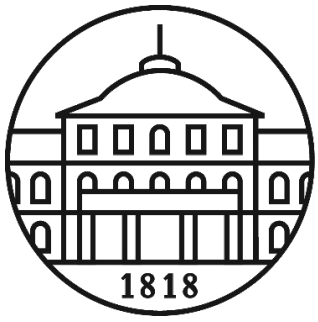

UNIVERSITY OF HOHENHEIM

An analysis of gender in intra-household decision-making as an important socio-economic factor in agriculture-nutrition linkages

Dissertation to obtain the doctoral degree of Agricultural Sciences (Dr. sc. agr.)

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Table of contents

List of tables

List of figures

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Executive summary

In 2018, almost 2 billion people around the globe experienced severe or moderate levels of food insecurity. Poverty is strongly linked with food insecurity, and most of the extreme poor live in rural areas where agriculture is the main livelihood. Thus, agricultural and rural development have profound implications for rural households. Agricultural produce is consumed or marketed or both; when marketed, the generated income can be used for (safe and nutritious) food purchases and non-food expenditures, including medical expenses and investments in sanitation. Some income may not be consumed directly but saved or invested in the form of physical, social or human capital. Moreover, considering that the end goal of development should be an environment in which people can be creative and freely enjoy a long and healthy life, rural and agricultural development will have implications for all elements of human development: health, education, poverty, environment, security, women's status, and finally, food and nutrition. The effect is seemingly more direct and profound in terms of its contribution to a healthy household environment and food security, which together determine nutritional outcomes. However, this seemingly straightforward linkage between agriculture and nutrition is challenged by numerous socio-economic factors.

This dissertation concentrates on the gender dynamics of intra-household decision-making as an important socio-economic factor in the agriculture and nutrition framework. Here, I refer to gender dynamics as the interactions and relations between men and women that can strengthen or confront the social norms of a society. Thus, the main objective is to examine the gender dynamics of decision-making as an important component of agriculture-nutrition linkages. There are three sub-objectives that concentrate on selected linkages within the framework. Given the high concentration of women's empowerment literature in social contexts in which females are underprivileged, the first sub-objective is to investigate the implications of women's empowerment in contexts in which women historically experienced equality or favoritism. Second, concentrating on the role of women's empowerment in the agriculture and nutrition framework, the next objective is to study the implications of women's empowerment on varietal adoption, diversified production, and consumption. The third objective is to examine the viability of production diversification as a strategy to improve household diets.

The findings of this dissertation are based on data collected from Bhutanese and Ethiopian households. The survey in Bhutan employed multistage random sampling; it was implemented in November 2017 and covered 251 households in two central districts of Bhutan: Tsirang and Dagana. The survey in Ethiopia was conducted in 2014 and 2016 and covered 390 Ethiopian households located in a radius of circa 150-200 km around the town of Hawassa. These households were randomly selected from a sample of farmers from a survey that was conducted by the International Food Policy Research Institute (IFPRI) for the Ethiopian Agricultural Transformation Agency (ATA) in 2012.

This dissertation has five chapters. The first chapter gives a general overview and provides a conceptual framework that helps to describe the research topics and questions investigated in the following chapters. The three following chapters are scientific papers that have been prepared for publication in scientific journals. The second chapter deals with the first sub-objective. It investigates women's participation in crucial domains of intra-household decision-making and its implications for dietary quality in Bhutanese households. The third chapter studies the effect of the main female's risk preference on the adoption of high-yielding varieties (HYVs) conditional on the dominance of female preferences declared in domestic decision-making. The fourth chapter explores the association between women's participation in decision-making and both agricultural production and dietary diversity. The final chapter concludes the dissertation, highlights main limitations, and gives recommendations for future research and policies.

Chapter 1 discusses the agriculture-nutrition linkages and interacting socio-economic factors of interest in the conceptual framework of the dissertation. Chapter 2 investigates the implications of women's participation in domestic decision-making processes for dietary quality in Bhutanese rural households. Bhutan was selected as the country of interest for this chapter because polyandry and matrilineal succession were still observed in some ethnic groups through the 20th century. We employ a mixed methods research approach to investigate women's participation in domestic decision-making processes and its implications for dietary quality at the household level. Considering the historical presence of matrilineal succession in Bhutan, we also check for any association between women's land ownership and participation in domestic decision-making using non-parametric tests. Quantitative analyses and in-depth interviews reveal no lack of participation in crucial domains of domestic decision-making for Bhutanese women. We observe a positive association between women's participation in decision-making and their property rights; thus, it is

plausible that the matrilineal succession might have provided for women's empowerment over time. Moreover, we find that gender equality in decision-making results in better dietary diversity in Bhutanese households. Given the results, we recommend that social programs focus not merely on women's empowerment, but gender-equal human development in general. The findings contribute to the gender literature and emphasize the importance of gender equality.

Considering that females are generally found to be more risk averse than males and that risk aversion hinders technology adoption, in Chapter 3, we study the importance of the main female decision-maker's risk preference for the adoption of HYVs in Ethiopia. Most often, food security is the ultimate goal for the rural poor in Ethiopia. Their risk preferences are likely to determine their willingness to trade some short-term security for a greater potential income and security in the future. Rural households are disinclined to adopt new varieties as they are unfamiliar and present a risk of failure.

The number of female decision-makers in a household is assumed to reflect the dominance of female preference declared in household decision-making. The main female decision-maker is assumed to be empowered to express her preferences more strongly and freely when the decision-making processes involves more female members. In this case, the impact of her risk preferences is likely to be more profound. To the best of my knowledge, this hypothesis has not been investigated before. Considering that rural households are constrained differently, we want to study both adoption and intensity of the HYV adoption. The results show no effect of the main female's or male's risk preferences on the adoption of HYV seeds. It is observed that the adoption decision is mostly determined by access and availability, which are captured by wealth, access to extension, and all-weather roads. We observe a positive association between the main female's risk preference and the intensity of the adoption at higher levels of women's participation in decision-making. As hypothesized, the conditionality of the effect of female risk preference on the level of female dominance in decision-making is observed. Given these results, we conclude that the main female's risk preference matters for the intensity of HYV adoption. Given the potential risk of crop failure when adopting HYV, a risk-taking female is willing to risk her household's short-run security to a potential learning effect from the new variety and potentially gain a higher income and more security in the long-run. The findings from this chapter contribute to the gender and technology adoption literature. The study interacts female risk preference with a proxy that measures female dominance in decision-making in an HYV adoption study. The results of our analysis of the role

of the main female's risk preferences in agricultural technology adoption signify the importance of a gendered lens to intra-household decision-making and risk preferences for future empirical studies.

Nutrition sensitive agricultural development programs consider diversified farm production as a promising strategy to achieve better dietary outcomes for rural poor who are mostly subsistence oriented. In Chapter 4, we mainly question the viability of this strategy for rural Ethiopian households. Furthermore, considering that both household-level production diversification and consumption choices are outcomes of intra-household decision-making, we investigate the implications of women's participation in the domains of decision-making for both outcomes. Thus, there are two objectives in Chapter 4. The first is to estimate the association between production diversification and household dietary diversity in various settings, and the second is to examine the association of female participation in decision-making with both livelihood outcomes separately. We find that on-farm diversification can be a feasible strategy to improve the diets of those who are mostly subsistence oriented and therefore highly dependent on agricultural production and those who live a great distance from markets. These results were obtained by employing and carefully interpreting multiplicative interaction models.

We find that women's participation in decision-making regarding which crops are grown is associated with more diversity both in terms of food groups and the number of different livestock and crop species produced. Nevertheless, we do not find any association when both evenness and richness of crop species are considered together as an indicator of diversification. This is due to the fact that sampled Ethiopian women are observed to be involved in decision-making on small plots, such as kitchen gardens, which contribute to the richness of species but not to the evenness in terms of the cultivated area. Furthermore, we estimate a positive association between women's decision-making regarding household expenditures (that include food, clothing, and household and agricultural assets) and dietary diversity indicators. In light of these results, we conclude that development programs could promote production diversification in remote rural areas where markets and non-farm income are hardly accessible, but even then, the viability of this strategy is very questionable due to the marginal effects that demand mostly unrealistic changes. We recommend that more attention and effort be directed toward gender-inclusive social and economic development policies together with infrastructural and market development projects to achieve sustainable returns to nutrition. We contribute to the agriculture and nutrition literature by

highlighting an important covariate, that is gendered decision-making, and calling attention to an in-depth approach to the analyses of this kind to better assist practitioners.

Overall, the main contribution of this dissertation is that the gender dynamics in intra-household decision-making is an important socio-economic factor in the agriculture and nutrition framework. The findings prove that gender sensitive policies and programs will contribute to this component and sustain the linkages between agriculture and nutrition in rural areas. It is observed that women's empowerment in farming and household-related decision-making positively contributes to various components like varietal adoption, diversification, and household-level dietary diversity in the agriculture and nutrition framework. However, extensive contextual knowledge is necessary to ensure that gender bias is correctly approached and treated to yield positive and sustainable outcomes in different societal settings.

Zusammenfassung

Im Jahr 2018 waren weltweit fast 2 Milliarden Menschen von hoher oder mittlerer Ernährungsunsicherheit betroffen. Armut ist eng mit Ernährungsunsicherheit verbunden, und die meisten der extrem Armen leben in ländlichen Gebieten wo Landwirtschaft wesentlich zum Einkommenserwerb beiträgt. Daher hat die landwirtschaftliche und ländliche Entwicklung tiefgreifende Auswirkungen auf die Haushalte. Landwirtschaftliche Produkte werden konsumiert, vermarktet oder beides; wenn sie vermarktet werden, kann das erwirtschaftete Einkommen für den Kauf von (sicheren und nahrhaften) Nahrungsmitteln und für Nicht-Nahrungsmittelausgaben einschließlich medizinischer Ausgaben und Investitionen in sanitäre Einrichtungen verwendet werden. Ein Teil des Einkommens wird möglicherweise nicht direkt konsumiert, sondern gespart oder in die Bildung von Sach-, Sozial- oder Humankapital investiert. Außerdem, wenn man bedenkt, dass das Endziel von Entwicklung darin bestehen sollte, zu einem Umfeld zu führen, in dem die Menschen kreativ sind und frei ein langes und gesundes Leben führen können, so wird die ländliche und landwirtschaftliche Entwicklung Auswirkungen auf alle Elemente der menschlichen Entwicklung haben, also auf Gesundheit, Bildung, Armut, Umwelt, Sicherheit, den Status der Frauen und schließlich auch auf Nahrung und Ernährung. Die Auswirkungen sind anscheinend direkter und tiefgreifender bezüglich ihres Beitrages zu einem gesunden Haushaltsumfeld und zur Ernährungssicherheit und damit letztendlich zur Ernährungslage der Menschen. Diese scheinbar direkte Verbindung zwischen Landwirtschaft und Ernährung wird jedoch durch zahlreiche sozioökonomische Faktoren in Frage gestellt.

Die vorliegende Dissertation konzentriert sich auf die geschlechtsspezifische Dynamik innerhäuslicher Entscheidungsfindung als wichtigen sozioökonomischen Faktor im Rahmen von Landwirtschaft und Ernährung. Ich beziehe mich hier auf die Geschlechterdynamik als Interaktionen und Beziehungen zwischen Männern und Frauen, die die sozialen Normen der Gesellschaft stärken oder sich ihnen entgegenstellen können. Daher besteht das Hauptziel darin, die Geschlechterdynamik der Entscheidungsfindung als wichtige Komponente der Verbindungen zwischen Landwirtschaft und Ernährung zu untersuchen. Es gibt drei Unterziele, die sich auf ausgewählte Verknüpfungen innerhalb des Rahmenkonzepts konzentrieren. In Anbetracht der hohen Fokussierung in der Empowerment-Literatur auf Frauen in sozialen Kontexten, in denen Frauen unterprivilegiert sind, besteht das erste Unterziel darin, die Auswirkungen in Kontexten zu

untersuchen, in denen Frauen historisch gesehen Gleichheit oder gar Bevorzugung erfahren haben. Das zweite Ziel konzentriert sich auf die Rolle der Ermächtigung von Frauen im Rahmen der Landwirtschaft und Ernährung und untersucht die Auswirkungen auf die Aneignung bezüglich der Nutzung von (Feldfrucht-)Sorten und der diversifizierten Produktion und Konsum von Nahrungsmitteln. Das dritte Ziel besteht darin, die Durchführbarkeit der Produktionsdiversifizierung als Strategie zur Verbesserung der Haushaltsernährung zu untersuchen.

Die Ergebnisse dieser Dissertation basieren auf Haushaltsdaten, die in Bhutan und Äthiopien erhoben wurden. Die Erhebung in Bhutan verwendete mehrstufige Zufallsstichproben; sie wurde im November 2017 durchgeführt und umfasste 251 Haushalte in zwei zentralen Distrikten Bhutans: Tsirang und Dagana. Die Erhebung in Äthiopien wurde in den Jahren 2014 und 2016 durchgeführt. Die Daten enthalten Informationen über 390 äthiopische Haushalte, die in einem Radius von etwa 150-200 km um die Stadt Hawassa liegen. Diese Haushalte wurden nach dem Zufallsprinzip aus einer Stichprobe von Bauern aus der Umfrage ausgewählt, die das Internationale Institut für Ernährungspolitik (IFPRI) im Jahr 2012 für die Ethiopian Agricultural Transformation Agency (ATA) durchgeführt hat.

Die Dissertation besteht aus fünf Kapiteln. Das erste Kapitel gibt einen allgemeinen Überblick und bietet den konzeptionellen Rahmen für die in den folgenden Kapiteln untersuchten Forschungsthemen und -fragen. Bei den drei folgenden Kapiteln handelt es sich um Fachartikel, die für die Veröffentlichung in wissenschaftlichen Fachzeitschriften vorbereitet wurden. Das zweite Kapitel befasst sich mit dem ersten Teilziel. Es untersucht die Beteiligung von Frauen in wichtigen Bereichen der innerhäuslichen Entscheidungsfindung und ihre Auswirkungen auf die Ernährungsqualität in bhutanischen Haushalten. Das dritte Kapitel untersucht die Auswirkungen der Risikopräferenz der wichtigsten Frau innerhalb eines Haushaltes für die Adoption von Hochertragssorten (HYV), in Abhängigkeit von der angegebenen Dominanz weiblicher Präferenzen bei der Entscheidungsfindung im Haushalt. Das vierte Kapitel untersucht den Zusammenhang zwischen der Beteiligung von Frauen an Entscheidungsprozessen, welche die landwirtschaftliche Produktion als auch die Ernährungsvielfalt betreffen. Das Schlusskapitel schließt die Dissertation ab und zeigt neben einer kritischen Bewertung der Forschung auch Empfehlungen für zukünftige Forschung und Politik auf.

