of both women and men (Tufan et al. 2018). In such paradigm, operational and structural challenges coexist.

The operational challenge lies primarily in the lack of disaggregated data: a review of English-language databases over the past 30 years (1985-2015) reports only 39 studies providing information on gendered trait preferences (Weltzien et al. 2019). Even in studies which link trait preferences, adoption and gender, the relationship is far from being straightforward. This is due to a lack of standardized methods for data collection which, paired with a gap in data availability, result in the impossibility to generalize results. For example, inserting sex in a multivariate adoption model is frequently inconclusive (Simtowe et al. 2016). Nonetheless, when it is intersected with other socioeconomic characteristics (for example, age), studies find that gender is a significant predictor (e.g., Fisher and Carr 2015).

The structural challenge is instead stylized by the existing tension between what crop choices and preferences are meaningful for women and what are restricted to women, for reasons which transcend individual choices. In investigating links between trait preferences and women’s empowerment, this study aims at understanding if the space of meaningful crop choices expands or restricts with changes in the collective social structure, captured by indices of women’s empowerment. The question is all but theoretical, as exemplified by Polar et al. 2021b. Choice is frequently viewed as an outcome of individual agency. Agency is equated to the ability of make choices and empowerment to the process by which the ability to make choices is acquired by those who have been denied that ability (Kabeer 2005). However, the power to make choices depend not solely by individual choices, but also on collective social structure (Akram 2010). The mutual interdependence of structure and agency, expressed as the process of structuration, means that structure can be enabling as well as constraining (Giddens 1984). For a trait choice to be meaningful for women, it must exist, and it must be perceived as a positive option which has value and is available. Conversely, restricted choices exist when there are no positive options to choose from under disempowering conditions (Polar et al. 2021b). In contexts with gender unequal collective social structures, varietal preferences might be “inappropriate adaptive preferences” (Khader 2011; Polar et al. 2021b). For example, the fact that women tend to choose less frequently traits related to the market value of the crop in favour of home consumption – related traits might reflect self-subordinating adaptation to a restricted choice, to accommodate their inferior access to labour, capital, farm equipment, seed, fertilizers, pest control products and market access (Polar et al. 2017; Polar et al. 2021b).

In this domain, linkages between indices of women’s empowerment, measure of the collective social structure, and trait preferences have been rarely investigated. Recent studies on individual women and men plot managers find that men tend to adopt more frequently improved varieties, but there are exceptions, depending on the level of gender inequality (Polar et al. 2021b). Differences between men and women producers in trait preferences often reflect underlying gender inequalities that constrain choice. One study finds that lower-adopting women producers in Malawi have less access to seed of improved varieties than men, but in Zambia where women producers benefited from the commercialization and intensification of farming, their level of adoption was the same as that of men (Djurfeldt et al. 2019). Another study utilizes an experimental investment game to study women’s intrahousehold decision making power, observing higher equality in crop decision-making in cases when women earn an off-farm income (Maligalig et al. 2019).

Building on these works, we investigate whether changes over time in district-level indices of women’s empowerment led women producers to list alternative top-ranked traits. Utilizing the women’s empowerment in agriculture index (or WEAI) as a comprehensive and standardized tool to measure women’s empowerment and inclusion in rural areas, we investigate whether changes in the five domains influenced by the gendered collective social structure (i.e., achievement of empowerment across the domain of production, resources, income, leadership and time allocation) result in changes in top – ranked crop traits by primary decision makers, through an enlargement of the space of meaningful choices for women within households.

Diagram

Description automatically generatedWe further question whether changes driven by women’s empowerment influence men and women primary decision makers equally, and whether the number of hours female workers spend on the plot plays any role in mediating the relation between the women’s empowerment and the choice of traits. The relations underlying our hypothesis are exemplified in Figure 1.

Fig. 1 | Hypothesis of the study

Black lines highlight empirical relations, dashed lines theoretical mechanisms. Dotted boxes highlight mechanisms variables, while the grey box signals the outcome variable.

* 1. **Women’s engagement in rural production in Bangladesh**

Similar to the recognition of women’s contribution to agriculture worldwide, women’s role in Bangladeshi agriculture tends to be underrepresented, due to the common view that women are not involved in agricultural production, because of cultural norms that value female seclusion and undervalue female labour (Sraboni et al. 2014). In 1990s, it was believed that women's labour accounted for at least 25% of the value added from sowing to post-harvest operation in Bangladeshi rice production (Scott and Carr 1985) and less than 20% in other cereal productions (Chakma and Ruba 2021). However, overall, a dearth of information existed on women’s involvement in agricultural production in Bangladesh, given the prevailing claim that they were involved only in the post-harvest processing of crops (Rahman 2000).

Participation of women in the agricultural sector has increased over time (Asaduzzaman 2010, citing Bangladesh Bureau of Statistics, in Sraboni et al. 2014). In the first years of 2000s, the number of employed persons in agriculture increased of about 15%. For women, the number has increased from 3.76 to 7.71 million (i.e., more than 100%). As a result of such changes, the proportion of women in the agricultural labour force has jumped from less than 20% in 1990 to 36% of the total in 2020 (Sraboni et al. 2014; Chakma and Ruba 2021). It is remarkable, although it is not yet clear how much of this change resulted from a true secular increase as opposed to better measurement of women’s participation.

Furthermore, there is evidence that the gender division of labour is not as clearcut as thought in Bangladesh (Zaman 1995; Chakma and Ruba 2021). For example, they tend to be more heavily involved in the harvesting of cash crops like legumes and vegetables, while their role is frequently confined to post-harvest activities in case of cereal (Rahman 2000). Nonetheless, women’s rural income is severely constrained by their limited use, ownership, and control of productive physical and human capital. Women in Bangladesh are disadvantaged with respect to assets brought to marriage (Quisumbing and Maluccio, 2003), current productive assets (including land, livestock, and agricultural machinery) (Quisumbing et al. 2013), and human capital. Moreover, remunerative employment of rural labour remains skewed in favour of men, since female labour is engaged only when the male labour supply is exhausted (Rahman 2000; Sraboni et al. 2014). As previously underlined, women tend to be primarily responsible for post-harvest duties in Bangladesh. This is even more true for cereals and legumes, with women being responsible for seedling raising, weeding, threshing, sorting, and cleaning, boiling, drying straw, and storing (Chakma and Ruba 2021; Rahman et al. 2016).

In such a context, understanding whether women’s empowerment relate to trait preferences of the primary decision maker is even more relevant: is a higher degree of empowerment reflected in different varietal preferences, more akin to the role and need of women in crop cultivation?

1. **Data**

**3.1 Bangladesh Integrated Household Survey (BIHS)**

The analysis is based on the three rounds of the Bangladesh Integrated Household Survey (BIHS), which were administered in 2011, 2015 and 2018 under the guidance of the International Food Policy Research Institute (IFPRI). Designed to monitor the progress of the US Government’s Feed the Future initiative in Bangladesh, the BIHS is performed in 64 districts, and it is nationally representative of rural areas (Seymour 2017). The first wave of BIHS followed a two-stage stratified sampling: in the first stage, the selection of primary sampling units (village) within each administrative division in Bangladesh was based on the probability proportional to the total number of households in each village, derived by the 2001 population census. In the second stage, 20 households were randomly selected from each village. This process resulted into approximately 6,500 households surveyed in 325 villages (Sraboni et al. 2013). Subsequent rounds of the survey in 2015 and 2018 interviewed the same respondents to form a balanced panel dataset.

Teams comprising male and female enumerators conducted one-on-one interviews with the self-identified, primary adult male and female decision makers for each household: a male enumerator interviewed the man (usually the household head), and a female enumerator interviewed the woman (typically the wife of the head of the household). The overall survey is composed by 27 separate modules, which collect comprehensive data on, among others, plot-level agricultural production and performs, dietary consumption of all household members, economic shocks, and women’s status. This study primarily uses two modules: the agriculture module and the women’s empowerment in agriculture (WEAI) index module.

Attrition rate among baseline and endline rounds was low: 4.41% between 2011 – 2015 and 14% between 2015 – 2018. To assemble the pooled dataset for this study, we relied on the unique household identification number contained in the household roster module; for households which have split between the three rounds of survey (e.g., due to marriage of an adult member), the original household identification number is reported with decimal places[[2]](#footnote-2), where \*\*.1 denote the parent household (i.e., originally interviewed at baseline). As we aim to measure trait preference changes within same household units across years, we opt for keeping only the originally interviewed parent household (Ahmed 2016). This reduces our final sample to 5,076 observations. Furthermore, the first BIHS round does not contain information on respondents’ trait preferences for each crop harvested in the previous season: thus, our main econometric model relies predominantly on the second and the third round, restricting our array of observations to 3,384. However, to mitigate issues of endogeneity, we present a third model specification (eq. 4) which requires variables lagged from the first BIHS round.

