The effect of gendered decision-making considering all household members on the adoption of crop rotation and livelihood outcomes in Ethiopia

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Abstract:

Empowering women is considered to affect households' livelihood outcomes both directly through emphasizing expenditure for food or social aspects (health, education), and indirectly through higher adoption rates of agricultural technologies increasing productivity, thus raising on-farm food availability and agricultural income. Drawing on women's intra-household decision-making power, the possibility of all (adolescent) household members actively participating in family decisions is widely ignored or undervalued in the literature. Therefore, this article applies a new decision-making index that allows all household members to be considered in decision-making processes. It investigates how women's bargaining power influences livelihood outcomes through different pathways: (i) the direct effect is measured as impact on social expenditures; (ii) the indirect effect is measured as impact on adopting crop rotation leading to higher agricultural productivity. Using data of 378 farming households living in a 200 km radius around Hawassa town, we estimate the effects by employing Tobit and log-linear regression models. Our findings suggest that women's participation in decision-making positively influences livelihood outcomes directly, reflected in higher social expenditures; and indirectly through increasing the adoption of crop rotation practices, thus improving farm productivity. Therefore, we conclude that households with higher women empowerment are likely to achieve higher livelihood outcomes.

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Therefore, this article applies a new decision-making index that allows all household members to be considered in decision-making processes. It investigates how women's bargaining power influences livelihood outcomes through different pathways: (i) the direct effect is measured as impact on social expenditures; (ii) the indirect effect is measured as impact on adopting crop rotation leading to higher agricultural productivity.

Using data of 378 farming households living in a 200 km radius around Hawassa town, we estimate the effects by employing Tobit and log-linear regression models. Our findings suggest that women's participation in decision-making positively influences livelihood outcomes directly, reflected in higher social expenditures; and indirectly through increasing the adoption of crop rotation practices, thus improving farm productivity. Therefore, we conclude that households with higher women empowerment are likely to achieve higher livelihood outcomes.

Keywords: gender, bargaining, decision-making, technology adoption, crop rotation, Ethiopia

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Introduction

Agriculture is often considered to play a key role in driving development processes in African countries. Particularly Ethiopia has recognized this and actively invests in agricultural innovations and a tight extension service network. Although the efforts did lead to progress in some areas, in general, the adoption rates among many rural farmers remain below expectations. Different studies address this issue of slow uptake of technologies and identify several reasons which mostly relate to various constraints. The focus of research is mostly on improved seed varieties (e.g. Kassie et al, 2014), fertilizer (e.g. Dercon & Christiansen, 2011), or a technology package related to soil and water conservation techniques (e.g. Wossen et al., 2015; Husen et al. 2017). Other technologies that are known to increase crop productivity, like crop rotation practices, are rarely addressed.

In this technology adoption context, women empowerment and gender are particularly important in modern agricultural innovation studies (Hay & Pearce, 2014; Obisesan, 2014; Simtowe et al., 2016). With higher bargaining power and access to productive resources, women are more likely to adopt agricultural innovations, hence contributing to general productivity increase (e.g. Doss, 2001). This also relates to engagement rates in collective actions (Janssens, 2010). Keeping this in mind, it is surprising that the effect of women empowerment on the adoption of crop rotation practices is neglected in the literature.

In addition, women empowerment is reported to improve many aspects of household livelihoods for women and their children (Malapit & Quisumbing, 2015) visible in higher household expenditures for health, education, or food and dietary diversity (Partners in Population and Development, 2013; Schmidt, 2012; Sraboni et al., 2014). Measuring women empowerment and its connected bargaining power is commonly done by resorting to

participation in decision-making as a proxy. However, most studies, especially in the technology adoption literature, only consider decision-making by the household head alone (whether male or female) or by household head and spouse together. This approach ignores the possibility of all family members being actively involved in decision-making processes. This is particularly relevant when acknowledging that especially adolescent household members provide already much labor to food production and income generating activities.

Moreover, policy recommendations provided in those studies lack applicability as they mostly suggest empowering women based on the fact that female headed household are better at adopting newly introduced practices. This does not tell us much about females in male headed households and potential benefit of their empowerment.

Therefore, this article applies a new decision-making index that allows all household members to be considered in decision-making processes, i.e. the women's participation in decision-making index (WPDMI) recently suggested by Sariyev et al. (2017). Based on theoretical consideration, the objectives of this article are to estimate the effect of increased women's decision-making power (i) on social expenditures like health, education, and clothing, and (ii) on the adoption of crop rotation as a pathway to achieve increased agricultural productivity.

Following this short introduction, we briefly reflect on relevant literature. Based on the review, we develop a conceptual framework on the impact pathways of how women's participation in decision-making may improve livelihood outcomes either directly or indirectly through influencing the adoption of agricultural technologies like e.g. crop rotation practices. Then we describe the database and applied methods. This is followed by the estimation of the effect of higher women empowerment on crop rotation and social household expenditures. To conclude, further implications and critical remarks on the analysis are discussed.

Conceptual framework and literature review

This section develops the theoretical concept for the analyses carried out in this article. We combine and extend different conceptual frameworks and ideas to develop a sound approach for assessing the effects of women's participation in decision-making on social expenditures and the adoption of crop rotation. In addition, we reflect on literature related to the role of gender for crop rotation, and the role of crop rotation for food security and agricultural income.

