ROLE OF WOMEN EMPOWERMENT ON CROP DIVERSIFICATION: EVIDENCE FROM RURAL BANGLADESH

by

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Submitted in partial fulfillment of the requirements
for the degree of Master of Arts

at

Dalhousie University
Halifax, Nova Scotia
December 2020

This thesis is dedicated to Ammu, Abbu, Fuppi, Choto Chachiamma, and my family. Thank you for always being there for me.

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Abstract

As arable land is declining and global climate is changing, crop diversification has become a desirable tool for safeguarding livelihood of farming household from extreme climate events, ensuring food security, and dietary diversity. With women comprising the large share of agriculture labor and having information on household food consumption, they can play a crucial role on farming household's diversification decisions. In this paper, I investigate the role of women empowerment to determine the crop diversification in farming households. I examine the relationship between women empowerment and crop diversification using two rounds of national data from the Bangladesh Integrated Household Survey. I use the recently developed women empowerment scores, the number of productive decisions sole/jointly taken by women, the number of productive assets sole/jointly owned by women, the number of groups women belong to as an indicator of women empowerment. To measure crop diversification, I use the Simpson crop diversification index, the number of crops produced by the household, and intercropping dummy. Ordinary Least Square (OLS), Zero Truncated Negative Binomial (ZTNB), and probit analysis suggest a positive relationship between crop diversification and women empowerment in Bangladesh. The magnitude of the coefficients, however, suggests a weak relationship between the variables of interest. However, different results obtained from two measures of diversification indicate women contribute to diversification through homestead farming decisions, rather than large scale farming in the cultivable lands. In addition, the analysis of wealth effect on the nexus of crop diversification and women empowerment provides mixed results in the two different rounds. Firstly, in round one, women from richer households are associated with crop diversification, in round two specialization is observed among all households. These results suggest, in later years women may engage in other farming activities such as livestock farming or participate in other employment opportunities. Nevertheless, providing incentives to the female farmers, enacting policy to establish women's property rights, developing women's agro-organization, and Agricultural Small and Medium Enterprises (Agri-SME) might increase women's participation in the agriculture sectors.

JEL Classification: A23, C13, C24, D13, J16, Q10.

List of Abbreviations Used

5DE Five domain empowerment score.

Agri-SME Agricultural Small and Medium Enterprises.

BIHS Bangladesh Integrated Household Survey.

CD Crop diversification.

COVID-19 Coronavirus disease of 2019.

DGP Data generating process.

GDP Gross domestic product.

HD Horizontal diversification.

HH Households.

HYV High-yielding variety.

IFPRI International Food Policy Research Institute.

IV Instrumental Variable.

NGO Non-government organization.

OLS Ordinary Least Square.

SCDI Simpson Crop Diversification Index.

VD Vertical diversification.

ZTNB Zero Truncated Negative Binomial.

ZTPR Zero-Truncated Poisson.

Acknowledgements

I want to express my gratitude to my supervisor, Daniel Rosenblum for constantly providing constructive feedback, new ideas, and supporting me. I am also pleased to have been supervised by other committee members, Professor Mevlude Akbulut-Yuksel, and Mrittika Shamsuddin who have shown interest in my work and provided productive feedback and suggestions. I would also like to thank Adnan M. S. Fakir (University of Western Australia) for providing valuable suggestions during the early stage of the thesis. I would like to thank Naveen Abedin (IFPRI) for providing me the data related files and valuable input.

Thanks to my friends and colleagues from Dalhousie University for supporting me. I want to thank my friend, Francisko Begolli for your immense support by constantly checking on the progress, and proofread the thesis. I also want to acknowledge everyone who has been affected by the COVID-19 pandemic. Thank you all my roommates, friends, and Bangladeshi community in Halifax for being there for me and believing in me. Thank you all for your support.

Chapter 1

Introduction

In the early '80s, introduction of High-yielding variety (HYV) crops mainly rice led to a growth of agriculture production in Bangladesh. (Mahmud et al., 1994) The adoption of producing other crops including high-value crops remained parsimonious in the later years. In the past decade, the crop-diversification strategy, and the importance of it had been outlined in various national policies. The Sixth Five Year Plan FY 2011-2015 (2011),National Agriculture Policy (2013), and the Seventh Five Year Plan FY 2016-2020 (2015) of Bangladesh emphasized the diversification of crops in terms of the shift to speciality crops such as vegetables, fruits, and horticulture products including inter-cropping two or more crops. In recent years, the Government of Bangladesh continues to provide various incentives to marginal and smallholder farmers, by supplying seeds and fertilizers, to ensure nutritional security through crop diversification (Daily Star, 2019). The motivation of promoting crop diversification is rooted by ensuring food and nutritional security, declining arable land, safeguarding from adverse climate events, and increasing employment opportunities. Diversifying production might be a risk reduction tool for the farming household and might lead to a more stable diet and income in the long run.

Women's role in the farming system has been overlooked for a long time. Lately, there have been new policies implemented that recognize their contribution to the overall farming mechanisms, as well as household welfare in rural Bangladesh. Quisumbing and Maluccio (2003) pointed out a positive relationship between various economic development indicators (such as food security, education) and women's control over productive assets. The yield of production on the farm can increase by 20 to 30 percent, if women have the same productive assets as men. In developing countries it can lead to an increase in agriculture output by as much as 4 percent FAO (2011). In the context of Bangladesh, women comprise a large share of agriculture labour

force where they are often underpaid, and take little or no participation in the decision making process. This can be attributed to the fact that women in Bangladesh enjoy less empowerment, especially in traditional farming systems where male domination is still persistent. However, Hossain and Jaim (2011) emphasize that crop production activities could provide a way of generating income for women that advocate their intra-household empowerment. Moreover, the traditional role of women as home-maker in rural Bangladesh, allows them to have information on intra-household consumption and nutritional demand. Hence, enabling women to take part in crop production decisions can be a way to meet the desired micro-nutritional demand, as well as ensuring food security. Women empowerment can help crop diversification and crop production decision through the information available to women as well as, anticipating to decision making process.

There have been past studies that previously addressed the role of women in agriculture that focused on productivity differential, the gendered perspective of decision making as a farm manager or household head. These studies can be considered as a rudimentary step in exploring the broader nexus between women empowerment and crop production. In this study, I try to examine the role of women empowerment to determine the crop diversification in farming households. This is important to assess the relationship because agricultural production has always been dominated by men. Whereas, women's contribution to agricultural decisions is marginal even though a large share of agriculture labor is female and they have more information on household's consumption demand than men. This paper contributes to the existing literature by shifting the concentration towards the relationship between individual-level empowerment and crop diversity within the household. Next it tries to point out the domains of empowerment that have a significant correlation with crop diversity as well as compare with other domains of empowerment to identify the opportunity of new policy implementation. Lastly, I try to address the role of women empowerment in crop diversity among rich and poor households divided by asset quantiles. I hypothesise that empowerment can only help diversification if the household has access to adequate resources. To the best of my knowledge, the nexus of the household wealth and the relationship between crop diversity and women's empowerment has

not been explored in the past. To examine this relationship, I use two rounds of a national data Bangladesh Integrated Household Survey (BIHS) data collected by the International Food Policy Research Institute (IFPRI).

The regression results indicate a significant positive relationship between crop diversification and women empowerment. The two different measures of crop diversification reveal that women contribute to the diversification through homestead farming, rather than large scale farming in cultivable land. In addition, a positive association is observed between crop diversification and women's contribution to productive decision-making, as well as ownership of productive assets during the second round of the survey. In contrast, panel regressions reveal the inverse relationship. This can be attributed to the fact that over the years, women with more property rights and decision-making capabilities might move away from crop farming and engage in non-farm activities or livestock farming. While in richer households, women empowerment and crop diversification are positively associated in the earlier years, the opposite is observed in the later years. This can might suggest that in later years richer households might diversify their livelihood to non-farm activities. It is possible to argue regarding potential endogenity issue arising from reverse causality between crop diversification and women empowerment. In particular, crop diversification may provide a way of income generation that improves women‘s intra-household empowerment. However, this issue is more prominent between productivity and empowerment rather than crop diversification and empowerment (Diiro et al., 2018).

In the next section, I present a brief background of my topic from the existing literature as well as discuss the concept of women empowerment and crop diversification. A brief description of data sources and summary statistics has been provided in chapter 3. In chapter 4 I provide an overview of the methodology and in chapter 5 I discuss the estimation results and limitations. The last chapter contains the concluding remarks.

Chapter 2

Background

2.1 Literature Review

In recent years diversification, in agriculture and crop farming has been highlighted as one of the salient tools for safeguarding the production from climate change, improved household income, risk management tool, and ensuring food security. Typically, households seek to maximize utility and reduce risk by trading-off the high mean profitability of one activity with low mean and variance originating from multiple enterprises. According to Samuelson (1967), diversification is optimal between two activities of independent and identically distributed returns. Motivation to diversify activities depends on two factors: push factors such as risk reduction, reaction to the liquidity crisis, and pulled factors such as specialization according to comparative advantages, or complementary activities. (Barret et al., 2001). Diversification can be viewed as the reorganization and recombination of resources from the original activity, to generate another source of income (Ilbery, 1991). Barnes et al. (2015) used national-level accounting surveys from 2000 to 2012 in Scotland and Sweden to show that a farm producing two or more crop enterprises is more viable than the specialized farm .

Rural Households (HH) diversify their income sources to smooth consumption and mitigate risk (Chibnik, 1994), as a loss management strategy (Valdivia et al., 1996). Demissie and Legesse (2013) found that farmers from drought and risk-prone areas, cultivate more crops to maintain food supply, and reduce staple crop failure risk. Using panel data from Eastern Norway, Culas and Mahendrarajah (2005) showed that large farms are more diversified, and their access to labor stimulates incentives to spread the risk. Their study also found that specialized farming is more environmentally undesirable due to soil and water contamination from large scale farming in developed countries. Lin (2011) argued that crop diversification can be a cost-effective

method to build climate-resilient, as well as safeguarding crop production from extreme climate events. He added that diversified agriculture ensures food security and production in the regions with limited technology, infrastructure, and resources.

Crop diversification has significant implications on household food security and dietary diversity. Adjimoti and Kwadzo (2018) asserted that crop diversification has a positive relationship with food security in rural Benin, and it makes households more resilient to food insecurity. Mukherjee (2015) however, argued that small and marginal farmers, hardly avoid malnutrition and poverty by practicing crop diversification, as well as producing high yield variety of crops. Nevertheless, he added that the effectiveness of diversification depends on the infrastructure and linkage to the market. Bosma et al. (2005) found evidence that diversification has contributed to the improved livelihoods and diet among the nuclear family in the region of Mekong Delta in Vietnam. Furthermore, after controlling the heterogeneity using Instrumental Variable (IV) approaches Lovo and Veronesi (2019) they found that crop diversification has a positive effect on a child's long-term nutritional status in rural Tanzania. While evidence of a similar positive relationship between crop diversification and improved household diet, has also been found in a number of studies in various developing countries like Bangladesh (Sraboni et al., 2014), Ethiopia (Tesfaye et al., 2020), Zimbabwe (Makate et al., 2016), Malawi (Madsen et al., 2020). On the other hand, Immink (2010) from his study provided evidence that the small farms are highly likely to have an adverse effect on generating income, obtaining food security and nutritional status in Guatemala. Albeit, crop diversification has a positive correlation with household diet diversity and income, households in developing countries produce more staple food instead of high-value crops such as vegetables Pellegrini and Tasciotti (2014).

Alongside this relationship between farm size and diversification, it has been discussed by many authors in the previous literature. Using pooled data from Agricultural Resource Management Surveys Mishra et al. (2004) presented suggestive evidence that larger farms are more specialized and there exists a positive relationship between crop insurance and diversification. Hart et al. (1994) proclaimed a

negative relationship between income distribution and crop diversification, it can be observed among the wealthier household with more diversification capability. Weiss and Briglauer (2002) found the evidence that, smaller farms tend to specialize and increase specialization over time. Likewise, Mbaye and Mulungu (2014) revealed that total asset value has a negative correlation with the diversification or shift to the other crops among the smallholder farmers in Kenya.

Manjur et al. (2014) reveled that, gender affects diversification options, the choice of income-generating activities, differential ownership of working capital, as well as access to assets in the Northern rural Ethiopia. A generous number of existing studies in the broader literature have examined the role of women in agriculture as farm managers, decision-makers as household heads, productivity differences, and as wage laborers. Mvula and Mulwafu (2018) found the mean difference in crop yield were significantly higher in the farms managed by male compare to the farms managed by female in rural Africa. In contrast, Simtowe (2010) found no significant difference in crop intensification between male and female-headed households. However, he affirmed that male-headed households use more input that results in gender-based productivity differences. He added that regardless of the aforementioned findings in Malawi, female-headed households are more likely to depend on both agriculture and daily wage labor. As a matter of fact, according to Udry et al. (1995) womens‘ access to the agriculture inputs of the same amount as the men, led to an increase of productivity by 10 to 20 percent. However, access to production resources to the farm managed by women is limited. Because they do not have property rights in the household, women are often denied a loan that requires collateral. Therefore, women are far behind from the means of production Satyavathi et al. (2010). They also claimed, women often play a role in various activities such as land preparation, harvesting as a farm labor in agriculture but their contribution to decision making is still limited. Women's ability to generate income in the agricultural sectors are constrained by limited use, ownership and control over productive assets. Udry (1996) found that within female-controlled household agriculture activities are under invested leading to a total lower household output. Sachs (1983) argued that male dominative desire in combination with social factors has exploited women in the agriculture sector for

instance; through the channel of unpaid family labor. Moreover, she also found in the early New England men ownership of means of production in subsistence farming, lead to the enforcement of patriarchal norms excluding women from productive works. Tavenner et al. (2019) found positive association between crop diversification and female control over decision making across gender-respondent-households typologies in East Africa. This study revealed that women have far more control over decision making on consumption than decision related to crop production and revenue expenditure. In my paper, I expand this analysis beyond the decision making domain and stretch it to investigate the relationship between diversification and resources as well as leadership domains.

Furthermore, keeping in mind the importance of crop diversification to combat adverse climate events, Huang et al. (2014) presented empirical evidence that farmers are more likely to diversify, to safeguard from extreme weather events. The study also found that, women produce more crops after experiencing adverse climate events, which can be attributed to the less risk-averse nature of women. In addition, participation in decision making, access to productive resources, ownership of an asset such as land, well defined contracts are found to be key determinants to the adoption of climate variability strategies among the smallholder women rice farmers in Northern Ghana Alhassan et al. (2019). Similarly, Mutenje et al. (2016) argued women with higher intra-household decision making power and skilled training can influence the selection of agriculture technology and resource allocation. A study by Nguyen (2017) provided evidence that improvement of women education and reducing the dependency ratio, contributes to the expansion of technical efficiency, which can increase crop production by 18.7% in Vietnam. However, women's participation in decision making is very low in agriculture due to the fact of being less confident, insufficient knowledge of technology, and restricted mobility (Chayal et al., 2013).

Although gender divisions of labor on the family farm are persistent, the interconnection between social and economic functions mitigate the distinction between male and female worker. A part of it is due to the fact that labor-intensive production requires cooperation from all the members of the family (Neth, 1995). The majority

of prior research has emphasized the gender differential and importance of women's role in improving overall farming systems by closing the gender gaps. Pattnaik et al. (2018) argued in his paper argued that women's contribution to agricultural labor adds to the existing work burden that has negative consequences on the overall well being of women in India. They also argued, women participation in agriculture is primarily driven by poverty. Moreover, they found that women's ownership of the land does not necessarily advocate their participation in agriculture sector.

Over time, an extensive literature has developed on the implications of crop diversification in Bangladesh. Rahman (2010a) presented evidence of increased land-use intensity, crop diversity, and land productivity over time. Lately, in more than half of the total area, farmers grow crops twice a year and production of cereal and few cash crops have been increased over time due to technological advancement (Islam and Hossain, 2016). Albeit in presence of opportunity to expand the crop output with existing resources Bangladesh still concentrating only on rice production (Rahman, 2010b). The author uncovered evidence that specialization, especially the monoculture of rice, is associated with a reduction of overall productivity through loss of diversification efficiency. The author maintained the importance of crop diversification for agricultural growth as well as technical efficiency. This is consistent with previous findings that rice has always been dominant in land-share of crop production at the cost of minor crops such as pulses, cash crops, or vegetables (Quasem and Rahman, 1993). He suggested formulating new policy to promote crop diversification targeting specific regions. From a study in coastal areas Kabir et al. (2016) found suggestive evidence that over the years farmers have diversified their production to a mixed farming system (rice and shrimp), owing to an increase in the salinity the the water. They suggested that rice-shrimp farming strategy is more viable than the rice-nonrice farming strategy. Similarly, in flood-prone areas, farmers protect against weather shocks by producing a combination of cash crops, which are vulnerable to regular floods, and staple crops, which are vulnerable to flash floods and drought (Rayhan et al., 2010). On the other hand, Islam and Rahman (2012) presented evidence of low crop diversification in steeped areas due to rugged terrains and in coastal areas for saline water. Akanda (2010) stated that as extreme and adverse climatic

events have recently become frequent, the groundwater level has reduced significantly in Bangladesh. Diversifying crop production can be an alternative to safeguard food security. Moreover, agricultural diversification is associated with the increase of nutritional supply, import-substitution, and growth of agriculture shares in Gross domestic product (GDP) of Bangladesh Islam and Ullah (2012).