Table 1 summarises relevant household characteristics for each of the three BIHS rounds.

Table 1 | Summary of household characteristics for each BIHS round (2011, 2015, 2018)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Panel | Round 1 (2011) | Round 2 (2015) | Round 3 (2018) |
| Women among Ag.PDM\* (%) | 10.1% | 17% | 7,3% | 6,2% |
| Age of Ag.PDM | 42.35 | 44.2 | 41.14 | 41.71 |
| Literacy of Ag.PDM\*\* (median) | 2 | 2 | 2 | 3 |
| Household size | 3.37 | 2.91 | 3.33 | 3.88 |
| Number of plots per household | 1.57 | 1.67 | 1.54 | 1.50 |
| Plot size (ha) | 24.64 | 24.9 | 24.23 | 24.80 |
| Households surveyed | 5,076 | 1,692 | 1,692 | 1,692 |
| If not otherwise specified, it is reported the mean. \*Ag.PDM = Agricultural primary decision maker. \*\*Literacy is a categorical variable, where 2 equals “Can sign only” and 3 equals “Can read only”. The median in each round is here reported. | | | | |

**3.2 Construction of the final dataset**

The module on women’s empowerment interviewed both household head and spouse[[3]](#footnote-3) in all BIHS rounds. However, data on varietal preferences are much more problematic. By the way in which BIHS was designed, the module on agricultural inputs was asked solely to the self-identified, primary male decision maker in each household. Primary female decision makers were interviewed only if the primary male decision maker was not available. This entails that, on the one hand, we have preferences only from the household heads and, on the other hand, women’s preferences are elicited predominantly from women in household head positions. The conceptual framework on intra-household trait preferences in McDougall et al. 2022 highlights the limitations of this approach, which we fully acknowledge.

As varietal preferences are elicited only in the second and third round of BIHS, we are left with around 7% of the observations stating trait preferences by primary female decision makers in each year of the survey (Table 1). We opt for looking at a sub-sample of the overall BIHS respondents to conduct our analysis, to mitigate the disproportion of women and men respondents. As trait preferences are asked for each crop in each plot, we start by the plot as unit of observation. Using a multivariate matching technique, we construct a pool of plots whose primary decision maker of reference is a man (control group) to match those plots whose primary decision maker is a woman (treatment group). We base the matching on the year, district, plot size, crop cultivated, season in which the plot is utilized, household size, primary decision maker’s literacy level and age. This technique helps us to mitigate the disproportion of male primary decision makers interviewed.

Our final dataset is composed by 1054 observations at the plot level (579 in 2015 and 475 in 2018) for each gender group. The total number of observations at the plot level is 2108. This corresponds to 364 women respondents (183 in 2015 and 181 in 2018) and as many men respondents.

An additional drawback in selecting solely the men decision makers as primary respondent is that we do not have a balanced panel dataset. Indeed, if the male primary decision maker is available in the next round of the survey, he is interviewed notwithstanding the fact that the same module was answered by the female counterpart in the previous round. It follows that we have a pooled cross section dataset and observations are independent. The treatment and the control group are comparable for socio-demographic and agronomic characteristics, while they differ for gender and top-ranked preferred traits (Table 2).

Table 2 | Characteristics associated to the treatment and control groups

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Treatment group**  *Women Ag. primary decision maker* | **Control group**  *Men Ag. primary decision maker* | **T-test** |
| Sex | Female | Male | - |
| Age | 40.8 (10.3) | 40.9 (10.2) | 0.88 |
| Literacy | 3 (1.18) | 3 (1.18) | 0.99 |
| Plot size | 22.1 (18.7) | 22.2 (18.3) | 0.94 |
| Harvesting season | 2.13 (0.95) | 2.13 (0.95) | 0.99 |
| Household size |  |  |  |
|  |  |  |  |
| First most preferred trait | 2.88 (3.88) | 2.60 (3.63) | 0.09(\*) |
| Second most preferred trait | 9.38 (4.07) | 9.12 (4.24) | 0.18 |
| Mean, standard deviation in parenthesis – if not otherwise specified.  The test is the Welch Two sample t-test. | | | |

**3.3 The empowerment gap**

The Women's Empowerment in Agriculture Index (WEAI) is a survey-based index that uses individual-level data collected from the primary male and female decision-makers within the same households to measure respondents’ empowerment in their roles and engagement across five domains (production, resources, income, leadership, and time allocation) within the agriculture sector (Alkire et al. 2013).Launched in February 2012 by IFPRI, Oxford Poverty, Human Development Initiative, and Feed the Future by the United States Agency for International Development (USAID), WEAI is a remarkably comprehensive and standardized tool to directly measure women’s empowerment and inclusion in rural areas.

The index is measured in terms of two metrics: the empowerment score and the empowerment gap. The first represent a weighted sum of primary female decision-maker’s achievement of empowerment across ten indicators belonging to the five domains previously listed (full listed present in the Table A1 in the appendix). Complementarily, the empowerment gap captures the difference in the empowerment scores of the primary female decision-maker and her spouse; it takes a value of zero if a woman’s empowerment score is greater than or equal to that of her spouse. To compute the WEAI metrics, we rely on the resources and instruments freely downloadable at the IFPRI website[[4]](#footnote-4) (for a comprehensive review of the tool and its composition, refer to Alkire et al. 2013).

Among the indices available from WEAI, this study focuses the gender parity index (GPI) as variables of interest. The GPI reflects the percentage of women who are empowered or whose achievements are at least as high as the men in their households. For those households that have not achieved gender parity, the GPI shows the empowerment gap that needs to be closed for women to reach the same level of empowerment as men. Following Alkire et al. 2013, we construct the GPI at the district level for all the three rounds of the BIHS.

Almost ubiquitously in all Bangladeshi districts, we find an improvement of the GPI between 2011 and 2018 (Figure 2). This is confirmed also by an overall average improvement of the GPI at country level (Table 3). These trends reflect findings which have employed WEAI metrics such as Quisumbing et al. 2020, De Pinto et al. 2020 and Sraboni et al. 2021. Higher the gender parity index in the district, higher the percentage of women who are empowered in agriculture at least as the men in their households. We test if this change in the collective social structure relate to changes in primary decision makers’ set of varietal choices.

Fig. 2 | Average empowerment gap in each district of Bangladesh (2011 and 2018)

Map

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Table 3 | GPI level in each year, average across districts

|  |  |
| --- | --- |
|  | **GPI**  *Average across districts, with min and max in brackets* |
| 2011 | 0.79 (0.62 – 0.93) |
| 2015 | 0.92 (0.74 – 0.99) |
| 2018 | 0.97 (0.87 – 0.99) |

**3.4 Trait preferences**

Information of agricultural inputs are present in the module H of BIHS. For 2015 and 2018, the survey also captures data on top-ranked trait preferences (first position and second, in order of importance) at the plot level for each group of crops (i.e., cereals, pulses, fruits, vegetables, oil, fibre, spices and others) and for each harvesting season (i.e., *aus* (or *kharif* 1), *aman* (or *kharif* 2), *boro* and annual).

Figure 3 shows the most preferred trait in each crop group in 2015 and 2018, for women (lower quadrant) and men(higher quadrant) primary decision makers. A breakdown of trait preferences per harvesting season ((*aus*, *aman*, *boro* or annual), per year and per crop group is reported in Table A2 in the Appendix. We can already observe a reduction in the heterogeneity of trait preferences between the two gender groups: notwithstanding the sex of the primary decision maker and the crop group of reference, we see a convergence in preferences and a reduction in the diversity of top ranked traits. Vegetables is here a good example: in case of men decision makers, low labour and taste are two traits which disappear from the top ranked positions in 2018 for vegetables, leaving solely size and yield as desired characteristics. Even more so for women decision makers, where only the yield trait ranks first in 2018. Across crops, traits like low labour requirement, low input, or colour are diffuse in 2015, but appear to be negligible in 2018. Conversely, both women and men primary decision makers tend to prioritize yield and market demand more often in 2018 than 2015.

Fig. 3 | First preferred trait in each crop group, for male and female primary decision makers (2015 – 2018)

Looking at the first ranked trait is surely informative, but the overall tendency to prioritize yield is somehow to be expected. Figure 4 shows the second preferred trait, which in most cases, guides the variety choice alongside yield. The homogeneity in preferences observed in the previous figure is here not present and both women and men primary decision makers show a variegate set of second-best traits. Market demand is the trait which presents the highest frequency change between 2015 and 2018 for female decision makers, followed by size and taste. Insect/ disease resistance and low input required are preferred attributes, which tend to disappear in 2018 both for female and male primary decision makers. Interestingly, if female growers tend to prioritize market demand as second preferred trait, male growers seem to be more interested in taste. This happens predominantly for vegetables, legumes, fruits and spices.