Impact pathways of women empowerment (women's participation in decision-making)

The theoretical framework guiding this research combines aspects of different concepts. With over 85 percent of the population depending on agriculture (DiFalco et al., 2011), it is clear that this sector is crucial for the Ethiopian economy, providing the livelihoods for the majority of people, especially in rural areas. Consequently, the "sustainable livelihood approach" (SLA) (Scoones, 1998) describes the underlying context. The SLA basically assumes that households are endowed with a set of assets or capitals which are utilized to implement different livelihood strategies and achieve livelihood outcomes. This general context is then linking to main agricultural development pathways discussed by Headey et al. (2011), namely agricultural food production and income generated through agricultural activities. Finally, women empowerment is added to the theoretical framework (Herforth & Harris, 2014). Combining these concepts and identifying the development pathways enables us to understand the underlying system and linkages addressed in this study.

Overall, three routes between agricultural livelihood strategies and livelihood outcomes are described. These are (i) agricultural food production, (ii) income generated through agricultural activities, and (iii) women empowerment.

Headey et al. (2011) describe the interaction between the elements of the first two routes (food production and agricultural income). At the macro level, agricultural livelihoods affect

the level of food production, which in turn is affected by and affects food prices. This interaction results in the positive or negative outcomes with regard to food consumption. The quality and level of food consumption then results in the nutritional outcomes for household members. Moreover, agricultural livelihood strictly affects the level of rural households' income generated through crop sales which obviously determines households' nutritional, health, educational and other social outcomes (Headey et al. 2011; Herforth & Harris, 2014).

The third and main route relates to women empowerment. Herforth & Harris (2014) mention that women empowerment is a combination of many different aspects. Decision-making is one of these aspects that is important with regard to the nutritional, educational and health status of the household members. When women gain control over productive resources, it may change the production choices and spending patterns of the households. Then, household expenditures are more likely to be directed towards nutritional and health outcomes like health, education or other social aspects.

In order to keep the focus on the objective of this article, i.e. assessing the role of women's decision-making power, the third impact pathway through women empowerment is of particular interest. In detail, this specific route is extended by hypothesizing a direct and an indirect impact pathway. Drawing on evidence showing that decision-making power is a suitable indicator for women empowerment and bargaining power, the direct route assumes that women's increasing decision-making power will result in more spending directed towards social outcomes like education, health, nutrition, etc. The indirect route assumes that increasing bargaining power (which is documented to be connected with better access to assets, information, etc.) will affect the adoption of agricultural technologies like crop rotation practices. Through a higher adoption rate of such productivity enhancing innovations, the path leads to higher food production, better yields, higher agricultural income, and ultimately

contributes to better livelihood outcomes. The final conceptual framework is visualized in figure 1.

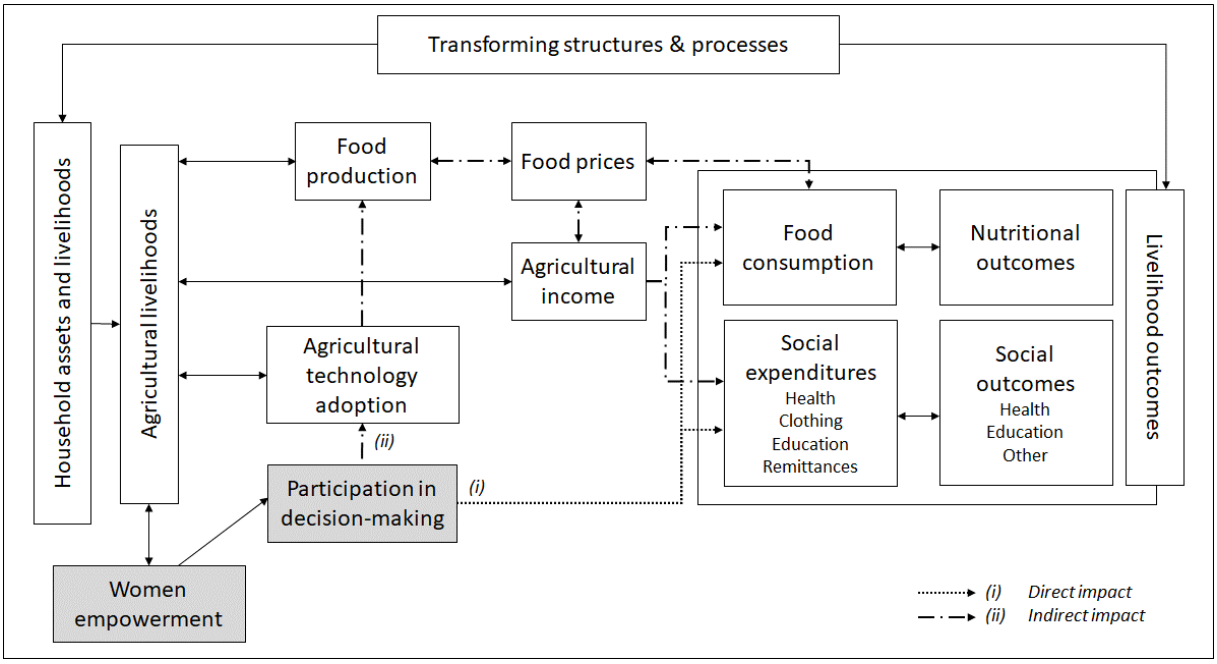

Figure 1: Impact pathways of women empowerment on livelihood outcomes
Source: Own illustration based on the SLA, Headey et al. (2011), and Herforth & Harris (2014)