Kapitel 1 diskutiert der Zusammenhänge zwischen Landwirtschaft und Ernährung und den relevanten interagierenden sozio-ökonomischen Faktoren und entwickelt den konzeptionellen Rahmen der Dissertation in Kapitel 1. Kapitel 2 untersucht die Auswirkungen der Beteiligung von Frauen an häuslichen Entscheidungsprozessen auf die Ernährungsqualität in bhutanischen ländlichen Haushalten. Bhutan wurde für die Untersuchung der Teilziele ausgewählt, weil sowohl Polyandrie als auch eine matrilineare Erbfolge in einigen ethnischen Gruppen während des 20. Jahrhunderts noch immer beobachtet. Wir verwenden einen Forschungsansatz mit gemischten Methoden, um die Beteiligung von Frauen an häuslichen Entscheidungsprozessen und ihre Auswirkungen auf die Ernährungsqualität auf Haushaltsebene zu untersuchen. Angesichts der historischen Präsenz matrilinearer Erbfolge in Bhutan prüfen wir mit Hilfe von nichtparametrischen Tests auch, ob ein Zusammenhang zwischen Landbesitz von Frauen und der Beteiligung an häuslichen Entscheidungsprozessen besteht. Quantitative Analysen und Tiefeninterviews zeigen keinen Mangel an Beteiligung bhutanischer Frauen in wichtigen Bereichen der häuslichen Entscheidungsfindung. Wir beobachten einen positiven Zusammenhang zwischen der Beteiligung von Frauen an Entscheidungsprozessen und ihren Eigentumsrechten; es ist daher plausibel, dass die matrilineare Erbfolge im Laufe der Zeit für die Stärkung der Frauen gesorgt haben könnte. Darüber hinaus stellen wir fest, dass die Gleichstellung der Geschlechter in Entscheidungsprozessen zu einer besseren Ernährungsvielfalt in bhutanischen Haushalten führt. Angesichts der Ergebnisse empfehlen wir, dass sich Sozialprogramme nicht nur um das Empowerment von Frauen, sondern auch auf die geschlechtergerechte menschliche Entwicklung insgesamt konzentrieren sollten. Die Ergebnisse tragen zur Gender-Literatur bei und unterstreichen die Bedeutung der Geschlechtergleichheit.

In Anbetracht der Tatsache, dass Frauen im Allgemeinen risikoscheuer sind als Männer und dass die Risikoaversion die Technologieadoption behindert, untersuchen wir in Kapitel 3 die Bedeutung der Risikopräferenz der Hauptentscheidungsträgerin für die Adoption von HYVs in Äthiopien. Meistens ist die Ernährungssicherheit das übergeordnete Ziel für die arme Landbevölkerung in Äthiopien. Wahrscheinlich bestimmt ihre Risikopräferenz die Bereitschaft, einen Teil der heutigen Sicherheit gegen ein größeres potenzielles Einkommen und zukünftige Sicherheit einzutauschen. Ländliche Haushalte sind abgeneigt neue Sorten zu übernehmen, da sie nicht vertraut sind und ein Versagensrisiko darstellen.

Es wird angenommen, dass die Zahl der weiblichen Entscheidungsträgerinnen die Dominanz der weiblichen Präferenz widerspiegelt, die für die Entscheidungsfindung der Haushalte angegeben wird. Es wird weiter davon ausgegangen, dass die Hauptentscheidungsträgerin in der Lage ist, ihre Präferenzen stärker und freier auszudrücken, wenn an den Entscheidungsprozessen mehr weibliche Haushaltsmitglieder beteiligt sind. In diesem Fall dürften die Auswirkungen ihrer Risikopräferenzen tiefgreifender sein. Nach meinem besten Wissen ist diese Hypothese bisher noch nicht untersucht worden. In Anbetracht der Tatsache, dass ländliche Haushalte unterschiedlich eingeschränkt werden, wollen wir sowohl die Adoptionsrate als auch die Intensität der HYV-Adoption untersuchen. Die Ergebnisse zeigen keinen Einfluss der Risikopräferenzen der wichtigsten Frauen oder Männer auf die Adoption von HYV-Saatgut. Es ist zu beobachten, dass die Adoptionsentscheidung hauptsächlich durch den Zugang und die Verfügbarkeit bestimmt wird, die durch den Wohlstand, den Zugang zu landwirtschaftlicher Beratung und Allwetterstraßen erfasst werden. Wir beobachten einen positiven Zusammenhang zwischen der Risikopräferenz der Hauptentscheidungsträgerin und der Intensität der Adoption auf höheren Ebenen der Beteiligung von Frauen an der Entscheidungsfindung. Wie vermutet, wird beobachtet, dass der Effekt der weiblichen Risikopräferenz durch die Ebene der weiblichen Dominanz in Entscheidungsprozessen bedingt wird. Angesichts der Ergebnisse kommen wir zu dem Schluss, dass die Risikopräferenz der Hauptentscheidungsträgerin für die Intensität der HYV-Adoption von Bedeutung ist. In Anbetracht des potentiellen Risikos eines Ernteausfalls bei der Adoption von HYV ist eine risikofreudige Frau bereit, die kurzfristige Sicherheit des Haushalts einem potentiellen Lerneffekt durch die neue Sorte und einem damit verbundenen potentiell höheren Einkommen und Sicherheit auf lange Sicht zu riskieren. Die Erkenntnisse aus diesem Kapitel fließen in die Literatur über Gender und Technologieadoption ein. Die Studie interagiert die weibliche Risikopräferenz mit einer Variablen, welche die weibliche Dominanz bei der Entscheidungsfindung in der HYV-Adoptionsstudie zu messen versucht. Die Ergebnisse unserer Analyse der Rolle der Risikopräferenzen der Hauptentscheidungsträgerin bezüglich der Adoption von Agrartechnologien zeigen auf, wie wichtig eine geschlechtsspezifische Betrachtung der innerhäuslichen Entscheidungsfindung und der Risikopräferenzen für künftige empirische Studien ist.

Ernährungssensible landwirtschaftliche Entwicklungsprogramme betrachten eine diversifizierte landwirtschaftliche Produktion als eine vielversprechende Strategie zur Erzielung besserer Ernährungsergebnisse für arme ländliche Bevölkerungsgruppen, die hauptsächlich für den

Eigenbedarf produzieren. In Kapitel 4 stellen wir vor allem die Tragfähigkeit dieser Strategie für ländliche äthiopische Haushalte in Frage. Da sowohl die Produktionsdiversifizierung auf Haushaltsebene als auch die Konsumentscheidungen das Ergebnis innerhäuslicher Entscheidungsfindung sind, untersuchen wir darüber hinaus die Auswirkungen der Beteiligung von Frauen in den jeweiligen Entscheidungsbereichen auf beide Ergebnisse. Somit gibt es zwei Ziele in Kapitel 4. Das erste Ziel besteht darin, den Zusammenhang zwischen der Produktionsdiversifizierung und der Ernährungsvielfalt in den Haushalten in verschiedenen Umfeldern abzuschätzen. Das zweite Ziel besteht darin, den Zusammenhang zwischen der Beteiligung von Frauen an Entscheidungsprozessen und den beiden Lebensunterhaltsergebnissen getrennt zu untersuchen. Wir stellen fest, dass die Diversifizierung auf dem Bauernhof eine machbare Strategie sein kann, um die Ernährung derjenigen zu verbessern, die hauptsächlich subsistenzorientiert und daher stark von der landwirtschaftlichen Produktion abhängig sind und die sehr weit entfernt von Märkten leben. Diese Ergebnisse wurden durch den Einsatz multiplikativer Interaktionsmodelle und deren sorgfältige Interpretation erzielt.

Wir stellen fest, dass die Beteiligung von Frauen an der Entscheidungsfindung in Bezug auf den Anbau von Nutzpflanzen mit einer größeren Vielfalt sowohl in Bezug auf die Nahrungsmittelgruppen als auch auf die Anzahl der verschiedenen produzierten Tier- und Pflanzenarten verbunden ist. Dennoch finden wir keinen Zusammenhang, wenn sowohl die Gleichmäßigkeit als auch der Reichtum an Nutzpflanzenarten gemeinsam als ein Indikator für die Diversifizierung betrachtet werden. Dies ist darauf zurückzuführen, dass für äthiopischen Frauen in der Stichprobe beobachtet wird, dass sie an der Entscheidungsfindung auf kleinen Parzellen wie Haus- und Nutzgärten beteiligt sind, die zwar zum Artenreichtum, nicht aber zur Gleichmäßigkeit in Bezug auf die Anbaufläche beitragen. Darüber hinaus sehen wir einen positiven Zusammenhang zwischen der Entscheidungsfindung von Frauen in Bezug auf Haushaltsausgaben (die Nahrungsmittel, Kleidung, Haushalts- und landwirtschaftliche Güter umfassen) und den Indikatoren für die Ernährungsvielfalt. Angesichts dieser Ergebnisse kommen wir zu dem Schluss, dass Entwicklungsprogramme die Produktionsdiversifizierung in abgelegenen ländlichen Gebieten fördern könnten, wo Märkte und nichtlandwirtschaftliches Einkommen kaum zugänglich sind. Allerdings ist selbst dann die Durchführbarkeit dieser Strategie aufgrund der marginalen Auswirkungen, die meist unrealistische Veränderungen erfordern, sehr fraglich. Wir empfehlen, der geschlechtergerechten sozialen und wirtschaftlichen Entwicklungspolitik zusammen mit

Infrastruktur- und Marktentwicklungsprojekten mehr Aufmerksamkeit und Anstrengungen zu widmen, um nachhaltige Erfolge bei der Ernährung zu erzielen. Wir leisten einen Beitrag zur Literatur über Landwirtschaft und Ernährung, in dem geschlechtsspezifische Entscheidungsfindung als wichtiger Bestimmungsgrund hervorgehoben wird, und ein vertiefter Ansatz für solche Analysen entwickelt wird, um Anwender besser unterstützen zu können.

Insgesamt gesehen besteht der Hauptbeitrag dieser Dissertation darin, dass die Geschlechterdynamik in der innerhäuslichen Entscheidungsfindung ein wichtiger sozioökonomischer Faktor im Rahmen der Landwirtschaft und Ernährung ist. Die Ergebnisse beweisen, dass geschlechtersensible Politiken und Programme zu dieser Komponente beitragen und die Verbindungen zwischen Landwirtschaft und Ernährung in ländlichen Gebieten aufrechterhalten werden. Es ist zu beobachten, dass die Stärkung der Rolle der Frau in der Landwirtschaft und in haushaltsbezogenen Entscheidungsprozessen einen positiven Beitrag zu verschiedenen Komponenten wie Sortenadoption, Diversifizierung und Ernährungsvielfalt auf Haushaltsebene im Rahmen der Landwirtschaft und Ernährung leistet. Es ist jedoch eine umfassende Kenntnis des Kontexts erforderlich, um sicherzustellen, dass die geschlechtsspezifische Voreingenommenheit richtig angegangen und behandelt wird, um positive und nachhaltige Ergebnisse in verschiedenen gesellschaftlichen Bereichen zu erzielen.

List of abbreviations

A-WEAI	Abbreviated Women's Empowerment in Agriculture Index
ARNS	African Regional Nutrition Strategy
ATA	Agricultural Transformation Agency (Ethiopia)
AU	African Union
BTN	Bhutanese ngultrum
CAPI	computer-assisted personal interviewing
CI	confidence interval
CRE	correlated random effects
DH	double-hurdle
ETB	Ethiopian birr
FAO	Food and Agriculture Organization of the United Nations
FGPD	food group production diversity
FPDM	female participation in decision-making
FVS	food variety score
GDP	gross domestic product
GED	gender equality in decision-making
GEDI	gender equality in decision-making index
HDDS	household dietary diversity score
HYV	high-yielding variety
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
KMO	Kaiser-Meyer-Olkin
LHV	left-hand-side variable

MDGs	Millennium Development Goals
PCA	principal component analysis
PDM	participant in decision-making (any gender)
PFP	pooled fractional probit
RHV	right-hand-side variable
SDGs	Sustainable Development Goals
SID	Simpson's Index of Diversification
SNNP	Southern Nations, Nationalities, and Peoples' Region
SSA	Sub-Saharan Africa
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WEAI	Women's Empowerment in Agriculture Index
WELI	Women's Empowerment in Livestock Index
WFP	United Nations World Food Programme
WHO	World Health Organization
WPDM	women's participation in domestic decision-making
WPDMI	women's participation in domestic decision-making index

Chapter 1: Introduction

1.1 General introduction

In the early 1950s, economic researchers were still reluctant to apply a gender lens when analyzing and evaluating socio-economic development. A decade later, economists had accepted the importance of gender in development studies; international organizations prioritized work toward gender equality, and policy makers started to put emphasis on gender in development and poverty alleviation work (Sen, 1987; World Legal Information Institute, 1962). Two decades later, pioneering work by Ester Boserup drew attention to the role of women in the development of both the agriculture and industry sectors (Boserup, 1970). Boserup predicted a feminization of the agricultural labor force in developing countries based on the assumption that in times of greater demand for food, dissemination of capital-intensive technologies will greatly suffer in developing countries, and demand for female labor will rise. Her predictions were focused on plantations that were export oriented, where cost efficiency was to be achieved at the expense of women's double burden. Boserup pointed out that females spend significantly more hours doing housework than men do and highlighted the double burden of women. Today, we observe that her predictions regarding the demand for female labor in developing countries were fairly correct (Boserup et al., 2007).

The FAO (2011) reports that women constitute on average 43 percent of the global agricultural labor force, and the World Bank (2012) reports that around 40 percent of the overall global labor force is female. The magnitudes vary significantly across regions. Eastern and Southeastern Asia and Sub-Saharan Africa (SSA) have a more balanced distribution of agricultural labor force in terms of gender. In contrast, relatively higher education, economic development, and relaxed cultural norms (in terms of culturally-defined barriers to female employment) in Latin America have led to the movement of females from agriculture to other sectors of development. It is important to highlight that in addition to their active economic employment, women undertake crucial unpaid household- and community-level activities that shape the well-being of households. Housework is predominantly women's work. Over time and across countries, there is a consistent gender difference in time devoted to housework, and women bear a very large share of housework and childcare responsibilities. Despite their obvious and significant contribution to household well-

being, women's own well-being tends to suffer a lot. This is partially due to the differences in time allocated to housework that translates to less time for education and employment. In many parts of the world, gender disparities in school enrolment persist, which hinder girls' personal and social well-being in the later stages of their lives (World Bank, 2012).

Agriculture is the main source of income generation in the rural areas of many developing countries. Although there are few myths regarding the gender differences in agriculture[1], women's limited access to key inputs hinders female farmers' agricultural productivity. An important productive resource, land is less likely to be owned or accessed by women across developing countries. When women enjoy access to this productive resource, the land is likely of poor quality and small size. Women are also challenged in terms of access to fertilizer due to their lack of credit and cash. For example, in Ghana, Doss and Morris (2001) observed that differences in the adoption of modern maize varieties and chemical fertilizer by men and women are due to the existing dissimilarities in access to main productive inputs. In this regard, fertilizer subsidy programs are encouraged to target women (Gladwin, 1992; Quisumbing & Pandolfelli, 2010).

Similar to the land ownership issue, there is gender inequality in livestock ownership. Livestock is an important asset and productive resource in many regions. Globally, on average, men are more likely to own more and larger animals. Moreover, in terms of agricultural labor, women are constrained as farm managers and wage laborers. Rural farms mostly depend on family labor, and female-headed households are likely to consists of mostly dependents (FAO, 2011). Women are also constrained as wage laborers. Since they perform most of the household work, women have less time to allocate to income generating off-farm activities. In this regard, also, inadequate nutrient consumption deteriorates women's physical productivity (Quisumbing & Pandolfelli, 2010). The World Health Organization (2016) reports that globally, in 2016, 40% of pregnant women and 32.5% of non-pregnant women suffered from anemia.