Diversification is also positively associated with household dietary diversity in Bangladesh Islam et al. (2018). One particular example is homestead vegetable farming can be helpful for generating income and providing food security to vulnerable communities in the basin regions (Karim et al., 2014). The availability of Integrated pest management technology along with access to credit, increases the overall vegetable production in farming households (Mahmoud et al., 2005). However, the study by Metzel and Ateng (1993) identified high input cost, low profitability, and extreme weather vulnerability as major constraints in crop diversification in Bangladesh. Moreover, a negative relationship between farm size and crop diversification has also observed that the larger farms tend to specialize in rice and a few other crops. In additon, Rahman (2008) asserted that small farmers are likely to diversify their production in Bangladesh and irrigation is the most important factor in crop diversification. Similarly, Mandal and Dutta (1993) claimed that the profitability, physical and agronomic potentials of non-rice crops especially potato and vegetables, are higher than HYV rice. Yet, the limited existence of non-rice crop irrigation technology and farmer's knowledge, impedes the diversification. Rahman and Kazal (2015) however, argued that specialization into cereals improves energy efficiency while the opposite is observed in the case of diversification among enterprises. The author provides suggestive evidence to maintain cereal as a base of diversification and then adding non-cereal crops to improve energy efficiency.

Female labor accounts for nearly thirty percent of total labor used in agriculture and significantly increases the technical efficiency in crop production Rahman (2010b). Also, diversification of crops and women property rights (such as land ownership) increase the proportion of hired female whereas Non-government organization (NGO) membership and ownership of land decreases the female labor supply within

family. A series of studies have recognized that the role of women among the farming systems of Bangladesh, in particular gender differential in productivity, decision making, and employment. Rehan et al. (2017) argued female participation in farming is found to be a notable determinant of crop diversification in Bangladesh. Seymour and Peterman (2017) suggested that reducing the gender gap in the household is associated with improved technical efficiency as much as 2.2%. Similarly in a national homestead gardening program, women in the treatment group is found to be more empowered, more aware of their contribution to household income generation as well as nutritional intake (Bushamuka et al., 2005). Nevertheless, Paul and Saadullah (1991) claimed, women are dominant in decision making regarding homestead activities. However, the majority of the decisions are taken jointly in Bangladesh. Oakley and Momsen (2005) provided evidence that the choice of planting improved varieties and local varieties of rice depends on women's decisions in the household. The study unveiled the existence of women's participation in deciding which crop to produce in the field. While their study focuses only two districts of Bangladesh and is limited to only one domain, my paper contributes to the existing literature by analysing multiple domain using nationally representative sample.

Notwithstanding the fact, women's participation in agriculture has increased sharply over time. Hossain and Jaim (2011) argued that they only contribute to domestic farming, livestock, or poultry farming rather than crop. In addition, they also found a considerable discrepancy in land allocation between male and female farmers. Female farmers have less land however, their participation in agricultural activities was higher than their male counterparts. Gender differential in the selection of crops has also been observed as female farmers were tending to allocate crops to vegetable production where the male was more towards potatoes. They also asserted that crop production activities provided a way of income generation for the women, which advocated their intra-household empowerment.

Even though studies have been conducted by many authors, in my opinion, the role of women in crop diversification is still insufficiently explored. Earlier research can only be considered as a first step towards a more profound understanding of

the existing relationship among crop diversification and women empowerment. Unlike previous literature which narrowed the focus on gender productivity differentials, farming decision making based on gender of household head or farm manager, this study solely explores the relationship between individual level empowerment and crop-farming decisions within a household. The contribution of this paper to the existing literature is three folds. First, I investigate the relationship between individual level empowerment in a household using women empowerment score. Second, I expand the analysis using disaggregated measures of women empowerment to discern the domain of empowerment that has more contribution to the choice of crop production. This will also help us to identify the domain of empowerment that needs attention and policy intervention for improvement. Third, analysis using household wealth (in terms of asset) and empowerment interaction will help to explore the relationship between empowerment and crop diversity among rich and poor households which was not addressed in previous literature.

In the next section, I present a conceptual discussion of crop diversification and women empowerment from existing literature. In addition, the relevant measurements of crop diversification and women empowerment that are to be used for this study are also provided.

2.2 Conceptualizing Crop-Diversification and Women Empowerment

2.2.1 Concept of Crop-Diversification

Past literature has provided various ways of conceptualizing crop diversification. Petit and Barghouti (1992) defined agriculture diversification as a shift from one crop production to multiple crop production on a farm to meet the growing demand for food. Joshi et al. (2006) referred agricultural diversification as the concentration on new areas of agriculture, producing alternative crops, and adopting new farming systems at a household level aimed at increasing household income and profit. Gunasena (2001) outlined two approaches of crop diversification, Horizontal diversification (HD) that refers to the addition of more crop farming systems utilizing various techniques,

and Vertical diversification (VD) that involves downstream activities such as producing a manufactured product. Cropping intensity and increased food production is associated with HD where VD reflects the stages of industrialization. Dasgupta and Bhaumik (2014) conceptualized diversification as a change of cropping pattern to high-value crops. Sraboni et al. (2014) used the total number of crops produced by a household as a measure of crop diversification. This measure however is limited since it ignores the utilization and diversity in land use. Chaplin (2000) and Vyas (2006) identified three stages of diversification where the first stage reflects a shift away from monoculture, the second stage involves the cultivation of more than one crops, as well as a variety of crops to meet market demand in that time of the year, and the third stage involves a shift in resources from one crop to mix of crops.

Number of crops grown and the maximum over-crop proportions of sales of a particular crop are used as typical measures of crop diversification Pope and Prescott (1980). Allowing the definition of diversification to be varied across countries as well as the data limitation on various aspects of the crop production in this paper, I propose the measure of diversification in terms of resource utilization (measured by plot), the number of various crops produced by the farming household, and intercropping.

Measuring crop diversification by land utilization

Both net income from the crop and crop acreages are potential variables to define crop diversification (Pope and Prescott, 1980). Acknowledging the proposition, Herfindahl index that measures Crop diversification (CD) in terms of income generating from the crop and Simpson index which incorporate crop acreages, are widely used along with Entropy and Gini coefficient measures (Pal and Kar, 2012). Both Simpson and Herfindahl index are calculated in a similar fashion [1].

[1] These indexes of diversification are calculated by the following equation:

$$SI = \sum (\frac{R_i}{\sum_{i=1}^{n} R_i})^2$$

Where R_i is the plot or income share of i^{th} crops produced by farming household. The sum of R_i is always equals to 1. Crop Diversification Index (CDI) by subtracting SI from 1. CDI = 1 – SI. (1 = complete diversification, 0 = complete specialization).

However, their are some limitation of the indices. First, the acreage measure can be found limited if two different crops with different acre usage yield same income. On the other hand, two different crops with same land usage yield different income, then income measure can be considered as indifferent choice. Moreover, a farming household can diversify their production solely for consumption purpose. In that case, information on the monetary value is missing, leading to the share of income zero and the summation of R_i equals to zero. As a consequence these households could be left out from the estimation. Unfortunately, in the BIHS data-set there are households which produce for own consumption and the monetary value or income share of the crops which was not reported, or reported as zero. Nevertheless, the data set contains information on plot level crop production data which enables us to estimate the crop share of the land in the farming households using their cultivable land. Hence, for this study I use the Simpson Index of crop diversification that measures the horizontal diversification by using the information on crops produced in cultivable land by the farming households.

One limitation of the data-set is that it does not provide detailed information of the homestead land utilization. In an ideal setting of rural Bangladesh, homestead farming is one of the key contributors to the crop diversification. For robust estimation, I need to look for alternative ways to measure crop diversification.

Measuring diversification as number of crops

The BIHS data set may exclude information on land use of fruits and vegetables that are grown in homestead since it only collected information from cultivable land. Hence, using land utilization as a measure of crop diversification may lead to underestimation problem. This is important because, women play a major role in homestead farming in rural Bangladesh. To solve this problem, total number of crops produced by a household can be used as an alternative measure to diversification as well as for robustness.

Inter cropping

One possible alternative measure of land utilization can be using inter-cropping dummy that is whether the farming household is producing more than one crop in the same plot. The data set reports the information on inter-cropping. Using this information I can estimate the probability of intercropping in farming household to get an insight of land utilization and crop diversification together.

2.2.2 Concept of Women Empowerment

Defining women empowerment is difficult owing to the fact that it is not directly observable (Mahmud et al., 2012) as well as contextual and cultural variation (Kabeer, 1999). The most notable and earlier attempt to define women empowerment was by Kabeer et al. (1999) who defined empowerment as the ability to make strategic life choices. In particular, the ability to make the choice incorporates three inter-related dimensions. First, the resource dimension that is defined to include both access and claims of human and social resources. Second, the agency which includes decision making, negotiation, and manipulation. Third, the achievement dimension that is the outcome of well being. She added that the agency is the process of the ability to make choices, whereas resource domain is the pre-condition by which agency can be exercised, and lastly achievements are the outcomes of the process. Similarly, Alsop and Heinsohn (2005) defined empowerment as the capacity to make effective choices towards what is valued, utilizing the concept of agency by Sen (1989). Furthermore, in the context of Bangladesh, Mahmud et al. (2012) suggested including the ability to intra-household decision-making in agriculture and non-farm enterprises, asset ownership, and control over income, as the indicators of women empowerment. Hossain and Jaim (2011) from their study proposed freedom of mobility outside the home border as an indicator of women empowerment. They argued that it is important to consider freedom of mobility, especially in farming households because firstly, mobility outside the home increases the confidence of women, and secondly mobility enables access to the input market and marketing of produce. However, most of the female participants in their study did not go to the non-local shop to purchase the inputs. The indicators used in the study is primarily based on the definition of Kabeer et al. (1999) developed by Alkire et al. (2013) and has been used in various recent studies

(Sraboni et al., 2014), (Cunningham et al., 2015), (Malapit et al., 2015b), (Seymour and Peterman, 2017), (Diiro et al., 2018). Below I provide a brief discussion on the measurement of the indicators.

Women Empowerment Score

To measure the women empowerment, I use Five domain empowerment score (5DE) developed by Malapit et al. (2015a) which is the modified version of Alkire et al. (2013). The 5DE is the weighted average of five sub-domain i) production ii) resource iii) income iv) leadership v) time. Details methodology of five domains of women empowerment is give in appendix. The 5DE index is a measure the empowerment that shows the number of domains in which women are empowered. The five-empowerment domain are defined as follows:

1. Resource: This domain concerns ownership, decision making and right on productive asset such as land, agriculture equipment, credit etc.

2. Production: This domain measures sole or joint decision on agriculture production, decision making on food or cash crop production in agriculture production and other productive decisions.

3. Income: This domain concerns the sole or joint decision and control over the income and expenditure.

4. Time: This domain concerns the time allocation among the productive and domestic works as well as satisfaction with the leisure time.

5. Leadership: This domain asses the community involvement measure by active membership in the number of social groups.

The 5DE is a continuous measure of women empowerment that comprise of these five domains of empowerment in agriculture ranges from zero to one and increasing in empowerment. This index provides information on individual-level empowerment in a household. See Appendix A.1 for details.

Disaggregated measure of Women Empowerment

In addition to the individual level women 5DE score I use disaggregated measure of women empowerment for the sub-domains. For measuring women empowerment in resource, production, and leadership domain I use number of productive asset sole/jointly own by the female member, number of productive decision taken by the female member and number of groups the female member belong to in the household respectively. This separated models allow us to investigate in which domain women are more empowered and which domain need improvement.

Chapter 3

Data

3.1 Data Source

For this paper I use two rounds data of Bangladesh Integrated Household Survey (BIHS) collected by International Food Policy Research Institute (IFPRI). The first round of data was collected between December 2011 to March 2012. The first round of data set consist of 5503 national statistically representative rural households seven administrative divisions. In the full sample, 2795 that is approximately 50% of the households are crop-farming and provided detailed information on land use, input and output of crop production, and marketing Ahmed (2013).

The second round of household data was collected during 2014 to 2015 with an attrition rate of 4.41. The second round of data set consist of 5,447 rural nationally representative households as 162 households interviewed in the first round split up into two or more households in this round Ahmed (2016). The second round of data set contains information on 2768 crop farming household which is also approximately 50% of the total sample. For our analysis we also included the splited household in the second round. The BIHS collected data on land usage by crop, input usage in the largest plot, marketing of agriculture products, information on empowerment for both male and female in a household. Besides, around 2,232 identical households in each of the round has aforementioned information. I used the those same households from both of the round for a two year panel analysis.

3.2 Descriptive Statistics

In this section I inspect the data of the two rounds, to get some insights prior to the econometric analysis. First, I conduct a categorical t-test in order to check whether there is statistically significant difference in the key variables of interest between

shocks rooted to natural disaster or adverse weather.

In case of Chittagong and Sylhet, those two divisions are comprised with mainly hill-tracks and rugged terrains. This could leave the farming household with little choices to diversify the crop production. Moreover, over time all the regions had experienced a sharp decline in the mean of crop diversification and mixed change in women empowerment measures. That is in Dhaka, Chittagong, Khulna women empowerment increased where other regions experienced a sharp decline.

I also wish to check how crop diversification differs among various level of household in terms of current asset holdings. To do so, I divide the sample into five asset quintiles. I use the current value of household asset as a measure of wealth. Table 3.2 reports the mean of crop diversification measures across five income quintiles. It is

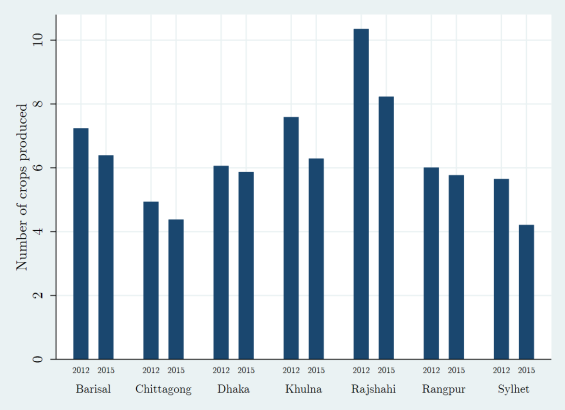
Table 3.2: Crop diversification measures across five income quintiles

	Round 1 (2011-12)			**Round 2 (2014-15)**		
	(1)	(2)	(3)	(1)	(2)	(3)
Lowest Asset HH	0.55	4.60	0.14	0.54	3.97	0.09
Low-Middle Asset HH	0.60	5.70	0.17	0.57	4.66	0.09
Middle Asset HH	0.66	6.76	0.16	0.61	5.50	0.11
High Middle Asset HH	0.67	7.26	0.21	0.70	7.18	0.13
Highest Asset HH	0.73	9.25	0.26	0.68	8.15	0.15

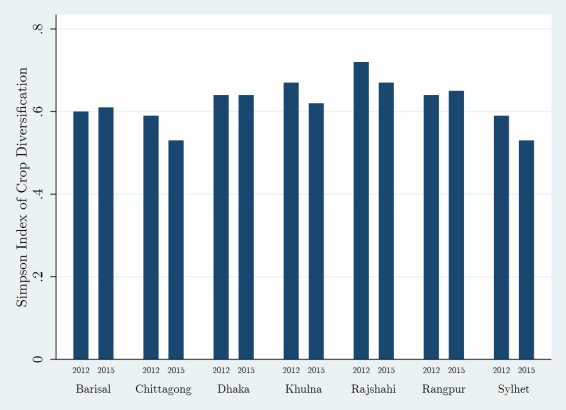
Note: 1 = Simpson index of crop diversification;
2= Number of crops produced by household; 3= Inter-cropping dummy.

clear that, as asset holding increases crop diversification also increases. That means, richer households are prone to more crop diversification. This is intuitive because richer household may have access to more resources and the means of production which enables them to diversify the crop production relative to the poorer households. Later, I will estimate the relationship between women empowerment and crop diversification across different level of households in order to investigate differential relationship of crop diversification and women empowerment among richer and poorer households.

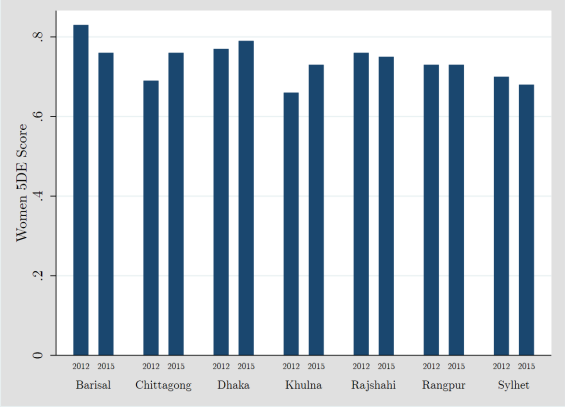
In addition, summary statistics tables are given in the appendix including other control variables for the two rounds of survey.