Reflections on women empowerment, social expenditures and adopting crop rotation

In general, the women empowerment literature reports that when women have a stronger say in household decisions, the household is more likely to direct income towards food purchase and better nutrition, to invest in education and formal schooling, and emphasize health and health care (see Thomas, 1993; Minsoo et al., 2011). For example, findings show that women's effective participation in household decision-making results in better health outcomes (Allendorf, 2007) and higher literacy levels of children (Hatlebakk & Gurung, 2014). Considering such findings, the participation of women in household decision-making should lead to a higher level of food consumption and more social expenditures, therefore, resulting in improved nutritional and social outcomes.

When it comes to agricultural technology adoption, gender is reported to play an important role. Yet, it is very unlikely that one will find a single technology that will resolve all productivity problems or women's challenges related to equality and equity. In any case, the adoption of agricultural technology will depend on access to productive resources like labor and land (Doss, 2001). In Tigray for example, it was observed that female headed households' lack in agricultural production falls back on different cultural barriers limiting their access to agricultural resources and hindering them to participate in extension programs (Pender & Gebremedhin, 2007). This is consistent with findings from eastern Uganda where Fisher & Carr (2015) showed women farmers to have lower adoption rates of drought tolerant maize seeds due to constraints related to the access to productive resources. Similar, the Ethiopian Ministry of Women's Affairs (2006) concluded that women significantly lack access to productive resources because of cultural factors. Overcoming these constraining factors through stronger empowerment of women is expected to open a path towards increased productivity and development.

Some agricultural technologies have short-term payoffs, but many have upfront costs and long-term payoffs. Considering that women are more vulnerable, they might prefer short-term payoff activities. This study looks at the effect of rising women's decision-making power on adopting crop rotation practices, which may show beneficial effects rather quickly. So one could assume that women empowerment will lead to increasing adoption rates. On the other hand, some claim that women are generally less likely to adopt, which implies that their empowerment would enforce a household's reluctance towards new technologies. So hence the sign is arbitrary.

However, many technology adoption studies already tried to analyze and identify gender differences in modern agricultural technology adoption. For example, Ndiritu et al (2014), in their study on sustainable agricultural intensification practices in Kenya. They conclude that

there is a gender bias in some practices. Their analyses concentrate on male, female and jointly (husband and wife) managed agricultural plots. Bargaining within the household and participation of all family members in the decisions regarding adoption of practices is ignored.

Mengistu et al. (2016) find that female headed households are less likely to adopt biogas technology than those headed by men in Ethiopia. They state that empowering women is likely to lead to an increase in adoption rates. In a different example looking at the determinants of adopting improved Pidgeonpea, Simtowe et al. (2016) report that the household head being male significantly decreased the adoption.

Overall, most, if not all previous research investigating the role of women empowerment for agricultural technology adoption in general, and crop rotation practices in particular, resort to the gender of the household head as a sole decision maker, or to joint decision-making by the household head and the spouse. This approach ignores intra-household decision dynamics such as between sons or daughters and mothers vis-a-vis fathers. Because this is particularly true for adolescent members bringing in their labor, experience, and other capital (SLF), we consider household members aged 15 years or older to be a potential decision maker. Assuming that women's decision-making power might actually be different when all household members are considered to potentially involve in decision-making processes, it may be assumed that the effect of women empowerment can be estimated in a more realistic way.

The role of crop rotation for agricultural productivity

In Ethiopia, the agricultural sector employs most of the rural labor force and provides food and income sources for the majority of people. Though a top priority of the government and several interventions being put into action, the sector still faces many problems, not reaching the full yield potential of most crops being one of the most pressing issues. This is due to a

number of constraints including e.g. soil fertility issues like topsoil erosion, depletion of nutrients in the soil and the loss of soil organic matter (IFPRI, 2010; Yirga & Hassan, 2010). This may be related to generally poor starting conditions in highland areas, but also to practicing monoculture, i.e. the repeated growth of the same crop season after season, which leads to nutrient depletion in the soil. Another problem may be associated with high weed pressure causing losses in the yield of e.g. wheat (Gorfu et al., 1996). These types of agricultural issues are likely to limit agricultural development and contribute to food insecurity (Bojö & Cassells, 1995).

An agricultural technology that empirically proved to contribute to increased crop productivity is crop rotation. This technique is shown to be one of the successful ways of dealing with the above mentioned problems (see Havlin et al., 1990; Ahmed, 2014; Jiang et al., 2016; Shahzad et al., 2016; Venter et al., 2016). Rotating different crop types with different requirements and traits will contribute to various agronomic aspects. Liniger et al. (2011) identify rotation practice as one of three fundamental principles of Conservational Agriculture (CA). Based on a meta-analysis of case studies, they present that crop rotation has a positive impact on yield, farm income and production diversification at household level. Crop rotation increases yield and soil quality in different ways. Based on Kurtz et al. (1984) and Deen et al. (2009), table 1 summarizes different advantages or benefits associated with using crop rotation practices.