Knowledge dissemination and the adoption of agricultural technology and farming practices are mostly determined by access to agricultural extension services in rural areas. These services

1 Doss et al. (2018) discusses four myths: (i) women make up 70% of the world's poor, (ii) they produce 60% to 80% of the world's food, (iii) they own 1% of the world's land resources, and (iv) they are more protective towards the environment. Authors show that these points are not based on any empirical evidence and are mostly misleading statistics.

generally do not reach to women. This is partially due to the biased notions that "women are not farmers" and extension reaches all household members when the information is delivered to the head. Moreover, there is biased dissemination of information to those who are resource rich, and thus, likely to adopt. This hinders women's access to extension information, since women are mostly resource poor. Furthermore, time spent on household care and low levels of education may limit women's participation and learning in extension meetings (Meinzen-Dick et al., 2010). Last but not least, access to finance is an important productive resource, and there is a gender gap in access to finance (FAO, 2011). In addition to the fact that cultural norms in many countries restrict women from having their own bank accounts, women also lack property rights over productive resources that they could use as a collateral to access credit. The fact that they are resource poor also hinders their economic activity and makes them more risk averse and more susceptible to risks that are inherent to agriculture. These outcomes lead to institutionalized discrimination against women (World Bank, FAO & IFAD, 2009).

In a glimpse of the level of agricultural productivity and gender inequality indicators across different countries, in many cases, it is possible to observe that gender inequality is negatively associated with agricultural productivity. This association can be interpreted two ways: gender-equal societies are more likely to have higher agricultural productivity; and higher agricultural yields contribute to gender equality (FAO, 2011). Considering gendered differences in access to productive resources, numerous studies have tried to evaluate gendered differences in agricultural productivity. Holden et al. (2001) report that the households in Ethiopian highlands that are headed by females are less productive, and controlling for access to various productive resources, this difference can be explained by factors like managerial skills. In contrast, Alene et al. (2008) find that although there are maize yield differences, this is mostly due to the access to education and land, and controlling for these factors, female-headed households in Kenya are as efficient as male-headed ones. Moreover, using a dataset from Burkina Faso, Udry et al. (1995) compare women's and men's plots within households. The findings show that women have significantly lower yields, which are likely due to unequal input application intensity between plots. Authors predict an output increase of up to 15% if inputs were reallocated. Quisumbing (1996) reviews empirical studies on the gender of farmers and agricultural productivity and concludes that overall, controlling for human capital and input level, female agricultural producers are as efficient as male producers. Nonetheless, she highlights that many of these studies are methodologically imperfect. Many of

these studies have extensively used household head's sex as the main variable of interest. This information does not capture intra-household decision-making. Plot-level disaggregation can be more relevant to analyze gendered differences in technical efficiency, since it is possible to indicate female plot managers in male-headed households (Quisumbing, 1996). Yet, plot-level analyses may not always yield robust results, as there is likely to be a relationship between plots and their managers (Doss & Quisumbing, 2020). Seymour (2017) estimates higher technical efficiency in both male- and jointly managed plots in rural Bangladesh when empowerment gaps are lower. This indicates that women's relative empowerment is associated with agricultural productivity in rural households. Moreover, Peterman et al. (2011) find that women's plots are less productive in Uganda and so are the households headed by women in Nigeria. The results are sensitive to the aggregation of the gender indicator as well as biophysical and agro-ecological characteristics. Employing only the Uganda dataset, they highlight the irrelevance of gender aggregation at the household level. The authors suggest concentrating on the decision-making level and conclude that the gender of the household head is an insufficient measure to reveal any potential gender differences in agricultural productivity.

Many studies have focused on intra-household decision-making to capture gendered differences and implications. For example, Bhagowalia, Menon et al. (2012) consider a woman's decision-making power as a measure of her empowerment and estimate the implications for child nutrition in Bangladesh. Garikipati (2008) and Allendorf (2007) look into women's decision-making power to evaluate the impact of lending to women and women's land rights on their empowerment. Moreover, the Women's Empowerment in Agriculture Index (WEAI) has been developed to capture women's agency, empowerment, and inclusion in the agricultural sector. Decision-making is an indicator across the production, resources, and income domains of WEAI (Alkire et al., 2013). WEAI has been used to evaluate implications of women's empowerment on agricultural productivity (Diiro et al., 2018), child and maternal nutrition (Malapit et al., 2015), and dietary diversity in rural households (Sraboni et al., 2014). Moreover, WEAI has been adapted to different settings. For example, the Abbreviated WEAI (A-WEAI) was created as a shorter version of WEAI that retains six out of the 10 original indicators. Decision-making indicators remain in A-WEAI (Malapit et al., 2017). Galiè et al. (2019) developed the Women's Empowerment in Livestock Index (WELI), which mostly focuses on intra-household decisions with regard to various indicators of empowerment dimensions. To summarize, decision-making power is a frequently used proxy of

women's empowerment (Malhotra et al., 2002) and a crucial indicator of dimensions of various aforementioned indicators.

Given that gender disparities limit women's contributions to development, empowerment is multidimensional and difficult to measure, and women's decision-making is a widely used proxy and dimension of their empowerment, it is relevant and promising to evaluate women's participation in domestic decision-making in rural households and to investigate how it contributes to the linkages between various livelihood aspects. Given the high concentration of the literature on the outcomes of women's empowerment in social contexts where females are underprivileged, a significant knowledge gap corresponds to the outcomes in areas where women historically experienced equality or favoritism. Moreover, concerning the nutrition-sensitive agricultural development, gender is an important interacting socio-economic factor in agriculture and nutrition linkages; the knowledge base would largely benefit from the study of implications of women's empowerment on varietal adoption, diversified production, and consumption.

1.2 Conceptual framework

Population and per-capita income growth are the major drivers of aggregate food demand at the country level. Economic and population growth positively influence demand for agricultural products. Considering that agriculture is the main sector for income generation in rural areas, these macroeconomic changes can significantly affect rural households' income and other aspects of rural livelihoods like nutrition in developing countries. Although, the linkage between rural and agricultural development and nutrition might seem straightforward, in reality, there are numerous indirect links between various components that are affected by different socio-economic factors. (Headey et al., 2012). The components, the links between them, and some determining socio-economic factors are discussed in this subchapter. It firstly discusses household-level food production and its link to nutrient consumption and healthcare in rural households. The socio-economic factors of interest are discussed throughout and at the end of the section. The next section presents the research topics, questions, and hypotheses analyzed in this dissertation. The conceptual framework of the agriculture and nutrition linkage with socio-economic factors of this dissertation's interests are explained at the end of the subchapter.

1.2.1 Food production, nutrition, and gender

In the face of the Zero Hunger by 2030 target, globally, 820 million people are currently undernourished. The numbers have been rising worldwide since 2015. The undernourishment rate is highest in Africa, but the absolute number of undernourished people in Asia is double that of Africa. The latest installment of "The State of the World" series by the Food and Agriculture Organization of the United Nations (FAO) states that "given these figures and the trends observed over the last decade, achieving Zero Hunger by 2030 appears to be an increasingly daunting challenge" (FAO, IFAD, UNICEF, WFP & WHO, 2019, p. 11).

Together, hunger and poverty eradication made up the first Millennium Development Goal (MDG). Although, they are separated in the Sustainable Development Goals (SDGs), there is a clear mutual causation between the two goals. Economic development or downturns affect the poor through various channels. As the poorest of the poor mostly live in rural areas and depend on agriculture, in times of economic downturns, they are likely to suffer more. Moreover, in terms of off-farm employment, reduced employment possibilities for rural migrants result in reduced urban to rural remittances and thus, in low farm investments and returns (FAO, IFAD, UNICEF, WFP & WHO, 2019).

Rural households access food through markets and home production. Affordability of the food from markets depends on the household's income, which in rural areas, mostly consists of agricultural income and off-farm employment. The level of a household's agricultural income is determined by their agricultural productivity. In summary, agricultural production generates food for households' direct consumption and commodities for market sale that generates income to be used for food and non-food purchases from markets. Moreover, the poor spend a very high share of their income on food; in times of economic downturn, food crisis, or other severe shocks, they reduce their food consumption, base their diets more on staples and less on non-staple foods, and invest less in other livelihood aspects like education, sanitation, and healthcare (Von Braun, 2008). Vitamins and minerals are mostly obtained from non-staple foods; for the poor, any reduction in the quality and quantity of non-staples consumed can have severe consequences in terms of nutrition (Bouis, 2008). Thus, economic development that translates to more agricultural income and better rural livelihoods can prevent such scenarios and lead to their inverse.

Considering that agriculture is the main source of income for the majority of rural smallholders, income generated from food production can define a rural household's access to a varied and nutritious diet. In their analysis from Kenya, Uganda, and Indonesia, Sibhatu and Qaim (2018a) report that income generated from markets is associated with varied diets at the household level. Furthermore, Bhagowalia, Headey et al. (2012) find that the level of agricultural income significantly explains the dietary patterns of Indian households. The contribution of agricultural production to nutrition is not just through the generated income. Consumption of home produce can be highlighted as one dimension of how food production contributes to diets. Considering that rural smallholder households regularly use some share of their produce for home consumption, many studies have recently looked at the association between diversified agricultural production and dietary outcomes. Employing nationally representative data from India, Bhagowalia, Headey et al. (2012) find that diversity of crops grown and ownership of poultry and milk-producing livestock are positively associated with diverse diets. Besides, authors find that the conditions of agricultural production, like livestock ownership and irrigation, matter for diets in rural Indian households. Sibhatu and Qaim (2018b) have recently reviewed studies from 26 countries that investigated the association between the production diversity in smallholder rural farms with diets and nutrition. Meta-analysis of estimated effects in reviewed studies have led the authors to a conclusion that there is a positive but small association between production diversity and diet and nutrition in rural smallholder households. It is found that the association is comparatively larger in SSA. Overall, given favorable infrastructural conditions and market-driven motivations, production diversity can be positively associated with advances in both income and nutrition in rural households (Pellegrini & Tasciotti, 2014; Sibhatu & Qaim, 2018a). Moreover, Girard et al. (2012) systematically review studies that focused on the agricultural interventions that contribute to the quantity and quality of agricultural production and their implications on health and nutrition. They observe a consistent significant contribution of agricultural interventions to improved diets and vitamin A intake for women and children. A recent similar systematic review focused on South Asia highlights the potential positive outcomes of agricultural interventions on the dietary diversity of households (Bird et al., 2019).

Diseases and inadequate nutrition are the main causes of malnutrition (UNICEF, 1990). Many children around the world suffer from inadequate access to clean water, sanitation, and healthcare that can result in illnesses that limit the absorption of nutrients (UNICEF, 2019). Nutrition status

is strongly influenced by access to proper sanitation, clean water, and health care services. Thus, household-level investment in sanitation, health care, and other basic necessities is important to enable a healthy environment within households where food can be safely produced, treated, and consumed. These facts signify that household budgets need to be attentively distributed between production inputs, marketing, food, health, and care necessities (Herforth & Harris, 2014). In a household's budget, the consumption of home produce can be seen as a share that would reflect in food expenditure otherwise spent to acquire the same calories and nutrients from markets. Thus, in many smallholder households, imputed and generated income from produced food would determine the level of non-food expenditure, like investment in sanitation and healthcare, and food expenditure that is to buy food products from market. Development of agricultural livelihoods that translates to higher yields and incomes would thus translate to nutritional outcomes in this chain. Furthermore, in some households, remittances received and income generated from off-farm activities would contribute to the household budget.

The linkage between agriculture and nutrition is multidirectional, and indirect influences through various socio-economic factors like decision-making, intra-household allocation of resources, education, taste, culture, sanitation, and so forth can be very strong (Headey et al., 2011). Culturally, regionally, and nationally enabling healthy environments determines the outcomes of the linkage between agriculture and nutrition. This linkage is further challenged by various socio-economic factors like low levels of education, poor labor availability, high numbers of dependents, intra-household inequality, and so forth. Intra-household inequality corresponds to different aspects of rural livelihoods. Gender bias in access to education, information, employment, finance, land, workload, and decision-making are a few examples of potential inequalities that interact with the agriculture-nutrition linkage (Headey et al., 2011; Herforth & Harris, 2014). Smith and Haddad (2000) estimated that advancements in women's education and their status relative to men's have defined more than half of the reduction in child malnutrition between 1970 and 1995. In terms of gender bias in domestic decision-making, Smith et al. (2003) estimate that an increase in women's relative decision-making power is associated with a lower probability of malnutrition for children in developing countries, which is especially stronger in poor households of South Asia and SSA. It is reported that women's relative decision-making power is also positively associated with a variety of child caregiving practices, like feeding frequency and dietary quality, and healthcare practices, like vaccination, in both regions. Jones et al. (2019) estimate that in East Africa, women's

empowerment could improve the nutritional outcomes of their children both directly and indirectly via improved maternal nutrition. In Uganda, a more specific study was conducted to investigate the adoption of vitamin A-biofortified orange sweet potatoes that are promoted among women and children and found that female decision-making with regard to the type of crop grown is associated with a higher probability of adoption of the biofortified sweet potatoes in jointly-owned plots (Gilligan et al., 2014). Moreover, women's decision-making power is positively associated with their uptake of reproductive health services (Hou & Ma, 2011; Rahman et al., 2014).

1.2.2 Research topics, questions, and hypotheses

Considering that rural households make various livelihood decisions, intra-household inequality in decision-making can affect their long-term welfare by influencing the numerous components of the linkage between agriculture and nutrition. Gender bias in agricultural production, consumption, and investment decisions that link to various outcomes in the agriculture and nutrition framework can impede the nutrition-sensitive agricultural interventions. Furthermore, considering that there are different risks involved in each decision that households make, decision-makers' risk preferences can also affect outcomes. In light of the importance of the intra-household decision-making processes, the main objective of this dissertation is to examine the gender dynamics in intra-household decision-making as an important socio-economic factor in agriculture-nutrition linkages. Here, considering the glossary of gender terms developed for USAID's Office of Women in Development (EQUATE Project, n.d.), I refer to gender dynamics as interactions and relations between men and women that can strengthen or confront the social norms that exist in society. This dissertation has three sub-objectives. The first is to investigate implications of women's participation in decision-making in contexts where they historically experienced equality or favoritism; second is to study its implications on varietal adoption, diversified production, and consumption; and third is to examine the viability of production diversification as a strategy to improve household diets. The objectives are pursued in three chapters.

First research topic: Women in household decision-making and implications for dietary quality in Bhutan

This topic is discussed in Chapter 2 of this dissertation. The following research questions and hypotheses are investigated within the chapter.

1. **Do Bhutanese women enjoy participation in crucial household-level decision making-processes?**

The literature on the outcomes of women's empowerment is concentrated on the social contexts in which females are disadvantaged, and the outcomes have not been tested in areas where women historically experienced equality or favoritism. Considering this gap in the literature, the Kingdom of Bhutan is selected as the research region where, in the early years of the past century, polyandry was still widely observed among many ethnic groups (Dorji, 2009). According to FAO (2000), Bhutan can be acknowledged as a matriarchal society in which the majority of the population follows matrilineal heritage. Considering the historical social context in Bhutan, it is hypothesized that women are not excluded from participation in intra-household decision-making.