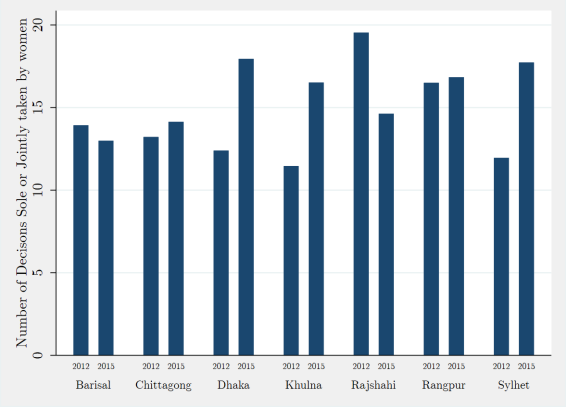
(a) Number of crops produced



(b) Simpson Index of Diversification



(c) Women 5DE Score



(d) Number of decision taken by women

Figure 3.1: Mean of key variables over time across regions

Chapter 4

Methodology

Farmers adoption of new technology or making new decision is rooted to the utility maximization theory (Rahm and Hauffman, 1984). They argued that, adopting new technology or taking new decision leaves farmers with uncertain outcomes. In the paper they presented a model of adoption behaviour with the assumption that, farmers make decision (such as diversification) on the objective of utility maximization. The theoretical framework to determine the diversification is adopted from Rahm and Huffman (1984) and Asante et al. (2018) that describes the utility of i^{th} farming households is denoted by $U_{ji}(R_{ji}, A_{ji})$ where j=0 if i^{th} farming household decides specialize their production and j=1 if the decides to diversify their production. Utility depends on the unobserved and unavailable vectors of variables R_{ji} and A_{ji} which represent net return from diversification and other attributes associated with diversification respectively. A linear relationship however, is proposed for the i^{th} farm between the utility derived from specialization and diversification, as well as a vector of observed household and farm specific characteristics such as soil type, irrigation method, assets, human capitals etc.

$$U_{ji} = X_i\alpha_j + \epsilon_{ji} \tag{4.1}$$

Given that utilities U_{ji} are random and the farmers will choose to diversify if the latent variable d_i[1] $= U_{1i} - U_{0i}$ is positive. Rahm and Huffman (1984) argued investment in education, information, empowerment enhances the efficiency of adoption decisions in a farming household. For this study, I am more interested in investigating the role of women empowerment to determine the crop diversification in a farming household.

[1] d_i is a qualitative variable which indexes the adoption decision

In order to examine the relationship between women empowerment and crop diversification I estimate the following equation:

$$\text{Diversification} = \beta_0 + \beta_1 \text{ women empowerment} + X^{'}\beta + \mu \tag{4.2}$$

β_1 is the correlation coefficient between diversification and women empowerment. As mentioned earlier, I will use various measures of diversification and women empowerment, hence I shall use multiple models to estimate the robust relationship. For the estimation I are using three diversification measures: (1) Simpson Crop Diversification Index which value ranges from 0 to 1 increasing in diversification, (2) Number of crop produced by the farming household which is count data ranging from 1 to 71; (3) Inter-cropping dummy that is whether a farming household is producing more than one crop in same land or not.

I will estimate four models with various measure of women empowerment. For *model 1* I will use women 5DE score, *model 2* number of productive decision sole/jointly taken by the women; *model 3* number of productive asset sole/jointly owned by the women; *model 4* - number of group women have active membership. For each of the estimates I will include other control variables such as household head education, household composition, soil type, water source, irrigation methods, cost of labour and equipment rental, revenue, consumption, harvest, current value of asset, cultivable land and division fixed effect. In addition, I will split the sample into asset quintiles and estimate the relationship between diversification and empowerment to see how it varies across various asset levels. My argument is that, empowerment can only help diversification if the household has access to adequate resources.

Given the continuous, count and binary nature of the dependant variables which are generated by different Data generating process (DGP), I will need separate estimation techniques for each of the measure of crop diversification. First, for the regression with Simpson Crop Diversification Index (SCDI) as dependent variable which is continuous, I will use a multiple linear regression model using ordinary least square (OLS) method. Next, another measure for crop diversification is the number

of crops produced by a farming household which I treat as count data. One natural way to start analysis of count data is using Poisson regression or the poisson model Cameron and Trivedi (2013) Most of the count data are often overdisparsed. One way to model overdispearsed data is using Negative binomial which explicitly models over dispersion. A negative binomial is regarded as gamma mixture Poisson random variables. The NB model accommodates overdispersion and it reduces to Poission model as overdispersion parameter, α converges to zero ($\alpha \to 0$) Cameron and Trivedi (2013), Cameron et al. (2009), Long (1997). In the dataset, every farming household is producing at least on of the crops (minimum is 1), hence in this case Zero Truncated Negative Binomial (ZTNB) and Zero-Truncated Poisson (ZTPR) would be appropriate to fit the data. One limitation of ZTNB model is that, even though the model analyzes mean response variable, the mean may not fully represent the distribution of data Liu et al. (2013). To the best of my knowledge, this is the first paper that uses ZTNB model in estimating the relationship using number of crops as a measure of diversity. Third, when using intercropping as dependent variable, I will use multivariate Probit regression model and average marginal effect to interpret the regression result.

I also include a two year panel analysis to look at the changes in empowerment within a HH relate to changes in diversification within a HH. Two-year panel is the simplest version of panel data. One way to use panel data is to view the unobserved factors affecting the dependant variable as consisting two types – constant and time variantWooldridge (2016). Let, *'i'* denotes the cross-sectional unit and *'t'* the time period, we can write our model:

$$\text{Diversification} = \beta_0 + \beta_1 \text{women empowerment}_{it} + X_{it}^{'}\beta + a_i + \mu_{it} \qquad (4.3)$$

The variable a_i captures all the time-invariant unobserved factors that effect y_{it}. Generally, a_i is called an unobserved heterogeneity or fixed effect. Fixed effect transformation is one way to eliminate the fixed effect a_i. The fixed effect transformation is also called within transformation that can be obtained by time-demeaning the data on y. A pooled cross-sectional data based on time-demeaned variable is also called fixed effect estimator.

Additionally, it should be noted that, I am using indexed variable for both dependent and independent variables. Sometimes, an index cannot be interpreted or translated in a meaningful way since it lacks proper unit. To solve this issue, I will use standardized coefficients to interpret the results. Standardized coefficient is useful to estimate the relationships, which are independent of the original unit of measure or, where substantive meaning to scale scores cannot be attained Landis (2005). Moreover, it helps to determine the relative effect on the variable of interest Hunter and Hamilton (2002). In particular, standardized coefficient can be calculated in two ways leading to the same result Bring (1994). First, I can standardized all the variables then estimate the model.

$$x_i^* = \frac{x_i - \bar{x}}{s_i} \tag{4.4}$$

Where, x_i is the variables of interest and s_i is the standard deviation of the variable. Alternatively, I can estimate the model using unstandardized variable and then multiply them by the ratio between the standard deviation of the variables of interest.

$$\hat{\beta}_i^s = \hat{\beta} \times (\frac{s_i}{s_y}) \tag{4.5}$$

Here, $\hat{\beta}_i^s$ is the standardized coefficient. For my study, I chose the second method since this is simpler and STATA command *'listcoef'* from the package *'spost13'* by Long and Freese (2014) reports the standardized coefficient. The standardized coefficients are interpreted in terms of change in standard deviation instead of comparing by unit.

Chapter 5

Result

To estimate the relationship among crop diversification and women empowerment I estimated several regressions of diversification on women empowerment measures for both the survey round of different years. Table 5.1 provides the ordinary least square (OLS), Zero-truncated Poisson (ZTPR), Zero Truncated negative binomial (ZTNB) regression, and Probit estimation results. Table 5.1 and 5.2 summarize the estimation results from various regressions. In the tables, I only included the variables of interests and leave the other control variables on the Table in the Appendix C.

First I estimate the relationship between women five domain empowerment score (5DE) and various measures of crop diversification. For the year 2011-12, in Table 5.1 the coefficient of women 5DE scores (Column 1-4) is not statistically significant in the regressions with crop diversification index (CDI) and the number of crops produced by the household. In round 2 (2014-15) Table 5.2 however, women empowerment score and Simpson crop diversification index has statistically significant positive relationship.

In particular, in 2014-15 (Table 5.2) one standard deviation increase in women empowerment score is associated with an increase of standard deviation of the crop diversification index by approximately 0.039. The coefficient is positive however, the magnitude is small. In addition, number of crop produced by the household in both cultivable land and homestead is positively associated with women empowerment score. That is, one standard deviation change in women empowerment score is correlated with the increase of expected count of number of crops produced in farming household by 1.024. In another way, a 0.10 unit increase in women empowerment score will increase the number of crop count by 0.102. In both of the rounds, intercropping is positively correlated with the women empowerment score. Though, I

could not find any significant relationship between crop diversification and women empowerment in two of the estimates of round 1, the regression result from Round 2, suggests that, women empowerment is positively associated with the improvement in overall crop diversification within a farming household.

Table 5.1: Estimation results from Round 1, (2011 -12)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	-0.0150	-0.163	-0.0405	-0.0530	0.255**
	-0.013				
		-0.039	0.990	0.987	0.061**
	(0.0168)	(0.396)	(0.0549)	(0.0510)	(0.129)
Constant	-0.663***	-19.35***	-2.760***	-3.079***	-3.761***
	(0.0641)	(1.600)	(0.230)	(0.204)	(0.504)
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.461	0.448			
Number of decisions sole/jointly taken by women	0.000635	0.0394***	0.00331**	0.00349***	0.0129***
	0.002				
	(0.000386)	(0.0117)	(0.00144)	(0.00125)	(0.00305)
Constant	-0.674***	-19.54***	-2.764***	-3.100***	-3.566***
	(0.0625)	(1.547)	(0.229)	(0.199)	(0.489)
Observations	2,777	2,777	2,777	2,777	2,777
R-squared	0.462	0.451			
Number of asset sole/jointly owned by women	0.00205	0.0519	0.00119	0.00256	0.0602***
	0.008				
	(0.00232)	(0.0647)	(0.00841)	(0.00721)	(0.0176)
Constant	-0.679***	-19.61***	-2.788***	-3.121***	-3.740***
	(0.0627)	(1.553)	(0.229)	(0.201)	(0.493)
Observations	2,777	2,777	2,777	2,777	2,777
R-squared	0.462	0.448			
Number of groups women belong to	-0.0234***	-0.196	-0.0251	-0.0415	-0.00186
	-0.086***				
	(0.00870)	(0.205)	(0.0283)	(0.0261)	(0.0625)
Constant	-0.666***	-19.40***	-2.777***	-3.102***	-3.562***
	(0.0627)	(1.557)	(0.228)	(0.200)	(0.493)
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.463	0.448			

Note: 1. Blue = X and Y coefficients are standardized
2. Green = X coefficient is standardized
3. Magenta = Y is Standardized
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Next I move on to the individual empowerment domain and estimate the relationship in similar fashion. First, I estimate the relationship between decision making domain measured by number of productive decision sole or jointly taken by the women in HH and various measure of crop diversification. Decision domain has no significant relationship in 2011-12 (Table 5.1) however it has statistically significant correlation

with allocating land towards more crops in 2014-15 (Table 5.2). In a farming HH, an

Table 5.2: Estimation results from Round 2, (2014 -15)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	0.0475***	0.0979	0.0715	0.102*	0.257*
	0.039***				
		0.023	1.017	1.024*	
	(0.0171)	(0.333)	(0.0560)	(0.0550)	(0.145)
Constant	-0.639***	-19.18***	-3.678***	-3.937***	-2.900***
	(0.0561)	(1.274)	(0.220)	(0.211)	(0.481)
Observations	2,720	2,720	2,720	2,720	2,720
R-squared	0.494	0.410			
Number of decisions sole/jointly taken by women	0.00201***	0.0172*	0.00363**	0.00506***	-0.00682*
	0.007***				
	(0.000436)	(0.00948)	(0.00149)	(0.00143)	(0.00389)
Constant	-0.608***	-19.09***	-3.615***	-3.863***	-2.612***
	(0.0542)	(1.261)	(0.216)	(0.206)	(0.462)
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.496	0.410			
Number of asset sole/jointly owned by women	0.00788***	0.0979**	0.0149**	0.0216***	-0.0170
	0.028***				
	(0.00214)	(0.0426)	(0.00685)	(0.00678)	(0.0176)
Constant	-0.612***	-19.17***	-3.614***	-3.872***	-2.625***
	(0.0543)	(1.263)	(0.215)	(0.206)	(0.463)
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.495	0.410			
Number of groups women belong to	-0.00469	-0.476***	-0.0636**	-0.0542**	-0.0203
	-0.017				
	(0.00763)	(0.141)	(0.0252)	(0.0246)	(0.0637)
Constant	-0.596***	-18.72***	-3.548***	-3.796***	-2.644***
	(0.0544)	(1.258)	(0.216)	(0.208)	(0.465)
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.493	0.411			

Note: 1. Blue = X and Y coefficients are standardized
2. Green = X coefficient is standardized
3. Magenta = Y is Standardized
4. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
5. Tables with Other controlled variables is included in appendix
6. Overdispersion parameter α is statistically significantly different from Zero.

additional increase in women contribution to productive decision making, increases the standard deviation of crop diversification index by 0.007. Likewise, decision domain has statistically significant positive association with HH's decision in producing more crops. Particularly an increase in women's contribution to productive decision is associated with an increase of the log count of crop numbers by 0.003 and 0.005 both of the years respectively. Although, the association is positive, the magnitude indicates the presence of weak relationship.

Second, I estimate the relationship between crop diversification and resource domain using number of productive asset women has sole/joint ownership in a farming household. From the estimation result I found, the control over resource or sole/joint ownership in productive asset is positively associated with crop diversification index as well as number of crops produced by farming household in round 2. However, there is no statistically significant relationship during round 1 in year 2011-12. In a household, an increase in sole or joint ownership over productive asset by women, is associated with an increase of the standard deviation of crop diversification index by approximately 0.03 and log count of number of crops by 0.02.

Third estimation includes leadership domain where I used number of groups that the women are active member of, as a measure of leadership and estimate the relationship between crop diversification. The independent variable is measured as the number of groups women are actively member of which include agriculture producer groups, micro-finance groups, trade business associations and other eight groups. Alkire et al. (2013), Sraboni et al. (2014) founds that number of group membership is one of key contributors of dis-empowerment of women empowerment score in agriculture households. That is, a woman who is active member in more groups tend to be less empowered in agriculture households. This is reflected in the regression results under estimations Tables 5.1 and 5.2.

I found from the sample estimation, that number of groups that women are active member of is significantly and negatively correlated with crop diversification index, as well as with the log count of crops produced by HHs. From the sample, an additional membership with the social groups decreases the log count of number of crops by 0.05 (Table 5.2) and decreases the standard deviation of crop diversification index by 0.09 (Table 5.1). There could be a few possible reasons for this relationship. It is possible that women with greater networking and more social involvement might enable them to move away from farming activities to engage in non-farm activities such as trading, wage labor in factories, for which they may have limited time leading to parsimonious contribution to the farming decisions. Another reason could be

women with least autonomy or empowerment in a household are encouraged to join the groups such as trade unions, micro-credit etc.

In addition, we run a fixed effect[1] panel analysis (Table 5.3). The result indicates a positive association between women empowerment score and crop diversification index. I also observed a significant negative relationship between number of crops produced and the decision domain, as well as the resource domain. It might be due to the fact that over time, women with more ownership and rights over assets, as well as more contribution to decision making move away from crop farming and engage in non-farming activities.[2]

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Women 5DE Score	0.0244*	-0.264	-0.0201	-0.0201	0.274
	(0.0142)	(0.284)	(0.0386)	(0.0386)	(0.332)
Year Dummy	-0.0355***	-1.061***	-0.178***	-0.178***	-0.464**
	(0.00830)	(0.166)	(0.0237)	(0.0237)	(0.193)
Constant	-0.471***	-13.88***		15.83	
	(0.0638)	(1.274)		(164.8)	
Observations	4,441	4,441	4,418	4,418	1,102
R-squared	0.329	0.302			
Number of HH	2,232	2,232	2,209	2,209	551
Number of Decision	0.000242	-0.0103	-0.00118	-0.00151*	-0.00303
	(0.000333)	(0.00666)	(0.000824)	(0.000821)	(0.00781)
Year Dummy	-0.0351***	-1.047***	-0.175***	-0.176***	-0.449**
	(0.00830)	(0.166)	(0.0237)	(0.0237)	(0.194)
Constant	-0.445***	-14.00***		14.87	
	(0.0629)	(1.258)		(173.7)	
Observations	4,446	4,446	4,428	4,428	1,104
R-squared	0.327	0.303			

[1]Hausman test for all the models favours Fixed Effect model at 5% significant level

[2]It should be noted, the panel regression package for ZTNB and ZTPR has not being developed yet. Hence, I rely on the Poisson and Negative binomial regression for this particular analysis

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Number of a01	2,232	2,232	2,214	2,214	552
Number of asset owned	0.00002	-0.0757**	-0.00846*	-0.00846*	-0.0238
	(0.00180)	(0.0359)	(0.00476)	(0.00476)	(0.0423)
Year Dummy	-0.0346***	-0.997***	-0.169***	-0.169***	-0.425**
	(0.00844)	(0.169)	(0.0242)	(0.0242)	(0.201)
Constant	-0.443***	-13.87***		15.61	
	(0.0630)	(1.260)		(557.7)	
Observations	4,446	4,446	4,428	4,428	1,104
R-squared	0.327	0.304			
Number of a01	2,232	2,232	2,214	2,214	552
Number of groups	0.000476	0.0749	-0.00150		0.318*
	(0.00635)	(0.127)	(0.0179)		(0.172)
Year Dummy	-0.0350***	-1.066***	-0.178***		-0.438**
	(0.00829)	(0.166)	(0.0237)		(0.194)
Constant	-0.450***	-14.12***			
	(0.0629)	(1.256)			
Observations	4,447	4,447	4,430		1,106
R-squared	0.328	0.303			
Number of a01	2,232	2,232	2,215		553

Robust standard errors in parentheses

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

Table 5.3: Regression results from Panel Analysis

5.0.1 Household Wealth and Women empowerment

In this section I estimate the relationship between women empowerment and crop diversification among various level of assets. To estimate, first I divide the sample into five asset quantiles using current value of asset in HHs. Then, I estimate the relationship using interaction between women 5DE score and four asset levels where HHs that belong to the lowest 20% asset is the reference group. Table 5.4 summarizes the estimation results. From the table it is clear that, only some of the interaction terms showed statistically significant results in the interaction between women empowerment score and asset levels. Surprisingly, in 2011-12,by adding interaction term to the regression the women 5DE score became significant (which were insignificant in earlier estimation) which indicates there may exist a conditional relationship among asset, empowerment and crop diversification. In

2011-12, women empowerment score is positively associated with the richer household that is the HH that belongs to the Higher and Highest 20% of the asset quiltiles.