Fig. 4 | Second preferred trait in each crop group, for male and female primary decision makers (2015 – 2018

Looking at the share of plots allocated to the diverse crop groups by female primary decision maker (Table 4), we decided to focus on cereals and legumes. These two crop groups represent alone 80% of the overall number of plots cultivated by women primary decision makers[[5]](#footnote-5).

Table 4 | Share of plots allocated to the diverse crop groups by women primary decision makers

|  |  |  |
| --- | --- | --- |
|  | **2015** | **2018** |
| Cereal | 435 (75) | 346 (73) |
| Fiber | 39 (6) | 42 (8) |
| Fruits | 1 | 2 |
| Oil | 17 | 22 |
| Other | 15 | 12 |
| Legumes | 33 (5) | 31 (6) |
| Spices | 17 | 12 |
| Vegetables | 22 (3) | 8 (1) |
| **Total** | **579 (100)** | **475 (100)** |

This choice also reflects productions where gender roles are relatively different. Data on gendered division of labour[[6]](#footnote-6) are summarized in Table 5. In line with the literature (Rahman 2010; Rahman 2000), overall hours work by men exceed overall women engagement in agriculture in Bangladesh. Moreover, the share of hired female labour is low and relatively constant notwithstanding the gender of the primary decision maker: it is on average, 3% for households with a female or a male primary decision maker across the two years. This finding is in line with precedent work in Bangladesh (Rahman 2000). Interestingly, however, hired male labour is covering almost half of the overall hours worked by men in the household. Indeed, the share of hired men labour with respect to overall men labour is 62% on average for the two years. This is again consistent across households with a female or male primary decision maker.

Table 5 | Share of hours worked allocated to the diverse crop groups by female primary decision maker

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Female (F)**  **primary decision maker** | | | **Male (M)**  **primary decision maker** | | | | **t-test F- M**  **in 2015, 2018** |
|  | **2015** | | **2018** | **2015** | | | **2018** |  |
| Hours worked by men+ | 91.6 | 63.3 | | 109 | 91.5 | | | \*\*\*, \*\*\* |
| Hours worked by hired men | 67 | 39.4 | | 52.3 | 40.8 | | | \*\*\*, \* |
| Hours worked by women+ | 28.1 | 23 | | 24.1 | 25.2 | | | \*\*\*, \*\*\* |
| Hours worked by hired women | 1 | 1 | | 3.21 | | 1.95 | | \*\*\*, \*\*\* |
| +Overall hours, not segmenting for hired or family labour. The t-test is the Welch Two sample t-test.  These estimates do not disaggregate for crop group. | | | | | | | | |

In the quest to relate trends in trait preferences with the GPI metric, we expressed our outcome of interest following the crop ontology by CGIAR (Pietragalla et al. 2022), created in 2008 (for further information, visit <https://cropontology.org/>). Trait preferences are clustered in trait classes (TC). represents the trait class of the most frequent trait preference T of order *k* (first or second position for importance) expressed by each decision maker *i*, across seasons, for each crop group *j* in year *y* (2015 and 2018). Table 6 summarizes the trait classes present in our study:

Table 6 | Trait classes based on Crop Ontology (Pietragalla et al. 2022)

|  |  |
| --- | --- |
| **Trait class** | **Trait preference in the survey** |
| Agronomic | Grain yield |
| Abiotic stress | Flood tolerant  Saline tolerant  Drought tolerant  Zinc enriched |
| Biotic stress | Insect / disease resistant |
| Morphological | Grain size  Nice colour |
| Quality | Market demand  Good taste  Good as animal feed  Low labour required  Low input required  Ease of processing |

We compute results both for trait classes and for trait preferences un-clustered. In Section 5 we report findings for trait classes, while results for trait frequencies un-clustered are reported in the Appendix (Table A3 and A4). In section 4, we attempt to formalize this descriptive evidence with an empirical exercise.

1. **Empirical specification**

Our empirical specification links the women’s empowerment to the outcome of interest, as follows:

where is the variable defining trait classes for respondent *i* at time *t*. is represented by a battery of dummies, which assume value 1 alternatively for each trait class. We treat top-ranked and second-best ranked traits separately.

Our variable of interest is which measures the gender empowerment gap in the district where household *i* at time *t* is located. This is a continuous variable, where 0 represents gender parity (so the absence of the empowerment gap). is a vector of household-specific controls drawn from the BIHS data. Standard errors are clustered at the district level, as we imagine observations within each district are reasonably not independently distributed. As previously underlined, the estimation sample consists of a pooled cross section.

Equation 1 will be correctly identified under restrictive conditions i.e., that changes in the empowerment gap is not influenced by existing trait preferences and that no other factors are influencing change in trait preferences beyond women’s empowerment. These assumptions can arguably be questioned under different circumstances: not only can trait priorities influence power dynamics within households, but the same could be said for some (omitted) variables that we cannot precisely account for in our analysis. In what follows, we try to address both issues while being aware that – absent an experimental setting – causal interpretation of the findings is impossible to achieve in our case.

A straightforward solution to account for unobserved heterogeneity is given by the fixed effects estimator with binary variables. The definition of fixed effect comes from the idea that the unobserved variable is considered to be a constant value in the population. Therefore, we proceed by including year () fixed effects (eq. 2). Time fixed effects control for year – specific differences, such as market and policy fluctuations. Also in this case, standard errors are clustered at the district level.

As is a set of dummies, eq. 2 is modelled into five fixed-effect Probit model in which every trait class outcome is treated as a separate dummy (taking value 1 if the outcome is the trait class of interest and 0 otherwise). The model is implemented in R 2021 using the package {*alpaca*} by Stammann 2018. The incidental parameter bias problem (Neyman and Scott 1948), which might arise from the fact that in some cases within-group sample size is limited, is addressed applying a post-estimation routine derived by Fernández-Val and Weidner 2016.

In the realm of household-specific controls, we are specifically interesting to isolate how the empowerment gap relate to trait preference changes according to the gender of the primary decision maker and according to the hours worked by women (family or hired labour) on the crop group. For this purpose, we expand eq. 2 with two additional terms:

where *gender* equals 1 when the agricultural primary decision maker is a woman. The term isolates the combined effect of changes in the empowerment gap with the gender of the primary decision maker in the household: are empowerment changes influencing more significantly trait preferences, if the agricultural primary decision maker is a woman? *Overall female hours* is a continuous variable accounting for the hours worked by female workers on the crop group of interest. This information is taken from the modules H5 and H6 of the BIHS, which record the labour allocation by gender during the crop life cycle. Interacting the empowerment gap for the fact that a crop is worked predominantly by the women in the household replies to the last research question of this study: are empowerment changes influencing more significantly the trait preferences when women have a predominant role in the cultivation?

Time-variant (omitted) variables remain uncaptured by eq. 2 and 3. For example, we cannot rule out the fact that trait preferences might vary due to households’ risk preferences changing over time. In the quest for mitigating time-variant sources of endogeneity, the use of the variable of interest in its lagged form remains common in economics (Blundell and Bond 2000; Wang and Bellemare 2019). In cases when lagged explanatory variables have no direct causal effect on the dependent variable or on the unobserved confounders, this method proves effective in mitigating the endogeneity problem (Wang and Bellemare 2019). In our exercise, we rely on the first wave of BIHS to compute the lagged empowerment gap in the year 2011 ( in eq. 4) and compute a two-stage least square (2SLS) model with fixed effects:

This lagged instrument is strongly correlated with the variable of interest (Table 7 and 8). It is plausible that the instrument is exogenous to trait preferences shown by respondents both in 2015 and in 2018. Weighted average varietal age for cereals in Asia is 17 years and for pulses 21 years (Gatto et al. 2021), while the gender parity index shows remarkable changes between 2011 and 2018 (Figure 2). Therefore, it is not likely for previous level of empowerment gap (4 years and 7 years old) to influence trait preferences at the moment of the data collection. Nonetheless, following Wang and Bellemare 2019, we interpret cautiously results from eq. 4 and – overall - we make no claim of causality in our reasoning.

1. **Results**

Table 7 and 8 report coefficients for the fixed-effect Probit model (eq. 3) and the coefficients for two-stage instrumental variable specification (eq. 4), for first and second top-ranked trait classes.

The first stage confirms the relation between the GPI in 2011 and the GPI in following years. We use two tests to confirm the validity of the 2SLS model: the Weak Instrument test and the Wu-Hausman test. The former is an F-test on the instrument in the first stage. The null hypothesis is that the instrument is weak, so a rejection means the instrument chosen is not weak. Complementarily, the Wu-Hausman tests the consistency of the OLS estimates under the assumption that the IV is consistent. When it is rejected, it means OLS is not consistent, suggesting endogeneity is present. For easiness of interpretation, we highlighted in grey whenever the 2SLS fixed-effect model is more robust than the Probit fixed-effect model and it should be considered in the interpretation of the results.