2. **How are women's participation levels in intra-household decision-making associated with household-level dietary quality in Bhutan?**

Considering the historical social context in Bhutan and the thoughts of Headey et al. (2011) that inequalities can result in leakages in the agriculture and nutrition linkage, an increase in female preferences declared in male-dominated decision-making domains will lead to better outcomes. The opposite is expected to have a similar positive effect. Negative outcomes are expected if changes in domestic decision-making behavior lead to inequality or dictatorship in intra-household decision-making. Thus, a nonlinear association between women's participation in decision-making and household-level dietary outcomes is hypothesized. Empowerment is expected to result in positive outcomes at low levels of women's decision-making power.

Second research topic: Implications of female risk preference on the adoption of high-yielding variety (HYV) seeds in Ethiopia

This topic is discussed in Chapter 3 of the dissertation. The following research question and its hypothesis are investigated.

1. **Does female risk preference matter for varietal adoption?**

The expansion of agricultural technologies offers productivity returns. Di Zeng et al. (2015) estimated a percentage drop of up to 1.3 in the poverty headcount index of rural Ethiopia attributable to the adoption of improved maize varieties. Although there are potentially high productivity returns, risk-averse farmers are less likely to take up newly introduced agricultural technologies (Baidu-Forson, 1999; Brick et al., 2012; Jianjun et al., 2015; Jumare et al., 2018; Liu,

2013). In terms of risk aversion, a review of both the economic and psychological literature shows that females are significantly more risk averse than males in most environments (Croson & Gneezy, 2009). Moreover, the literature has contradicting conclusions with regard to the effect of gender on the adoption of improved seed varieties; some studies find that females are more likely to adopt (Simtowe et al., 2016), others find that males are more likely to adopt (Jumare et al., 2018), and still others find no gender effects (Ndiritu et al., 2014). Considering these and the aforementioned conclusions from literature, the objectives of this chapter are to find the effects of female risk preferences on (i) the incidence of adoption and (ii) the extent of adoption of HYVs. It is hypothesized that higher female risk preference increases adoption conditional on women's participation in decision-making.

Third research topic: Investigating the links among intra-household decision-making, production diversity, and dietary quality in Ethiopia

This topic is studied in Chapter 4 of the dissertation. The following research questions and their hypotheses are investigated.

1. **Can on-farm diversification be a robust strategy to diversify diets in rural households?**

A review of literature predominantly from SSA by Jones (2017) indicates a positive association between agricultural diversification and dietary outcomes, but the magnitudes of the association indicate a need for unrealistic increases in the number of crop and livestock species produced to have a meaningful change in dietary diversity. The chapter discusses the importance of household characteristics like market orientation, off-farm income, and availability of food to purchase as modifying factors of the association between production diversity and dietary quality. The first part of the analyses tests the hypothesis that production diversification can be a strategy to improve the diets of the rural poor who are comparatively resource poor and mostly subsistence oriented. In terms of dietary diversity, market-oriented households with diversified income are not expected to directly benefit from production diversification.

2. **How is female participation in decision-making associated with on-farm production and household-level dietary diversity in rural Ethiopian households?**

Both production and dietary diversity are determined by various demographic, socio-economic, and infrastructural factors, like household demographics, wealth, access to market, and other

infrastructural and institutional services. Moreover, gender is linked to various aspects of rural livelihoods like adoption of agricultural technologies (Ndiritu et al., 2014), investment of generated income and credit (Garikipati, 2008), and food security (Larson et al., 2019). As both diversification of on-farm production and diets are decisions that are outcomes of household decision-making processes in which household members belonging to different gender and socio-demographic backgrounds may intensively participate, it is necessary to investigate the effect of female participation in decision-making on both livelihood outcomes. It is hypothesized that women's participation in intra-household decision-making positively influences diversity in agricultural production and diets.

The conceptual framework of the dissertation, which is based on the agriculture and nutrition linkages, is depicted in Figure 1.1. Consistent with the research topics, socio-economic factors of interest, their links to different livelihood outcomes, and the interlinkages between these outcomes are described. Shaded arrows indicate the analyzed linkages. Chapter 2 corresponds with the analyses of linkages between intra-household inequality in decision-making and dietary outcomes. The main body of the dissertation starts with this topic to discuss gender in domestic decision-making and its implications on dietary outcomes in an under-researched context with a long history of matrilineal heritage. Chapter 3 corresponds with the analyses of the linkage between women's risk preferences and decision-making and technology adoption. In this part, the implications of the gendered nature of decision-making is investigated on the technology adoption component of the agriculture-nutrition framework that is always a burning issue in rural areas of developing countries, like Ethiopia. Chapter 4 corresponds with the linkage between agricultural production and dietary outcomes. Moreover, it corresponds with the links from women's participation in decision-making to both agricultural production and dietary outcomes. This is the closing chapter of the main body of the dissertation where, in contrast to Chapter 2, the analyses concentrate on the linkages between the gendered nature of intra-household decision-making, agricultural production, and dietary outcomes in a patriarchal society.

Moreover, socio-economic development can affect intra-household decision-making by influencing the bargaining powers of household members. For example, as per cooperative-bargaining models, the changes that make individuals better-off outside the marriage, strengthen these individuals' bargaining power and resources within the marriage (Lundberg & Polak, 1993; McElroy, 1997;). Doss (1996) explains this with an example of support payments given to divorced

mothers that would increase the women's utility outside the marriage and thus, alter the bargaining power of married women within the marriage. This effect of socio-economic development on the factors of interest is depicted in the conceptual framework of this dissertation. However, since this is beyond the objectives of this dissertation, it is neither analyzed nor discussed to any greater extent in the following chapters. Moreover, this dissertation does not investigate the agriculture-nutrition linkage through non-food expenditures or investments in livelihood aspects, like healthcare or sanitation, that further determine nutritional outcomes.

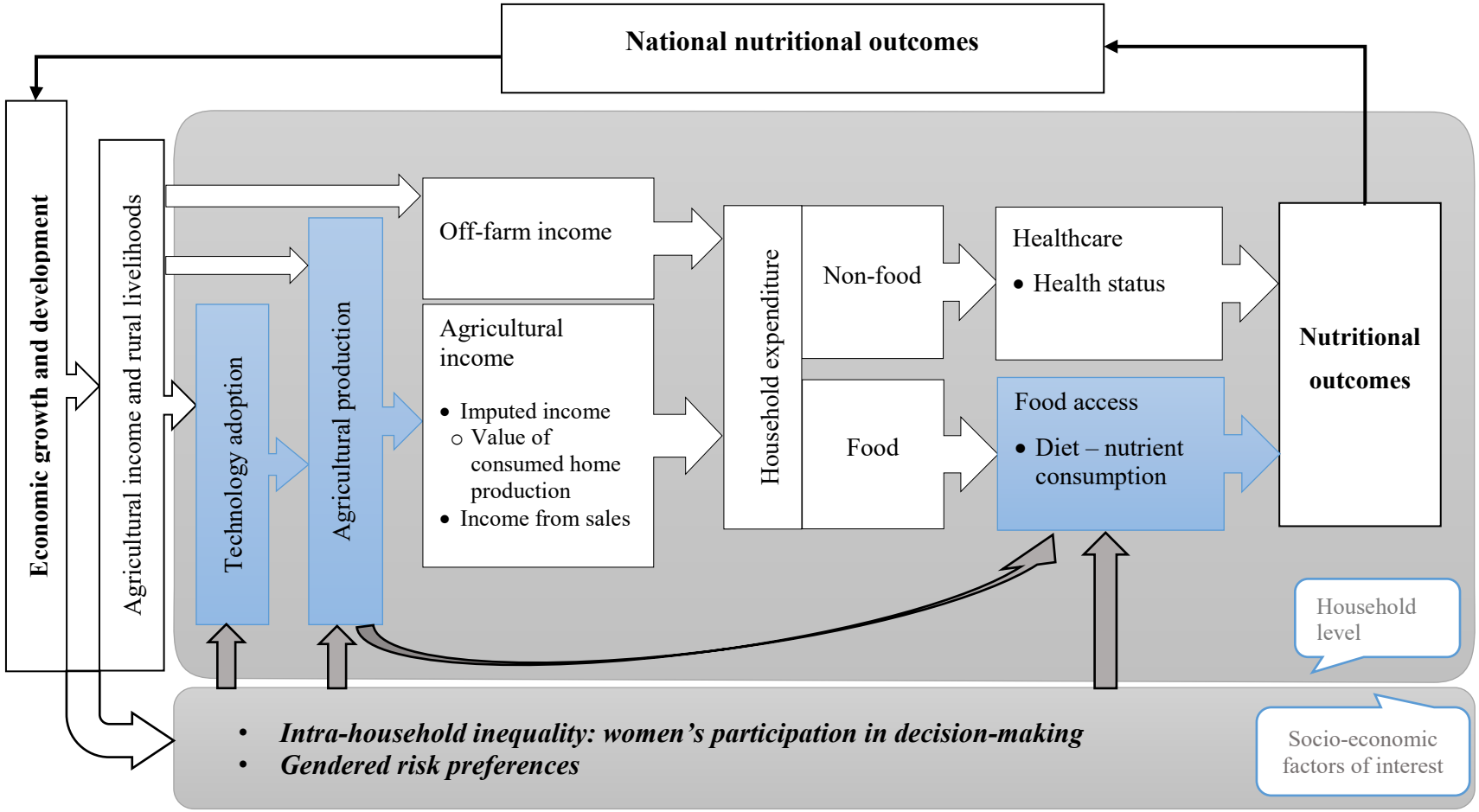

Figure 1.1. Conceptual framework: Agriculture and nutrition linkages

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Chapter 2: Women in household decision-making and implications for dietary quality in Bhutan[2]

Abstract

Despite the wide range of literature supporting the linkages between women's empowerment and food security, it is not examined in social contexts where females historically enjoy equality and even favoritism, for instance where there is female succession and/or polyandry. This study was done in the Kingdom of Bhutan where matrilineal succession and polyandry were prevalent during the 20th century.

Both quantitative and qualitative survey methods were employed with the objectives of (i) investigating women's participation in crucial domestic decision-making processes and (ii) identifying the implications of female involvement in domestic decision-making on household-level dietary quality.

While descriptive analyses and qualitative interviews revealed that women do not lack significant participation in domestic decision-making, the estimations indicate that the relationship between women's participation in decision-making and dietary diversity is nonlinear. Further analyses indicate a positive association between (perfect) gender equal decision-making regarding household livelihoods and household-level dietary quality.

2.1 Introduction

Seventeen sustainable development goals have been set to be achieved by 2030 (World Health Organization, 2018). Gender equality is one of the cross-cutting issues highlighted in several of these goals. Fostering gender equality will contribute to and enhance the speed of achieving other goals including, for example, zero hunger (Nilsson, 2017).

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There are numerous studies in the literature showing that women's empowerment is a pathway to sustainable livelihoods. Women are more likely to invest in health and education (Schmidt, 2012). Their empowerment has a positive impact on the dietary status of the households (Sraboni et al., 2014). Moreover, gender per se or gender-linked differences in access to resources, in many cases, was found to be a powerful determinant of the adoption of agricultural practices and technologies that increase yield and protect the environment and agro-biodiversity (Doss and Morris 2001; Fisher & Carr, 2015; Ndiritu et al., 2014; Ragasa, 2012; Simtowe et al., 2016). Kabeer (2001) defines empowerment as an expansion of one's abilities to make crucial life choices. Obviously, these choices not only affect one's own life but have significant effects at the household and community levels.

Many recent studies present the linkage between women's empowerment and household livelihood outcomes. Programs that contribute to agricultural development will be more effective if they target women. When agricultural income is in women's hands, it is more likely to be spent on health, education, and nutrition. When women have control over assets and decision-making power they favor agricultural products that support and ensure household food security (Schutter, 2013). Sraboni et al. (2014) find a positive association between women's empowerment and dietary diversity as well as calorie availability. However, studies find that male-headed households are more food secure than female-headed households, a finding that can be explained by women's limited access to productive resources (Agidew & Singh, 2018; Magaña-Lemus et al., 2016; Tibesigwa & Visser, 2016). Although literature about the outcomes of women's empowerment is rich, to the authors' best knowledge, there is no literature about its outcomes in areas where females historically enjoyed equality and even in some cases were favored in asset inheritance and experienced polyandry (that is, women take two or more husbands) marriage practices.

This study is done in Bhutan, a country where polyandry was still reported as a prevailing domestic custom in the early years of the 20th century (Shakespear, 2012) and vestiges like fraternal polyandry were still reported in a few nomadic ethnic groups in the early years of 21st century (Dorji, 2003).

Considering the above-mentioned gap, we aim to contribute to the literature by focusing on one important aspect of empowerment: intra-household decision-making. This study's objectives are (i) to investigate intra-household decision-making and women's participation in crucial decision-making processes of Bhutanese households' livelihoods, and (ii) the outcome of their participation

level on the household's dietary diversity that reflects household-level dietary quality. The study adopts the latest methodology introduced by Sariyev et al. (2020) in building an index for women's participation in domestic decision-making and aims to investigate the linkage between dietary quality and empowerment in Bhutanese households.

This paper begins with the background information on the research country (Bhutan) and the status of its female population, it proceeds with a literature review on the linkages between women's status and household food and nutrition security that is followed by a review of tools for measuring empowerment. In the second section, the conceptual framework of the paper is presented. The third section describes the data and methodology employed. The fourth section presents result and discusses them and is followed by concluding remarks in the final section.

2.1.1 Bhutan and the status of women

The Kingdom of Bhutan is a landlocked South Asian country located in the Himalayas and bordered by India and China. The country remained isolated from the world until the early 1960s. Agriculture has been and remains a dominant sector of the economy. The country is mountainous and widely covered by forests. Except for significant investment in hydroelectric power production there is little industrial development (Neuhoff et al., 2014). Its population mainly lives in rural areas and depends on agricultural production. The remoteness of rural areas is a remarkable challenge for people and their livelihoods. Nonetheless, significant positive improvements were brought by the government's commitment to infrastructural development (Minten & Dukpa, 2010). Bhutan's economy is growing fast. In fact, per capita GDP growth remained above 6 per cent in past few years. It is forecasted that the growth will continue and Bhutan might become the fastest growing economy in South Asia (Asian Development Bank, 2018).

In 2016, the agricultural sector contributed around 17 per cent to the GDP of the country and it employed around 58 per cent of the labor force. Infrastructural development has enhanced the cash crop production of farmers who were mainly subsistence farmers during the 20th century (National Statistics Bureau, 2017). Bhutan has achieved noteworthy progress in the participation of women in the labor force. Nevertheless, much still remains to be improved with regard to the quality of jobs held by women. Moreover, general perceptions in the society about gender roles have moved toward more equality and women are given off-farm work opportunities, while men increasingly support their wives with child care (World Bank, 2013). In rural areas, unemployment rates are

higher for women than for men and in general, the unemployment rate is higher for rural than for urban females. Women constitute a considerable share of educated jobseekers in Bhutan and they also constitute more of the agricultural labor force than men and their working hours are longer than men's (Asian Development Bank, 2014). Bhutan ranks 110th on the gender inequality index, better than most South Asian countries, especially its culturally and historically close neighbors, India and Nepal. In fact, only the Maldivies and Sri Lanka have a better ranking than Bhutan (United Nations Development Program, 2018).