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Round (1)					
Women 5DE Score	-0.0805*	-0.410	-0.196	-0.170	-0.0406
	-0.070*				
		-0.098	0.954	0.960	-0.010
	(0.0421)	(0.708)	(0.144)	(0.139)	(0.314)
HH in Low-Middle 20% Asset	-0.0321	-0.0225	-0.0941	-0.108	-0.334
	(0.0421)	(0.729)	(0.134)	(0.130)	(0.326)
HH in Middle 20% Asset	-0.0512	0.0210	-0.0715	-0.0370	-0.156
	(0.0439)	(0.902)	(0.147)	(0.138)	(0.343)
HH High-Middle 20% Asset	-0.0657	-1.040	-0.260*	-0.215	-0.417
	(0.0417)	(0.857)	(0.141)	(0.136)	(0.328)
HH in Highest 20% Asset	-0.0524	-0.247	-0.193	-0.119	-0.0249
	(0.0406)	(1.029)	(0.140)	(0.130)	(0.303)
Women 5DE Score × HH in Low-Middle 20% Asset	0.0352	-0.635	0.0541	0.0698	0.433
	0.041				
			-0.031	1.017	0.138
	(0.0559)	(0.938)	(0.177)	(0.172)	(0.421)
Women 5DE Score × HH in Middle 20% Asset	0.0865	-0.249	0.0824	0.0547	0.167
	0.101				
			-0.012	1.027	0.053
	(0.0573)	(1.130)	(0.191)	(0.180)	(0.440)
Women 5DE Score × HH in High-Middle 20% Asset	0.103*	1.227	0.293	0.266	0.629
	0.120*				
			0.060	1.098	0.201
	(0.0538)	(1.103)	(0.183)	(0.177)	(0.416)
Women 5DE Score × HH in Highest 20% Asset	0.0984*	1.134	0.232	0.146	0.218
	0.108*				
			0.052	1.072	0.065
	(0.0535)	(1.356)	(0.181)	(0.173)	(0.395)
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.463	0.450			
Round (2)					
Women 5DE Score	0.128***	0.425	0.174	0.217*	0.236
	0.106***				
		1.041	0.954	1.052*	0.055
	(0.0410)	(0.545)	(0.126)	(0.127)	(0.311)
HH in Low-Middle 20% Asset	0.119***	0.854	0.279**	0.275**	-0.425
	(0.0432)	(0.636)	(0.137)	(0.139)	(0.396)
HH in Middle 20% Asset	0.0961**	0.490	0.242*	0.253*	0.0167
	(0.0439)	(0.655)	(0.133)	(0.135)	(0.354)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
HH High-Middle 20% Asset	0.128***	0.485	0.200	0.228*	0.0322
	(0.0420)	(0.781)	(0.137)	(0.138)	(0.356)
HH in Highest 20% Asset	0.102**	2.286**	0.239*	0.264*	0.200
	(0.0453)	(0.931)	(0.145)	(0.145)	(0.349)
Women 5DE Score × HH in Low-Middle 20% Asset	-0.136**	-0.901	-0.241	-0.248	0.423
	-0.044**				
		-0.288	0.926	0.924	0.135
	(0.0544)	(0.789)	(0.170)	(0.171)	(0.484)
Women 5DE Score × HH in Middle 20% Asset	-0.0930*	-0.205	-0.182	-0.182	0.00878
	-0.030*				
		-0.065	0.944	0.944	0.003
	(0.0552)	(0.829)	(0.165)	(0.167)	(0.442)
Women 5DE Score × HH in High-Middle 20% Asset	-0.0868*	0.588	-0.0145	-0.0296	-0.0425
	-0.028*				
		0.190	0.995	0.990	-0.014
	(0.0520)	(0.972)	(0.169)	(0.171)	(0.439)
Women 5DE Score × HH in Highest 20% Asset	-0.0901	-1.146	-0.0950	-0.118	-0.189
	-0.028				
		-0.357	0.971	0.964	-0.059
	(0.0571)	(1.164)	(0.180)	(0.178)	(0.433)
Observations	2,720	2,720	2,720	2,720	2,720
R-squared	0.498	0.411			

Note: 1. Blue = X and Y coefficients are standardized
2. Green = X coefficient is standardized
3. Magenta = Y is Standardized
4. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
5. Tables with Other controlled variables is included in appendix
6. Overdispersion parameter α is statistically significantly different from Zero.

Table 5.4: Regression results from Wealth and Empowerment interactions

In particular, women that belong to the Higher and Highest 20% asset HHs a standard deviation increase will increase the standard deviation of crop diversification by 0.12 and 0.10 respectively. The relative variability is higher in high-middle asset holding households compare to the highest asset holding households. This supports my argument introduced earlier that, women empowerment can only help crop diversification if the HH has access to adequate means of productions and resources.

On the other hand, estimation results from 2014-15 shows completely different results. In this estimation women empowerment is negatively associated with the crop diversification in all levels of HHs. From Table 5.4, it is clear that, an increase in women empowerment will decrease land allocation to more crops in all four levels of asset (Highest 20% being insignificant). In the Low-Middle, Middle, and High-Middle households, a standard deviation increase in women empowerment score will change the standard deviation of crop diversification index by -0.14, -0.1, and - 0.09 respectively. This also suggests, that HH belongs to the lower level of household with empowered women tend to be specialized in their crop production. One possible reason could be, women in the lower quanitles do not have capital or the resources to utilize in crop diversity. In addition, they may involved in domestic work, wage-labor, or household workers which restrict them involving in farming decision. Similarly, the richer household might not need to diversify the production at all if they diversify their livelihood into non-farm activities and meet the demand of dietary intake from existing market rather than own production. On the other hand Eswaran et al. (2013) found evidence that suggests relationship between women empowerment and HH status measured by wealth might be negative. They showed that greater family status may lead to lower female autonomy let alone the empowerment. In richer households women are often put into more restrictive environment that tied up with the notion 'family honor' or '*parda*' culture. This might be a possible explanation to the negative relationship between women empowerment and diversification in various asset level.

Further discussion:

Overall, until now I have observed few noticeable differences in the estimation results. First, there is a stark difference in relationship between women empowerment and using land allocation as a measure of crop diversification (which uses information only from cultivable land) verses number of crops produced by the household (which uses information on crop produced both in homestead and cultivable land). Second, there is a sharp difference in relationship between both of the year in particular an apparent significant positive relationship in 2014-15 and negative in 2011-12 sample. One general step would be to provide possible explanations for the differences.

First, I found from the sample study that, there is a significant difference in estimation between CDI and number of crops produced by the HH especially in decision domain. In round one estimation, I could not find any significant relationship with CDI and number of decision taken by the women while in round two the significant relationship exists. One possible explanation could be, in an ideal setting of rural households in Bangladesh, women are more engaged in domestic farming. That is,

women in farming households may be more likely to produce vegetables, fruits in their homestead land and take decision on what to produce in homestead rather than in cultivable land, where their male counterparts take the majority of the decisions. Since, women are more aware of food intake in a household, they might produce various non-cereal crops in homestead in order to meet nutritional demand in the household. Also, various agricultural policies notably Agriculture Extension Policy 2013, emphasizes on homestead gardening and promoted various program especially targeting women in order to meet micro-nutrition demand in a family, as well as increasing family welfare. This may result in a significant positive relationship between women empowerment and number of crops produced by the HH including homestead. It should be noted that, most of our analysis revealed a strong significant positive relationship between number of crops produced and proportion of children (both male and female) age 5-19 years old in a household. That is the household might produce more crops in response to meet the demand for micro-nutrients of these particular age groups.

Second, I have seen prodigal difference in the estimation result between round one and round two. In round one, women empowerment is related with crop specialization where in round two it is the opposite. In 2013, government of Bangladesh enacted National Agriculture Extension Policy which was designed to promote participation of women in agriculture. In particular, the policy promoted women collaboration in agriculture through the development of women farmers group, women agri-based SME business development and encouraged to lead decision making positions in high level farming. This is clearly reflected on the estimation results. Overall, women empowerment impacted in all measure of crop diversification in 2014-15. It could be the case that with better information on household's food demand being a homemaker, and additional information on market through empowerment, women‘s contribution to diversification increased in 2014-15. This explanation however, should be taken with cautions since the policy was implemented in a national level and my estimations do not separate the policy effects from both rounds.

So far I have seen, policy targeted to encourage women participation in agriculture which can lead to a significant change in crop production. Crop diversification could play an important role for ensuring food security, income diversification, nutritional intake, as well as reducing dependency on international food market of a country. At micro level women are better informed with HH's food intake, and with additional information on the macro level food market can enable them to take part in crop-diversification and other important decisions on crop farming. One way to make them more equipped with information is through the increase of empowerment in every domain. Policy targeted toward securing property rights of women can improve the position of them in the

household, which in turn contributes to the crop production decisions such as diversification. A study on nationally run program Majumder and Shivakoti (2001) found that the institutional inefficiency in planning, monitoring, and transferring the technology, crop diversification programs could not bring satisfactory results. Nevertheless, Providing opportunities for women to contribute in decision making could significantly improve crop production decision in a farming household which may result in better intra-household nutritional status and improved household welfare.

5.1 Limitation

The study contains several limitations. Firstly, the data lacks information on the input-output of the plots that is controlled by male and female separately. If the information was collected I could have investigate how male and female controlled plot differed in input and output of production. This would enable us to examine the Pareto efficiency of resource allocation within a household that may provide rigorous picture of women's position in household. I would recommend collecting the land use and input data for homestead farming to be used for future research. This would in turn help us to understand women's role in agriculture production, their state of empowerment, and to identify the sectors which might need suitable interventions for the improvement. Secondly, the autonomy or freedom of mobility was not included in the empowerment indicators as well as in the women empowerment index for the unavailability of the data. The mobility domain is important as it provides access to the input market let alone the marketing of the produce. Since, women in rural Bangladesh have limited mobility outside their home boundaries future research can look into this aspect for deeper understanding. Third, the possible argument on endogeneity between diversification and women empowerment may arise. However, past literature suggests that women empowerment may be endogenous to agriculture productivity (Diiro et. al., 2018), and no evidence have been found on endogeneity between crop diversity and women empowerment. Lastly, our analysis does not include some potential explanatory variables such as number of male and female labour used, temperature, precipitation and others. The analysis can be extended further by including these variables for better estimation.

Chapter 6

Conclusion

In this paper, I examine the relationship between women empowerment and crop diversification. The discussion provides suggestive evidence of the implications of crop diversification in food security, climate change, the decline in arable land, overall household welfare, and sustainable farming. It also points out the overlooked gender segment in the area of agriculture research. As Trauger (2004) argued productivist agricultural models tend to ostracize women from the knowledge space where sustainable agriculture amalgamates the spaces of women empowerment among the female farmers. As women are better informed about household food demand and overall welfare, a combination of their input can increase the efficiency of the diversification decision. I used women's five domain empowerment score, decision making, resource, and leadership domain as an indicator of women empowerment. For the crop diversification measure, I took the liberty to use the Simpson crop diversification index, the number of crops produced by household, and intercropping dummy.

The results of this study revealed the significant positive association between crop diversity and women empowerment. In particular, an standard deviation increase in women empowerment score is associated with a 0.039 standard deviation increase in crop diversification index. Similarly, an additional contribution to productive decision making is correlated with a 0.007 standard deviation increase in crop diversification and log count of crops by 0.003 to 0.005. Ownership of assets has also a positive association with crop diversification in particular 0.03 standard deviation increase in crop diversification index and 0.02 log count of the crops. I, however, found a negative relationship between leadership indicators and crop diversity. This can be attributed to the reason that, women with greater social involvement may be engaged in non-farm activities or less empowered women tend to join various social and financial groups. Hence, they have less motivation and space for contributing to farming decisions. The difference in result from the different measurements of crop diversification indicates homestead farming has been in control of women, however they are far behind from farming in cultivable lands.

I also examine the wealth effect on women empowerment and crop diversification nexus and the findings have been mixed between two years. While in the first round, women empowerment is associated with increased diversification in richer households compare to the poorer counterparts, results from the second round provided the opposite result. One reason could be, in the later years in richer household women deviated away from farming and involved in non-farming income activities. This paper contributes to the existing literature by investigating this nexus that to my best knowledge has not been addressed before.

The results bring into play some policy implications. First, the agriculture extension policies should be designed in a way that it promotes homestead gardening but also large-scale farming in cultivable land. Second, policies that provide incentives to women farmers by accessing finance, inputs, insurance, technology, and developing women agri-organizations, women agri-SME business are recommended as well. Third, the policies should ensure women's property rights which can leverage the decision making in large scale farming beyond their homestead spare. Lastly, increasing institutional capacity in implementing women-friendly policies is highly desirable.

It is worth mentioning due to the recent Coronavirus disease of 2019 (COVID-19) pandemic the world food supply chain has been disrupted and many people are likely to force down to the poverty level. It may have a negative impact on agriculture production, women empowerment status, and welfare of farming households. It brings out a scope of future research in this area.

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Appendix A

Constructing Women Empowerment Indexes

A.1 Women 5DE empowerment Score

The construction is obtained from Alkire et al. (2013) and Malapit et al. (2015a). The 5DE index are measured using six indicators with their corresponding weight that are given in the table below. Each indicator measures whether individual has adequate achievement with respect to each indicator. The 5DE index captures the women's empowerment within their household . The first step to compute

Dimension	**Indicator**	**Weights**
Production	Input in productive decisions	1/5
Resources	Ownership of Asset	2/15
	Access to and decisions on credit	1/15
Income	Control over use of income	1/5
Leadership	Group Membership	1/5
Time	Workload	1/5

Table A.1: The domains, indicators, and weights in the 5DE

the 5DE index is computing the disempowered index and then compute (1- M_0). An inadequacy score is computed for each person according to the inadequacies across all the domain. The score of each person is calculated by summing the weighted inadequacies experienced to keep the score between 0 and 1. A person with no inadequacy on any indicator receives a c_i score equal to 0.

$$c_i = w_1 I_1 + w_2 I_2 + ...w_n I_n$$

where $I_i = 1$ if the person has an inadequate achievement in indicator i and $I_i = 0$ otherwise, and w_i is the weight attached to indicator i with the sum equals to 1. A second cut-off or threshold is used to identify the disempowered. The disempowerment cut-off is the share of (weighted) inadequacies a woman must have to be considered disempowered, and we will denote it by k. For those whose inadequacy score is less than or equal to the disempowerment cut-off (in our case 20%), even if it is not 0, their score is replaced by 0, and any existing inadequacies are not considered in the

"censored headcounts." M_0 combines two key pieces of information: (1) the proportion or incidence of individuals (within a given population) whose share of weighted inadequacies is more than k and (2) the intensity of their inadequacies—the average proportion of (weighted) inadequacies they experience. The first component is called the disempowered headcount ratio (H_p):

$$H_p = \frac{q}{n}$$

Here q is the number of individuals who are disempowered, and n is the total population.

The second component is called the intensity (or breadth) of disempowerment (A_p). It is the average inadequacy score of disempowered individuals and can be expressed as follows:

$$A_p = \frac{\sum_{i=1}^{n} c_i(k)}{q}$$

where $c_i(k)$ is the censored inadequacy score of individual i and q is the number of disempowered individuals.