Table 1: Benefits of complex crop rotation practices

Benefits	Effect type	Expected influence level of benefits in the future
Source of Nitrogen	chemical	Increase
Increase of yield	economic	Higher than current level

Weed, insect and disease control	biological	Increase
Distribution of labor	non-agronomic	Remain the same as today
Improved water quality	physical	Unclear
Enhanced soil quality	chemical	Small increase

Source: Adapted from Kurtz et al. (1984) and Deen et al. (2016)

When including nitrogen fixing leguminous plants like beans in the crop rotation, a fertilizing effect can be expected. Closely linked to soil nutrients is also a general improvement of soil quality through e.g. increased soil organic matter which not only improves water holding capacity, but may also reduce surface water runoff and thereby soil erosion. Rotating different plant types like e.g. grains after legumes, after tubers, may also break reproduction cycles of pests (stem borers, weevils) and diseases. With a smart design and the appropriate crop choice it is also possible to develop strategies against different weeds. Overall, higher yields and increased productivity can be expected. Crop rotation can develop into very complex systems which may affect productivity significantly stronger than simple rotations of just two crops. In general, there is a growing awareness about the potential benefits of increased rotation complexity. Hence, it is not surprising that a shift towards more sophisticated rotation designs is expected in the future (Deen et al., 2016), which may result in cropping systems that are environmentally favorable and efficient for sustainable agricultural growth (Ma & Wu, 2016).

Recapitulating, the conceptual framework illustrates the expected positive impact of women's participation in decision-making on (i) social expenditures of the household, and (ii) on the adoption of crop rotation practices. The latter is assumed to contribute to farm productivity, and ultimately to livelihood outcomes.

Methodology and Data

This section shortly presents the database used for the econometric analyses. Following a short overview of the applied index for women's participation in decision-making, the two output variables of interest are described. Finally, the methods to estimate the effects of higher bargaining power of women on social expenditures and crop rotation are discussed.

Data

In this study, a sub-sample of the nationally representative baseline survey conducted in 2012 by the International Food Policy Research Institute (IFPRI) for the Agricultural Transformation Agency of Ethiopia was selected and respondents interviewed in a follow-up survey in 2014. Covering an area defined by a ca. 200 km radius around Hawassa town, 404 farming households were visited. The sample comprises 29 kebeles (Ethiopia's smallest administrative units) from Oromiya and SNNP region with a range of different agro-ecological zones, ethnic groups and livelihood strategies in general. In order to apply the selected women's participation in decision-making index, the sample was limited to households in which gender related bargaining may actually occur, which leaves an adjusted sample of 378 households for analyses. By conducting computer assisted personal interviews through well-trained enumerators a high level of data quality could be ensured. The gathered information comprises socio-economic household characteristics, household decision-making, infrastructure and social network, agricultural production, household asset ownership, household expenditures, land endowment, agricultural technology adoption and other questions related to agricultural activities of households.

Women's participation in decision-making index

In order to allow for cases in which several or all household members participate in decision-making processes, the women's participation in decision-making index (WPDMI) recently suggested by Sariyev et al. (2017) was selected. The approach applies Principal Component

Analysis to generate an index combining different decision-making variables capturing key decision domains within a household. Following Sariyev et al (2017), for each of the decision variables i – i.e. household purchases (incl. food, clothing, and other expenditures), agricultural technology adoption, animal marketing, use of income from animal sales, crop grown, input use, and harvest use – women participation in decision-making ($WPDM_i$) is calculated using equation 1:

$$WPDM_i = \frac{\sum FDM_i}{\sum DM_i} \quad (1)$$

Where:

- FDM_i = female decision maker(s) in the *i*th decision domain
- DM_i = decision maker in the *i*th decision domain

The resulting variables $WPDM_i$ range between 0 (=no female participation) and 1 (=only female participation) and are used in the Principle Component Analyses. Details on the results including Eigenvalue (4.998), Factor loadings (0.797-0.897) and Kaiser-Meyer-Olkin measure of adequacy (0.897) are available upon request. Overall, all validity tests indicate the suitability and appropriateness of the index.

Estimating the effect of WPDMI on social expenditures

In order to assess the direct impact of women's participation in decision-making on livelihood outcomes, per capita social expenditures were selected as the measure of interest. Here, we define social expenditures as any type of expenditure and costs *C* related to social aspects of family or community life. In detail, social expenditures are considered to include expenses for education, health, clothing and outgoing remittance in the past 12 months (equation 2):

$$C_{social} = C_{education} + C_{health} + C_{clothing} + C_{remittance} \quad (2)$$

Where:

- $C_{education}$ includes costs like school fees, books, and school uniforms
- C_{health} includes costs related to doctor visits, acquiring medicine, etc.
- $C_{clothing}$ includes expenses for clothing (including shoes)
- $C_{remittances}$ includes cash or in-kind payments to relatives, friends, government, etc.