FAO (2000) reported that 70 per cent of the land was owned by women in Bhutan and matrilineal heritage was seen as the major reason for female favoritism in land inheritance by the end of the 20th century. Kotikula (2013) indicates the matrilineal inheritance practice supports and creates opportunities for Bhutanese women in their empowerment and advancement, and contributes to the gender parity. In 2002, a member of the planning commission reported that in some areas of Bhutan, females controlled around 60 per cent of property (ThingsAsian, 2002). Moreover, Martin Brauen (1997) (as cited in Pain & Pema (2004)) in his study in Bhutan provides clear family examples evidencing matrilineal inheritance and female domination in land ownership and household headship. In Bhutan, according to the Land Act of 1979, men and women have the same rights in land ownership. Moreover, there is no reported gender discrimination in land distribution in Bhutan, unlike in other South Asian countries. In this regard, Agarwal's book "A field of one's own land: Gender and land rights in South Asia" (Agarwal, 1994) where Bhutan is neither covered nor appears on the map, highlights the importance of land ownership on women's empowerment. Thus, as also mentioned by Pain and Pema (2004), one would need to carefully search for an answer as to whether Agarwal's argument that ownership has enhanced women's well-being holds true in case of Bhutan. The Asian Development Bank (2014) does not confirm this pattern and reports that Bhutanese culture also enables women to be powerful participants in household decision-making processes. Although, land is an important resource, this does not mean that females are absolutely better off. Rural women have higher illiteracy rates than men and their access and use of financial resources is limited (World Bank, 2013).

While, historically, matrilineal heritage supported daughters in land inheritance, nowadays, it has moved toward more equality. All children regardless of their gender inherit lands from their parents mostly in equal shares. It is questionable if historical favoritism of women in land inheritance actually gave them any economic benefits. Despite the favoritism in land inheritance, their

decision-making power over land was mostly limited. Men are reported to be the main decision-makers regarding land use. While decisions were generally found to be taken jointly, females were found to be sole decision-makers mostly only in the case of an absent male (World Bank, 2013).

2.1.2 Women's status and food and nutrition security

Although, it is widely cited that women produce around 60 per cent of the world's food, empirically it is impossible to quantify female contribution to the food production as the production process involves both genders and disaggregation is in most cases not possible. What is important is to highlight that women are principal in food production (Doss, 2014) and homestead lands that are mostly used by females contribute a great deal to the dietary diversity of the households (Doss et al., 2018).

Women's status is found to have a significant positive effect on the nutritional status of children in South Asia, Sub-Saharan Africa (SSA), and Latin America. Sariyev et al. (2020) show a positive effect of women's participation in household decision-making on dietary diversity in Ethiopian households. In Malawi, analysis shows that if female-headed households enjoy equality in access to productive resources their food security significantly improves (Kassie et al., 2015).

In many parts of South Asia, there are inequalities in distribution of power within families. These inequalities can have different individual level outcomes regarding education, employment, and nutrition. The presence of this intra-household inequality can be observed as females eating left-over food and female children being fed less than male children. This is expressly present in poor households (Mukherjee, 2009). Poor households are poor because of their limited productive resources and it is often observed that food is assigned to higher priority members of the household who are quite often male (Miller, 1997). Thus, the status of women may directly affect both their own and their daughters' nutritional status. Malapit et al. (2015) find positive implications for different specifications of female empowerment on dietary diversity of women and children in Nepal. Moreover, in Bangladesh, the status of women is found to be positively linked with long-term nutritional status of children (Bhagowalia et al., 2012).

The large pool of literature on the interaction of food security and gender shows that investing in rural women is a proven method to contribute to household-level food and nutrition security. Among many analyses regarding food security, empowerment and their interaction in South Asia, the authors here fail to find any such studies in Bhutan or in any similar context. The study aims to

contribute a good deal to the literature on women's participation in intra-household decision-making.

2.1.3 Measuring empowerment

Kabeer (2001) finds that empowerment should be seen as a process of expansion in one's freedom to make choices that affect one's life. Its aim is to grant one's deserved control over resources and decisions (Malhotra & Schuler, 2005). In this study, we look at the decision aspect. As mentioned, land is a crucial productive resource over which Bhutanese women exercise control and, in most cases, even enjoy favoritism.

Empowerment is difficult to measure as it is not directly observable. In light of this well-known difficulty, Malhotra and Schuler (2005) identify four possible ways of measuring empowerment. One of these approaches measures empowerment through survey questionnaires that capture aspects of one's empowerment. This study uses the same strategy and tries to measure women's empowerment through their participation in decision-making. Women's participation in household decision-making is widely considered a good measure of empowerment (Acharya & Bennett, 1983; Allendorf, 2007; Bhagowalia et al., 2012; Schuler et al., 1996)

Malhotra and Mather (1997) consider domestic decision-making one of the dimensions of empowerment along with paid work and education. Becker et al. (2006) reported and analyzed decision-making as a measure of empowerment using analysis of husband and wife reports on household decision-making, which revealed differences in the reported participation of wives. As mentioned, this is considered the main shortcoming of this approach of measuring empowerment. Hashemi et al. (1996) and Garikipati (2008), both use decision-making power as a proxy of empowerment along with a few other proxies to investigate the effect of credit programs on women in Bangladesh and India. Another example is from a nation close to Bhutan – Nepal, where empowerment was measured through questions on decision-making power. The analysis concentrates on uncovering the effect of owning land on the decision-making power of women. The results suggest that there is a high probability that women who own land have a final say or at least participate in joint decision-making (Allendorf, 2007). This proves our earlier suspicion. A similar effect could be expected in Bhutan as well. To capture the level of female voices heard and preferences declared in domestic decision-making, we adopt a recently suggested approach by

Sariyev et al. (2020) that enables the consideration of possible participation by all members in decision-making processes and aims to quantify women's participation in them.

2.1.4 Conceptual framework

The underlying conceptual framework described in Figure 2.1 is adapted from Headey et al. (2011). It describes linkages between agriculture and nutrition affected by different socio-economic factors. One key aspect is intra-household inequality, which is presumed to cause a leakage in the pathway. Agricultural policy at the national level influences the production of food, household income, and the amount spent on food and non-food purchases. This is followed by its effect on the households' nutritional and health outcomes, which are determinants of individual nutritional intake and healthcare, respectively. Intra-household inequality can cause leakages in the pathway toward better nutrition. Headey et al. (2011) introduce intra-household inequalities that cause leakages with regard to food allocation among household members, and thus individuals' food security. This study extends this approach and aims to discover the relation to the household-level dietary quality, measured by the food variety score (FVS) and the household dietary diversity score (HDDS). An increase in female participation in decision-making in households where inequality exists and males enjoy much stronger decision-making power than females is expected to positively contribute to the linkage.

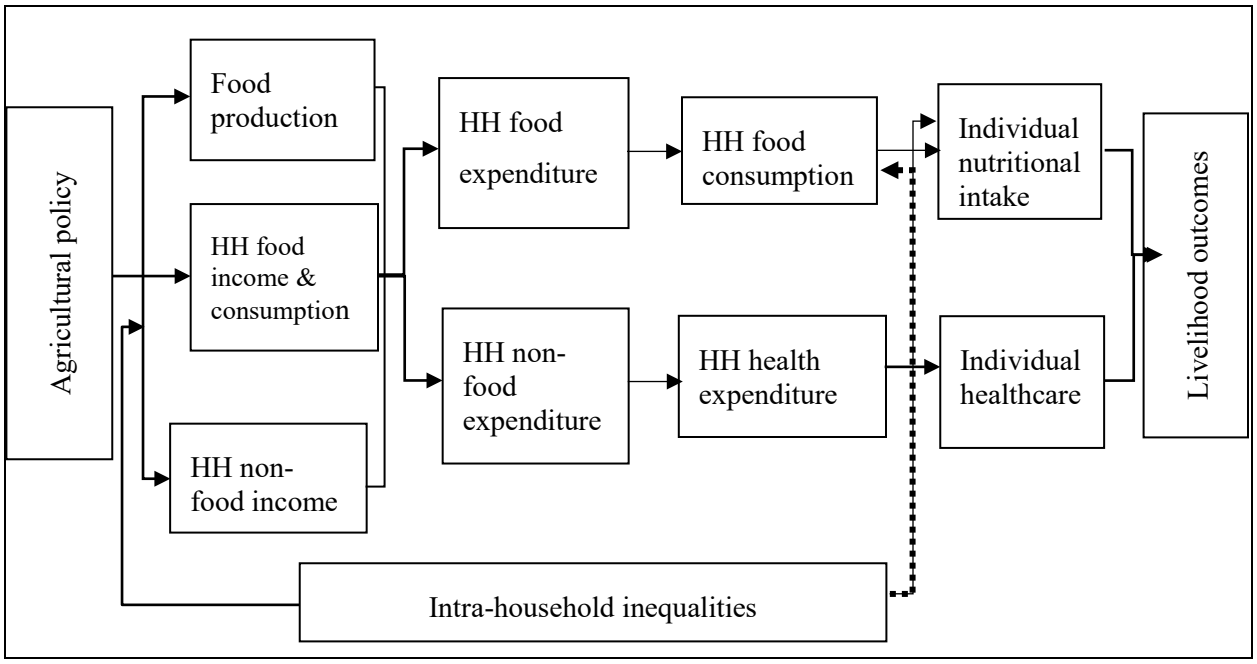


Figure 2.1. Linkages between agriculture and nutrition: Effects of intra-household inequality
Source: Adapted from Headey et al. (2011)

In general, gender inequality is a cross-cutting issue that needs to be considered if good nutritional attainments are to be achieved (Headey et al., 2011). Emphasizing that this study investigates intra-household decision-processes of Bhutanese households and aims to identify the effect of women's participation level in domestic decision-making on the Bhutanese household nutritional outcomes, the study will test the following hypotheses:

H I. Considering historical matrilineal heritage in Bhutan, women are not expected to be significantly lacking in participation in domestic decision-making.

H II. The level of women's participation in household decision-making determines the level of dietary diversity in the households. Echoing the thoughts of Headey et al. (2011), an increase in participation in decision-making will be associated with better outcomes in low levels of gender equality, but negative outcomes if it leads to inequality or one gender's dictatorship in decision-making. Thus, the association between women's intra-household decision-making power and household-level dietary quality is expected to be nonlinear.

2.2 Methods

2.2.1 Data

The data analyzed in this study were collected in November 2017 and cover 251 households in two central western *Dzongkhags* (districts) of Bhutan: Tsirang and Dagana. It needs to be noted that because of time and financial constraints, this study was done in two central western regions of Bhutan with better road infrastructure than the north of the country. Multistage sampling was used. Simple random sampling was employed in all stages. In each of the seven randomly selected *Gewogs* (wards), three *Chiwogs* (villages) were randomly selected. Using the household lists acquired from the administration office, 12 randomly selected households were interviewed in each *Chiwog*. The survey was conducted by trained enumerators with a very good command of the local languages of the survey area. In order to secure data quality during data collection, computer-assisted personal interviewing (CAPI) devices were carried. The questionnaire covered 10 sections that were related to household socio-economic characteristics, infrastructural situations, social networks, extension, household assets, land endowment, crop production, livestock production, labor and seasonality, food consumption and expenditure. Farmers were asked questions regarding domestic decision-making in all areas where households make crucial decisions that affect their livelihoods.

Moreover, qualitative in-depth interviews were conducted in randomly selected households in both Dzongkhags. These enabled us to freely discuss, understand, and capture different perceptions in the intra-household decision-making of Bhutanese households and served as complementary information to the quantitative survey.

Although the minimum legal age of marriage, which one could regard as the formation of a new household, is 18 (Tahirih Justice Center, 2014), UNICEF (2013) reports marriage at the age of 15 for 6.2 per cent of the married population. Thus, the age eligibility criteria for consideration as a potential participant in domestic decision-making is 15 years. Members younger than 15 were not considered potential participants of decision-making processes. During the in-depth interviews, this cut-off point proved practically valid and was expressed distinctly by a farmer in Tsirang Dzongkhag who had two sons and a daughter:

> *"For smaller things no need to give the headache. I want my children to feel considered, or they might think we don't care about their ideas. Class 10 is the time when they became*

an adult, that is when they are around 15-16 years old. When they are younger, their attention is to the school, no need to discuss with them anything, that is just an additional headache then."

and he added, "My kids studied until class 10, after, they decided to quit, and it was already their decision."

This farmer reported that the decision was mostly taken by him and his wife, and children were also consulted in a few cases. Moreover, another farmer in Tsirang Dzongkhag on a question regarding children and their age to be eligible to participate in decision-making replied, laughing, "I was 14 years old when I got married, that was already a big decision," and added, "I also consult my son, because later this land will be his land. I must discuss it with him."

Thus, in light of different perspectives regarding children and their eligibility to participate in decision-making, this study determines and concentrates on individuals who are 15 and older in the analysis of decision-making as the early marriage age and in-depth interviews signal that the age specification should be between 14 and 16 years old.

Although the full sample contains 251 households, the analysis concentrates on 213 households as the rest of the households do not contain either male or female adult members within the appropriate age range, and thus we are unable to capture any potential gender bargaining in decision-making in those 38 households. This high drop-out rate can be explained by the social situation in Bhutan where one can find many households with only one gender present, for example, where couples live separately or where a family member is employed and lives in an urban area.

2.2.2 Methodology

In interviews regarding domestic decision-making processes, household heads were first given a choice of reporting if the decision had been made by one household member, jointly by two household members, jointly by all household members or by someone outside the household. The names and household member IDs of the decision-makers in options of one household member and two household members were inserted by enumerators into the CAPIs. This enables the identification of the sex of decision-makers by way of cross link to the household roster in CAPIs. Overall, as suggested by Sariyev et al. (2020), the decision made is considered a unit outcome in the analysis. To identify women's participation levels in the decisions, this study adopts this approach and uses the following formula:

$$WPDM_i = \frac{\sum FPDM_i}{\sum PDM_i} \quad (2.1)$$

Where *WPDM* stands for women's participation in decision-making and *FPDM* and *PDM* represent female participant and any gender participant in decision-making processes, respectively, in the *i*th domain. Thus, the number of female participants is divided by the total number of participants in decision-making which leads to *WPDM* ranging from 0 (no female participation) to 1 (full control over decision-making by females).

Households must make various decisions to devise their livelihoods. This study investigates all potential decision-making processes that households hold. Naturally, households have different socio-economic characteristics and participate in different and various activities that might not be consistent among all households. That is why, in measuring women's participation in domestic decision-making, the analyses are limited to the most important aspects of household livelihoods, that is the decisions observed to be taken by almost all sample households in Bhutan. In this regard, the analyses consider decision-making processes regarding (i) household asset purchases, (ii) food purchases, (iii) crops grown, (iv) harvest use, (v) use of income from crop, (vi) input use, and (vii) land use. Variables of these seven decision-making processes (their respective WPDMs) are generated and weights are assigned based on Formula 1. This is followed by a principal component analysis (PCA) to transform this set of correlated decision-making variables into one index: women's participation in domestic decision-making or intra-household decision-making (*WPDMI*). The terms "domestic" and "intra-household" are used interchangeably.

Further, we investigate *WPDM* variables to understand the intra-household decision-making in Bhutanese households. Moreover, to test H I, non-parametric statistical analyses are employed between three land ownership groups: male, female, and jointly owned. We define the land ownership variable as the ownership status of the largest parcel that household owns.