First, we observe that a relation does exist between the closing of the empowerment gap at the district level and the evolution of trait preferences over time. The econometric exercise shows that an increase in gender parity is significantly correlated with the probability of the primary decision maker to select a quality trait as the top-ranked option for cereals and legumes. This means that, with the closing of the empowerment gap, primary decision makers appear to value more quality traits – with the relation being driven by a shift in preferences for market demand, goof taste and low labour requirement. The relation seems to be robust across crop groups and (surprisingly) across gender. *Au contraire*, it seems that when women have a predominant role in the cultivation of that crop group (role expressed in terms of hours worked on the crop), the relation between the gender parity index and the shift in favour of quality traits is reinforced.

If the attention shifts toward quality traits, the opposite can be said about agronomic traits, in this specific dataset represented by yield alone. An increase in the gender parity index at the district level seems to relate with a decrease in the probability of ranking yield as the top-ranked attribute choice. As for the class of quality traits, the relation appears to be reinforced by the role of women in the crop cultivation, while gender of the primary decision maker seems to be less relevant. Furthermore, morphological traits show a positive relation with the gender parity index, with grain size and colour acquiring importance following the reduction of the empowerment gap. Finally, neither abiotic stress nor biotic stress trait classes acquire sufficient importance to be ranked among top-rated attribute choices for cereals or legumes in the period between 2015 and 2018.

Coefficients for the second-best ranked trait class present a picture which is less clearcut. The gender parity index is hardly showing any significant relation with the probability of a primary decision maker to choose one trait class over another. Interestingly, however, a reduction in the empowerment gap at the district level is negatively correlated with the probability of primary decision makers to opt over time for quality traits as the second-best preferences. As significant and positive the correlation is in the case of the top-ranked preferences, as significant and negative the correlation exists between the parity index and the quality traits in case of second-best ranked choices. The negative relation is once again reinforced by the predominant role of women in the cultivation of crop.

Table 7 | Coefficients for top ranked trait classes

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | | | |
| **[First stage]**  **GPI 2011**  **0.12\*\*\***  (0.03) |  | | | | | | | | | |
|  | **Agronomic** | | **Abiotic stress** | | **Biotic stress** | | **Morphological** | | **Quality** | |
|  | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS |
| **GPI** | 2.09  (2.17) | **-8.46\*\***  (3.90) | - | - | - | - | **1.73\*\***  (0.77) | 0.60  (1.18) | **-4.02\*\***  (1.98) | **9.00\*\***  (3.92) |
| Cereal | -1.01  (1.84) | 0.14  (0.13) | - | - | - | - | -1.08  (0.78) | -0.07  (0.04) | 2.28  (1.46) | -0.09  (0.13) |
| Legumes | -1.30  (1.90) | -0.19  (0.18) | - | - | - | - | -1.18  (0.78) | -0.05  (0.05) | **2.87\***  (1.48) | 0.27  (0.18) |
| Female Ag. PDM\*\* | -0.23  (0.64) | -0.03  (0.11) | - | - | - | - | **-0.67\*\*\***  (0.24) | -0.02  (0.03) | 0.87  (0.79) | 0.08  (0.11) |
| Women hours worked | **-0.03\*\***  (0.01) | **-0.03\***  (0.01) | - | - | - | - | 0.003  (0.001) | 0.0003  (0.0005) | **0.02\***  (0.01) | **0.003\***  (0.001) |
| *Time dummy* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (village)* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak instruments | - | 8.50\*\*\* | - | - | - | - | - | 8.50\*\*\* | - | 8.50\*\*\* |
| Wu-Hausman | - | 10.19\*\*\* | - | - | - | - | - | 0.19 | - | 14.18\*\*\* |
| Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*).  (\*\*) Ag.PDM = Agricultural primary decision maker.Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the village level computed using the R package {*sandwich*} by Zeileis 2006. Weak instruments: this is an F-test on the instruments in the first stage. The null hypothesis is that the instrument is weak, so a rejection means the instrument chosen is not weak. Wu-Hausman: this tests the consistency of the OLS estimates under the assumption that the IV is consistent. When it is rejected, it means OLS is not consistent, suggesting endogeneity is present. | | | | | | | | | | |

Table 8 | Coefficients for second-best ranked trait classes

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | | | | |
| **[First stage]**  **GPI 2011**  **0.12\*\*\***  (0.03) |  | | | | | | | | | | |
|  | **Agronomic** | | | **Abiotic stress** | | **Biotic stress** | | **Morphological** | | **Quality** | |
|  | Probit | 2SLS | | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS |
| **GPI** | -0.05  (1.01) | | 1.50  (1.40) | - | - | 0.12  (0.21) | 0.73  (1.03) | -0.91  (1.01) | 3.02  (2.35) | -1.07  (2.50) | **-4.84\***  (3.0) |
| Cereal | 0.50  (0.82) | | -0.08  (0.06) | - | - | **-0.38\***  (0.21) | **-0.09\*\***  (0.04) | 1.02  (0.93) | -0.009  (0.10) | 0.33  (1.86) | 0.17  (0.13) |
| Legumes | 1.55  (1.00) | | -0.001  (0.07) | - | - | -0.28  (0.22) | -0.01  (0.05) | 0.63  (1.16) | **0.20\***  (0.12) | 0.11  (2.04) | -0.17  (0.15) |
| Female Ag. PDM\*\* | -0.30  (0.41) | | -0.02  (0.04) | - | - | 0.17  (0.14) | 0.002  (0.03) | -0.04  (0.65) | -0.04  (0.07) | 0.36  (0.88) | 0.06  (0.09) |
| Women hours worked | -0.001  (0.006) | | 0.0006  (0.0007) | - | - | -0.004  (0.003) | 0.0001  (0.0005) | -0.01  (0.01) | **0.002\***  (0.001) | **0.04\*\***  (0.02) | **-0.002\***  (0.001) |
| *Time dummy* | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (village)* | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak instruments | - | | 11.29\*\*\* | - | - | - | 11.29\*\*\* | - | 11.29\*\*\* | - | 11.29\*\*\* |
| Wu-Hausman | - | | 1.01 | - | - | - | 1.79 | - | 2.34 | - | 4.82\*\* |
| Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*).  (\*\*) Ag.PDM = Agricultural primary decision maker.Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the village level computed using the R package {*sandwich*} by Zeileis 2006. Weak instruments: this is an F-test on the instruments in the first stage. The null hypothesis is that the instrument is weak, so a rejection means the instrument chosen is not weak. Wu-Hausman: this tests the consistency of the OLS estimates under the assumption that the IV is consistent. When it is rejected, it means OLS is not consistent, suggesting endogeneity is present. | | | | | | | | | | | |

1. **Discussion**

We hypothesized that changes in top-ranked trait choices by primary decision makers related to changes in women’s empowerment at the district level. Results confirm this statement, with an increase in the probability of choosing quality traits for primary decision makers. We questioned whether the relation would be reinforced by the sex of the primary decision maker and the number of hours female workers spent on the crop plot. We find no direct relation between the gender of the primary decision maker and the probability of a shift in trait preferences with the closing of the empowerment gap, while we do observe a reinforcing mechanism acting through the role of women in the crop plots.

In a social environment where women gradually achieve more agency in terms of access and management of agricultural inputs and succeed in speaking-up and allocating time more freely, varietal choices for both legumes and cereals are influenced. Higher attention is paid not solely to quality traits which are traditionally attributed to women (such as good taste and easiness of processing), but also to market demand. The reduction of an immobilizing collective social structure seems to enable an increase in the choice space of primary decision makers (Polar et al. 2021b), independently from their gender. The closing of the empowerment gap contributes to a redefinition of the structure of preferences, following the typology framework of McDougall et al. 2022. The fact that the gender parity index discourages the ranking of quality traits in second-best positions further confirm this trend.

In looking for reinforcing channels, we find that women role trumps gender in boosting the relation between preferences and empowerment. This is not entirely surprising: a blossoming recent literature looks at the crop management, considering beyond gender women roles and knowledge in crop decision-making (Doss et al. 2018; Quisumbing et al. 2014; Okonya et al. 2021).

These findings highlight a close-knit relationship between women empowerment and varietal choices: efforts in client-oriented breeding should acknowledge this relation, while thriving for gendered technology development. In developing tools and methods for trait ranking and data collection, cross-functional breeding teams should recognize the role of women’s empowerment and the overall collective social structure in the area under analysis. Following Polar et al. 2021b, our findings call for a new framework for “socio-genomic” research that recognizes that technical decisions are contingent on social categories like gender in ways that are not self-evident (Goisauf et al. 2020).