Social expenditure was chosen both for its indication of social orientation of the household which is often strongly influenced by women, as well as for its proxy-function of household welfare (e.g. Henry et al., 2003). For analyzing the effect of WPDMI on per capita social expenditures, a log-linear regression model was selected. The setup of log-linear models allows for the estimated effect being not constant, but rather describes a one unit change in the independent variable to result in $100*\beta_i$ percentage change in the dependent variable (Stock & Watson, 2015). The logarithmic transformation was necessary to ensure normality of the dependent variable, hence allowing to run the regression. As various factors other than gender are known to influence household budget being allocated towards social expenditures, a range of control variables were included in the model. In addition, heteroscedasticity robust standard errors were calculated.

Estimating the effect of WPDMI on the share of agricultural land under crop rotation

In order to assess the indirect impact of women's participation in decision-making on crop rotation as the first step on the crop productivity related impact pathway, the share of land under crop rotation practices was selected as the measure of interest. Other determining factors reported in the literature to influence the adoption of this agricultural technique were controlled for in the analysis.

Looking at the share of land area under crop rotation will reveal figures ranging between zero, i.e. no crop rotation used, and 100 percent, i.e. crop rotation applied on total farmland. Naturally, it may be assumed that many respondents declare no adoption, while other farmers have very different intensities of implementation. In fact, the respective data used in this study

reports many of the households not applying crop rotation, many other farmers have different levels of adoption rates. To address this challenge in econometric regression models, Tobin (1958) suggested a suitable model that was later named Tobit after him.

A Tobit model is also known as a censored regression model which is applicable in data that are cut off from above or below, meaning there is a probability mass in some point or two points in the data while the rest is continuous. Wooldridge (2010) identifies two main categories of models including the corner solution model. This specification widely used in econometrics, as it fits many encountered cases with variables being censored in their nature. In essence, there is a variable *y* describing choices of respondents which takes the value of zero in many cases and is continuous over values that are positive. This implies that a probability mass is present at zero (Wooldridge, 2010). The share of land under crop rotation is a very good example of this kind of variable. Farmers are facing an optimization problem where they first decide whether to adopt crop rotation, and then decide on the intensity of adoption, i.e. the share of land managed with crop rotation practices. In this case, some farmers decide not to adopt crop rotation practices resulting in zero values for all farmers with this behavior. All other farmers will utilize the agricultural technique on a share of their land. This situation perfectly fits the corner solution outcome. Thus, we have data with many zeros and that are continuous over positive values which can be explained by a Tobit model that predicts nonnegative values and non-constant partial effects. As we are interested in the marginal effects, i.e. means of observed values, different derivations including the inverse Mills ratio (see Cameron & Trivedi, 2009) were estimated to allow proper interpretation.

Empirical results

This section first provides an insight into the data by presenting some descriptive statistics. It then discusses the effects of women's participation in decision-making on social expenditures,

and closes by assessing the respective effects on crop rotation, i.e. the share of land managed with crop rotation practices.

Descriptive statistics of sample and adoption of crop rotation

In order to get a better understanding of the sampled households and their socio-economic characteristics, table 2 summarizes selected information at the same time indicating variables used in the regression analyses.

Although only about 13% of households are female headed, the actually larger role of women in household decision-making is seen in the frequent occurrence of bargaining over decisions (70.2%) reported in other research by the authors. On average, household heads are 44.5 years old and enjoyed formal schooling for 3.3 years (i.e. primary school). More relevant for the analyses is the maximum level of education in the household as a proxy for household's overall education, in our sample 6.6 years. Average household size was 6.5 members with each family member basically relying on 0.24 hectares. Based on the number of extension contacts in the past 12 month prior to the survey, 71% of the households have access to this service. This illustrates the dedication of the government to establish a wide coverage of agricultural extension services. It remains to be assessed how valuable the information by extension agents is for male and female farmers. Fifteen percent of the households reported to have access to financial services, which hints towards a credit constraint.

Table 2: Sample means of selected socio-economic characteristics

Variables included in the log-liner and Tobit model are marked with x and *, respectively			N = 378	
			Mean	s.d.
x	*	Gender of household head [1-male]	0.87	0.34
	*	Age of household head [years]	44.49	13.91

		Education level of household head [years]	3.32	3.64
x	*	Highest education within household [years]	6.60	3.40
x		Household size	6.48	2.22
	*	Extension [1-access]	0.71	0.45
x	*	Credit [1-access]	0.15	0.36
x	*	Per capita farm size [ha]	0.24	0.20
		Food Variety Score	11.07	3.82
		Per capita social expenses (ETB)	761,56	793.99
		Health	87.97	266.07
		Clothing	582.98	397.59
		Remittance	36.88	442.38
		Educational	53.73	177.05
x		*Per capita income [ETB]*	2,844.64	9,318.96
		Non-labor income	158.80	894.09
	*	Off farm income	487.95	1,114.76
		Income from livestock	680.65	1,613.12
		Income from crop sales	1,517.24	9,038.90
		Infrastructure [minutes]		
x		Travel time to nearest periodic market	52.04	44.58
x		Travel time to nearest health center	44.20	41.34
		Travel time to nearest hospital	108.58	69.85
x		Travel time to nearest input vendor	42.06	39.08
	*	Average travel time to nearest to parcels	15.55	27.67

Source: Own data

Looking at the income situation, in the past 12 months prior to the survey, the average per capita income was 2,845 ETB. Contributing income sources included crop sales as the main activity (1,517 ETB), livestock (681 ETB), off-farm income (488 ETB), and remittances (159 ETB). This reflects the focus of the research on households with agricultural livelihood strategies.

