**Women’s empowerment and trait preferences for cereals and pulses in Bangladesh[[1]](#footnote-1)**

Occelli, M.1\* and H. Tufan1

1School of Integrative Plant Sciences, Cornell University (Ithaca, USA)

\*mo386@cornell.edu

**Abstract**

*Dearth of information exists on women’s involvement in agricultural production in Bangladesh with a prevailing claim that they are involved only in the post-harvest processing of crops.*

**Keywords:** empowerment gap, trait preference, WEAI, BIHS, Bangladesh

1. **Introduction**

RQ: Observed changes in preferred traits by primary agricultural decision makers are related to changes in women’s empowerment at the district level? Is the relationship enforced by the fact that the primary decision maker is a woman or by the numbers of hours female workers spend on the plot?

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

[Present TOC which links preferred traits with women’s empowerment index in agriculture]

* 1. **Women’s participation in the production of cereals, pulses, and vegetables in Bangladesh**

[Describe women’s role in agriculture in Bangladesh especially related to cereals, pulses and vegetables]

1. **Data**
   1. **Bangladesh Integrated Household Survey (BIHS)**

This 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 panel 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 (thus employing all the 5,076 observations). Table 1 summarises relevant household characteristics for each of the three BIHS rounds.

Table 1 | Summary of household characteristics for each BIHS round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Panel | Round 1 (2011) | Round 2 (2015) | Round 3 (2018) |
| Women among Ag.PDM\* (%) | 7% |  | 7,3% | 6,2% |
| Age of Ag.PDM |  |  |  |  |
| Education of Ag.PDM |  |  |  |  |
| Household size |  |  |  |  |
| Number of plots per household |  |  |  |  |
| Plot size |  |  |  |  |
| Households (number) | 5.076 | 1.692 | 1.692 | 1.692 |
| If not otherwise specified, it is reported the mean with standard deviation in parenthesis.  \*Ag.PDM = Agricultural primary decision maker. | | | | |

[Comment table]

As the paper aims at exploring the role of women’s empowerment and gender on changes in trait preferences, utilizing the BIHS dataset is relatively problematic. By design, the module on agriculture 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. Conversely, the module on women’s empowerment was instead employed to interview both household head and spouse[[3]](#footnote-3).

By the way in which BIHS was designed, we are left with 7% of the observations stating trait preferences by primary female decision makers in each year of the survey. Therefore, we are forced to look at a sub-sample of the overall BIHS respondents to conduct our gendered analysis on trait preferences and women’s empowerment. Using a multivariate matching technique, we construct a pool of plots whose primary decision maker of reference is a male (control group) to match those plots whose primary decision maker is a female (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 sex group. The total number of observations at the plot level is 2108. This corresponds to 364 treatment households (183 in 2015 and 181 in 2018) and as many control households.

Another drawback of selecting solely the male decision maker as primary respondent is that we do not have a panel dataset. Indeed, if the male primary decision maker is available in the next round of the survey (i.e., 2018), 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 preferred traits (Table 2).

Table 2 | Characteristics associated to the treatment and control groups

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Treatment group**  *Female Ag. primary decision maker* | **Control group**  *Male 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. | | | |

* 1. **Women's Empowerment in Agriculture Index (WEAI)**

The 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 two 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).

This study employs the empowerment gap at the household level as variables of interest.

Fig. 1 | Average empowerment gap in each district of Bangladesh (2011 and 2018)

Map

Description automatically generatedGraphical user interface

Description automatically generated

[Add further descriptive details in this section]

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) |

* 1. **Trait preferences, trait classes and division of labour**

BIHS contains data of trait preferences (first position and second, in order of importance) at the plot level for the round 2015 and 2018, for each group of crops and for each harvesting season (i.e., *aus* (or *kharif* 1), *aman* (or *kharif* 2), *boro* and annual). In the need to reconcile this richness of data at the plot level with the WEAI measurements at the household level, we expressed our outcome of interest in two forms. First, in terms of trait class (TC). Derived by the Crop Ontology for Agricultural Data (Pietragalla et al. 2022), represents the trait class to which the trait preference T of order *k* (first or second position for importance) expressed by each household *i* and for each crop group *j* in year *y* (2015 and 2018). Trait classes are listed in Table 3:

Table 4 | 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 | Low labour required  Low input required  Ease of processing  Market demand  Good taste  Good as animal feed |

Second, in terms of frequency (TF):

For each household *i* and for each crop group *j* (either cereals, pulses or vegetables) in year *y* (2015 and 2018), we take the trait preference *T* of order *k* (first or second position for importance) which registers the highest frequency between seasons *s*. In section 5 (Results), we report findings for trait classes, while results for trait frequencies are reported in the Appendix (Table A3 and A4).