1. **Conclusions**

With the concept of women’s empowerment being pivotal for to international development practice, client-oriented breeding cannot afford to ignore the relation between patterns of gender empowerment gap and varietal choices. Our study sheds a light on this relation by investigating how the gender parity index (one of metrics of the women’s empowerment in agriculture index, or WEAI) correlate with first and second top-ranked trait preferences among cereal and legume growers in Bangladesh. We find that a closing of the empowerment gap correlates positively and significantly with the probability of primary decision makers to choose quality traits over yield. We further question whether primary decision makers’ gender or the number of hours female workers spent on the crop plot act as reinforcing channels in this relation. We find no evidence for the gender of the primary decision maker, while we do observe reinforcing mechanism acting through the time women spend on cereal and legume plots. We explain these findings in terms of changes in the collective social structure, which allow women to retain more agency over agricultural inputs and the overall agricultural decisions, expanding their set of choices and their advocacy power within the households.

Our analysis is descriptive in nature and suffers from some methodological shortcomings: first and foremost, we have no intra-household trait preference data. Despite being a remarkable effort, the Bangladesh Integrated Household Survey collects intra-household data only in terms of women’s empowerment index. Trait preferences are asked to the primary decision maker alone and this prevents us from further investigating any intra-household mechanisms over time. Furthermore, the module collecting information on trait preferences was designed for being answered by the male primary decision maker. The women who answered the module were interviewed because the men primary decision maker was not available: this makes our sample hardly representative.

Nonetheless, our findings are indicative of how gendered analysis enables recognition of patterns of social structures and their consequences for client-oriented breeding. A balanced approach to trait ranking and ultimately breeding product profiling requires careful consideration of the elements of women’s empowerment and choice.

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**Appendix**

Table A1 | Indicators belonging to the 5 domains of women’s empowerment (Alkire et al. 2013, p. 74)

|  |  |  |
| --- | --- | --- |
| **Domain** | **Indicator** | **Weights** |
| *Production* | Input in productive decisions | 1/10 |
|  | Autonomy in production | 1/10 |
| *Resources* | Ownership of assets | 1/15 |
|  | Purchase, trade, or transfer of assets | 1/15 |
|  | Access to and decisions on credit | 1/15 |
| *Income* | Control over use of income | 1/5 |
| Leadership | Group member | 1/10 |
|  | Speaking in public | 1/10 |
| Time | Workload  Leisure | 1/10  1/10 |
|  |  |  |

Fig. A1 | Respondents meeting the acceptable level of empowerment in (a) leisure time, (b) ability to speak in public, (c) decision on incomes and resources and (d) ability to decide on agricultural inputs, sex disaggregated, years 2011 and 2018

Chart, box and whisker chart

Description automatically generated

Table A2 | Trait preferences expressed by households, per harvesting season, per year and per crop group

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | | | | **2018** | | | |
|  | *Aman* | *Aus* | *Boro* | *Annual* | *Aman* | *Aus* | *Boro* | *Annual* |
| Cereal | 1652 | 228 | 1691 | 1 | 1728 | 221 | 1740 | 2 |
| Fiber | 12 | 295 | 13 | 6 | 8 | 292 | 10 | 2 |
| Fruits | 4 | - | 5 | 41 | - | - | 7 | 38 |
| Oil | 34 | 55 | 216 | - | 10 | 19 | 183 | - |
| Other | 24 | 9 | 207 | 69 | 11 | 9 | 191 | 62 |
| Legumes | 20 | 26 | 262 | 6 | 22 | 10 | 256 | 1 |
| Spices | 20 | 27 | 239 | 30 | 14 | 18 | 208 | 15 |
| Vegetables | 95 | 53 | 160 | 35 | 94 | 63 | 173 | 29 |
| **Total** | 1861 | 693 | 2793 | 188 | 1887 | 632 | 2768 | 149 |

Fig. A2 | First most preferred seed trait in each crop group, per gender and year

Chart, bar chart

Description automatically generated

Fig. A3 | Second most preferred seed trait in each crop group, per gender and year

Chart

Description automatically generated

Fig. A4 | First most preferred trait class in each crop group, per gender and year

Chart, bar chart

Description automatically generated

Fig. A5 | Second most preferred trait class in each crop group, per gender and year

Chart, bar chart

Description automatically generated

If we look at the number of hours declared by the respondents in the survey, we find some interesting patterns depending on whether the primary decision maker declaring the hours is a woman or a man (Figure A5 and A6 in the Appendix). In case of men primary decision makers, men are more engaged in working on legumes, beyond cereals which are by far the most occupying crop group both in 2015 and 2018. When primary decision makers are women, men are relatively less engaged in all the three crop productions. Between 2015 and 2018, we see a reduction in hours worked by men in legumes plots in case of women primary decision makers, while the trend is reversed for male primary decision makers.

The number of hours declared to be worked by women (Fig. 5) are on average less with respect to those declared to be worked by men, for all crops. If the trend is relatively unchanged for cereal, we see a considerable reduction in the hours worked by women on legumes and vegetables between 2015 and 2018 - even more so, when the primary decision maker declaring the hours is a woman.

Fig. 4 | Number of hours worked by men in cereal and legumes plots, for male and female ag. primary decision makers (2015 – 2018)

![Chart, box and whisker chart

Description automatically generated]()

Fig. 5 | Number of hours worked by women in cereal and legumes plots, for male and female ag. primary decision makers (2015 – 2018)

![Chart, box and whisker chart

Description automatically generated]()

Changes in empowerment gaps within the household (i.e., WE variable) seem to relate significantly with changes in the most preferred class of traits. However, the sign as well as the magnitude of the relation varies with the group of crops harvested.

For cereals, the major crop group in Bangladesh, households where the empowerment gap .

Table 6 | Coefficient for top ranked trait class, probit model with time fixed effect (marginal effects)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | |
|  | **Agronomic** | **Abiotic stress** | **Biotic stress** | **Morphological** | **Quality** |
| **GPI** | 2.09  (2.17) | - | - | **1.73\*\***  (0.77) | **-4.02\*\***  (1.98) |
| Cereal | **0.89\*\*\***  (0.25) | - | - | **0.97\*\*\***  (0.13) | **-0.97\*\*\***  (0.02) |
| Legumes | 0.31  (0.22) | - | - | **0.99\*\*\***  (0.0001) | **-0.51\*\***  (0.23) |
| Female Ag. PDM\*\* | 0.17  (0.21) | - | - | **0.99\*\*\***  (0.001) | **0.24\*\*\***  (0.10) |
| Women hours worked | **0.02\*\***  (0.01) | - | - | -0.03  (0.01) | **-0.02\***  (0.01) |
|  |  |  |  |  |  |
| **GPI interacted with\*** |  |  |  |  |  |
| Cereal | -1.01  (1.84) | - | - | -1.08  (0.78) | 2.28  (1.46) |
| Legumes | -1.30  (1.90) | - | - | -1.18  (0.78) | **2.87\***  (1.48) |
| Female Ag. PDM\*\* | -0.23  (0.64) | - | - | **-0.67\*\*\***  (0.24) | 0.87  (0.79) |
| Women hours worked | **-0.03\*\***  (0.01) | - | - | 0.003  (0.001) | **0.02\***  (0.01) |
|  |  |  |  |  |  |
| *Time dummy* | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (cluster village)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| AIC | 611 | - | - | 541 | 173 |
| Probit model for trait class (TC) with time fixed effects. (\*) GPI is interacted with the variables that follow. (*\*\*) Ag.PDM = Agricultural primary decision maker.* Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. Coefficients are expressed as marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the village level computed using the R package {*sandwich*} by Zeileis (2006). (+) Controls include literacy level and age of Ag. PDM and season harvested. | | | | | |