M_0 is the product of both: $M_0 = H_p \times A_p$. Finally, 5DE is easily obtained by (1- M_0)

Appendix B

Summary Statistics

B.1 Summary Statistics of Variables of Round 1

Variable	Obs	Mean	Std. Dev.	Min	Max
Women 5DE Score	2,792	0.74	0.24	0	1
Number of Productive Asset owned by women	2,791	2.61	1.71	0	11
Number of Decision taken by women	2,791	13.83	9.87	0	48
Number of groups women belongs to	2,792	0.30	0.48	0	3
Simpson Index	2,795	0.64	0.27	0	0.98
Number of Crop Produced by Household	2,795	6.71	6.52	1	71
Intercropping Dummy	2,795	0.19	0.39	0	1
Years of Education of HH Head	2,795	3.37	3.97	0	16
Age of HH Head	2,795	45.71	13.45	18	95
Proportion of males 0–4 years old	2,795	0.05	0.10	0	0.6
Proportion of males 5–10 years old	2,795	0.07	0.12	0	0.67
Proportion of males 11–18 years old	2,795	0.08	0.13	0	0.67
Proportion of males 19–59 years old	2,795	0.23	0.14	0	0.75
Proportion of males 60 years and older	2,795	0.06	0.12	0	0.5
Proportion of females 0–4 years old	2,795	0.05	0.10	0	0.67
Proportion of females 5–10 years old	2,795	0.07	0.12	0	0.75
Proportion of females 11–18 years old	2,795	0.07	0.12	0	0.67
Proportion of females 19–59 years old	2,795	0.28	0.12	0	1
Household Size	2,795	4.51	1.68	1	17
Ln (HH Total Cultivable Land+1)	2,787	4.32	0.97	0	7.40
Access to Extension Service Dummy	2,795	0.10	0.30	0	1
Ln (HH Value of Asset + 1)	2,795	9.85	1.26	0	13.72

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Number of Irrigation Method Used	2,795	1.71	0.72	1	5
Number of Water Source Used	2,795	1.67	0.68	1	5
Ln (Annual Labor Cost + 1)	2,792	7.42	2.89	0	12.10
Ln (Annual Rental Cost + 1)	2,792	7.27	0.94	3.93	10.36
Number of Varity Crops Produced	2,795	1.49	0.57	1	3
Ln (Revenue + 1)	2,791	7.27	4.18	0	12.88
Ln (Consumption + 1)	2,791	6.73	1.20	0	11.28
Ln (Harvest + 1)	2,791	7.96	1.13	3.04	11.57
Number of types of soil	2,787	1.20	0.47	1	5
Division Dummy 1	2,792	0.07	0.25	0	1
Division Dummy 2	2,792	0.11	0.32	0	1
Division Dummy 3	2,792	0.34	0.47	0	1
Division Dummy 4	2,792	0.12	0.33	0	1
Division Dummy 5	2,792	0.13	0.34	0	1
Division Dummy 6	2,792	0.11	0.31	0	1
Division Dummy 7	2,792	0.11	0.32	0	1

B.2 Summary Statistics of Round 2

Variable	**Obs**	Mean	**Std. Dev.**	**Min**	**Max**
Women 5DE Score	2,741	0.75	0.23	0	1
Number of Productive Asset owned by women	2,747	3.65	1.95	0	11
Number of Decision taken by women	2,747	16.37	9.05	0	48
Number of groups women belongs to	2,747	0.29	0.55	0	4
Simpson Index	2,768	0.62	0.28	0	0.98
Number of Crop Produced by Household	2,768	5.89	5.66	1	63
Intercropping Dummy	2,768	0.11	0.32	0	1
Years of Education of HH Head	2,480	3.28	3.90	0	16
Age of HH Head	2,480	48.01	12.78	21	105
Proportion of males 0–4 years old	2,768	0.04	0.08	0	0.5
Proportion of males 5–10 years old	2,768	0.06	0.11	0	0.60
Proportion of males 11–18 years old	2,768	0.08	0.12	0	0.60
Proportion of males 19–59 years old	2,768	0.21	0.13	0	0.8
Proportion of males 60 years and older	2,768	0.05	0.11	0	0.5
Proportion of females 0–4 years old	2,768	0.04	0.08	0	0.50
Proportion of females 5–10 years old	2,768	0.06	0.10	0	0.60
Proportion of females 11–18 years old	2,768	0.08	0.12	0	0.60
Proportion of females 19–59 years old	2,768	0.25	0.11	0	1
Household Size	2,768	5.20	2.05	1	21
Ln (HH Total Cultivable Land+1)	2,763	4.35	0.97	0	7.86
Access to Extention Service Dummy	2,751	0.13	0.33	0	1
Ln (HH Value of Asset + 1)	2,768	10.80	1.03	6.99	13.85
Number of Irrigation Method Used	2,768	1.53	0.57	1	4
Number of Water Source Used	2,768	1.51	0.56	1	4
Ln (Annual Labor Cost + 1)	2,768	7.69	3.21	0	12.33
Ln (Annual Rental Cost + 1)	2,768	7.86	1.46	0.00	10.90
Number of Varity Crops Produced	2,768	1.45	0.58	1	3
Ln (Revenue + 1)	2,768	7.41	4.40	0	13.76

Variable	**Obs**	Mean	**Std. Dev.**	**Min**	**Max**
Ln (Consumption + 1)	2,768	6.40	1.46	0	8.97
Ln (Harvest + 1)	2,768	7.81	1.24	0.00	11.25
Number of types of soil	2,763	1.18	0.44	1	4
Division Dummy 1	2,768	0.07	0.25	0	1
Division Dummy 2	2,768	0.13	0.33	0	1
Division Dummy 3	2,768	0.33	0.47	0	1
Division Dummy 4	2,768	0.12	0.33	0	1
Division Dummy 5	2,768	0.13	0.33	0	1
Division Dummy 6	2,768	0.13	0.33	0	1
Division Dummy 7	2,768	0.10	0.30	0	1

Appendix C

Regression Tables

Round 1 Model 1 - Women Empowerment Score

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	-0.0150	-0.163	-0.0405	-0.0530	0.255**
	(0.0168)	(0.396)	(0.0549)	(0.0510)	(0.129)
Proportion of males 0-4 years old	0.0146	0.925	0.424**	0.465***	-0.150
	(0.0555)	(1.151)	(0.195)	(0.180)	(0.458)
Proportion of males 5–10 years old	-0.0189	0.202	0.354**	0.318**	-0.332
	(0.0493)	(1.022)	(0.174)	(0.154)	(0.400)
Proportion of males 11–18 years old	0.0201	0.928	0.484***	0.476***	0.229
	(0.0473)	(1.130)	(0.173)	(0.153)	(0.390)
Proportion of males 19–59 years old	-0.00469	1.137	0.486***	0.456***	-0.313
	(0.0485)	(1.087)	(0.174)	(0.157)	(0.405)
Proportion of males 60 years and older	0.0471	1.315	0.537**	0.555***	0.188
	(0.0574)	(1.365)	(0.212)	(0.190)	(0.483)
Proportion of females 0–4 years old	-0.0411	-1.489	0.0957	0.0934	-0.547
	(0.0556)	(1.136)	(0.192)	(0.170)	(0.482)
Proportion of females 5–10 years old	-0.00110	1.206	0.508***	0.488***	-0.0428
	(0.0496)	(1.087)	(0.179)	(0.158)	(0.400)
Proportion of females 11–18 years old	0.0254	1.932*	0.543***	0.582***	0.218
	(0.0482)	(1.129)	(0.179)	(0.160)	(0.390)
Proportion of females 19–59 years old	0.00281	0.904	0.333**	0.285**	-0.0968
	(0.0394)	(0.910)	(0.157)	(0.137)	(0.335)
Household Size	0.00175	0.0124	-0.00424	-0.000859	0.0266
	(0.00277)	(0.0710)	(0.00864)	(0.00863)	(0.0209)
Ln (HH Total Cultivable Land+1)	0.0112	1.379***	0.207***	0.232***	0.188***
	(0.00735)	(0.152)	(0.0233)	(0.0225)	(0.0541)
Access to Extension Service Dummy	0.00987	0.480	0.0265	0.0271	0.110
	(0.0118)	(0.414)	(0.0402)	(0.0387)	(0.0921)
Ln (HH Value of Asset + 1)	0.00712*	0.176**	-0.000540	0.00250	0.0600**

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
	(0.00368)	(0.0843)	(0.0126)	(0.0114)	(0.0283)
Number of Irrigation Method Used	0.0211**	0.859**	0.0700**	0.0843***	0.178**
	(0.0102)	(0.368)	(0.0302)	(0.0316)	(0.0903)
Number of Water Source Used	0.0576***	0.224	0.0967***	0.121***	-0.0278
	(0.0112)	(0.401)	(0.0357)	(0.0359)	(0.0972)
Ln (Annual Labor Cost + 1)	-0.00638***	-0.171***	-0.0132**	-0.0166***	-0.0547***
	(0.00181)	(0.0417)	(0.00612)	(0.00539)	(0.0128)
Ln (Annual Rental Cost + 1)	0.0333***	-0.199	-0.00287	0.00873	0.0106
	(0.00600)	(0.146)	(0.0196)	(0.0183)	(0.0441)
Number of variety Crops Produced	0.0862***	1.857***	0.230***	0.253***	0.276***
	(0.00605)	(0.194)	(0.0213)	(0.0208)	(0.0548)
Ln (Revenue + 1)	0.00513***	0.0838***	0.0224***	0.0232***	0.0340***
	(0.00131)	(0.0189)	(0.00399)	(0.00398)	(0.00994)
Ln (Consumption + 1)	0.0136**	0.272***	0.0842***	0.0698***	0.0426
	(0.00538)	(0.0927)	(0.0174)	(0.0169)	(0.0378)
Ln (Harvest + 1)	0.0698***	1.663***	0.252***	0.259***	0.00934
	(0.00780)	(0.160)	(0.0247)	(0.0247)	(0.0539)
Number of types of soil	0.0335***	0.974***	0.115***	0.123***	0.0342
	(0.00709)	(0.266)	(0.0258)	(0.0254)	(0.0622)
Constant	-0.663***	-19.35***	-2.760***	-3.079***	-3.761***
	(0.0641)	(1.600)	(0.230)	(0.204)	(0.504)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.461	0.448			

Robust standard errors in parentheses

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

Table C.1: Regression results between women empowerment score and various measure of crop diversification (2011-12)

Round 1: Model 2- Number of Decision Taken

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of Decision taken by women	0.000635	0.0394***	0.00331**	0.00349***	0.0129***
	(0.000386)	(0.0117)	(0.00144)	(0.00125)	(0.00305)
Proportion of males 0-4 years old	0.0136	0.961	0.413**	0.451**	-0.0868
	(0.0554)	(1.138)	(0.193)	(0.179)	(0.455)
Proportion of males 5–10 years old	-0.0234	0.0451	0.324*	0.285*	-0.360
	(0.0493)	(1.010)	(0.172)	(0.153)	(0.400)
Proportion of males 11–18 years old	0.0129	0.671	0.449***	0.439***	0.202
	(0.0472)	(1.127)	(0.174)	(0.153)	(0.390)
Proportion of males 19–59 years old	-0.00316	1.334	0.486***	0.457***	-0.248
	(0.0485)	(1.076)	(0.172)	(0.156)	(0.402)
Proportion of males 60 years and older	0.0480	1.494	0.543***	0.554***	0.248
	(0.0573)	(1.350)	(0.209)	(0.188)	(0.478)
Proportion of females 0–4 years old	-0.0441	-1.527	0.0718	0.0629	-0.562
	(0.0556)	(1.125)	(0.189)	(0.169)	(0.484)
Proportion of females 5–10 years old	-0.00616	1.026	0.476***	0.456***	-0.0500
	(0.0497)	(1.079)	(0.179)	(0.158)	(0.398)
Proportion of females 11–18 years old	0.0177	1.695	0.502***	0.532***	0.208
	(0.0481)	(1.137)	(0.180)	(0.160)	(0.388)
Proportion of females 19–59 years old	0.00103	0.906	0.309**	0.262*	-0.105
	(0.0393)	(0.914)	(0.157)	(0.137)	(0.334)
Household Size	0.00237	0.0514	-0.000431	0.00284	0.0359*
	(0.00280)	(0.0717)	(0.00888)	(0.00875)	(0.0213)
Ln (HH Total Cultivable Land+1)	0.0119	1.398***	0.211***	0.235***	0.186***
	(0.00732)	(0.151)	(0.0231)	(0.0223)	(0.0538)
Access to Extension Service Dummy	0.00993	0.484	0.0260	0.0260	0.113
	(0.0118)	(0.414)	(0.0399)	(0.0386)	(0.0923)
Ln (HH Value of Asset + 1)	0.00635*	0.128	-0.00419	-0.00135	0.0441
	(0.00371)	(0.0877)	(0.0130)	(0.0115)	(0.0286)
Number of Irrigation Method Used	0.0200*	0.795**	0.0627**	0.0770**	0.163*
	(0.0102)	(0.361)	(0.0297)	(0.0312)	(0.0913)
Number of Water Source Used	0.0585***	0.273	0.102***	0.126***	-0.0124
	(0.0112)	(0.395)	(0.0352)	(0.0354)	(0.0984)
Ln (Annual Labor Cost + 1)	-0.00639***	-0.167***	-0.0131**	-0.0164***	-0.0527***
	(0.00181)	(0.0414)	(0.00613)	(0.00538)	(0.0129)
Ln (Annual Rental Cost + 1)	0.0335***	-0.181	-0.00251	0.0104	0.0181
	(0.00601)	(0.145)	(0.0196)	(0.0183)	(0.0442)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0864***	1.864***	0.232***	0.254***	0.279***
	(0.00606)	(0.194)	(0.0214)	(0.0208)	(0.0548)
Ln (Revenue + 1)	0.00530***	0.0895***	0.0236***	0.0243***	0.0365***
	(0.00131)	(0.0189)	(0.00402)	(0.00400)	(0.0100)
Ln (Consumption + 1)	0.0140***	0.276***	0.0823***	0.0696***	0.0352
	(0.00540)	(0.0919)	(0.0173)	(0.0169)	(0.0375)
Ln (Harvest + 1)	0.0682***	1.599***	0.244***	0.251***	-0.00450
	(0.00784)	(0.159)	(0.0245)	(0.0246)	(0.0542)
Number of types of soil	0.0337***	0.988***	0.118***	0.125***	0.0411
	(0.00708)	(0.267)	(0.0258)	(0.0254)	(0.0623)
Constant	-0.674***	-19.54***	-2.764***	-3.100***	-3.566***
	(0.0625)	(1.547)	(0.229)	(0.199)	(0.489)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,777	2,777	2,777	2,777	2,777
R-squared	0.462	0.451			

Robust standard errors in parentheses

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

Table C.2: Regression results between number of productive decision taken and various measure of crop diversification (2011-12)

Round 1: Model 3Number of Asset sole or jointly owned

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of asset sole/jointly owned	0.00205	0.0519	0.00119	0.00256	0.0602***
	(0.00232)	(0.0647)	(0.00841)	(0.00721)	(0.0176)
Proportion of males 0-4 years old	0.0153	0.971	0.418**	0.460**	-0.0251
	(0.0556)	(1.142)	(0.195)	(0.180)	(0.456)
Proportion of males 5–10 years old	-0.0201	0.205	0.346**	0.310**	-0.262
	(0.0493)	(1.008)	(0.173)	(0.154)	(0.399)
Proportion of males 11–18 years old	0.0170	0.904	0.473***	0.463***	0.296
	(0.0471)	(1.114)	(0.172)	(0.153)	(0.390)
Proportion of males 19–59 years old	-0.00253	1.221	0.481***	0.453***	-0.196
	(0.0490)	(1.076)	(0.175)	(0.158)	(0.404)
Proportion of males 60 years and older	0.0496	1.414	0.531**	0.550***	0.323
	(0.0576)	(1.354)	(0.213)	(0.191)	(0.481)
Proportion of females 0–4 years old	-0.0426	-1.483	0.0872	0.0815	-0.518
	(0.0556)	(1.128)	(0.192)	(0.170)	(0.484)
Proportion of females 5–10 years old	-0.00273	1.202	0.498***	0.479***	0.0345
	(0.0497)	(1.076)	(0.179)	(0.158)	(0.398)
Proportion of females 11–18 years old	0.0199	1.861	0.527***	0.560***	0.251
	(0.0480)	(1.141)	(0.180)	(0.161)	(0.388)
Proportion of females 19–59 years old	0.00166	0.907	0.324**	0.274**	-0.0762
	(0.0393)	(0.921)	(0.158)	(0.137)	(0.333)
Household Size	0.00215	0.0226	-0.00398	-0.000281	0.0346
	(0.00280)	(0.0725)	(0.00900)	(0.00882)	(0.0212)
Ln (HH Total Cultivable Land+1)	0.0120	1.392***	0.209***	0.235***	0.187***
	(0.00731)	(0.151)	(0.0230)	(0.0223)	(0.0538)
Access to Extension Service Dummy	0.00970	0.476	0.0262	0.0266	0.111
	(0.0118)	(0.414)	(0.0401)	(0.0386)	(0.0922)
Ln (HH Value of Asset + 1)	0.00685*	0.169**	-0.000609	0.00219	0.0523*
	(0.00370)	(0.0855)	(0.0127)	(0.0114)	(0.0286)
Number of Irrigation Method Used	0.0205**	0.845**	0.0686**	0.0823***	0.168*
	(0.0103)	(0.370)	(0.0304)	(0.0317)	(0.0907)
Number of Water Source Used	0.0583***	0.238	0.0977***	0.123***	-0.0149
	(0.0112)	(0.404)	(0.0359)	(0.0360)	(0.0980)
Ln (Annual Labor Cost + 1)	-0.00650***	-0.172***	-0.0135**	-0.0169***	-0.0555***
	(0.00181)	(0.0415)	(0.00608)	(0.00537)	(0.0128)
Ln (Annual Rental Cost + 1)	0.0333***	-0.197	-0.00305	0.00887	0.0160
	(0.00601)	(0.146)	(0.0196)	(0.0183)	(0.0442)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0865***	1.862***	0.230***	0.253***	0.281***
	(0.00606)	(0.193)	(0.0213)	(0.0209)	(0.0549)
Ln (Revenue + 1)	0.00527***	0.0860***	0.0228***	0.0237***	0.0357***
	(0.00131)	(0.0189)	(0.00400)	(0.00399)	(0.0100)
Ln (Consumption + 1)	0.0143***	0.284***	0.0851***	0.0714***	0.0462
	(0.00540)	(0.0923)	(0.0174)	(0.0169)	(0.0382)
Ln (Harvest + 1)	0.0684***	1.639***	0.249***	0.256***	-0.00360
	(0.00784)	(0.160)	(0.0246)	(0.0247)	(0.0545)
Number of types of soil	0.0336***	0.976***	0.115***	0.123***	0.0406
	(0.00708)	(0.266)	(0.0258)	(0.0254)	(0.0623)
Constant	-0.679***	-19.61***	-2.788***	-3.121***	-3.740***
	(0.0627)	(1.553)	(0.229)	(0.201)	(0.493)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,777	2,777	2,777	2,777	2,777
R-squared	0.462	0.448			