Regarding the second objective of this study, *WPDMI* is regressed against two dietary diversity indicators: FVS and HDDS. Both are calculated using the reported domestic food consumption in the seven days before the interview. Here, FVS is a simple count of different food items consumed by household members (Hatløy et al., 1998). Following guidelines by Kennedy et al. (2011), food items are aggregated into 12 food groups. HDDS is a simple count of households' consumption of food items from aggregated food groups. Obscure cut-off point in the number of food groups

consumed to determine nutritional adequacy and minimum required size of serving for consideration in a food group are the main critics of dietary diversity scores. Dietary diversity indicators are not comprehensive food security measures (Cafiero et al., 2014). Nevertheless, household-level dietary diversity is found to be a good measure of household food access in multi-country level analysis (Hoddinott & Yohannes, 2002), and its strong association with household-level per capita energy availability makes it an appropriate food security indicator for this study (Ruel, 2003). Moreover, Headey and Ecker (2013) mention that dietary diversity indicators perform better than other food security indicators across various food security criteria. Individual dietary diversity is observed to increase the probability of nutrient adequacy (Foote et al., 2004; Hatløy et al., 1998; Steyn et al., 2006). Considering that individual and household dietary diversities are correlated (Fongar et al., 2019; Koppmair et al., 2017), we assume dietary diversity indicators are good measures of household-level dietary quality. Hatløy et al. (1998) find that the association of HDDS with nutrient adequacy is stronger than that of FVS. Although, HDDS is simpler to collect during field surveys than FVS, we employed both measures for robust estimates. Following Ruel's (2003) recommendations for the recall period, we used the seven-day recall as it is the longest reference period with the least recall error.

Dietary diversity indicators are regressed against *WPDMI* in linear regression models (2) and (3) to discover the linkage between women's participation in decision-making and household-level dietary quality. Moreover, consistent with H II, nonlinear models in (4) and (5) were checked against the hypothesis that the interaction is linear.

$$FVS_i = \beta_0+\beta_1 WPDMI+ \beta_2 X+u_i \quad (2.2)$$

$$HDDS_i = \beta_0+\beta_1 WPDMI+ \beta_2 X+u_i \quad (2.3)$$

$$FVS_i = \beta_0+\beta_1 WPDMI+ \beta_2 X+ \beta_3 WPDMI^2+ \beta_4 WPDMI^3 \ldots+ \beta_r WPDMI^r+u_i \quad (2.4)$$

$$HDDS_i = \beta_0+\beta_1 WPDMI+ \beta_2 X+ \beta_3 WPDMI^2+ \beta_4 WPDMI^3 \ldots+ \beta_r WPDMI^r+u_i \quad (2.5)$$

Where X (a control variable), r (the degree of polynomial that needs to be identified in the analyses) and u_i (the residual term's normal distribution) are assumed based on the central limit theorem.

2.3 Results

This section begins with a statistical description of sample households then with regard to objective (i) and H I, women's participation in different household-level decision-making processes is

investigated. Then, regarding objective (ii) and H II, econometric estimations of the association between women's participation in domestic decision-making on two dietary quality indicators (FVS and HDDS) are presented and discussed.

2.3.1 Descriptive analyses

Table 2.1 presents descriptive statistics of the sample population. Of the sampled households, 69 per cent are headed by males and the average age of heads is 52. Households have on average around three members and a dependency ratio of 0.17. Here, dependency ratio captures the share of dependents who are below 15 years of age or above 64 in the household. On average, households are 10 minutes away from their parcels that they have reported to have an average soil quality of a little above moderate. The average farm size is 3.92 acres. Households plant on average three to four different crops and have two types of livestock on their farms. Over the year, on average, an income of almost 77,900 BTN[3] is earned from on-farm activities by sample households who are on average eight minutes away from farm roads. In the sample households, FVS ranges from 3 to 29, HDDS ranges from 3 to 12. Mean HDDS and FVS of the sample households are 8.7 and 15.2, respectively. This gives the impression that good dietary diversity exists in the sampled Bhutanese households.

Looking at the descriptive statistics regarding women's participation levels in different aspects of domestic decision-making shown in Table 2.1 it becomes clear that females do not fully lack participation. They are involved in 40 per cent to 50 per cent of decision-making, which approaches equality in participation. In a few decision-making areas, like crops grown, food purchases, harvest use, and use of income generated from crop production, females' thoughts even enjoy a little more consideration than those of males. Whereas, on average, males' preferences are considered more in decision domains like animal purchases and sales, use of income from animals, land use, and household and agricultural asset purchases. Interestingly, it becomes apparent that on average females' voices are more heard in decisions regarding crop production than males', while males' voices are stronger in decisions regarding animal production. Besides, it is observed that, decision-making processes regarding agricultural asset purchases account for more male

3 Bhutanese ngultrum. USD 1 = BTN 65.40 and EUR 1= BTN 77.25 at the time of the survey (Deutsche Bundesbank, 2018).

participation than any other domestic decision-making fields, while female voices are stronger in food purchases.

Table 2.1. Descriptive statistics of the sample households

Variables	Mean	SD
Household head sex [0=female, 1=male]	0.69	0.46
Household head age [years]	52.48	14.34
Household size	3.46	1.30
Dependency ratio	0.17	0.20
Farm size [acres]	3.92	2.89
Average distance to the parcels [minutes]	10.20	15.94
Soil quality [1: very poor – 5: very good]	3.48	0.59
Crop diversity [# of different crops produced]	3.44	1.44
Livestock diversity [# of different animals owned]	2.18	1.53
Total agricultural income [BTN]	77,867.67	277,429.4
Distance from farm road [minutes]	7.83	10.59
HDDS	8.74	2.04
FVS	15.24	5.58
WPDM regarding household asset purchases	0.44	0.22
WPDM regarding agricultural asset purchases	0.41	0.29
WPDM regarding animal purchases, sales &inputs	0.44	0.24
WPDM regarding crop grown	0.52	0.21
WPDM regarding food purchases	0.52	0.29
WPDM regarding harvest use decisions	0.51	0.20
WPDM regarding animal income use	0.44	0.24
WPDM regarding the use of income from crop	0.51	0.20
WPDM regarding input use for crop	0.48	0.24
WPDM regarding land use	0.47	0.25

Source: Authors' data

Figure 2.2 highlights the distributions with regards to the different decision-making domains of WPDM variables. WPDM variables range from 0 to 1 where 0 and 1 imply sole decision-making. A score of 0.5 indicates perfect gender equality in decision-making. Here it becomes more

detectable that most of the observations fall around 0.5, indicating high levels of gender equal decision-making in Bhutanese sample households. Again, it is evident that decision-making regarding agricultural asset purchases seems to be dominated by males in one-quarter of the sample households.

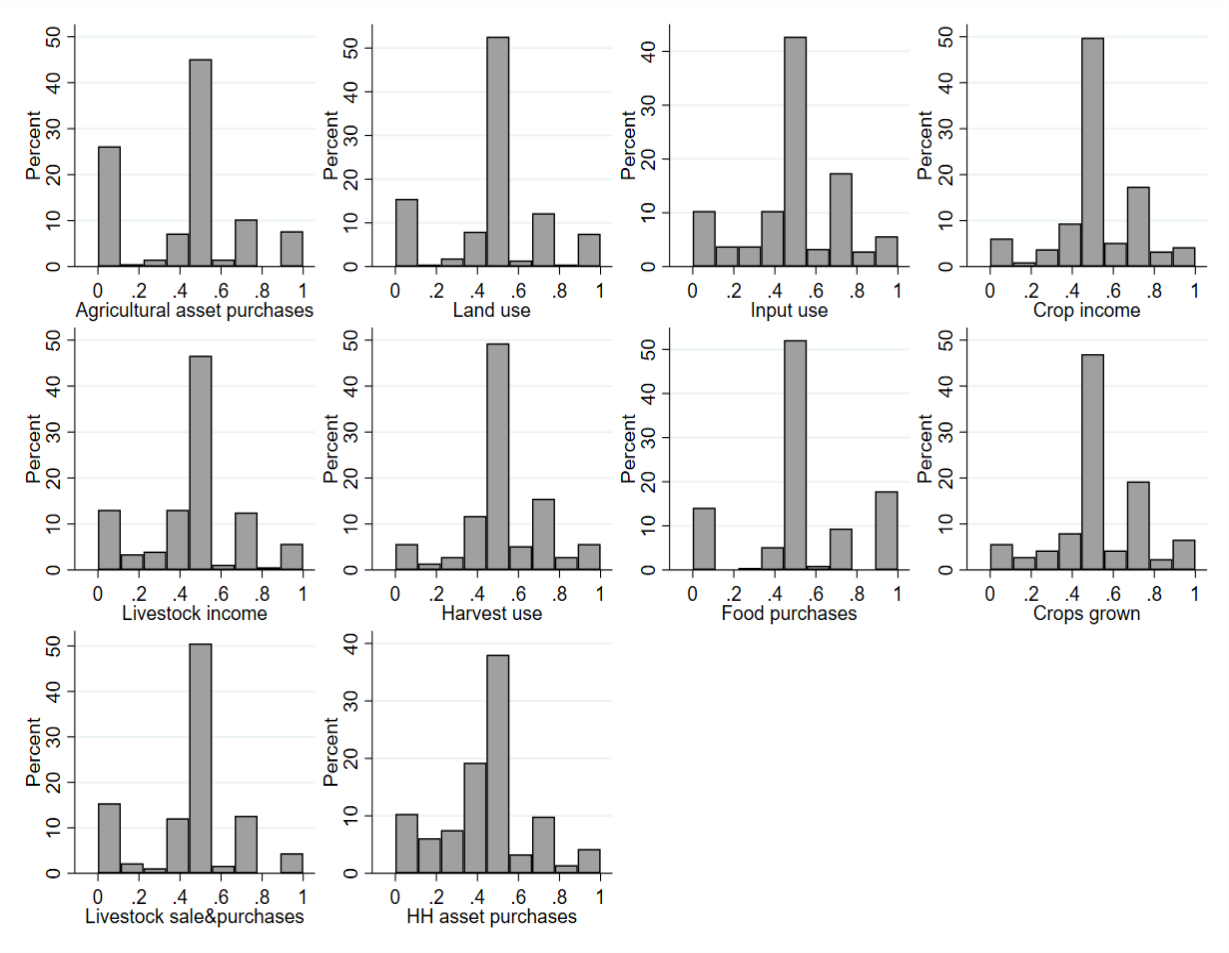


Figure 2.2. Histograms of WPDM variables
Source: Author's data

In-depth interviews were conducted with households from different ethnic and social backgrounds. Overall, in most of the households, we observe that females do not lag behind in terms of participation in decision-making regarding crucial aspects of household livelihoods. It is worthwhile to mention that in families of Nepalese origin, males were observed to be dominant (sole) in decision-making. We would also like to highlight our observation during the in-depth interviews that females seemed very interested and wanted to hear and contribute to the interview when the head is male, and in a unique household, the man declared that his wife knows all the details and we should be talking to her if we are to ask about household livelihoods.

2.3.2 Land ownership and participation in domestic decision-making

In order to account for the presence of historical matrilineal succession in Bhutan, the analyses look at WPDM in three different land ownership scenarios: male, female and joint ownership. Land ownership is captured on the largest parcel that the household owns. In 27 and 39 households, females and males own the largest parcel in the household, respectively. Thus, the remaining 142 households fall into the joint ownership category. A non-parametric Wilcoxon rank-sum test (Wilcoxon, 1945) was conducted between groups of land ownership types to find out if statistical differences exist. Table A1 of the Appendices presents a pairwise comparison of WPDM in the three situations throughout seven household decision-making domains. Further analyses will be limited to the decision-making domains that are observed in almost all sample households:(i) asset purchases, (ii) food purchases, (iii) crops grown, (iv) harvest use, (v) income use, (vi) input use and (vii) land use. In the sample households, results of the tests suggest that in almost all seven fields of decision-making, WPDM's distribution is statistically different for all three land ownership groups. Overall, regarding the WPDM, households in the female lands category rank higher than expected in contrast to households in the male and jointly owned land categories. For a better understanding we look into the probabilities of each group having a greater WPDM than others in Table 2.2. WPDM is expected to be greater in households where a female owns the largest parcel than in households where a male owns the largest parcel with highest probability of 87 per cent observed in decision-making regarding land use. The second column compares the WPDM of households in the female ownership category with those in the joint ownership category. Here, the highest probability (79%) is observed in decisions regarding land use and the lowest probability (54%) is in the decisions regarding asset purchases. Moreover, a comparison of male and joint ownership groups in the third rows shows that the probability of WPDM being higher in male owned lands than jointly owned lands is generally low, with the lowest probability in decision-making regarding asset purchases (15%) and the highest regarding crops grown (37%).

Table 2.2. Estimated probabilities of greater WPDM between land ownership groups

Domestic decision-making regarding	*WPDM in…*		
	Female owned > Male owned	Female owned > Jointly owned	Male owned > Jointly owned
Asset purchases	0.78	0.54	0.15
Food purchases	0.78	0.67	0.27
Land use	0.87	0.79	0.27
Crops grown	0.77	0.72	0.37
Input use	0.77	0.62	0.28
Income use	0.74	0.63	0.35
Harvest use	0.78	0.69	0.35

Source: Authors' estimation

Additionally, in-depth interviews did not reveal any significantly observable gender difference in land inheritance. In most cases, household heads declared that they will divide the land equally between their children and added that this has something to do with the government's advocacy regarding gender equality. It is necessary to highlight a section from an interview with a female who was living with her husband in her father's house during the survey in Dagana Dzongkhag:

> *"In my family, after we make a decision with my husband, we still report and discuss it with my dad. In the future, when it is just me and my husband, I would be the main decision-maker, since I will have the land inherited from my parents. It is even me now who is much stronger."*

Altogether, regarding objective (i) of this study, the descriptive analyses of women's participation in domestic decision-making in sample Bhutanese households suggest that women do not lack any significant participation. This is consistent with H I. This was also widely observed during qualitative interviews. In a few exceptional cases, males had sole decision-making power and, in these cases, we were able to observe a limited socio-economic status of female members in the household. The reason was explained by a 57-year-old lady:

"I am not educated, and I do not feel confident… I think my husband knows best as he is educated. I would not risk trying to change his decision".

This supports the well-known positive effect of education on empowerment. Moreover, the matrilineal succession practice may have contributed to women's empowerment over time as we observe a positive association with women's property rights over land and participation in decision-making.

2.3.3 WPDMI and dietary quality

By means of PCA, seven WPDM variables are used to generate the *WPDMI*. In order to address the second objective and test H II, the index is used as an explanatory variable and its effects on HDDS and FVS are estimated.

The WPDM variables show a significantly strong pairwise correlation, as presented in Table A2 of the Appendices, which is a prerequisite of PCA. The factor analyses yield only one factor with an eigenvalue above 1 (4.5295), which captures 65 per cent variation in the WPDM variables. This captured information is believed to be the participation in decision-making. We retain only this factor in the analyses according to the Kaiser criterion (Kaiser 1960). Table 2.3 presents factor loadings and Kaiser-Meyer-Olkin (KMO) values of WPDM variables. All variables yield factor loadings of greater than 0.4 and KMO results are great (> 0.8) for four variables and superb (> 0.9) for the rest of the variables. These results indicate that the factors are reliable, and predicted index, *WPDMI* is representative of the common information shared by WPDM variables (Kaiser 1974).