With respect to per capita expenditures related with social costs, the average expenses added up to 762 ETB per person in the past year. As expected, clothing accounted for most expenses (583 ETB), followed by health (88 ETB), education (54 ETB), and outgoing remittances, gifts, donations and alike (37 ETB). Not displayed here are the average per capita weekly costs for food (129 ETB). The food consumption diversity measured with the Food Variety Score (simple count of all food item types consumed) reached 11.1 different food items consumed. However, these figures only reflect the survey time period, i.e. March-June 2014. Linking data on seasonal dietary diversity with the impact pathways of women empowerment is left for further research.

Considering the time required to reach different institutions and services, households need on average 15 minutes to go to their nearest parcel. To get to the nearest input vendor, health center, and periodic market takes about 42, 44, and 52 minutes, respectively. This basically indicates local centers with access to basic services in a somewhat acceptable distance. If more serious health issues occur which make a hospital visit necessary, it will take on average 109 minutes to reach more demanding medical attention.

Adopting crop rotation

Figure 2 visualizes the adoption pattern of crop rotation in our sample. At the time of survey, 280 (74%) of the 378 households were aware of rotation practices. 191 (68%) of those farmers currently applied this management method in their agricultural lands, at least to some extent. Of the remaining households aware of the innovation, 73 (82%) claimed to adopt the

technology in the near future. Only 16 households were not interested in taking over crop rotation. This rather high figures reflect the strong interest in adopting crop rotation by sample households.

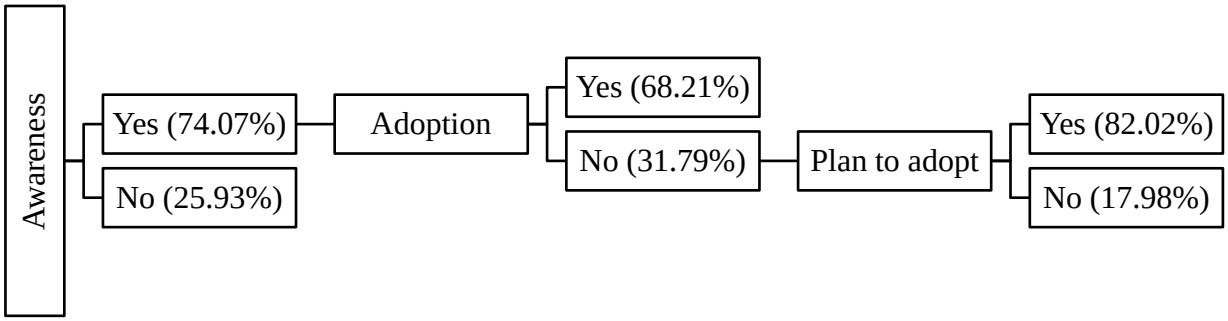

Figure 2: Adoption of crop rotation practices
Source: Own calculations

Regarding decision-making with respect to crop rotation, 119 (62.3%) of the adopters declared that the decision about establishing the practices was made by a single household member, 23 (12%) mentioned joint decision-making by two household members, and 49 (25.7%) stated that it was a family decision, i.e. that there was discussion among several household members on whether to implement rotation practices.

With respect to the intensity of adoption, farmers using crop rotation practices, performed the operation on average on 55.6% of their agricultural land. The earliest adopters started in the late 1970s, reaching 50% in the mid-1990s, and 100% in 2005. As the farmers still follow the practice, it may be assumed that they experienced advantages of doing so. In fact, productivity improvements and improved soil fertility were reported to be the main and most frequently named reasons for adopting crop rotation (see table 3).

Table 3. Declared reasons for adopting crop rotation practices

Reasons for adopting crop rotation	Main response		Multiple responses	
	N	(share)	N	(share)
Improved productivity (higher yield)	149	78.0	159	83.3
Improved soil fertility	39	20.4	101	52.9
Other reasons	3	1.6	20	10.5

Source: Own data

Effects of WPDMI on households' per capita social expenditures

The direct impact pathway of women empowerment and bargaining power on livelihood outcomes is addressed by estimating the effect of WPDMI on per capita social expenditures. The results of the applied log-linear model are presented in table 4.

The main independent variable of interest (WPDMI) shows a positive and highly significant effect on the level of households' social expenditures. It is estimated that a unit increase in the WPDMI would result in an on average 17.7% increase in the households' per capita social expenditures, ceteris paribus. One has to note that WPDMI ranges between -1.52 and 3.16, thus a unit increase may be considered a rather high change. In any case, this result shows that more intensive participation of females in household decision-making processes results in expenses that are directed more towards health, education, clothing, and/or remittances (incl. donations, gifts, etc.). This is in line with findings of other researchers like Doss (1996), Minsoo et al. (2011), Thomas (1993), or Phipps & Burton (1998).