Robust standard errors in parentheses

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

Table C.3: Regression results between number of productive asset sole or jointly owned and various measure of crop diversification (2011-12)

Round 1: Model 4 - Number of Groups Belong to

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of groups women belongs to	-0.0234***	-0.196	-0.0251	-0.0415	-0.00186
	(0.00870)	(0.205)	(0.0283)	(0.0261)	(0.0625)
Proportion of males 0-4 years old	0.0174	0.943	0.419**	0.465***	-0.100
	(0.0555)	(1.149)	(0.195)	(0.180)	(0.458)
Proportion of males 5–10 years old	-0.0152	0.226	0.350**	0.317**	-0.280
	(0.0492)	(1.017)	(0.173)	(0.153)	(0.401)
Proportion of males 11–18 years old	0.0250	0.960	0.481***	0.475***	0.291
	(0.0472)	(1.127)	(0.173)	(0.153)	(0.391)
Proportion of males 19–59 years old	0.000625	1.180	0.484***	0.458***	-0.292
	(0.0485)	(1.085)	(0.174)	(0.157)	(0.404)
Proportion of males 60 years and older	0.0488	1.327	0.532**	0.552***	0.207
	(0.0574)	(1.364)	(0.212)	(0.190)	(0.483)
Proportion of females 0–4 years old	-0.0400	-1.484	0.0922	0.0893	-0.502
	(0.0556)	(1.134)	(0.192)	(0.170)	(0.483)
Proportion of females 5–10 years old	0.00218	1.226	0.503***	0.487***	0.0132
	(0.0496)	(1.081)	(0.178)	(0.158)	(0.400)
Proportion of females 11–18 years old	0.0322	1.979*	0.540***	0.584***	0.300
	(0.0483)	(1.129)	(0.180)	(0.160)	(0.390)
Proportion of females 19–59 years old	0.00564	0.924	0.329**	0.282**	-0.0645
	(0.0394)	(0.914)	(0.158)	(0.137)	(0.335)
Household Size	0.00222	0.0167	-0.00360	0.000114	0.0244
	(0.00277)	(0.0708)	(0.00869)	(0.00866)	(0.0208)
Ln (HH Total Cultivable Land+1)	0.00951	1.366***	0.207***	0.230***	0.178***
	(0.00737)	(0.153)	(0.0233)	(0.0225)	(0.0539)
Access to Extension Service Dummy	0.0103	0.483	0.0270	0.0271	0.114
	(0.0117)	(0.415)	(0.0402)	(0.0386)	(0.0920)
Ln (HH Value of Asset + 1)	0.00688*	0.174**	-0.000667	0.00211	0.0590**
	(0.00370)	(0.0843)	(0.0126)	(0.0114)	(0.0283)
Number of Irrigation Method Used	0.0193*	0.844**	0.0679**	0.0809**	0.181**
	(0.0102)	(0.370)	(0.0303)	(0.0316)	(0.0903)
Number of Water Source Used	0.0591***	0.237	0.0982***	0.124***	-0.0274
	(0.0112)	(0.402)	(0.0356)	(0.0358)	(0.0971)
Ln (Annual Labor Cost + 1)	-0.00634***	-0.170***	-0.0134**	-0.0167***	-0.0532***
	(0.00180)	(0.0417)	(0.00612)	(0.00539)	(0.0128)
Ln (Annual Rental Cost + 1)	0.0335***	-0.197	-0.00253	0.00938	0.0124
	(0.00600)	(0.145)	(0.0196)	(0.0183)	(0.0441)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0856***	1.851***	0.230***	0.252***	0.273***
	(0.00605)	(0.194)	(0.0213)	(0.0208)	(0.0548)
Ln (Revenue + 1)	0.00509***	0.0836***	0.0225***	0.0233***	0.0335***
	(0.00131)	(0.0189)	(0.00398)	(0.00398)	(0.00991)
Ln (Consumption + 1)	0.0140***	0.276***	0.0846***	0.0707***	0.0389
	(0.00537)	(0.0923)	(0.0174)	(0.0168)	(0.0377)
Ln (Harvest + 1)	0.0701***	1.665***	0.251***	0.259***	0.0156
	(0.00777)	(0.160)	(0.0246)	(0.0246)	(0.0538)
Number of types of soil	0.0332***	0.971***	0.115***	0.122***	0.0352
	(0.00708)	(0.266)	(0.0258)	(0.0254)	(0.0622)
Constant	-0.666***	-19.40***	-2.777***	-3.102***	-3.562***
	(0.0627)	(1.557)	(0.228)	(0.200)	(0.493)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.463	0.448			

Robust standard errors in parentheses

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

Table C.4: Regression results between number of group women belongs to and various measure of crop diversification (2011-12)

Round 2: Model 1 - Women Empowerment Score

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	0.0475***	0.0979	0.0715	0.102*	0.257*
	(0.0171)	(0.333)	(0.0560)	(0.0550)	(0.145)
Proportion of males 0-4 years old	-0.0406	-0.598	-0.128	-0.0973	-0.0552
	(0.0520)	(0.985)	(0.177)	(0.171)	(0.461)
Proportion of males 5–10 years old	-0.0401	-1.657**	-0.334**	-0.283**	-0.984**
	(0.0397)	(0.785)	(0.136)	(0.130)	(0.388)
Proportion of males 11–18 years old	0.0618*	1.075	0.175	0.213*	0.190
	(0.0353)	(0.826)	(0.131)	(0.123)	(0.320)
Proportion of males 19–59 years old	0.00119	1.835**	0.187	0.152	-0.731**
	(0.0376)	(0.873)	(0.137)	(0.129)	(0.347)
Proportion of males 60 years and older	0.0737	1.413	0.231	0.291*	-0.0785
	(0.0502)	(1.163)	(0.186)	(0.169)	(0.441)
Proportion of females 0–4 years old	0.00948	-2.143**	-0.193	-0.158	-0.0464
	(0.0539)	(0.927)	(0.169)	(0.164)	(0.476)
Proportion of females 5–10 years old	-0.0142	0.325	0.0832	0.0623	0.652*
	(0.0422)	(0.909)	(0.155)	(0.143)	(0.352)
Proportion of females 11–18 years old	0.0435	1.194	0.214	0.252**	0.163
	(0.0373)	(0.862)	(0.132)	(0.126)	(0.342)
Proportion of females 19–59 years old	-0.0617	-0.429	-0.142	-0.170	-0.111
	(0.0397)	(0.727)	(0.130)	(0.131)	(0.356)
Household Size	-0.000548	0.0157	-0.00184	0.00243	-0.0176
	(0.00230)	(0.0549)	(0.00783)	(0.00763)	(0.0207)
Ln (HH Total Cultivable Land+1)	-0.00691	0.769***	0.0359	0.0894***	0.316***
	(0.00786)	(0.140)	(0.0297)	(0.0326)	(0.0583)
Access to Extension Service Dummy	0.00149	0.416	0.0151	0.00943	0.171*
	(0.0112)	(0.311)	(0.0385)	(0.0380)	(0.0924)
Ln (HH Value of Asset + 1)	0.0156***	0.515***	0.0692***	0.0729***	0.0347
	(0.00429)	(0.0831)	(0.0143)	(0.0137)	(0.0401)
Number of Irrigation Method Used_method	0.0513***	1.148	0.105	0.120**	0.393**
	(0.0128)	(0.792)	(0.0712)	(0.0608)	(0.154)
Number of Water Source Used	0.0528***	-0.151	0.0648	0.0855	-0.0294
	(0.0128)	(0.831)	(0.0758)	(0.0632)	(0.156)
Ln (Annual Labor Cost + 1)	-0.00211	-0.0622**	-0.00692	-0.00925*	-0.0337***
	(0.00163)	(0.0258)	(0.00538)	(0.00535)	(0.0127)
Ln (Annual Rental Cost + 1)	0.0582***	0.616***	0.232***	0.215***	-0.0290
	(0.00612)	(0.0891)	(0.0396)	(0.0388)	(0.0294)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0653***	1.105***	0.121***	0.170***	0.415***
	(0.00616)	(0.199)	(0.0249)	(0.0235)	(0.0613)
Ln (Revenue + 1)	0.0113***	0.124***	0.0295***	0.0305***	0.0177
	(0.00131)	(0.0178)	(0.00449)	(0.00454)	(0.0116)
Ln (Consumption + 1)	0.0272***	0.0754	0.0750***	0.0722***	-0.0439
	(0.00444)	(0.0677)	(0.0146)	(0.0136)	(0.0285)
Ln (Harvest + 1)	0.0207**	0.879***	0.182***	0.174***	-0.0317
	(0.00840)	(0.146)	(0.0332)	(0.0375)	(0.0464)
Number of types of soil	0.0250***	0.871***	0.0950***	0.104***	0.00991
	(0.00762)	(0.242)	(0.0277)	(0.0257)	(0.0717)
Constant	-0.639***	-19.18***	-3.678***	-3.937***	-2.900***
	(0.0561)	(1.274)	(0.220)	(0.211)	(0.481)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,720	2,720	2,720	2,720	2,720
R-squared	0.494	0.410			

Robust standard errors in parentheses

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

Table C.5: Regression results between women empowerment score and various measure of crop diversification (2014-15)

Round 2: Model 2- Number of Decision taken by women

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of Decision taken by women	0.00201***	0.0172*	0.00363**	0.00506***	-0.00682*
	(0.000436)	(0.00948)	(0.00149)	(0.00143)	(0.00389)
Proportion of males 0-4 years old	-0.0239	-0.461	-0.106	-0.0567	-0.128
	(0.0521)	(0.997)	(0.179)	(0.172)	(0.463)
Proportion of males 5–10 years old	-0.0330	-1.610**	-0.318**	-0.265**	-0.965**
	(0.0398)	(0.784)	(0.136)	(0.129)	(0.390)
Proportion of males 11–18 years old	0.0600*	1.035	0.166	0.198	0.241
	(0.0351)	(0.820)	(0.131)	(0.123)	(0.322)
Proportion of males 19–59 years old	0.0123	1.987**	0.211	0.179	-0.826**
	(0.0374)	(0.875)	(0.137)	(0.129)	(0.349)
Proportion of males 60 years and older	0.0849*	1.611	0.256	0.320*	-0.214
	(0.0502)	(1.175)	(0.188)	(0.170)	(0.442)
Proportion of females 0–4 years old	0.0273	-1.981**	-0.158	-0.114	-0.104
	(0.0542)	(0.931)	(0.169)	(0.164)	(0.479)
Proportion of females 5–10 years old	-0.0146	0.298	0.0764	0.0535	0.659*
	(0.0419)	(0.906)	(0.155)	(0.142)	(0.352)
Proportion of females 11–18 years old	0.0450	1.155	0.207	0.247*	0.193
	(0.0371)	(0.860)	(0.132)	(0.126)	(0.340)
Proportion of females 19–59 years old	-0.0630	-0.505	-0.155	-0.182	-0.0861
	(0.0397)	(0.726)	(0.130)	(0.131)	(0.356)
Household Size	0.000405	0.0245	-5.98e-05	0.00477	-0.0261
	(0.00232)	(0.0554)	(0.00800)	(0.00770)	(0.0207)
Ln (HH Total Cultivable Land+1)	-0.00705	0.781***	0.0379	0.0909***	0.310***
	(0.00782)	(0.140)	(0.0295)	(0.0323)	(0.0584)
Access to Extension Service Dummy	0.00209	0.388	0.0133	0.00795	0.179*
	(0.0111)	(0.309)	(0.0383)	(0.0377)	(0.0923)
Ln (HH Value of Asset + 1)	0.0128***	0.483***	0.0623***	0.0644***	0.0419
	(0.00433)	(0.0854)	(0.0146)	(0.0140)	(0.0403)
Number of Irrigation Method	0.0492***	1.173	0.104	0.119*	0.427***
	(0.0127)	(0.788)	(0.0715)	(0.0615)	(0.152)
Number of Water Source	0.0538***	-0.190	0.0637	0.0830	-0.0671
	(0.0127)	(0.826)	(0.0761)	(0.0640)	(0.154)
Ln (Annual Labor Cost + 1)	-0.00220	-0.0633**	-0.00717	-0.00974*	-0.0336***
	(0.00162)	(0.0257)	(0.00538)	(0.00534)	(0.0127)
Ln (Annual Rental Cost + 1)	0.0586***	0.617***	0.232***	0.217***	-0.0278
	(0.00611)	(0.0889)	(0.0394)	(0.0386)	(0.0296)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0655***	1.111***	0.123***	0.169***	0.414***
	(0.00612)	(0.200)	(0.0249)	(0.0234)	(0.0613)
Ln (Revenue + 1)	0.0114***	0.125***	0.0295***	0.0306***	0.0178
	(0.00131)	(0.0178)	(0.00446)	(0.00451)	(0.0115)
Ln (Consumption + 1)	0.0266***	0.0703	0.0732***	0.0692***	-0.0405
	(0.00443)	(0.0672)	(0.0145)	(0.0136)	(0.0285)
Ln (Harvest + 1)	0.0211**	0.882***	0.183***	0.176***	-0.0327
	(0.00831)	(0.146)	(0.0332)	(0.0372)	(0.0466)
Number of types of soil	0.0236***	0.846***	0.0921***	0.1000***	0.00549
	(0.00762)	(0.240)	(0.0274)	(0.0256)	(0.0714)
Constant	-0.608***	-19.09***	-3.615***	-3.863***	-2.612***
	(0.0542)	(1.261)	(0.216)	(0.206)	(0.462)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.496	0.410			

Robust standard errors in parentheses

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

Table C.6: Regression results between number decision taken by women and various measure of crop diversification (2014-15)

Round 2: Model 3 - Number of Productive Asset owned by women

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of Productive Asset	0.00788***	0.0979**	0.0149**	0.0216***	-0.0170
	(0.00214)	(0.0426)	(0.00685)	(0.00678)	(0.0176)
Proportion of males 0-4 years old	-0.0251	-0.396	-0.105	-0.0582	-0.103
	(0.0521)	(0.995)	(0.179)	(0.172)	(0.465)
Proportion of males 5–10 years old	-0.0319	-1.588**	-0.314**	-0.262**	-0.968**
	(0.0398)	(0.784)	(0.136)	(0.129)	(0.388)
Proportion of males 11–18 years old	0.0658*	1.084	0.175	0.215*	0.220
	(0.0352)	(0.822)	(0.131)	(0.123)	(0.321)
Proportion of males 19–59 years old	0.0154	2.098**	0.216	0.190	-0.800**
	(0.0377)	(0.881)	(0.138)	(0.130)	(0.350)
Proportion of males 60 years and older	0.0858*	1.719	0.259	0.330*	-0.182
	(0.0506)	(1.177)	(0.189)	(0.171)	(0.442)
Proportion of females 0–4 years old	0.0274	-1.924**	-0.156	-0.109	-0.0901
	(0.0544)	(0.930)	(0.169)	(0.164)	(0.478)
Proportion of females 5–10 years old	-0.0113	0.337	0.0844	0.0627	0.644*
	(0.0420)	(0.908)	(0.155)	(0.142)	(0.352)
Proportion of females 11–18 years old	0.0483	1.187	0.215	0.256**	0.180
	(0.0371)	(0.861)	(0.133)	(0.126)	(0.340)
Proportion of females 19–59 years old	-0.0634	-0.526	-0.155	-0.184	-0.0874
	(0.0398)	(0.726)	(0.130)	(0.131)	(0.356)
Household Size	0.000201	0.0276	-0.000376	0.00446	-0.0235
	(0.00233)	(0.0556)	(0.00803)	(0.00775)	(0.0207)
Ln (HH Total Cultivable Land+1)	-0.00686	0.786***	0.0378	0.0910***	0.310***
	(0.00783)	(0.140)	(0.0295)	(0.0323)	(0.0583)
Access to Extension Service Dummy	0.00256	0.392	0.0142	0.00916	0.177*
	(0.0111)	(0.309)	(0.0384)	(0.0377)	(0.0923)
Ln (HH Value of Asset + 1)	0.0133***	0.477***	0.0628***	0.0650***	0.0379
	(0.00432)	(0.0850)	(0.0145)	(0.0139)	(0.0404)
Number of Irrigation Method	0.0500***	1.165	0.105	0.119*	0.417***
	(0.0128)	(0.787)	(0.0712)	(0.0617)	(0.152)
Number of Water Source Used	0.0520***	-0.197	0.0594	0.0800	-0.0567
	(0.0128)	(0.825)	(0.0758)	(0.0643)	(0.154)
Ln (Annual Labor Cost + 1)	-0.00216	-0.0633**	-0.00690	-0.00953*	-0.0339***
	(0.00163)	(0.0257)	(0.00541)	(0.00537)	(0.0127)
Ln (Annual Rental Cost + 1)	0.0585***	0.616***	0.231***	0.216***	-0.0273
	(0.00611)	(0.0887)	(0.0394)	(0.0384)	(0.0296)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0655***	1.115***	0.122***	0.169***	0.414***
	(0.00613)	(0.200)	(0.0249)	(0.0234)	(0.0612)
Ln (Revenue + 1)	0.0115***	0.125***	0.0296***	0.0307***	0.0179
	(0.00131)	(0.0178)	(0.00446)	(0.00451)	(0.0116)
Ln (Consumption + 1)	0.0269***	0.0708	0.0740***	0.0701***	-0.0421
	(0.00443)	(0.0670)	(0.0145)	(0.0136)	(0.0284)
Ln (Harvest + 1)	0.0208**	0.880***	0.183***	0.176***	-0.0315
	(0.00835)	(0.146)	(0.0332)	(0.0373)	(0.0464)
Number of types of soil	0.0234***	0.841***	0.0911***	0.0992***	0.00604
	(0.00764)	(0.241)	(0.0275)	(0.0257)	(0.0714)
Constant	-0.612***	-19.17***	-3.614***	-3.872***	-2.625***
	(0.0543)	(1.263)	(0.215)	(0.206)	(0.463)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.495	0.410			