Table 2.3. Factor loadings and KMO values of WPDM variables

WPDM regarding…	Factor loading	KMO
Asset purchases	0.6660	0.8711
Crops grown	0.9124	0.8311
Food purchases	0.5413	0.8714
Harvest use	0.9155	0.8078
Income use	0.8148	0.9422

Input use	0.9079	0.9319
Land use	0.7962	0.9431
Eigenvalue = 4.5295		
$KMO_{overall}$ = 0.8791		

Source: Authors' estimation

WPDMI is used to investigate the association between women's participation level in domestic decision-making and dietary diversity of the households. FVS and HDDS are regressed on *WPDMI* and other explanatory variables. Regressions results are reported in Table 2.4 . H II is tested by employing polynomials of *WPDMI*. First, exploring the coefficients of other independent variables, we find a robust negative association between the dependency ratio and household dietary diversity in all employed models. Soil quality has a positive association in almost all models to both FVS and HDDS. Diversity in agricultural production (that is, simple count of crop and livestock types produced over 12 months) is strongly associated with the higher HDDS and distance to the farm road is found to be negatively associated with the FVS.

Table 2.4. Linear, quadratic and cubic estimations of WPDMI on FVS and HDDS

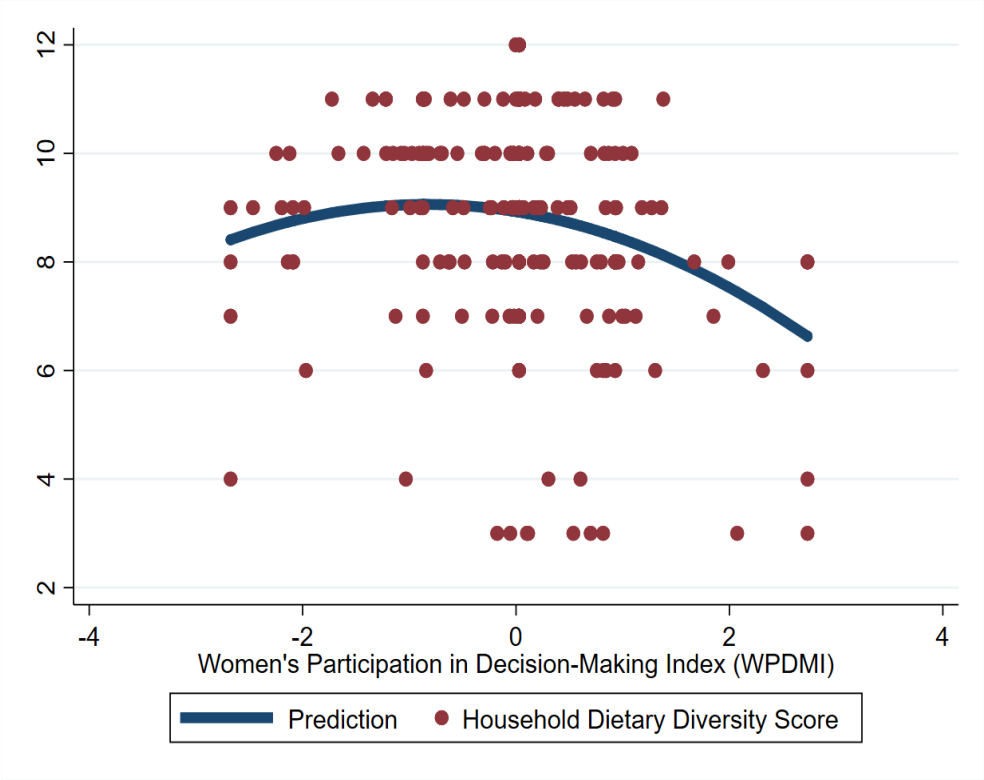
	FVS			HDDS		
Variables	Linear	Quadratic	Cubic	Cubic	Quadratic	Cubic
WPDMI	-0.783**	-0.853***	-1.538***	-0.296**	-0.318***	-0.423**
	(0.349)	(0.303)	(0.587)	(0.117)	(0.104)	(0.199)
$WPDMI^2$		-0.622***	-0.645***		-0.191***	-0.195***
		(0.162)	(0.159)		(0.063)	(0.063)
$WPDMI^3$			0.165*			0.025
			(0.092)			(0.036)
Head age [years]	-0.031	-0.022	-0.023	-0.010	-0.007	-0.007
	(0.025)	(0.026)	(0.026)	(0.009)	(0.009)	(0.009)

Member with highest education [years]	0.070	0.061	0.059	0.019	0.016	0.016
	(0.081)	(0.077)	(0.077)	(0.029)	(0.028)	(0.028)
Household size	0.435	0.462	0.446	0.127	0.135	0.133
	(0.311)	(0.308)	(0.311)	(0.105)	(0.106)	(0.106)
Dependency ratio	-3.424*	-2.927*	-2.955*	-1.453**	-1.301*	-1.305*
	(1.806)	(1.740)	(1.734)	(0.708)	(0.682)	(0.684)
Farm size [Log]	-0.535	-0.383	-0.390	-0.160	-0.113	-0.114
	(0.436)	(0.430)	(0.434)	(0.123)	(0.124)	(0.125)
Production diversity	0.306*	0.258	0.232	0.199***	0.184***	0.180***
	(0.171)	(0.164)	(0.162)	(0.058)	(0.056)	(0.057)
Distance to the nearest farm road [minutes]	-0.060**	-0.051**	-0.050**	-0.014	-0.011	-0.011
	(0.024)	(0.024)	(0.023)	(0.010)	(0.009)	(0.009)
Soil quality	2.343***	2.524***	2.540***	0.345	0.401**	0.403**
	(0.570)	(0.552)	(0.552)	(0.210)	(0.199)	(0.199)
Observations	213	213	213	213	213	213
Adjusted R-squared	0.217	0.250	0.253	0.364	0.387	0.385

Note: Estimations include location dummies to control for Gewog level characteristics; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' estimation

Coming back to the main independent variable of interest, regression results suggest that cubic and quadratic regression models are better fits in estimating the effect of *WPDMI* on FVS and HDDS, respectively. This means that the interactions between *WPDMI* and dietary diversity indicators are nonlinear, as hypothesized. This provokes further exploration as to whether this means that moving further from gender equality toward inequality in either direction is negatively associated with dietary diversity of households. In this regard, Figure 2.3 depicts the predicted cubic regression

line with the scatterplot of FVS and HDDS data holding other independent variables at their sample averages. It is apparent that an increase in *WPDMI* is associated with an increase in both FVS and HDDS in low levels of *WPDMI*, while after some threshold level the association is negative. For FVS, there is a point where the decline is substituted with a somewhat constant effect in very high levels of *WPDMI*. Consistent with the second hypothesis of this study, here, the question of interest is whether the initial threshold point is perfect gender equality. Unfortunately, the nature of the participation in the decision-making index generated by PCA does not allow for any such judgement to be made.



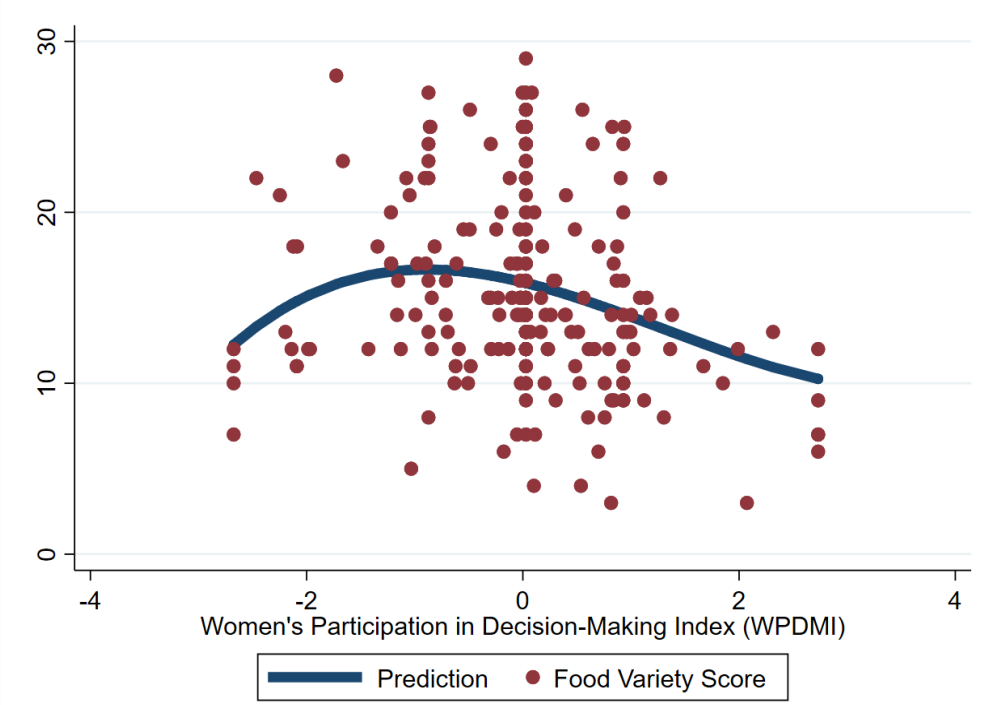


Figure 2.3. Estimated quadratic and cubic regression graphs of WPDMI on HDDS and FVS
Source: Author's graph

Therefore, we transform the original WPDM variables into variables reflecting the level of gender equality in decision-making (GED). As 0.5 in WPDM variables indicates perfect gender equality in decision-making any movement away from 0.5 must be seen as movement toward inequality. This is captured using the following formula (6):

$$GED_i = 1 - \frac{|WPDM_i - 0.5|}{0.5} \tag{2.6}$$

GED variables have values ranging between 0 and 1, representing perfect gender equality and perfect inequality in decision-making, respectively. In the next step, PCA is applied to bundle these highly correlated GED variables in an index referred to as the gender equality in domestic decision-making index (*GEDI*). Table A3 of the Appendices shows PCA results that indicate the index is representative of the common information shared by GED variables.

We employ a linear regression to capture the association between *GEDI* and household dietary diversity indicators. The results are reported in Table 2.5. The main independent variable of interest, *GEDI* is found to be significantly positively associated with both FVS and HDDS. This result suggests that movement in any direction from perfect gender equality in decision-making will result in negative outcomes regarding the Bhutanese households' nutritional status. Moreover,

production diversity, which is an unweighted count of crop and livestock units, shows a positive association with HDDS but not with FVS. It is observed that the significance of the association is different for dietary diversity indicators. Similar findings can be observed in meta-analysis by Sibhatu and Qaim (2018). The distance to the nearest farm road is negatively associated with household FVS. Access to the farm road captures households' market access, which is an important determinant of dietary diversity (Sibhatu & Qaim, 2018). Increase in household size is associated with better dietary diversity. Additionally, keeping household size and other variables constant, an increase in the dependency ratio associates with lower HDDS. Households size and age structure are human capital indicators of welfare (Henry et al., 2003). A negative association between dependency ratio and HDDS can be explained by the decrease in the household labor force that translates into a loss in overall wealth and thus, access to a varied diet.

Table 2.5. Linear estimation of association between gender equality in decision-making and dietary diversity indicators

	FVS		HDDS	
Variables	Coefficient	Robust SE	Coefficient	Robust SE
GEDI	1.326***	0.355	0.411***	0.125
Head age [years]	-0.013	0.026	-0.004	0.009
Member with highest education [years]	0.044	0.076	0.010	0.028
Household size	0.676**	0.310	0.206*	0.107
Dependency ratio	-2.417	1.791	-1.124*	0.669
Farm size [Log]	-0.251	0.422	-0.067	0.123
Production diversity	0.212	0.159	0.168***	0.055
Distance to the nearest farm road [minutes]	-0.045*	0.026	-0.009	0.011
Soil quality	2.679***	0.543	0.462**	0.197

Observations	213	213
Adjusted R-squared	0.249	0.381

Note: Estimations include location dummies to control for Gewog level characteristics; *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' estimation

2.4 Discussion

The linkage between women's empowerment and food and nutrition security is widely supported by the literature but lacks robustness checks in societies where females historically enjoyed equality or even favoritism in cases like property inheritance, as in Bhutan. Therefore, the first objective of this study was to investigate one aspect of empowerment: women's participation in domestic decision-making. The second objective was to investigate the association between their participation in domestic decision-making and household-level dietary quality.

Historically, women enjoyed favoritism in land inheritance and experienced polyandry in Bhutan. Nowadays, in comparison with other countries in the region, Bhutanese women are found to be better off in terms of equality in many fields of social and household life. This study concentrated on and measured women's participation in different fields of domestic decision-making. Descriptive analyses were conducted to understand the present situation of women. An index was created to quantify their overall participation in domestic decision-making and investigate the association with household-level dietary diversity.

We found that, on average, females have a higher participation rate in a number of decision-making domains. Of the sample households, 45 per cent to 50 per cent declared proximity to gender equality in decision-making regarding different fields of domestic decision-making. Non-parametric test results show that women's participation levels in decision-making is significantly different in different land ownership scenarios. Overall, the probability of women participating in decision-making processes is higher in households where a female owns the largest parcel. This is also the case, when comparing jointly owned lands with male owned lands. We observe an association between land ownership and women's empowerment within households. Overall, we do not find that Bhutanese women lack any significant participation in domestic decision-making. Furthermore, we find positive association between gender equal decision-making and dietary diversity indicators.

Our results are limited in its ability to assess causality between gender equality and dietary quality, and to rigorously investigate the impact of land succession on women's empowerment. Future research could investigate the impact of matrilineal succession practice on women's status more rigorously using a country-level representative long-term panel data, and causality between equality and dietary quality can be addressed employing tools like matching estimators or instrumental variable approach.

2.5 Conclusion

The results lead to two policy implications. Initial analysis in which we employ linear, quadratic, and cubic estimations of the association between WPDMI and dietary diversity measures finds that, as hypothesized, the linkage between women's participation in decision-making and dietary quality is nonlinear. Results revealed that women's participation in decision-making is initially associated with positive outcomes. At some point the association is reversed; a further increase in participation level is then negatively associated with the dietary quality indicators. Thus, women's over-empowerment can distort the objectives of social programs and result in significant negative returns. Social programs that support women's empowerment and nutrition need extensive knowledge of the societies and cultures in which they operate to ensure the effectiveness of their interventions. Therefore, we recommend undertaking ex-ante qualitative research in these types of social programs. Moreover, future research should elaborate on the negative returns of over-empowerment.

To address the second hypothesis and further investigate the nonlinear association between women's participation in decision-making and dietary quality, we generated an index capturing gender equality in decision-making (*GEDI*). Dietary diversity indicators were regressed on *GEDI*. The results suggest that an increase in intra-household equality in decision-making is positively associated with household FVS and HDDS. The results imply that in social programs, the focus should be on achieving intra-household equality, and not merely on empowering women. Considering that current literature mostly focuses on implications of women's empowerment rather than equality, our findings contribute to the gender literature and highlight the importance of gender equality together with the need to empower women in discriminative societies. Overall, the results confirm the fifth sustainable development goal of the United Nations that is to achieve gender equality.

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Chapter 3: Does female risk preference matter for varietal adoption? The case of Ethiopian rural households

Abstract

Considering that females are generally found to be more risk averse than males and that risk aversion hinders adoption, this study looks into the effect of the main female decision-maker's risk preference for the adoption of high-yielding varieties (HYVs) conditional on the dominance of female preferences declared in intra-household decision-making.