Table 7 | Coefficient for second best ranked trait class for cereals, legumes and vegetables, probit model (marginal effects)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | |
|  | **Agronomic** | **Abiotic stress** | **Biotic stress** | **Morphological** | **Quality** |
| **GPI** | -0.05  (1.01) | - | 0.12  (0.21) | -0.91  (1.01) | -1.07  (2.50) |
| Cereal | **-0.98\*\*\***  (0.04) | - | 0.20  (0.25) | **-0.90\*\*\***  (0.14) | -0.19  (0.82) |
| Legumes | -0.38  (0.38) | - | **0.99\*\*\***  (0.03) | -0.17  (0.15) | -0.21  (2.48) |
| Female Ag. PDM\*\* | **0.90\***  (0.52) | - | -0.03  (0.03) | 0.04  (0.60) | -0.37  (1.04) |
| Women hours worked | 0.001  (0.006) | - | 0.003  (0.002) | 0.01  (0.01) | **-0.04\*\***  (0.02) |
|  |  |  |  |  |  |
| **GPI interacted with\*** |  |  |  |  |  |
| Cereal | 0.50  (0.82) | - | **-0.38\***  (0.21) | 1.02  (0.93) | 0.33  (1.86) |
| Legumes | 1.55  (1.00) | - | -0.28  (0.22) | 0.63  (1.16) | 0.11  (2.04) |
| Female Ag. PDM\*\* | -0.30  (0.41) | - | 0.17  (0.14) | -0.04  (0.65) | 0.36  (0.88) |
| Women hours worked | -0.001  (0.006) | - | -0.004  (0.003) | -0.01  (0.01) | **0.04\*\***  (0.02) |
|  |  |  |  |  |  |
| *Time dummy* | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (cluster village)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| AIC | 247 | - | 143 | 489 | 612 |
| Probit model for trait class (TC) with time fixed effects. (\*) GPI is interacted with the variables that follow. (*\*\*) Ag.PDM = Agricultural primary decision maker.* Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. Coefficients are expressed as marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the village level computed using the R package {*sandwich*} by Zeileis (2006). (+) Controls include literacy level and age of Ag. PDM and season harvested. | | | | | |

Table A3 | Coefficient for first trait preference, fixed effects Poisson model

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | |
|  | **First trait preference\*** | | | | | | | |
|  | **Cereal** | **Fiber** | **Legumes** | **Oil** | **Spices** | **Vegetables** | **Fruits+** | **Other+** |
|  |  |  |  |  |  |  |  |  |
| **GPI** | **2.12\*\*\***  (0.27) | **1.81\*\***  (0.79) | **2.94\*\*\***  (0.71) | -0.84  (0.92) | **3.46\*\*\***  (1.08) | **2.27\*\*\***  (0.87) | -1.26  (4.30) | **1.24\***  (0.74) |
|  |  |  |  |  |  |  |  |  |
| Sex of Ag.PDM | -0.16\*\*  (0.07) | 0.56\*\*\*  (0.16) | -0.33\*  (0.18) | -0.80\*\*  (0.42) | 0.10  (0.35) | -1.37\*\*\*  (0.46) | - | - |
| Age of Ag.PDM | -0.004  (0.006) | -0.001  (0.002) | -0.003  (0.001) | -0.05\*  (0.002) | -0.003  (0.002) | -0.007\*\*\*  (0.002) | 0.002  (0.005) | 0.0008  (0.002) |
| Literacy of Ag.PDM  *(baseline: illiterate)*  can sign only  can read only  can read and write | 0.04\*\*  (0.02)  -1.48\*\*  (0.70)  -0.01  (0.02) | -0.04  (0.07)  -  -0.13\*  (0.07) | -0.01  (0.06)  -  -0.02  (0.06) | 0.25\*\*\*  (0.08)  -  -0.20\*\*  (0.08) | 0.15\*  (0.07)  -  0.05  (0.07) | 0.14\*\*  (0.07)  -  0.08  (0.07) | 0.43  (0.32)  -  0.60\*\*  (0.30) | 0.52\*\*\*  (0.10)  -  0.46\*\*\*  (0.10) |
| *District FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Year FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Individual FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| AIC |  |  |  |  |  |  |  |  |
| Observations | 6785 | 584 | 552 | 483 | 534 | 672 | 91 | 557 |
| \*Fixed effect Poisson model for trait frequency (TF) in each crop group.  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). In parenthesis for all models, standard error of the mean. + For these crop groups, no interviewed agricultural primary decision makers were female.  Year fixed effects (Year FE) control for year – specific differences. Fixed effects at the individual’s level (Individual FE) clean the estimation from all time constant demographic, skill, and attitudinal differences. Individual fixed effects also capture average differences in soil quality and climate across farms. Fixed effects at the district level (District FE) controls for district – specific differences. | | | | | | | | |

Table A4 | Coefficient for first trait preference, fixed effects Poisson model

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | |
|  | **Second trait preference\*** | | | | | | | |
|  | **Cereal** | **Fiber** | **Legumes** | **Oil** | **Spices** | **Vegetables** | **Fruits+** | **Other+** |
|  |  |  |  |  |  |  |  |  |
| **GPI** | **0.89\*\*\***  (0.14) | 0.30  (0.40) | **-1.47\***  (0.86) | 0.69  (0.46) | **1.33\*\*\***  (0.52) | -0.59  (0.52) | **-6.17\*\*\***  (2.29) | -0.58  (0.58) |
|  |  |  |  |  |  |  |  |  |
| Sex of Ag.PDM | 0.03  (0.04) | -0.13  (0.12) | -0.30  (0.19) | 0.05  (0.14) | 0.17  (0.42) | 0.28\*\*  (0.16) | - | - |
| Age of Ag.PDM | -0.0005\*  (0.003) | -0.0009  (0.001) | -0.0003  (0.001) | -0.0004  (0.001) | -0.001  (0.001) | 0.004\*\*\*  (0.001) | -0.006  (0.004) | 0.002\*  (0.001) |
| Literacy of Ag.PDM  *(baseline: illiterate)*  can sign only  can read only  can read and write | -0.01  (0.01)  -1.19\*\*\*  (0.40)  -0.02\*\*  (0.01) | -0.03  (0.04)  -  -0.03  (0.05) | -0.13\*  (0.06)  -  -0.03  (0.06) | -0.05  (0.05)  -  0.03  (0.05) | -0.06  (0.05)  -  0.03  (0.05) | 0.007  (0.04)  -  0.03  (0.04) | 0.28  (0.21)  -  -0.10  (0.20) | -0.003  (0.05)  -  -0.05  (0.05) |
| *District FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Year FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Individual FE* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| AIC |  |  |  |  |  |  |  |  |
| Observations | 6785 | 584 | 552 | 483 | 534 | 672 | 91 | 557 |
| \*Fixed effect Poisson model for trait frequency (TF) in each crop group.  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). In parenthesis for all models, standard error of the mean. + For these crop groups, no interviewed agricultural primary decision makers were female.  Year fixed effects (Year FE) control for year – specific differences. Fixed effects at the individual’s level (Individual FE) clean the estimation from all time constant demographic, skill, and attitudinal differences. Individual fixed effects also capture average differences in soil quality and climate across farms. Fixed effects at the district level (District FE) controls for district – specific differences. | | | | | | | | |