Robust standard errors in parentheses

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

Table C.7: Regression results between number of productive asset sole or jointly owned and various measure of crop diversification (2014-15)

Round 2: Model 4 - Number of groups women belongs to

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of groups women belongs to	-0.00469	-0.476***	-0.0636**	-0.0542**	-0.0203
	(0.00763)	(0.141)	(0.0252)	(0.0246)	(0.0637)
Proportion of males 0-4 years old	-0.0448	-0.677	-0.152	-0.117	-0.0697
	(0.0521)	(0.987)	(0.178)	(0.171)	(0.461)
Proportion of males 5–10 years old	-0.0347	-1.582**	-0.322**	-0.269**	-0.953**
	(0.0398)	(0.780)	(0.135)	(0.129)	(0.388)
Proportion of males 11–18 years old	0.0663*	1.142	0.183	0.229*	0.222
	(0.0353)	(0.820)	(0.130)	(0.123)	(0.320)
Proportion of males 19–59 years old	-0.00508	1.930**	0.184	0.145	-0.751**
	(0.0375)	(0.872)	(0.137)	(0.129)	(0.345)
Proportion of males 60 years and older	0.0596	1.378	0.204	0.252	-0.129
	(0.0499)	(1.153)	(0.185)	(0.168)	(0.437)
Proportion of females 0–4 years old	0.0129	-2.135**	-0.191	-0.152	-0.0537
	(0.0540)	(0.926)	(0.168)	(0.164)	(0.475)
Proportion of females 5–10 years old	-0.0139	0.308	0.0874	0.0600	0.650*
	(0.0422)	(0.904)	(0.154)	(0.141)	(0.352)
Proportion of females 11–18 years old	0.0477	1.226	0.217*	0.258**	0.180
	(0.0373)	(0.859)	(0.132)	(0.126)	(0.340)
Proportion of females 19–59 years old	-0.0577	-0.387	-0.124	-0.152	-0.0965
	(0.0400)	(0.727)	(0.131)	(0.131)	(0.355)
Household Size	-0.000956	0.0206	-0.00210	0.00191	-0.0203
	(0.00229)	(0.0542)	(0.00777)	(0.00758)	(0.0206)
Ln (HH Total Cultivable Land+1)	-0.00802	0.751***	0.0329	0.0846***	0.311***
	(0.00786)	(0.140)	(0.0295)	(0.0322)	(0.0583)
Access to Extension Service Dummy	0.00278	0.396	0.0163	0.0120	0.177*
	(0.0111)	(0.309)	(0.0382)	(0.0376)	(0.0922)
Ln (HH Value of Asset + 1)	0.0159***	0.511***	0.0690***	0.0729***	0.0330
	(0.00429)	(0.0830)	(0.0144)	(0.0138)	(0.0399)
Number of Irrigation Method Used_method	0.0542***	1.249	0.119*	0.135**	0.408***
	(0.0127)	(0.783)	(0.0701)	(0.0605)	(0.152)
Number of Water Source Used	0.0493***	-0.281	0.0477	0.0662	-0.0536
	(0.0127)	(0.820)	(0.0744)	(0.0629)	(0.154)
Ln (Annual Labor Cost + 1)	-0.00203	-0.0566**	-0.00637	-0.00880	-0.0339***
	(0.00163)	(0.0258)	(0.00543)	(0.00539)	(0.0128)
Ln (Annual Rental Cost + 1)	0.0586***	0.620***	0.230***	0.216***	-0.0270
	(0.00617)	(0.0886)	(0.0394)	(0.0389)	(0.0294)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Number of variety Crops Produced	0.0647***	1.119***	0.123***	0.169***	0.417***
	(0.00614)	(0.198)	(0.0247)	(0.0233)	(0.0612)
Ln (Revenue + 1)	0.0113***	0.124***	0.0295***	0.0304***	0.0182
	(0.00131)	(0.0178)	(0.00447)	(0.00453)	(0.0116)
Ln (Consumption + 1)	0.0274***	0.0745	0.0750***	0.0724***	-0.0435
	(0.00443)	(0.0676)	(0.0145)	(0.0135)	(0.0283)
Ln (Harvest + 1)	0.0206**	0.880***	0.183***	0.174***	-0.0319
	(0.00839)	(0.146)	(0.0332)	(0.0373)	(0.0463)
Number of types of soil	0.0241***	0.837***	0.0885***	0.0986***	0.00413
	(0.00761)	(0.239)	(0.0274)	(0.0258)	(0.0716)
Constant	-0.596***	-18.72***	-3.548***	-3.796***	-2.644***
	(0.0544)	(1.258)	(0.216)	(0.208)	(0.465)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,726	2,726	2,726	2,726	2,726
R-squared	0.493	0.411			

Robust standard errors in parentheses

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

Table C.8: Regression results between number of groups women belong to and various measure of crop diversification (2014-15)

Panel: Model 1 - Women 5DE Score

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Women 5DE Score	0.0244*	-0.264	-0.0201	-0.0201	0.274
	(0.0142)	(0.284)	(0.0386)	(0.0386)	(0.332)
Proportion of males 0-4 years old	-0.0345	-0.268	-0.157	-0.157	1.540
	(0.0611)	(1.221)	(0.171)	(0.171)	(1.504)
Proportion of males 5-10 years old	-0.00590	0.134	-0.0911	-0.0911	-0.762
	(0.0567)	(1.132)	(0.155)	(0.155)	(1.368)
Proportion of males 11-18 years old	-0.00430	0.587	-0.0252	-0.0252	1.022
	(0.0487)	(0.972)	(0.133)	(0.133)	(1.138)
Proportion of males 19-59 years old	-0.0409	1.227	0.0727	0.0727	-1.185
	(0.0447)	(0.894)	(0.119)	(0.119)	(1.004)
Proportion of males 60 years and older	0.147**	3.436**	0.397**	0.397**	0.852
	(0.0722)	(1.442)	(0.196)	(0.196)	(1.619)
Proportion of females 0–4 years old	-0.0231	-1.762	-0.220	-0.220	-0.858
	(0.0595)	(1.189)	(0.166)	(0.166)	(1.485)
Proportion of females 5–10 years old	0.0462	0.156	0.144	0.144	-0.338
	(0.0528)	(1.055)	(0.147)	(0.147)	(1.283)
Proportion of females 11–18 years old	0.0634	0.405	0.0704	0.0704	1.603
	(0.0435)	(0.869)	(0.120)	(0.120)	(1.101)
Proportion of females 19–59 years old	0.00782	-1.101	-0.209	-0.209	0.0615
	(0.0479)	(0.958)	(0.131)	(0.131)	(1.122)
Household Size	0.00642	0.151	0.00945	0.00945	-0.0642
	(0.00513)	(0.102)	(0.0138)	(0.0138)	(0.107)
Ln (HH Total Cultivable Land+1)	0.0492***	1.751***	0.306***	0.306***	0.384*
	(0.00836)	(0.167)	(0.0259)	(0.0259)	(0.203)
Ln (HH Value of Asset + 1)	0.00484	0.129	0.0120	0.0120	-0.0250
	(0.00443)	(0.0884)	(0.0124)	(0.0124)	(0.106)
Number of Irrigation Method Used	0.00965	0.265	0.0284	0.0284	0.949***
	(0.0119)	(0.238)	(0.0265)	(0.0265)	(0.262)
Number of Water Source Used	0.0463***	0.727***	0.0868***	0.0868***	-0.000653
	(0.0125)	(0.250)	(0.0282)	(0.0282)	(0.270)
Ln (Annual Labor Cost + 1)	0.00115	-0.0247	0.00428	0.00428	-0.0215
	(0.00156)	(0.0311)	(0.00460)	(0.00460)	(0.0379)
Ln (Annual Rental Cost + 1)	0.0327***	0.275***	0.0796***	0.0796***	-0.139*
	(0.00401)	(0.0801)	(0.0116)	(0.0116)	(0.0824)
Number of variety Crops Produced	0.0407***	0.493***	0.0639***	0.0639***	0.591***
	(0.00650)	(0.130)	(0.0163)	(0.0163)	(0.141)

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Ln (Revenue + 1)	0.00755***	0.101***	0.0232***	0.0232***	0.0222
	(0.00110)	(0.0220)	(0.00362)	(0.00362)	(0.0300)
Ln (Consumption + 1)	0.00799**	0.0569	0.0169	0.0169	-0.119
	(0.00360)	(0.0718)	(0.0108)	(0.0108)	(0.0819)
Ln (Harvest + 1)	0.0370***	0.682***	0.130***	0.130***	0.0864
	(0.00588)	(0.117)	(0.0186)	(0.0186)	(0.146)
soil_type	0.00903	0.502**	0.0427*	0.0427*	0.307
	(0.0102)	(0.205)	(0.0246)	(0.0246)	(0.215)
Year Dummy	-0.0355***	-1.061***	-0.178***	-0.178***	-0.464**
	(0.00830)	(0.166)	(0.0237)	(0.0237)	(0.193)
Constant	-0.471***	-13.88***		15.83	
	(0.0638)	(1.274)		(164.8)	
Observations	4,441	4,441	4,418	4,418	1,102
R-squared	0.329	0.302			
Number of a01	2,232	2,232	2,209	2,209	551

Robust standard errors in parentheses

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

Table C.9: Regression results between women empowerment score and various measure of crop diversification (Panel)

Panel: Model 2 - Number of Decision taken by women

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Number of Decision	0.000242	-0.0103	-0.00118	-0.00151*	-0.00303
	(0.000333)	(0.00666)	(0.000824)	(0.000821)	(0.00781)
Proportion of males 0-4 years old	-0.0366	-0.285	-0.156	-0.169	1.566
	(0.0609)	(1.218)	(0.170)	(0.170)	(1.507)
Proportion of males 5-10 years old	-0.00228	0.0542	-0.0927	-0.0925	-0.772
	(0.0565)	(1.131)	(0.155)	(0.155)	(1.367)
Proportion of males 11-18 years old	-0.000275	0.513	-0.0308	-0.0237	1.045
	(0.0485)	(0.971)	(0.133)	(0.133)	(1.139)
Proportion of males 19-59 years old	-0.0407	1.173	0.0688	0.0672	-1.223
	(0.0447)	(0.894)	(0.119)	(0.119)	(1.003)
Proportion of males 60 years and older	0.148**	3.369**	0.395**	0.415**	0.791
	(0.0720)	(1.440)	(0.196)	(0.195)	(1.619)
Proportion of females 0–4 years old	-0.0258	-1.759	-0.215	-0.207	-0.855
	(0.0594)	(1.188)	(0.166)	(0.166)	(1.486)
Proportion of females 5–10 years old	0.0494	0.173	0.147	0.154	-0.347
	(0.0526)	(1.052)	(0.147)	(0.147)	(1.280)
Proportion of females 11–18 years old	0.0648	0.366	0.0693	0.0582	1.628
	(0.0434)	(0.867)	(0.119)	(0.119)	(1.102)
Proportion of females 19–59 years old	0.00743	-1.125	-0.200	-0.193	0.0390
	(0.0478)	(0.956)	(0.131)	(0.131)	(1.120)
Household Size	0.00681	0.147	0.00869	0.00607	-0.0664
	(0.00512)	(0.102)	(0.0138)	(0.0138)	(0.108)
Ln (HH Total Cultivable Land+1)	0.0476***	1.771***	0.307***	0.302***	0.383*
	(0.00836)	(0.167)	(0.0259)	(0.0259)	(0.204)
Ln (HH Value of Asset + 1)	0.00429	0.138	0.0127	0.0128	-0.0246
	(0.00443)	(0.0886)	(0.0124)	(0.0124)	(0.106)
Number of Irrigation Method Used	0.0104	0.280	0.0308	0.109***	0.945***
	(0.0119)	(0.238)	(0.0265)	(0.0141)	(0.262)
Number of Water Source Used	0.0457***	0.717***	0.0855***		0.00915
	(0.0125)	(0.249)	(0.0281)		(0.270)
Ln (Annual Labor Cost + 1)	0.00111	-0.0260	0.00417	0.00468	-0.0257
	(0.00155)	(0.0311)	(0.00460)	(0.00459)	(0.0379)
Ln (Annual Rental Cost + 1)	0.0327***	0.274***	0.0786***	0.0807***	-0.141*
	(0.00400)	(0.0800)	(0.0117)	(0.0116)	(0.0828)
Number of variety Crops Produced	0.0404***	0.490***	0.0623***		0.585***
	(0.00649)	(0.130)	(0.0163)		(0.141)

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Ln (Revenue + 1)	0.00753***	0.101***	0.0231***	0.0248***	0.0232
	(0.00110)	(0.0220)	(0.00361)	(0.00358)	(0.0299)
Ln (Consumption + 1)	0.00789**	0.0647	0.0185*	0.0205*	-0.116
	(0.00360)	(0.0719)	(0.0109)	(0.0108)	(0.0821)
Ln (Harvest + 1)	0.0369***	0.674***	0.129***	0.134***	0.0928
	(0.00587)	(0.118)	(0.0186)	(0.0186)	(0.147)
soil_type	0.00996	0.474**	0.0399	0.0420*	0.295
	(0.0102)	(0.204)	(0.0246)	(0.0245)	(0.215)
Year Dummy	-0.0351***	-1.047***	-0.175***	-0.176***	-0.449**
	(0.00830)	(0.166)	(0.0237)	(0.0237)	(0.194)
Constant	-0.445***	-14.00***		14.87	
	(0.0629)	(1.258)		(173.7)	
Observations	4,446	4,446	4,428	4,428	1,104
R-squared	0.327	0.303			
Number of a01	2,232	2,232	2,214	2,214	552

Robust standard errors in parentheses

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

Table C.10: Regression results between number of decision taken by women and various measure of crop diversification (Panel)

Panel: Model 3 - Number of Productive Asset owned by women

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Number of productive asset owned	1.71e-05	-0.0757**	-0.00846*	-0.00846*	-0.0238
	(0.00180)	(0.0359)	(0.00476)	(0.00476)	(0.0423)
Proportion of males 0-4 years old	-0.0373	-0.368	-0.170	-0.170	1.521
	(0.0610)	(1.219)	(0.170)	(0.170)	(1.510)
Proportion of males 5-10 years old	-0.00291	-0.0261	-0.108	-0.108	-0.787
	(0.0566)	(1.131)	(0.155)	(0.155)	(1.367)
Proportion of males 11-18 years old	-0.000830	0.477	-0.0360	-0.0360	1.034
	(0.0486)	(0.971)	(0.133)	(0.133)	(1.141)
Proportion of males 19-59 years old	-0.0423	1.143	0.0647	0.0647	-1.217
	(0.0447)	(0.893)	(0.120)	(0.120)	(1.003)
Proportion of males 60 years and older	0.146**	3.250**	0.381*	0.381*	0.772
	(0.0721)	(1.442)	(0.196)	(0.196)	(1.622)
Proportion of females 0–4 years old	-0.0267	-1.855	-0.227	-0.227	-0.891
	(0.0595)	(1.189)	(0.166)	(0.166)	(1.485)
Proportion of females 5–10 years old	0.0486	0.110	0.143	0.143	-0.374
	(0.0527)	(1.053)	(0.147)	(0.147)	(1.280)
Proportion of females 11–18 years old	0.0645	0.376	0.0750	0.0750	1.629
	(0.0434)	(0.867)	(0.119)	(0.119)	(1.102)
Proportion of females 19–59 years old	0.00639	-1.164	-0.200	-0.200	0.0792
	(0.0478)	(0.956)	(0.131)	(0.131)	(1.123)
Household Size	0.00665	0.144	0.00845	0.00845	-0.0672
	(0.00512)	(0.102)	(0.0138)	(0.0138)	(0.107)
Ln (HH Total Cultivable Land+1)	0.0479***	1.767***	0.306***	0.306***	0.383*
	(0.00835)	(0.167)	(0.0259)	(0.0259)	(0.204)
Ln (HH Value of Asset + 1)	0.00460	0.137	0.0124	0.0124	-0.0282
	(0.00442)	(0.0883)	(0.0124)	(0.0124)	(0.106)
Number of Irrigation Method Used	0.0107	0.277	0.0305	0.0305	0.950***
	(0.0119)	(0.238)	(0.0264)	(0.0264)	(0.263)
Number of Water Source Used	0.0456***	0.714***	0.0848***	0.0848***	0.00800
	(0.0125)	(0.249)	(0.0281)	(0.0281)	(0.270)
Ln (Annual Labor Cost + 1)	0.00106	-0.0257	0.00433	0.00433	-0.0255
	(0.00155)	(0.0311)	(0.00459)	(0.00459)	(0.0380)
Ln (Annual Rental Cost + 1)	0.0326***	0.276***	0.0795***	0.0795***	-0.141*
	(0.00400)	(0.0799)	(0.0116)	(0.0116)	(0.0829)
Number of variety Crops Produced	0.0402***	0.489***	0.0627***	0.0627***	0.580***
	(0.00649)	(0.130)	(0.0163)	(0.0163)	(0.142)