As previously specified, both TF and TC are calculated for the first as well as the second most preferred trait. The reason why we account for both positions in the ranking [ expand the reasoning on why we do not consider yield as yield always comes first – cite paper by Hale]

Fig. 2 shows the most preferred trait in each crop group in 2015 and 2018, for female (lower quadrant) and male (higher quadrant) primary decision makers. We observe a reduction in the heterogeneity of trait preferences within the two 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 male 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 female decision makers, where only the yield trait ranks first in 2018. More broadly, traits like low labour requirement, low input, or colour are diffuse in 2015, but appear to be negligible in 2018. Conversely, both female and male primary decision makers tend to prioritize yield and market demand more often in 2018 than 2015.

Fig. 2 | First preferred trait in each crop group, for male and female primary decision makers (2015 – 2018)

As previously underlined, looking solely for the first preferred trait is surely interesting, but the overall tendency to prioritize yield is somehow to be expected. Fig. 3 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 female and male 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, pulses, fruits and spices.

Fig. 3 | 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 5), we decided to focus on cereals, pulses, and vegetables. These three crop groups represent alone 80% of the overall number of plots cultivated by female primary decision makers[[5]](#footnote-5). Nonetheless, women’s role varies substantially across crops: they tend to be more heavily involved in the harvesting of cash crops like pulses and vegetables, while their role is frequently confined to post-harvest activities in case of cereal (Rahman 2000). For this reason, we select cereal, pulses and vegetables as representative of two different production paradigm: the former usually male-dominated and the latter usually female-dominated.

Table 5 | Share of plots allocated to the diverse crop groups by female ag. primary decision maker

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

Data on gendered division of labour[[6]](#footnote-6) are summarized in Table 6. 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 6 | 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. | | | | | | | | |

Fig. 4 and 5 further plot data by year, gender, and for the three crop groups of focus (i.e., cereal, pulses and vegetables). If we look at the number of hours declared by the respondents, we find some interesting patterns depending on whether the primary decision maker declaring the hours is a woman or a man. In case of male primary decision makers, men are more engaged in working on pulses and vegetables, beyond cereals which are by far the most occupying crop group both in 2015 and 2018. When primary decision makers are female, 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 pulses and vegetables plots in case of female primary decision makers, while the trend is reversed for male primary decision makers.

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

![Chart, box and whisker chart

Description automatically generated]()

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 pulses and vegetables between 2015 and 2018 - even more so, when the primary decision maker declaring the hours is a woman.

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

![Chart, box and whisker chart

Description automatically generated]()

In section 4, we attempt to formalize this descriptive evidence with an empirical exercise which tries to understand how changes in women’s empowerment relate to changes in trait preferences in Bangladesh.

1. **Empirical specification**

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

where is the variable defining trait preferences for respondent *i* at time *t*. This outcome is represented by trait frequency (TF) and trait class (TC) for crop groups, using the first and second most important traits for household’s agricultural primary decision maker in the years 2015 and 2018. Trait frequencies and trait classes are calculated across each season (*aus*, *aman*, *boro* or annual). A breakdown of trait preferences per harvesting season, per year and per crop group is reported in table A2 in the appendix.

Following the discussion in section 2, our variable of interest is which measures the empowerment gap between the primary male and primary female 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 repeated cross section. Equation 2 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 could be hard 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. 3). 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.

When is the trait frequency outcome, eq. 3 is represented by a fixed-effect Poisson model which we implement using the R (2021) package {*pglm*} (Table A4 and A5 in the appendix). When is instead represented by trait class outcome, eq. 3 is modelled according to a 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).