Table A8 | Coefficient for first most preferred trait class for cereals and legumes, pooled probit model (marginal effects)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | *Dependent variable* | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **First most preferred trait class\*** | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Agronomic** | | | | | **Abiotic stress** | | | | | | **Biotic stress** | | | | **Morphological** | | | | | | **Quality** | | | | |
| **Cereal (n=538)** | |  | |  | |  | | |  | | |  | | |  | |  | |  | | |  | | |  | | |
|  | **WEAI** | | -1.93  (1.80) | | -1.70  (1.81) | | | - | | - | | | | - | | - | | **-1.06\*\*\***  (0.42) | | | **-0.25\*\***  (0.11) | | **4.06\*\***  (1.53) | | | | **3.84\*\***  (1.88) | |
|  | **Female Ag. PDM** | | - | | -0.06  (0.12) | | | - | | - | | | | - | | - | | - | | | 0.002  (0.004) | | - | | | | 0.05  (0.10) | |
|  | **Women hours** | | - | | -0.0002  (0.001) | | | - | | - | | | | - | | - | | - | | | 0.0001  (0.0005) | | - | | | | -0.0004  (0.001) | |
| **Legumes and vegetables (n=53)** | |  | |  | |  | | |  | | |  | | |  | |  | |  | | |  | | |  | | |
|  | **WEAI** | | -0.52  (5.79) | | 0.69  (2.49) | | | - | | - | | | | - | | - | | - | | | - | | 0.62  (4.78) | | | | -0.07  (0.28) | |
|  | **Female Ag. PDM** | | - | | 1.33  (0.96) | | | - | | - | | | | - | | - | | - | | | - | | - | | | | -0.001  (0.01) | |
|  | **Women hours** | | - | | -0.002  (0.004) | | | - | | - | | | | - | | - | | - | | | - | | - | | | | 0.0003  (0.0002) | |
|  | *Time dummy* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
|  | *Controls+* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
|  | *Robust SE* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
| \*Linear model for trait class (TC) for cereal and legumes. *\*\*Ag.PDM = Agricultural primary decision maker.*  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. Coefficients are expressed as marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the district level computed using the R package {*sandwich*} by Zeileis (2006). (+) Controls include literacy level and age of Ag. PDM and season harvested. | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table A9 | Coefficient for second most preferred trait class for cereals and legumes, pooled probit model (marginal effects)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | *Dependent variable* | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Second most preferred trait class\*** | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Agronomic** | | | | | **Abiotic stress** | | | | | **Biotic stress** | | | | **Morphological** | | | | | | **Quality** | | | | |
| **Cereal (n=538)** | |  | |  | |  | | |  | | |  | |  | |  | |  | | |  | | |  | | |
|  | **WEAI** | | **2.01\***  (1.07) | | **1.32\***  (0.75) | | | - | | - | | | **1.27\***  (0.77) | | **0.67\***  (0.41) | | 0.31  (1.21) | | | 0.49  (1.18) | | **-3.01\***  (1.77) | | | | **-2.92\***  (1.67) | |
|  | **WEAI\*Female Ag. PDM** | | - | | -0.01  (0.05) | | | - | | - | | | - | | 0.02  (0.01) | | - | | | 0.01  (0.12) | | - | | | | -0.02  (0.12) | |
|  | **WEAI\*Women hours** | | - | | **-0.001\*\*\***  (0.0008) | | | - | | - | | | - | | -0.0006  (0.0002) | | - | | | -0.001  (0.001) | | - | | | | **0.003\*\***  (0.001) | |
| **Legumes and vegetables (n=76)** | |  | |  | |  | | |  | | |  | |  | |  | |  | | |  | | |  | | |
|  | **WEAI** | | - | | - | | | - | | - | | | - | | - | | -1.05  (0.75) | | | 5.15  (5.07) | | -10.8  (8.52) | | | | **-11.56\*\***  (6.29) | |
|  | **WEAI\*Female Ag. PDM** | | - | | - | | | - | | - | | | - | | - | | - | | | -4.89  (4.60) | |  | | | | - | |
|  | **WEAI\*Women hours** | | - | | - | | | - | | - | | | - | | - | | - | | | -2.29  (3.60) | |  | | | | 0.007  (0.01) | |
|  | *Time dummy* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
|  | *Controls+* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
|  | *Robust SE* | | ✓ | | ✓ | | ✓ | | | | ✓ | | ✓ | | ✓ | | ✓ | | ✓ | | | ✓ | | | ✓ | | |
| \*Linear model for trait class (TC) for cereal and legumes. *\*\*Ag.PDM = Agricultural primary decision maker.*  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*). Time dummies are inserted for the year 2015 and 2018 to account for the pooled cross-sectional nature of the data. Coefficients are expressed as marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the district level computed using the R package {*sandwich*} by Zeileis (2006). (+) Controls include literacy level and age of Ag. PDM and season harvested. | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 3 | Coefficient for most preferred trait class in each crop group, fixed effects Probit model (reported as average marginal effects)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | *Dependent variable* | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **First preferred trait class\*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Agronomic** | | | | | | **Abiotic stress** | | | | | | **Biotic stress** | | | | | | **Morphological** | | | | | **Quality** | | | | | |
| **Cereal (n=6785)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | **-0.42\*\*\***  (0.16) | | | **-0.46\*\*\***  (0.17) | | | 0.04  (0.03) | | | 0.04  (0.04) | | | 0.01  (0.02) | | | 0.01  (0.02) | | | -0.08  (0.08) | | -0.08  (0.08) | | | **0.44\*\*\***  (0.16) | | | | **0.48\*\*\***  (0.16) | |
|  | **WEAI\*Gender Ag.PDM** | | **-1.44\*\***  (0.70) | | | - | | | -0.01  (0.02) | | | - | | | 0.005  (0.03) | | | - | | | -0.11  (0.10) | | - | | | **1.25\*\***  (0.60) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | -0.09  (0.36) | | | - | | | -0.007  (0.02) | | | - | | | 0.006  (0.01) | | | - | | 0.04  (0.21) | | | - | | | | 0.05  (0.31) | |
| **Fiber (n=584)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | -0.47  (0.41) | | | -0.38  (0.41) | | | - | | | - | | | - | | | - | | | -0.30  (0.23) | | -0.35  (0.24) | | | **0.65\***  (0.39) | | | | 0.62  (0.41) | |
|  | **WEAI\*Gender Ag.PDM** | | **7.98\*\*\***  (1.96) | | | - | | | - | | | - | | | - | | | - | | | 0.09  (0.15) | | - | | | **-5.96\*\*\***  (1.67) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | 0.92  (0.75) | | | - | | | - | | | - | | | - | | | - | | 0.003  (0.16) | | | - | | | | -0.98  (0.64) | |
| **Legumes (n=552)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | **-0.09**  (0.65) | | | -0.21  (0.66) | | | 10.57  (9.10) | | | - | | | - | | | - | | | -0.97  (1.71) | | -1.56  (1.91) | | | 0.50  (0.60) | | | | 0.92  (0.67) | |
|  | **WEAI\*Gender Ag.PDM** | | **76.86\*\*\***  (16.98) | | | - | | | 0.002  (0.03) | | | - | | | - | | | - | | | **-1.46\***  (0.80) | | - | | | -1.25  (0.96) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | 0.38  (0.55) | | | - | | | - | | | - | | | - | | | - | | 0.08  (0.10) | | | - | | | | -0.92  (0.59) | |
| **Oil (n=483)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | 0.39  (0.49) | | | 0.34  (0.51) | | | - | | | - | | | - | | | -0.91  (0.75) | | | - | | 0.0005  (0.07) | | | -0.22  (0.46) | | | | -0.22  (0.48) | |
|  | **WEAI\*Gender Ag.PDM** | | -0.30  (0.54) | | | - | | | - | | | - | | | - | | | - | | | - | | - | | | 0.40  (0.53) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | -0.15  (0.66) | | | - | | | - | | | - | | | -3.96  (3.17) | | | - | | 0.21  (0.47) | | | - | | | | 0.12  (0.66) | |
| **Spices (n=534)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | **-1.24\***  (0.76) | | | **-1.29\***  (0.76) | | | - | | | - | | | - | | | - | | | - | | 5.31  (4.28) | | | **1.16\***  (0.71) | | | | **1.20\***  (0.71) | |
|  | **WEAI\*Gender Ag.PDM** | | -5.50  (4.36) | | | - | | | - | | | - | | | - | | | - | | | - | | - | | | 4.94  (4.02) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | 1.32  (1.82) | | | - | | | - | | | - | | | - | | | - | | -0.43  (0.55) | | | - | | | | -1.01  (1.74) | |
| **Vegetables (n=672)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | -0.43  (0.65) | | | -0.39  (0.68) | | | - | | | - | | | - | | | - | | | - | | -0.51  (0.34) | | | **1.11\*\***  (0.64) | | | | **1.15\***  (0.66) | |
|  | **WEAI\*Gender Ag.PDM** | | -0.61  (1.33) | | | - | | | - | | | - | | | - | | | - | | | - | | - | | | 0.46  (1.21) | | | | - | |
|  | **WEAI\*Women managed** | | - | | | -1.42  (1.56) | | | - | | | - | | | - | | | - | | | - | | -0.04  (0.30) | | |  | | | | 0.49  (1.35) | |
| **Fruits+ (n=91)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | -0.02  (0.35) | | | 0.54  (3.13) | | | - | | | - | | | - | | | - | | | - | | **-2.48\***  (1.52) | | | -0.47  (2.89) | | | | -0.42  (2.40) | |
|  | **WEAI\*Women managed** | | - | | | **-1.63\*\*\***  (4.36) | | | - | | | - | | | - | | | - | | | - | | **-2.89\*\***  (1.43) | | | - | | | | **17.67\***  (10.8) | |
| **Other+ (n=557)** | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | **WEAI** | | **-1.15\*\***  (0.64) | | | **-1.17\***  (0.64) | | | - | | | - | | | - | | | - | | | -5.52  (5.65) | | 0.13  (0.18) | | | 0.12  (0.17) | | | | **1.17\***  (0.69) | |
|  | **WEAI\*Women managed** | | - | | | 0.11  (1.63) | | | - | | | - | | | - | | | - | | | - | | **-3.01\***  (1.85) | | | - | | | | 1.64  (1.56) | |
|  |  | |  | | |  | | |  | | |  | | |  | | |  | | |  | |  | | |  | | | |  | |
|  | *District FE* | | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | ✓ | | | |
|  | *Year FE* | | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | ✓ | | | |
|  | *Individual FE* | | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | ✓ | | | |
| \*Fixed effect Poisson model for trait class (TC) in each crop group. *\*\*Ag.PDM = Agricultural primary decision maker.*  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*).+In this subset, no interviewed agricultural primary decision makers were female. Models are computed using the *feglm* command from the R package {*alpaca*} by Stamman 2018. The incidental parameter bias problem (Neyman and Scott, 1948) is addressed applying a post-estimation routine derived by Fernández-Val and Weidner (2016). Coefficients are expressed as average marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the district level computed using the R package {*sandwich*} by Zeileis (2006). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 4 | Coefficient for second most preferred trait class in each crop group, fixed effects Probit model (reported as average marginal effects)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | *Dependent variable* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Second most preferred trait class\*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | **Agronomic** | | | | | | | **Abiotic stress** | | | | | | | | **Biotic stress** | | | | | | **Morphological** | | | | | | | | **Quality** | | | | | | |
| **Cereal (n=6785)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | 0.07  (0.11) | | | 0.04  (0.11) | | | | 0.07  (0.06) | | | 0.06  (0.05) | | | | | -0.005  (0.08) | | | 0.02  (0.08) | | | **-0.65\*\*\***  (0.15) | | | | **-0.67\*\*\***  (0.15) | | | **0.73\*\*\***  (0.17) | | | | | **0.74\*\*\***  (0.17) | | |
|  | **WEAI\*Gender** | | **-0.72\***  (0.39) | | | - | | | | **-4.21\*\***  (1.71) | | | - | | | | | 0.12  (0.23) | | | - | | | -0.008  (0.53) | | | | - | | | **-0.70\*\***  (0.18) | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | -0.01  (0.27) | | | | - | | | -0.17  (0.17) | | | | | - | | | -0.33  (0.24) | | | - | | | | 0.15  (0.38) | | | - | | | | | 0.28  (0.40) | | |
| **Fiber (n=584)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | 0.38  (0.33) | | | 0.39  (0.22) | | | | - | | | - | | | | | **2.05\***  (1.19) | | | 0.59  (0.68) | | | **-1.96\*\*\***  (0.47) | | | | **-1.98\*\*\***  (0.45) | | | **1.15\*\***  (0.49) | | | | | **1.28\*\*\***  (0.47) | | |
|  | **WEAI\*Gender** | | -0.23  (0.24) | | | - | | | | - | | | - | | | | | **-2.69\***  (1.56) | | | - | | | -0.74  (0.94) | | | | - | | | **4.93\*\*\***  (0.98) | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | -0.65  (0.56) | | | | - | | | - | | | | | - | | | 0.14  (7.10) | | | - | | | | -0.55  (1.05) | | | - | | | | | 1.72  (1.50) | | |
| **Legumes (n=552)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | - | | | **-1.39\***  (0.85) | | | | - | | | - | | | | | - | | | - | | | 0.43  (0.52) | | | | 0.74  (0.58) | | | -0.18  (0.61) | | | | | -0.17  (0.36) | | |
|  | **WEAI\*Gender** | | - | | | - | | | | - | | | - | | | | | - | | | - | | | **-11.1\*\*\***  (3.14) | | | | - | | | **2.37\***  (1.41) | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | -0.20  (0.45) | | | | - | | | - | | | | | - | | | - | | | - | | | | -0.20  (0.77) | | | - | | | | | -0.62  (0.70) | | |
| **Oil (n=483)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | - | | | **-0.92\***  (0.57) | | | | - | | | - | | | | | - | | | - | | | -0.40  (0.38) | | | | -0.29  (0.38) | | | **1.57\***  (0.92) | | | | | 0.56  (0.52) | | |
|  | **WEAI\*Gender** | | - | | | - | | | | - | | | - | | | | | - | | | - | | | - | | | | - | | | - | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | -2.55  (1.81) | | | | - | | | - | | | | | - | | | - | | | - | | | | -0.69  (0.97) | | | - | | | | | 1.22  (1.42) | | |
| **Spices (n=534)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | - | | | -0.05  (0.43) | | | | - | | | - | | | | | - | | | - | | | - | | | | **-1.45\*\*\***  (0.61) | | | - | | | | | **1.51\*\*\***  (0.64) | | |
|  | **WEAI\*Gender** | | - | | | - | | | | - | | | - | | | | | - | | | - | | | - | | | | - | | | - | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | -0.43  (0.71) | | | | - | | | - | | | | | - | | | - | | | - | | | | -1.29  (1.77) | | | - | | | | | **3.45\***  (2.11) | | |
| **Vegetables (n=672)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | - | | | 0.02  (0.35) | | | | - | | | - | | | | | - | | | 0.46  (0.31) | | | -0.41  (0.42) | | | | -0.38  (0.42) | | | -0.35  (0.52) | | | | | -0.29  (0.52) | | |
|  | **WEAI\*Gender** | | - | | | - | | | | - | | | - | | | | | - | | | - | | | 0.59  (0.98) | | | | - | | | - | | | | | - | | |
|  | **WEAI\*Women managed** | | - | | | **7.52\***  (4.17) | | | | - | | | - | | | | | - | | | -0.08  (0.79) | | | - | | | | 3.56  (7.03) | | | - | | | | | **-4.87\***  (2.72) | | |
| **Fruits+ (n=91)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | 4.41  (8.35) | | | **-3.41\*\*\***  (4.75) | | | | - | | | - | | | | | - | | | - | | | 0.22  (1.80) | | | | -0.47  (1.91) | | | -0.36  (0.99) | | | | | -0.71  (2.87) | | |
|  | **WEAI\*Women managed** | | - | | | **-1.52\*\*\***  (2.12) | | | | - | | | - | | | | | - | | | - | | | - | | | | 20.83  (20.27) | | | - | | | | | **-9.08\*\***  (1.60) | | |
| **Other+ (n=557)** | |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |
|  | **WEAI** | | 0.70  (0.73) | | | 0.71  (0.73) | | | | - | | | - | | | | | 39.29  (31.58) | | | 39.07  (31.40) | | | -0.76  (0.60) | | | | -0.63  (0.60) | | | -0.26  (0.69) | | | | | -0.40  (0.70) | | |
|  | **WEAI\*Women managed** | | - | | | 0.31  (1.55) | | | | - | | | - | | | | | - | | | 0.14  (0.50) | | | - | | | | -1.26  (1.93) | | | - | | | | | 1.11  (2.15) | | |
|  |  | | |  | | |  | | | |  | | | |  | | | |  | | |  | | |  | | | |  | | | |  | | | |  | | |
|  | *District FE* | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | | | | ✓ | | | ✓ | | | ✓ | | | | ✓ | | | | ✓ | | | |
|  | *Year FE* | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | | | | ✓ | | | ✓ | | | ✓ | | | | ✓ | | | | ✓ | | | |
|  | *Individual FE* | | ✓ | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | | | | ✓ | | | ✓ | | | ✓ | | | | ✓ | | | | ✓ | | | |
| \*Fixed effect Poisson model for trait class (TC) in each crop group. *\*\*Ag.PDM = Agricultural primary decision maker.*  Significance level: p-value <0.01 (\*\*\*); < 0.05(\*\*); < 0.10 (\*).+In this subset, no interviewed agricultural primary decision makers were female. Models are computed using the *feglm* command from the R package {*alpaca*} by Stamman 2018. The incidental parameter bias problem (Neyman and Scott, 1948) is addressed applying a post-estimation routine derived by Fernández-Val and Weidner (2016). Coefficients are expressed as average marginal effects. In parenthesis for all models, heteroskedasticity-consistent robust standard errors of the mean, clustered at the district level computed using the R package {*sandwich*} by Zeileis (2006). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