	CDI	Number of crops			Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	NB-FE	Logit-FE
Ln (Revenue + 1)	0.00753***	0.102***	0.0232***	0.0232***	0.0227
	(0.00110)	(0.0220)	(0.00361)	(0.00361)	(0.0299)
Ln (Consumption + 1)	0.00808**	0.0627	0.0180*	0.0180*	-0.116
	(0.00359)	(0.0718)	(0.0108)	(0.0108)	(0.0818)
Ln (Harvest + 1)	0.0367***	0.675***	0.129***	0.129***	0.0955
	(0.00587)	(0.117)	(0.0186)	(0.0186)	(0.147)
soil_type	0.00963	0.480**	0.0407*	0.0407*	0.296
	(0.0102)	(0.204)	(0.0245)	(0.0245)	(0.215)
Year Dummy	-0.0346***	-0.997***	-0.169***	-0.169***	-0.425**
	(0.00844)	(0.169)	(0.0242)	(0.0242)	(0.201)
Constant	-0.443***	-13.87***		15.61	
	(0.0630)	(1.260)		(557.7)	
Observations	4,446	4,446	4,428	4,428	1,104
R-squared	0.327	0.304			
Number of a01	2,232	2,232	2,214	2,214	552

Robust standard errors in parentheses

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

Table C.11: Regression results between number of productive asset sole or jointly owned and various measure of crop diversification (Panel)

Panel: Model 4 - Number of groups women belongs to

	CDI	Number of crops		Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	Logit-FE
Number of groups	0.000476	0.0749	-0.00150	0.318*
	(0.00635)	(0.127)	(0.0179)	(0.172)
Proportion of males 0-4 years old	-0.0409	-0.274	-0.161	1.430
	(0.0610)	(1.219)	(0.171)	(1.510)
Proportion of males 5-10 years old	-0.00509	0.0622	-0.0919	-0.975
	(0.0566)	(1.131)	(0.155)	(1.375)
Proportion of males 11-18 years old	-0.00198	0.520	-0.0262	0.878
	(0.0486)	(0.971)	(0.133)	(1.145)
Proportion of males 19-59 years old	-0.0430	1.237	0.0746	-1.232
	(0.0447)	(0.893)	(0.119)	(1.006)
Proportion of males 60 years and older	0.146**	3.445**	0.399**	0.756
	(0.0721)	(1.440)	(0.196)	(1.617)
Proportion of females 0-4 years old	-0.0235	-1.728	-0.216	-1.067
	(0.0595)	(1.188)	(0.166)	(1.492)
Proportion of females 5-10 years old	0.0476	0.191	0.146	-0.459
	(0.0527)	(1.053)	(0.147)	(1.283)
Proportion of females 11-18 years old	0.0661	0.362	0.0698	1.456
	(0.0435)	(0.868)	(0.120)	(1.106)
Proportion of females 19-59 years old	0.00615	-1.078	-0.206	0.0346
	(0.0479)	(0.956)	(0.131)	(1.122)
Household Size	0.00653	0.152	0.00978	-0.0781
	(0.00513)	(0.102)	(0.0138)	(0.107)
Ln (HH Total Cultivable Land+1)	0.0494***	1.758***	0.306***	0.394*
	(0.00835)	(0.167)	(0.0259)	(0.205)
Ln (HH Value of Asset + 1)	0.00476	0.127	0.0112	-0.0234
	(0.00442)	(0.0882)	(0.0123)	(0.106)
Number of Irrigation Method Used	0.0105	0.264	0.0286	0.937***
	(0.0119)	(0.238)	(0.0264)	(0.264)
Number of Water Source Used	0.0456***	0.725***	0.0867***	0.0332
	(0.0125)	(0.249)	(0.0281)	(0.272)
Ln (Annual Labor Cost + 1)	0.00124	-0.0234	0.00456	-0.0215
	(0.00156)	(0.0311)	(0.00459)	(0.0377)
Ln (Annual Rental Cost + 1)	0.0324***	0.275***	0.0796***	-0.150*
	(0.00401)	(0.0800)	(0.0116)	(0.0819)
Number of variety Crops Produced	0.0401***	0.502***	0.0640***	0.601***
	(0.00650)	(0.130)	(0.0163)	(0.142)

	CDI	Number of crops		Intercropping
VARIABLES	OLS-FE	OLS-FE	PR-FE	Logit-FE
Ln (Revenue + 1)	0.00744***	0.101***	0.0230***	0.0201
	(0.00110)	(0.0220)	(0.00361)	(0.0303)
Ln (Consumption + 1)	0.00791**	0.0566	0.0167	-0.111
	(0.00359)	(0.0718)	(0.0108)	(0.0828)
Ln (Harvest + 1)	0.0370***	0.684***	0.131***	0.0938
	(0.00588)	(0.117)	(0.0186)	(0.147)
Number of types of soil	0.00931	0.488**	0.0415*	0.307
	(0.0102)	(0.204)	(0.0245)	(0.215)
Year Dummy	-0.0350***	-1.066***	-0.178***	-0.438**
	(0.00829)	(0.166)	(0.0237)	(0.194)
Constant	-0.450***	-14.12***		
	(0.0629)	(1.256)		
Observations	4,447	4,447	4,430	1,106
R-squared	0.328	0.303		
Number of a01	2,232	2,232	2,215	553

Robust standard errors in parentheses

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

Table C.12: Regression results between number of productive groups women belong and various measure of crop diversification (Panel)

Round 1: Wealth Effect

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	0.128***	0.425	0.174	0.217*	0.236
	(0.0410)	(0.545)	(0.126)	(0.127)	(0.311)
HH in Low-Middle 20% Asset	0.119***	0.854	0.279**	0.275**	-0.425
	(0.0432)	(0.636)	(0.137)	(0.139)	(0.396)
HH in Middle 20% Asset	0.0961**	0.490	0.242*	0.253*	0.0167
	(0.0439)	(0.655)	(0.133)	(0.135)	(0.354)
HH High-Middle 20% Asset	0.128***	0.485	0.200	0.228*	0.0322
	(0.0420)	(0.781)	(0.137)	(0.138)	(0.356)
HH in Highest 20% Asset	0.102**	2.286**	0.239*	0.264*	0.200
	(0.0453)	(0.931)	(0.145)	(0.145)	(0.349)
Women 5DE Score × HH in Low-Middle 20% Asset	-0.136**	-0.901	-0.241	-0.248	0.423
	(0.0544)	(0.789)	(0.170)	(0.171)	(0.484)
Women 5DE Score × HH in Middle 20% Asset	-0.0930*	-0.205	-0.182	-0.182	0.00878
	(0.0552)	(0.829)	(0.165)	(0.167)	(0.442)
Women 5DE Score × HH in High-Middle 20% Asset	-0.0868*	0.588	-0.0145	-0.0296	-0.0425
	(0.0520)	(0.972)	(0.169)	(0.171)	(0.439)
Women 5DE Score × HH in Highest 20% Asset	-0.0901	-1.146	-0.0950	-0.118	-0.189
	(0.0571)	(1.164)	(0.180)	(0.178)	(0.433)
Ln (HH Total Cultivable Land+1)	-0.00664	0.766***	0.0395	0.0921***	0.319***
	(0.00781)	(0.140)	(0.0297)	(0.0324)	(0.0583)
Proportion of males 0-4 years old	-0.0230	-0.444	-0.101	-0.0625	-0.0532
	(0.0523)	(0.981)	(0.176)	(0.171)	(0.463)
Proportion of males 5–10 years old	-0.0411	-1.647**	-0.331**	-0.276**	-0.964**
	(0.0398)	(0.783)	(0.136)	(0.129)	(0.388)
Proportion of males 11–18 years old	0.0642*	1.166	0.179	0.217*	0.187
	(0.0354)	(0.825)	(0.132)	(0.123)	(0.322)
Proportion of males 19–59 years old	0.00505	1.901**	0.204	0.164	-0.736**
	(0.0377)	(0.885)	(0.138)	(0.129)	(0.348)
Proportion of males 60 years and older	0.0816	1.410	0.255	0.313*	-0.0957
	(0.0499)	(1.168)	(0.186)	(0.167)	(0.441)
Proportion of females 0–4 years old	0.0148	-2.089**	-0.180	-0.148	-0.0502
	(0.0537)	(0.929)	(0.169)	(0.164)	(0.474)
Proportion of females 5–10 years old	-0.00919	0.390	0.0844	0.0652	0.661*
	(0.0419)	(0.910)	(0.155)	(0.142)	(0.352)
Proportion of females 11–18 years old	0.0430	1.295	0.209	0.250**	0.170
	(0.0374)	(0.862)	(0.133)	(0.126)	(0.344)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Proportion of females 19–59 years old	-0.0550	-0.386	-0.0985	-0.131	-0.116
	(0.0397)	(0.725)	(0.130)	(0.131)	(0.355)
Household Size	8.97e-05	0.0173	0.00160	0.00560	-0.0181
	(0.00228)	(0.0549)	(0.00779)	(0.00760)	(0.0208)
Access to Extension Service Dummy	0.00293	0.412	0.0189	0.0147	0.168*
	(0.0112)	(0.313)	(0.0392)	(0.0381)	(0.0919)
Number of Irrigation Method Used_method	0.0537***	1.158	0.108	0.126**	0.397**
	(0.0128)	(0.789)	(0.0711)	(0.0606)	(0.155)
Number of Water Source Used	0.0511***	-0.147	0.0632	0.0804	-0.0349
	(0.0128)	(0.829)	(0.0757)	(0.0628)	(0.156)
Ln (Annual Labor Cost + 1)	-0.00191	-0.0645**	-0.00637	-0.00867	-0.0344***
	(0.00162)	(0.0258)	(0.00534)	(0.00532)	(0.0126)
Ln (Annual Rental Cost + 1)	0.0579***	0.626***	0.233***	0.216***	-0.0292
	(0.00609)	(0.0896)	(0.0397)	(0.0386)	(0.0295)
Number of variety Crops Produced	0.0646***	1.093***	0.116***	0.167***	0.421***
	(0.00616)	(0.199)	(0.0250)	(0.0234)	(0.0612)
Ln (Revenue + 1)	0.0111***	0.123***	0.0292***	0.0302***	0.0169
	(0.00132)	(0.0178)	(0.00449)	(0.00453)	(0.0116)
Ln (Consumption + 1)	0.0263***	0.0734	0.0742***	0.0712***	-0.0457
	(0.00445)	(0.0686)	(0.0147)	(0.0137)	(0.0286)
Ln (Harvest + 1)	0.0211**	0.878***	0.186***	0.177***	-0.0293
	(0.00829)	(0.146)	(0.0337)	(0.0374)	(0.0461)
Number of types of soil	0.0248***	0.881***	0.0944***	0.102***	0.0116
	(0.00758)	(0.243)	(0.0277)	(0.0257)	(0.0720)
Constant	-0.567***	-14.52***	-3.212***	-3.423***	-2.510***
	(0.0533)	(1.097)	(0.213)	(0.212)	(0.444)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,720	2,720	2,720	2,720	2,720
R-squared	0.498	0.411			

Robust standard errors in parentheses

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

Table C.13: Regression results from Wealth and Empowerment interactions (2011-12)

Round 2: Wealth Effect

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Women 5DE Score	-0.0805*	-0.410	-0.196	-0.170	-0.0406
	(0.0421)	(0.708)	(0.144)	(0.139)	(0.314)
HH in Low-Middle 20% Asset	-0.0321	-0.0225	-0.0941	-0.108	-0.334
	(0.0421)	(0.729)	(0.134)	(0.130)	(0.326)
HH in Middle 20% Asset	-0.0512	0.0210	-0.0715	-0.0370	-0.156
	(0.0439)	(0.902)	(0.147)	(0.138)	(0.343)
HH High-Middle 20% Asset	-0.0657	-1.040	-0.260*	-0.215	-0.417
	(0.0417)	(0.857)	(0.141)	(0.136)	(0.328)
HH in Highest 20% Asset	-0.0524	-0.247	-0.193	-0.119	-0.0249
	(0.0406)	(1.029)	(0.140)	(0.130)	(0.303)
Women 5DE Score × HH in Low-Middle 20% Asset	0.0352	-0.635	0.0541	0.0698	0.433
	(0.0559)	(0.938)	(0.177)	(0.172)	(0.421)
Women 5DE Score × HH in Middle 20% Asset	0.0865	-0.249	0.0824	0.0547	0.167
	(0.0573)	(1.130)	(0.191)	(0.180)	(0.440)
Women 5DE Score × HH in High-Middle 20% Asset	0.103*	1.227	0.293	0.266	0.629
	(0.0538)	(1.103)	(0.183)	(0.177)	(0.416)
Women 5DE Score × HH in Highest 20% Asset	0.0984*	1.134	0.232	0.146	0.218
	(0.0535)	(1.356)	(0.181)	(0.173)	(0.395)
Ln (HH Total Cultivable Land+1)	0.0120	1.376***	0.209***	0.233***	0.192***
	(0.00735)	(0.151)	(0.0232)	(0.0225)	(0.0542)
Proportion of males 0-4 years old	0.0144	1.033	0.419**	0.457**	-0.149
	(0.0557)	(1.138)	(0.192)	(0.180)	(0.457)
Proportion of males 5–10 years old	-0.0195	0.350	0.350**	0.315**	-0.324
	(0.0493)	(1.019)	(0.172)	(0.154)	(0.399)
Proportion of males 11–18 years old	0.0222	1.169	0.489***	0.478***	0.244
	(0.0478)	(1.122)	(0.172)	(0.154)	(0.391)
Proportion of males 19–59 years old	-0.000716	1.397	0.491***	0.460***	-0.269
	(0.0487)	(1.071)	(0.171)	(0.157)	(0.406)
Proportion of males 60 years and older	0.0480	1.395	0.534**	0.551***	0.166
	(0.0574)	(1.353)	(0.209)	(0.190)	(0.483)
Proportion of females 0–4 years old	-0.0378	-1.368	0.104	0.0960	-0.539
	(0.0557)	(1.123)	(0.191)	(0.171)	(0.478)
Proportion of females 5–10 years old	-0.00326	1.346	0.506***	0.482***	-0.0598
	(0.0497)	(1.078)	(0.177)	(0.157)	(0.397)
Proportion of females 11–18 years old	0.0266	2.145*	0.543***	0.580***	0.228
	(0.0484)	(1.121)	(0.177)	(0.161)	(0.389)

	CDI	Number of crops			Intercropping
VARIABLES	OLS	OLS	ZTPR	ZTNB	Probit
Proportion of females 19–59 years old	0.00586	1.002	0.340**	0.284**	-0.0650
	(0.0395)	(0.903)	(0.156)	(0.138)	(0.331)
Household Size	0.00232	0.0168	-0.00367	-0.000182	0.0302
	(0.00274)	(0.0711)	(0.00859)	(0.00857)	(0.0208)
Access to Extension Service Dummy	0.0107	0.437	0.0246	0.0269	0.111
	(0.0119)	(0.409)	(0.0400)	(0.0390)	(0.0925)
Number of Irrigation Method Used	0.0211**	0.859**	0.0702**	0.0848***	0.179**
	(0.0103)	(0.365)	(0.0302)	(0.0315)	(0.0899)
Number of Water Source Used	0.0578***	0.243	0.0973***	0.121***	-0.0262
	(0.0113)	(0.398)	(0.0358)	(0.0358)	(0.0967)
Ln (Annual Labor Cost + 1)	-0.00637***	-0.167***	-0.0130**	-0.0165***	-0.0527***
	(0.00181)	(0.0416)	(0.00612)	(0.00540)	(0.0128)
Ln (Annual Rental Cost + 1)	0.0328***	-0.210	-0.00390	0.00780	0.00783
	(0.00599)	(0.145)	(0.0193)	(0.0181)	(0.0438)
Number of variety Crops Produced	0.0856***	1.840***	0.229***	0.253***	0.275***
	(0.00605)	(0.194)	(0.0213)	(0.0208)	(0.0548)
Ln (Revenue + 1)	0.00509***	0.0842***	0.0223***	0.0230***	0.0344***
	(0.00131)	(0.0188)	(0.00397)	(0.00397)	(0.00995)
Ln (Consumption + 1)	0.0132**	0.261***	0.0824***	0.0679***	0.0412
	(0.00537)	(0.0926)	(0.0174)	(0.0169)	(0.0379)
Ln (Harvest + 1)	0.0706***	1.689***	0.254***	0.261***	0.0143
	(0.00778)	(0.161)	(0.0245)	(0.0246)	(0.0538)
Number of types of soil	0.0330***	0.965***	0.114***	0.122***	0.0327
	(0.00711)	(0.267)	(0.0258)	(0.0254)	(0.0621)
Constant	-0.557***	-17.58***	-2.632***	-2.955***	-3.050***
	(0.0650)	(1.400)	(0.226)	(0.212)	(0.511)
Division Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,778	2,778	2,778	2,778	2,778
R-squared	0.463	0.450			

Robust standard errors in parentheses

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

Table C.14: Regression results from Wealth and Empowerment interactions (2014-15)