In the realm of household-specific controls, we are specifically interesting to isolate how the empowerment gap effect 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. 3 with two additional terms:

where *gender* equals 1 when the agricultural primary decision maker is a female. Interacting the empowerment gap with this gender dummy helps us to test the second research question of this study: are empowerment changes influencing more significantly trait preferences, if the agricultural primary decision maker is a female? The term isolates the combined effect of changes in the empowerment gap with the gender of the primary decision maker in the household. *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 third research question of this study: are empowerment changes influencing more significantly the trait preferences of crops worked predominantly by women?

The functional form of eq. 3-4 is a fixed-effect Probit model and it is computed using the *feglm* command from the R package {alpaca} by Stamman 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).

Time-variant (omitted) variables remain uncaptured by equations 3 and 4. 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. 5).

This lagged instrument is strongly correlated with the variable of interest (Table A5 in the Appendix), but it is dubious, even though potentially plausible, whether the instrument is exogenous to trait preferences shown by respondents both in 2015 and in 2018. Therefore, we interpret cautiously results from eq. 6, as suggested by Wang and Bellemare, 2019. For this reason, findings of eq. 6 are not inserted in the Results section below, but they are reported in the Appendix (Table A5 and A6) and used as robustness check.

1. **Results**

Table 3 and 4 report the coefficients for the fixed effects Probit model, for first and second preferred trait class in each crop group. These derive from eq. 3 and 4 described in the previous section. Results in terms of trait frequency confirm the findings for trait classes and are reported in the appendix (Table A3 and A4 in the appendix).

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) |
| Pulses | 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) |
| Pulses | -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, pulses 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) |
| Pulses | -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) |
| Pulses | 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. | | | | | |

1. **Discussion**
2. **Conclusion**
3. **References**

Ahmed, A.U. (2016). *Description of the Bangladesh integrated household survey*. Dhaka, Bangladesh: International Food Policy Research Institute (IFPRI). Available at: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BXSYEL (last accessed: April 12, 2022).

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A., Seymour, G. and Vaz, A. (2013). The women’s empowerment in agriculture index. *World development*, 52: 71-91.

Blundell, R. and Bond, S. (2000). GMM estimation with persistent panel data: An application to production functions. *Econometric Reviews*, 19(3): 321–340.

Pietragalla, J., Valette, L., Shrestha, R., Laporte, M.A., Hazekamp, T., Arnaud, E. (2022) *Guidelines for creating crop-specific Ontology to annotate phenotypic data: version 2.1*. Alliance Bioversity International and CIAT.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rahman, S. 2000. Women's employment in Bangladesh agriculture: composition, determinants and scope. *Journal of Rural Studies*, 16(4): 497-507.

Rahman, S. 2010. Women’s labour contribution to productivity and efficiency in agriculture: empirical evidence from Bangladesh. *Journal of Agricultural Economics*, 61(2): 318-342.

Sraboni, E., Quisumbing, A.R. and Ahmed, A.U. (2013). The women’s empowerment in agriculture index: Results from the 2011-2012 Bangladesh Integrated Household Survey. *Project Report submitted to the US Agency for International Development. International Food Policy Research Institute*, Dhaka, Bangladesh. Available at:

https://www.a4nh.cgiar.org/files/2013/04/IFPRI-PRSSP\_Bangladesh-WEAI-Report\_Final\_14-April-2013.pdf (last accessed: April 12, 2022).

Stammann, A., Heiß, F., McFadden, D. 2016. Estimating Fixed Effects Logit Models with Large Panel Data, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Microeconometrics, No. G01-V3, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

Wang Y. and Bellemare M.F. (2019). Lagged variables as instruments, *Working Paper, Department of Applied Economics, University of Minnesota*. Pre-print available at: http://marcfbellemare.com/wordpress/wp-content/uploads/2019/05/WangBellemareLaggedIVsMay2019.pdf (last accessed: April 11, 2022).

