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

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**Abstract**

*[250 words]*

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1. **Introduction**

RQ1: When the empowerment gap within the household decrease, do we observe any changes in trait preferences of the agricultural decision maker?

RQ2: Are empowerment changes influencing more significantly trait preferences, if the agricultural primary decision maker is a female?

RQ3: Are empowerment changes influencing more significantly the trait preferences of crops managed predominantly by women?

1. **Background and context**
   1. **Linking women’s empowerment and trait preferences**
   2. **Women’s participation in agriculture in Bangladesh**
2. **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 paper primarily uses two modules: agriculture and women’s empowerment in agriculture (WEAI) index. The former module was answered solely by the self-identified, primary adult decision maker (male or female) in each household; women account for 7% of the respondents in this module. The module on women’s empowerment was employed to interview both household head and spouse[[2]](#footnote-2).

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[[3]](#footnote-3), 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. 3) 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.* | | | | |

* 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

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* 1. **Trait preferences**

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 frequency (TF):

For each household *i* and for each crop group *j* 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*.

Second, 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) belongs. Trait classes are listed in Table 2:

Table 2 | 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 |
| Other | Other |

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

Fig. 2 | First most preferred trait class in each crop group, per year

Chart, bar chart

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Fig. 3 | Second most preferred trait class in each crop group, per year

Chart, bar chart

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1. **Empirical specification**

In our empirical analysis, we are interested in understanding how changes in women’s empowerment relate to changes in trait preferences in Bangladesh. 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 frequency and trait class 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 household *i* at time *t*. 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. The estimation sample consists of a balanced panel covering 3,384 observations over two rounds (2015 and 2018) of the Bangladesh Integrated Household Survey (Table 1).

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.

In order to deal with endogeneity, we include individual () and year () fixed effects (eq. 3). Fixed effects at the respondents’ level clean the estimation from all time constant demographic, skill, and attitudinal differences. These respondents’ fixed effects also capture average differences in soil quality and climate across farms, which might influence changes in trait preferences. In a similar fashion, time fixed effects control for year – specific differences, such as market 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 the empowerment gap when the agricultural primary decision maker is a woman and when most of the labour on a specific crop is done by women in the household. For this purpose, we expand eq. 3 in the following two specifications:

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.

The second specification is:

where *women managed* assumes vale 1 if the activities within a specific crop group are managed predominantly by the women in the household. 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 managed 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 managed predominantly by women?

The functional form of eq. 3-4-5 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, 4 and 5. 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).

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, 4 and 5 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 [COMPLETE RESULTS]

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)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  | | *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. **Discussion**
2. **Conclusion**
3. **References**

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**Appendix**

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

(INSERT TABLE)

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

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dependent variable* | | | | | | | |
|  | **First trait preference\*** | | | | | | | |
|  | **Cereal** | **Fiber** | **Pulses** | **Oil** | **Spices** | **Vegetables** | **Fruits+** | **Other+** |
|  |  |  |  |  |  |  |  |  |
| **WEAI** | **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+** |
|  |  |  |  |  |  |  |  |  |
| **WEAI** | **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. | | | | | | | | |

**Focus on trait preference changes and primary decision maker for the ag. activities**

* We steer our focus predominantly on trait changes. We investigate the following questions:
  + do we observe changes in preferred traits and are these changes diverging for plots whose primary agricultural decision maker is a woman or a man?
  + if we observe changes of preferred traits for female primary agricultural decision makers, are these related to changes in women’s empowerment at the district level?
  + Do we observe changes in the women labor role?
* Using a multivariate matching technique, we construct a pool of plots whose primary decision maker of reference is a male to match those plots whose primary decision maker is a female. 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 by the BIHS.
* This 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 therefore 2108 (1054 doubled). This corresponds to 364 female households (183 in 2015 and 181 in 2018) and as many male households.
* Due to the structure of our sampling, we have pooled cross section (i.e., for each time point a set of data is sampled, which can be different among different time points): we will need to include in the model dummy variables for all but one period. This allows different intercept for each time period, and it allows outcome to change on average for each time period.
* We decide to focus on cereals and pulses trait preferences (see Table A6).

Table A5 | Characteristics associated to the case and control groups

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Case 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. | | | |

Table A6 | 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 | 8 |
| **Total** | **579 (100)** | **475 (100)** |

Fig. A6 shows the most preferred trait in each crop group in 2015 and 2018, for female (lower quadrant) and male (higher quadrant) ag. primary decision makers. Firstly, 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. The group of vegetables or spices provide 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. A6 | First preferred trait in each crop group, for male and female ag. 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. A7 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. A7 | Second preferred trait in each crop group, for male and female ag. primary decision makers (2015 – 2018)

What happens to the number of women-managed plots[[5]](#footnote-5)? Do we observe changes depending on the year or the sex of the primary decision maker declaring the hours worked?

Table A7 | Share of hours worked allocated to the diverse crop groups by female ag. 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. | | | | | | | | |

Table A7 presents some interesting results. 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 consistent across households with a female or male primary decision maker. The share of hired female labour over overall hours worked by women is lower and relatively constant: it is on average, 3% for households with a female or a male primary decision maker across the two years.

Fig. A8 and A9 further plot data by year, gender, and for the two crop groups of focus (i.e., cereal and pulses). If we look at the number of hours declared to be worked by men (Fig. A8), 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 seem to be more engaged in working on pulses, beyond cereals which are by far the most occupying crop group both in 2015 and 2018. When primary decision makers are female, men seem to be less engaged in pulses production. Between 2015 and 2018, we see a reduction in hours worked by men in pulses plots in case of female primary decision makers, while the trend is reversed for male primary decision makers.

Fig. A8 | Number of hours worked by men in cereal and pulses plots, for male and female ag. primary decision makers (2015 – 2018)



The number of hours declared to be worked by women (Fig. A9) are on average less with respect to those declared to be worked by men, both in the case of cereal and pulses. If the trend is relatively unchanged for cereal, we see a considerable reduction in the hours worked by women on pulses between 2015 and 2018 - even more so, when the primary decision maker declaring the hours is a woman.

Fig. A9 | Number of hours worked by women in cereal and pulses plots, for male and female ag. primary decision makers (2015 – 2018)



Table A8 | Coefficient for first trait preference, fixed effects Poisson model

1. This draft t 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. 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-2)
3. 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-3)
4. https://weai.ifpri.info/weai-resource-center/guides-and-instruments/ [↑](#footnote-ref-4)
5. We define a plot to be managed by women if the number of hours worked by women over a given recall period exceed the number of hours worked by men. 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-5)