Table 4. Determining factors of per-capita social expenditures (log-linear model)

Independent variables	Coefficient		s.e.
WPDMI	0.1775	***	(0.0448)

ln of total per capita income	0.1028	***	(0.0357)
ln of per capita farmsize	0.1599	***	(0.0631)
Household size	-0.0006		(0.0198)
Credit [1-access]	-0.0384		(0.1514)
Highest education level [years]	0.0379	***	(0.0142)
Distance to nearest health center [minutes]	0.0008		(0.0015)
Distance to nearest market [minutes]	-0.0004		(0.0019)
Distance to nearest agricultural input vendor [minutes]	-0.0015		(0.0012)
Sickness [1-had a sick member]	0.6572	***	(0.0931)
Region [1-Oromiya]	0.4397	***	(0.0882)
_cons	5.3352	***	(0.3473)
N	378		
R^2	0.307		
adj. R^2	0.287		

Heteroscedasticity robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Own calculations

It is estimated that, all else constant, a percentage increase in the per capita total income of the household would result in a significant, but on average very small 0.1% increase in the per capita social expenditures of the household. While Idalinya et al. (2011) observed a positive but statistically insignificant effect of income on educational and health expenditures, they did observe a significant effect of income on other social expenditures like remittances in western Kenya.

A percentage increase in the per capita farm size results in a significant, on average, 0.16% increase in the per capita social expenditures. Unexpectedly, household size and access to credit show negative effects on the outcome variable. These, however, are statistically insignificant. Further, an additional year of formal schooling of the household member with the highest education level, i.e. the highest grade completed, significantly increases social expenditures by on average 3.8%. Also, if a household had a sick member in the past 12 months its social expenditures are on average 66% higher than in cases with no sick members. This significant cost element can be explained by the comparably high prices of medical drugs and other variable costs involved, like travel costs to a health center.

Infrastructure and access related variables like the distance to the nearest health center, market, and input vendor were not significant. When considering the signs, the increasing cost effect of further distance to health centers feeds into the explanation of incidents of households with sick members. The possibly unexpected negative effect of distance to market and input vendors on per-capita social expenditures may be a result of high opportunity costs, i.e. households living further from rural centers rather choose not to travel and spend money, unless there is a real reason. After all, none of the distance variables showed statistically significant effects. Finally, a household located in Oromiya would have on average 44% more social expenditure than a household located in SNNP region. While this variable was included as a pure control variable, it may yet be an indication of the role of ethnic groups. Sticking to terminology, different nations, nationalities, and peoples may put different emphasize on social aspects of life.

Effect of WPDMI on crop rotation

The indirect impact pathway of women empowerment and bargaining power on livelihood outcomes links the adoption of crop rotation practices as a suitable agricultural technology increasing productivity with crop yields. We address the first step of this route and focus on

the effect of WPDMI on adoption intensity, i.e. the share of land area under crop rotation. The results of the applied Tobit regression model are presented in table 5.

The results show that WPDMI significantly contributes to a larger share of land managed with crop rotation practices. It is estimated that a unit increase in WPDMI, results in a 3.4 percentage point increase in the actual share of land under crop rotation. This finding proves the connection between women participation in decision-making and its positive impact pathway through the adoption of agricultural technologies in general, and crop rotation in particular.

The intensity of crop rotation is significantly influenced by other determinants, too. Highly significant variables increasing the share of land under crop rotation include per capita farm size, access to credit, and off-farm income. In detail, the results indicate that a one percent increase in the per capita farm size, having access to credit sources, and higher off-farm income significantly raises adoption intensity by 8.2, 10.9, and 0.001 percentage points, respectively. Assuming that these three variables may be linked to the welfare status of households, this could indicate that better off households either have the financial resources to purchase seed of different crops, or have sufficient risk-bearing ability in case of crop rotation not working out.

Regarding variables associated with experience and capacities the household head's age as a proxy for farming experience and the dependency ratio did not indicate significant effects. On the other hand, the estimation results indicate that education and extension do play a significant role. Considering the household member with the highest education level, an additional year of formal schooling in a 1.3 percentage point increase in the actual share of land under crop rotation. Having access to extension services is also contributing positively with 7.9 percentage points more land under crop rotation than household with no access to extension services. These findings are fairly consistent with Ahmed (2014) reporting positive

and statistically significant effects of extension contact and household head's education level on the probability of adoption of crop rotation practices in Ethiopia.

The variables slope of and distance to parcel show negative effects. Assuming that farmers would prefer permanent crops in steep slopes, and that more distant fields would imply investing more time and labor to follow crop rotation practices, these results were expected. An increase in the slope results in a 4 percentage points decrease; a minute increase in distance to parcels results in a 0.14 percentage points decrease in the actual share of land under crop rotation. Both findings are statistically significant at a 10% level. Significant at 5%, but with a seemingly low positive marginal effect of 0.001 percentage points is a meter increase in altitude.

Analyzing the adoption of crop rotation practices from a soil quality perspective, it is indicated that households who reported poor soil quality have 22.2 percentage points more actual share of land under crop rotation than those who declared to be endowed with very good soil quality on their fields. Regarding moderate and good quality soils, as compared to very good soils, the increase is 11.5 and 12.6 percentage points, respectively. While the latter (good soil quality) is statistically significant at α=0.05, the other two (poor and moderate soil quality) are statistically significant at α=0.10. These findings indicate that household with comparatively poorer soil quality would follow crop rotation more intensively aiming at increasing the soil quality of their parcels. Considering that many farmers already started to follow crop rotation several years, it would be interesting to investigate which long term effects were or are observed over a longer time period.