**Appendix**

Table A1 | Indicators belonging to the 5 domains of women’s empowerment (Seymour, 2017)

|  |  |  |  |
| --- | --- | --- | --- |
| **Domain** | **Indicator** | **Definition of indicator** | **Weights** |
| *Production* | Input in productive decisions | Sole or joint decision making over food and cash-crop farming, livestock, and fisheries. | 1/10 |
|  | Autonomy in production | Autonomy in agricultural production. Reflects the extent to which the respondent’s motivation for decision making reflects his/her values rather than a desire to please others or avoid them. | 1/10 |
| *Resources* | Ownership of assets | Sole or joint ownership of major household assets | 1/15 |
|  | Purchase, trade, or transfer of assets | Whatever respondent participates in decision to buy, sell or transfer his/her own assets | 1/15 |
|  | Access to and decisions on credit | Access to and participation in decision making regarding credit | 1/15 |
| *Income* | Control over use of income | Sole or joint control over income and expenditures | 1/5 |
| Leadership | Group member |  |  |
|  | Speaking in public |  |  |
|  |  |  |  |

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 |
| Pulses | 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

Table A5 | Coefficients for top ranked trait class, 2SLS model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | |
| **First stage** | **GPI** | | | | |
| **GPI 2011** | **0.12\*\*\***  (0.03) | | | | |
| **Second stage** | **Agronomic** | **Abiotic stress** | **Biotic stress** | **Morphological** | **Quality** |
| **GPI** | **-8.46\*\***  (3.90) | - | - | 0.60  (1.18) | **9.00\*\***  (3.92) |
| Cereal | 0.14  (0.13) | - | - | -0.07  (0.04) | -0.09  (0.13) |
| Pulses | -0.19  (0.18) | - | - | -0.05  (0.05) | 0.27  (0.18) |
| Female Ag. PDM\*\* | -0.03  (0.11) | - | - | -0.02  (0.03) | 0.08  (0.11) |
| Women hours worked | **-0.03\***  (0.01) | - | - | 0.0003  (0.0005) | **0.003\***  (0.001) |
| *Time dummy* | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (cluster village)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak instruments | 8.50\*\*\* | - | - | 8.50\*\*\* | 8.50\*\*\* |
| Wu-Hausman | 10.19\*\*\* | - | - | 0.19 | 14.18\*\*\* |
| 2SLS model for trait class (TC) with time fixed effects. (*\*\*) 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. 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 A6 | Coefficient for second best ranked trait class 2SLS coefficients (odds ratio)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | |
| **First stage** | **GPI** | | | | |
| **GPI 2011** | **0.12\*\*\***  (0.03) | | | | |
| **Second stage** | **Agronomic** | **Abiotic stress** | **Biotic stress** | **Morphological** | **Quality** |
| **GPI** | 1.50  (1.40) | - | 0.73  (1.03) | 3.02  (2.35) | **-4.84\***  (3.0) |
| Cereal | -0.08  (0.06) | - | **-0.09\*\***  (0.04) | -0.009  (0.10) | 0.17  (0.13) |
| Pulses | -0.001  (0.07) | - | -0.01  (0.05) | **0.20\***  (0.12) | -0.17  (0.15) |
| Female Ag. PDM\*\* | -0.02  (0.04) | - | 0.002  (0.03) | -0.04  (0.07) | 0.06  (0.09) |
| Women hours worked | 0.0006  (0.0007) | - | 0.0001  (0.0005) | **0.002\***  (0.001) | **-0.002\***  (0.001) |
| *Time dummy* | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Robust SE (cluster village)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak instruments | 11.29\*\*\* | - | 11.29\*\*\* | 11.29\*\*\* | 11.29\*\*\* |
| Wu-Hausman | 1.01 | - | 1.79 | 2.34 | 4.82\*\* |
| 2SLS model for trait class (TC) with time fixed effects. (*\*\*) 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. 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 A3 | Coefficient for first trait preference, fixed effects Poisson model

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | |
|  | **First trait preference\*** | | | | | | | |
|  | **Cereal** | **Fiber** | **Pulses** | **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** | **Pulses** | **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 pulses, 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) | |
| **Pulses 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 pulses. *\*\*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 pulses, 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) | |
| **Pulses 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 pulses. *\*\*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) | |
| **Pulses (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) | | |
| **Pulses (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. [↑](#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 fiber production, this crop group has not been considered in this study because fiber 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)