1. This draft is preliminary. Please do not cite nor circulate without authors’ consent. We would like to thank Agnes Quisumbing, Greg Seymour, and Kalyani Raghunathan for their insights on the WEAI tools. Finally, we thank IAFFE 2022 Conference participants for their eye-opening feedback on an early version of this work. [↑](#footnote-ref-1)
2. A clarifying example: \*\*.1 is marked as the original household interviewed in the first round (2011), also defined as parent household. \*\*.2, \*\*.3 are new households formed after the split. [↑](#footnote-ref-2)
3. The term spouse is adopted from Seymour 2017. It should be understood throughout the article to refer to either a spouse or partner, although common law marriages in Bangladesh are unusual. [↑](#footnote-ref-3)
4. https://weai.ifpri.info/weai-resource-center/guides-and-instruments/ [↑](#footnote-ref-4)
5. Despite the numerosity of plots allocated to fibre production, this crop group has not been considered in this study because fibre production is solely market oriented. [↑](#footnote-ref-5)
6. The recall period goes from December 1st, 2013, to November 30th, 2014, for the 2015 dataset and from December 1st, 2016, to November 30th, 2017, for the 2018 dataset. Hours are enumerated on the following activities: land preparation, planting, briquette fertilizer application, other fertilizer application, pesticide application, weeding, irrigation, harvest, carrying from farm to home, animal used for threshing, machine/tractors used for threshing, threshing, drying crop, sorting, packaging. [↑](#footnote-ref-6)