Table 5. Tobit estimates for influencing factors of share of land under crop rotation

Independent variables	Marginal	s.e.	VIF[2]

	effect[1]			
WPDMI	3.404	**	(1.645)	1.05
Age [years]	0.157		(0.114)	1.18
Dependency ratio	3.010		(9.456)	1.29
Highest education level [years]	1.297	**	(0.542)	1.18
Extension [1-access]	7.889	*	(4.410)	1.15
Credit [1-access]	10.947	***	(4.070)	1.04
Ln of per capita farmsize	8.215	***	(2.101)	1.24
Off-farm income [ETB]	0.001	**	(0.000)	1.07
Altitude [meters above sea level]	0.014	***	(0.003)	1.19
Slope (scale 1-5)	-3.999	*	(2.273)	1.14
Distance to agricultural parcel [minutes]	-0.138	*	(0.076)	1.03
Poor soil quality[+]	22.201	*	(12.09)	1.22
Moderate soil quality[+]	11.465	*	(5.877)	3.82
Good soil quality[+]	12.645	**	(5.816)	3.74
/sigma	53.278	***	(2.525)	∅ 1.25
Prob>F	0.0000			
Pseudo R^2	0.0334			
N	378			

[1] Marginal effects on the actual share of land under crop rotation: $(\partial E(y \mid x))/\partial x$

[2] VIF measures the level of inflation in the variance of coefficients to describing the level of existing multicollinearity (Minitab, 2016)

[+] indicates dummy variable (0=no, 1=yes), reference is "very good soil quality"

Heteroscedasticity robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Own calculations

In additional to the presented analysis including WPDMI, two separate Tobit regression models were run in which the single WPDM variables for technology adoption and crop choices were included instead of the WPDMI. The results revealed that all coefficients remained with the same signs, i.e. direction effect, and that all coefficients (with the exception of moderate soil quality) have consistent significance levels in all three regressions. This indicates a certain robustness of the analyses regarding effects of independent variables.

As an additional quality check, the variance inflation factors (VIF) were calculated for all explanatory variables. All of the individual VIFs are smaller than four and are distinctly smaller than ten, which implies that multicollinearity is not problematic (Myers, 1990; cited in Keil et al., 2013).

Discussion and conclusion

In this article we investigate different impact pathways of women empowerment for improving livelihood outcomes. Resorting to a recently suggested decision-making index that allows to capture decision-making processes in which all household members involve, the first objective was to estimate the effect of women's participation in decision-making (WPDMI) on social household expenditures including, health, education, clothing and remittances. The second objective was to assess the effect of WPDMI on crop rotation as a suitable technology leading to increased agricultural productivity, and ultimately to improved livelihoods.

To address the research tasks, an underlying conceptual framework was developed that depicts the direct and indirect impact pathways of women empowerment. Based on the theoretical considerations and tapping into socio-economic survey data collected in 2014 in

Ethiopia, a log-linear regression model was applied in order to identify and quantify the impact of different driving factors, WPDMI in particular, on social expenditures. The assessment of the effects of women's participation in decision-making on the adoption of crop rotation practices was conducted by employing a Tobit corner solution model.

Starting with the descriptive analysis we found that crop rotation is a rather common technology in the research area. With 74% of households being aware of this agricultural management technique, and 68% of those currently applying the practice, the impression is conveyed that it is a well perceived innovation. This is also reflected in the respondents reporting productivity improvement and improved soil fertility to be the main reasons of adoption.

Considering social expenditures, we found that a higher participation of women in decision-making significantly increases the expenses on health, education, clothing, and remittances. Other variables significantly contributing to social expenditures include per capita income, per capita farm size, the highest education level in the household, whether there was an incident of sickness, and the region. The findings are consistent with the literature, supporting the approach of women empowerment for better health, educational and nutritional outcomes for society. To draw lessons from these findings, we conclude that Ethiopian policy reforms directed towards improving education, health and nutrition should work together with interventions directed to women empowerment. More in general, another implication may be that social programs targeting poverty alleviation through direct money transfers could benefit from specifically addressing women.

Regarding crop rotation, the estimated results showed that an increase in women's participation in household decision-making significantly increases the adoption intensity, i.e. the share of land under crop rotation. A significant effect fostering adoption was also observed for access to extension and credit, highest education level in the household, per

capita farm size, off-farm income, altitude, poor, moderate, and good soils quality (as compared to very good soil quality). A steeper slope of and longer travel times to the fields significantly reduce the share of land under crop rotation. The findings imply that policies aiming at improving adoption rates of crop rotation and other agricultural technologies should be implemented together with policies designed to serve women empowerment and/or attention could be payed to areas that already have experience with women empowerment projects. Mainstreaming gender into policies and effectively implementing this in projects or programs may prove more sustainable and effective for adopting agricultural innovations than gender-neutral interventions. However, empowering women may often require substantial behavioral change. Any project or policy should be aware of this situation.

Overall, we were able to show that women empowerment, measured as women's participation in decision-making, plays a significant role when it comes to direct or indirect impact pathways to improving livelihood outcomes in rural, agricultural settings. Further, to the best of the authors' knowledge, this study is the first to examine the potential gender bias in agricultural technology adoption considering a potential participation of all adult household members and not only household head, spouse or joint decision-making of couples in household decision-making processes.

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