Principal component analysis (PCA) is employed to develop an index that captures women's participation in domestic decision-making. Further, the risk preference elicited by a risk game is interacted with the decision-making index in a double-hurdle (DH) model to estimate HYV adoption. The findings suggest that (i) the main female decision-maker's risk preference does not affect the incidence of HYV adoption, but (ii) her risk preference increases the extent of HYV adoption when women's participation in decision-making is high. Access to extension, the wealth status of the household, and distance to all-weather roads are significant determinants of the adoption decision.

3.1 Introduction

Eradicating poverty remains the main priority of the Sustainable Development Goals (SDGs) of the United Nations Development Program after it was first highlighted in the Millennium Development Goals (MDGs). Although poverty eradication has many pathways, none are easy to follow for international or local organizations, governments, or rural households themselves.

Improvements in agricultural productivity is one pathway that has yielded good outcomes in Asia where the Green Revolution has contributed to the livelihoods of rural people. Improvements in agricultural productivity showed spillover effects and benefited non-farm employment (Larson et al., 2016). Overall, the effect of the Green Revolution was very significant for the poor (Datt & Ravallion, 1998; Evenson & Gollin, 2003; Hazell, 2009). It is characterized by the success of high-yielding varieties (HYVs), which were introduced in late 1950s and have been increasingly adopted by farmers over the years. For major crops like wheat, maize, and rice, HYV adoption rates in Sub-Saharan Africa (SSA) remained lower than in Asia and Latin-America (Evenson & Gollin, 2003).

Janvry and Sadoulet (2002) highlight that technological development in agriculture contributes to poverty reduction both in direct and indirect terms depending on the region. The direct effect is especially dominant in Africa, while indirect effects are more prevalent in Asia. For example, Minten and Barrett (2008) find that adoption of agricultural technologies significantly enhances yields, which results in lower food prices and thus, higher real wages in Madagascar. Despite evident productivity gains, attributing the outcomes to the adoption of new technologies is still frequently challenged. Barrett et al. (2004)'s findings from Madagascar suggest that half of the gains can be attributed to agricultural innovations, but the other half is reflected by farm- and farmer-level characteristics. Plot-level characteristics appear to have very little effect. Thus, it is important to consider farm- and farmer-level characteristics during targeting to achieve good outcomes from interventions that concentrate on agricultural technology adoption. In this regard, farmers' risk preferences and their risk bearing capacity are important to consider. Moreover, the participation of women in household decision-making is found to influence the technology choice and adoption decision (Mutenje et al., 2016; Shiferaw et al., 2008). In this paper, we question whether the female risk preference used in decision-making affects the adoption of agricultural technologies. Although the literature on the effect of risk preferences on agricultural technology adoption is well documented, those studies mostly concentrate on the risk preference of the household head. We consider the potential participation of other household members in decision-making and investigate if the main female's risk preference matters for the adoption decision.

We draw three conclusions from the literature: (i) risk aversion reduces the adoption of yield enhancing technologies, (ii) females are more likely to be risk averse, and (iii) the direction of the effect of gender is not straightforward. Considering these conclusions, our objective is to find the effects of female risk preferences on (i) the incidence of adoption and (ii) the extent of adoption of HYVs. We hypothesize that higher female risk preference increases adoption conditional on women's participation in decision-making. The findings of this study contribute to the gender and technology adoption literature and, by exploring the importance of gendered risk preferences, offers targeting improvement methods for practitioners.

This paper continues with the materials and methods section, which starts by elaborating on the aforementioned conclusions that were drawn from the literature and motivate this study. The following sections include a description of the sampling and methodologies used in the analyses,

presentation and discussion of the results, and an explanation of our study's shortcomings and policy implications.

3.2 Materials and methods

3.2.1 Motivation

Recent developments in agricultural technologies offer high productivity returns. Di Zeng et al. (2015) estimated a percentage drop of 0.8 to 1.3 in the poverty headcount index of rural Ethiopia, which is attributed to the adoption of improved maize varieties. In Kenya, a similar study on hybrid maize adoption reports positive contributions to household income and assets (Mathenge et al., 2014). Larochelle et al. (2015) find positive impacts of improved bean variety adoption on dietary diversity and average yield in Rwanda and Uganda. Overall, adoption of improved crop varieties have contributed to farm productivity in SSA (Fuglie & Marder, 2015). Despite these promises, their diffusion has been slow and arduous (Jumare et al., 2018; Fuglie & Marder, 2015).

Any newly introduced technology is likely to face resistance to adoption in the field. Since the adoption decision bears the risk of failure, rural households are disinclined to adopt a newly introduced technology unless they can afford the failure, or they are risk lovers. Although the current technology or practice in use is not fully satisfying, households know what to expect from it. Thus, for adoption to even be considered, households need to be well informed of the potential outcomes of the new technology (Napier et al., 1991). Once they are informed, individuals' characteristics, like risk preference, are likely to determine the adoption and use intensity. Kebede et al. (1990) emphasize that besides the financial and technical feasibility of the new technology, Ethiopian farmers' risk preferences are determinants of their adoption decision. Knight et al. (2003) summarize the adoption decision as an outcome of the tradeoff between security and income. Most often, a poor household's primary goal is to secure food availability, and in the long run, they may trade some security for produce in the future. Their risk preferences are what will determine their willingness to experience lower short-run security in exchange for greater income and security in the long run. Moreover, Barrett et al. (2004) find that yield risks limit the adoption of new systems of rice intensification technologies among Malagasy households who have lower risk bearing capacity than their Asian counterparts. This finding shows that a household's risk bearing capacity, which is highly correlated with risk preference and wealth, is a significant determinant of their adoption of new technology.

Risk preference or attitude toward risk is an important determinant of various cropping decisions like technology adoption (Feder, 1980; Roumasset, 1976). A review of the existing literature shows that risk averse households are less likely to adopt newly introduced technologies, although the productivity returns are high (Baidu-Forson, 1999; Brick & Visser, 2015; Jianjun et al., 2015; Jumare et al., 2018; Liu, 2013). Besides the adoption decision, the direction of the effect remains the same when looking at the extent of the adoption (Baidu-Forson, 1999; Simtowe, 2006). Moreover, Shimamoto (2018) find that risk averse farmers are more likely to adopt post-harvesting technology (i.e. moisture meter). Overall, risk attitudes have been proven to be significant determinants of adoption decisions of agricultural technologies.

There are different risks involved in each decision that households make. It is clear that in addition to the farm characteristics, individuals' risk preferences will affect the final outcome. In this regard, decision-makers' risk preferences will significantly contribute to the adoption decision about modern agricultural technology. Doss (2001) highlights the importance of considering that households are comprised of individuals who are willing to cooperate to different degrees, sometimes fully, sometimes less. Households' decision-making behaviors (that is, unitary or non-unitary (Doss 1996)) will vary, as will risk preferences brought to the decision-making process. In this study we approach this issue from a gender perspective. Croson and Gneezy (2009) review both economic and psychological literature and conclude that females are significantly more risk averse than males in most environments. Looking into more specific literature, we found that women are more likely to opt for safer investments and thus are more conservative in the use of their financial resources. Irrespective of the ambiguity and cost associated with the choice, males are more risk seeking than females in financial decisions (Bajtelsmit & Bernasek, 1997; Embrey & Fox, 1997; Powell & Ansic, 1997). In light of the widely documented gender differences with regard to risk preferences, Eckel and Grossman (2003) question the stereotype of the gender of the person being a signal of their risk preference. Their study finds women to be more risk averse than men. Still, a wide range of literature supports that women are more risk averse than men, which translates into their preferences and decisions.

When it comes to the effect of gender on adopting improved seed varieties, findings in the literature are not uniform, with all three possibilities being observed: female more likely to adopt (Simtowe et al., 2016), male more likely to adopt (Jumare et al., 2018), or no gender effects (see Ndiritu et al., 2014). These variations could be attributed to context specific constraints, like access to and

ownership of productive resources, markets, and extension (Jumare et al., 2018). The plot manager's characteristic, including education, age, credit access, and family status, are found to be important determinants of the adoption decision (Theriault et al., 2017). Moreover, differences in preferences could arise from various factors like taste and cooking time. In this article, we investigate whether risk preferences matter. Overall, looking into recent reviews of the literature on gender (e.g. Doss 2001 and Quisumbing & Pandolfelli 2010), it becomes obvious that most of the studies only consider the gender of the household head when making conclusions regarding the gendered differences or the gender effects (Ndiritu et al., 2014).

3.2.2 Data

The data used in this study was collected by trained enumerators using computer assisted personal interviews (CAPI) in 2014 in Ethiopia. The information was collected from the most informed household member, who is most often the household head. The sample is a sub-sample of a nationally representative survey that was conducted by the International Food Policy Research Institute (IFPRI) for the Agricultural Transformation Agency (ATA) of Ethiopia in 2012. Due to logistical constraints, the research area defined for this follow-up sub-sample covers all baseline-households living in a 350 km diameter around the town of Hawassa. As many agro-ecological zones and agricultural production systems are covered, we assume some generalizability of the findings. Our questionnaire covered household decision-making, crop production, agricultural technology adoption, access to extension, asset ownership, and games and questions regarding risk preferences. As we are interested in households with both male and female respondents, we restrict the analyses to those households where both genders are present. This ensures that bargaining may occur in the decision-making processes. Overall, the database used for this paper encompasses 248 households.

3.2.3 Measuring female participation in decision-making and risk preference

The number of female decision-makers reflects the dominance of female preference declared in household decision-making. The decision-making processes that involve more females are likely to empower the main decision-maker to express herself more strongly and freely. Thus, we hypothesize that the risk preference of the main female decision-maker will significantly determine the adoption decision and the extent of HYV adoption conditional on the level of female participation in household decision-making.

In order to capture the level of women's participation in household decision-making, we use the methodology of Sariyev et al. (2020). With the understanding that decision-making processes in rural households are complex and can involve more than two household members, the method approaches decision-making processes as having a unit outcome that is the decision reached and looks at the share of females in the total number of decision-makers in the decision-making process. This is expressed as:

$$WPDM_i = \frac{\sum FPDM_i}{\sum PDM_i} \tag{3.1}$$

Where, $FPDM_i$ represents the number of females participating in decision-making and PDM_i represents the total number of decision-makers in a particular decision domain, represented as i. Household members below the age of 15 are not considered in the analyses. $WPDM_i$ stands for women's participation in decision-making in the i^{th} domain, and takes values ranging from zero to one where zero means no female participation and one means full female domination over decision-making.

Principal component analysis (PCA) is employed to develop the women's participation in household decision-making index (WPDMI). PCA linearly transforms WPDM variables into an uncorrelated set of components that capture the common information shared in the original variables (Dunteman, 1989). In the first step, we are interested in the explained variation in the data that is captured by each component and their Eigenvalues. Kaiser (1960) (cited in Field, 2009, p 640) suggests retaining only the components that have an Eigenvalue larger than 1. In the next step, after identifying the relevant component, absolute loadings of the variables are checked where 0.4 is the suggested cut-off point (Stevens, 2002) (cited in Field 2009, p 645)). Lastly, the validity of PCA results is checked with the Kaiser-Meyer-Olkin (KMO) measure of adequacy, which ranges between zero and one, and here, a greater value indicates a more reliable factor (Kaiser, 1974 cited in Field, 2009, p 647). We use PCA to decrease the number of variables, and to focus the information of interest and reflect it in the index that is developed using the factor command in STATA 15.

We concentrate the PCA on seven decision domains: production, input use for crops, crop harvest use, livestock purchases, income from livestock, agricultural technology adoption, and household and agricultural asset purchases. These are the domains in which all 248 households were active and made decisions. We note that decision-making processes regarding a specific technology can

only be captured if the household has adopted that technology. Thus, the technology adoption domain of the WPDMI includes the average decision-making of different adopted technologies to reflect female participation in decision-making regarding technology adoption. For robustness, we develop another version of WPDMI without the technology adoption domain (but keeping the six other decision domains) and run the same regressions, with the results (which are available from the authors upon request) remaining very much the same. The analysis is based on the decision-making within the household reported by the household head.

To measure risk, this study adapts a method used by Akay et al. (2012) in Tigray, northern Ethiopia. A risk game with real monetary incentives was played with the main female decision-maker. The nine-round game elicited risk preferences by offering either an uncertain 20 ETB[4] payout or a certain payout of between 2 ETB and 18 ETB, the amount increasing with each round. The point at which respondents switched from the risky option to the sure payment is used as a risk preference variable in the analysis. After going through the nine rounds, the enumerators randomly selected one of the scenarios and the respondents received the payout according to their choice made during the game. Thus, the female risk preference variable range between one and nine, where nine indicates that the female shows a risk loving attitude and can be described as fully prepared to take risks, and one indicates full risk aversion. Enumerators were instructed to play the game with the household head and with the main decision-maker of the opposite gender. The cases with only one respondent are dropped from the analyses as the estimations need to control for the risk preferences of the both main male and female decision-makers.

3.2.4 Determinants of HYV adoption

Access to information regarding improved varieties is mostly through extension services and is an essential factor determining the HYV adoption decision (Adesina & Baidu-Forson, 1995; Awotide et al., 2016; Chandio & Yuansheng, 2018; Fisher et al., 2015; Kaliba et al., 2000; Nkonya et al., 1997; Saka & Lawal, 2009; Shiferaw et al., 2008; Tambo & Abdoulaye, 2012). Wealthier households have more resources to both access and purchase the new technology and cope with potential production failure (Hardaker et al., 1997). Thus, a household's wealth status is found to be a significant determinant of both the adoption decision and adoption intensity (Langyintuo & Mungoma, 2008; Shiferaw et al., 2008; Tambo & Abdoulaye, 2012). Wealth indicators like farm

4 Ethiopian birr. USD 1 = ETB 19.78 and EUR 1= BTN 27.41 at the time of the survey (Deutsche Bundesbank, 2014).

size, household size, and agricultural asset ownership are found to contribute significantly to the adoption decision (Chandio & Yuansheng, 2018; Mutenje et al., 2016; Simtowe et al., 2011; Fisher et al., 2015; Mottaleb et al., 2015). Wealth status is also a good proxy for a household's risk bearing capacity. Thus, it is crucial to control for the wealth status of rural households.

Households' human capital is widely proven to be an important determinant of HYV adoption. Overall, the literature has conflicting findings regarding the effect of age on the adoption decision (Adesina, 1993; Adesina & Baidu-Forson, 1995; Langyintuo & Mungoma, 2008; Chandio & Yuansheng, 2018; Tambo & Abdoulaye, 2012). The need to understand, follow and interpret the requirements of the new varieties signifies the direction of the effect and importance of education in HYV adoption (Hossain et al., 2006; Langyintuo & Mungoma, 2008; Chandio & Yuansheng, 2018). Moreover, households' access to off-farm income generating activities is found to positively contribute to HYV adoption (Langyintuo & Mungoma, 2008; Tambo & Abdoulaye, 2012). We control for these factors in the analysis, and additionally, we control for access to loans as well as access to an all-weather road, which determines one's ability to access markets, input suppliers, and agricultural offices, which were also found to be determining factors of adoption (Awotide et al., 2016; Simtowe et al., 2011; Tambo & Abdoulaye, 2012).

3.2.5 Analytical approach to HYV adoption

The adoption of modern agricultural technologies has been analyzed using different econometric models like Logistic, Probit, Tobit or two-stage models, like double-hurdle models (DHs). When the adoption intensity is known, the Tobit or two-stage models are widely employed. The main shortcoming of the Tobit model is that a single mechanism is assumed to be determining the decision to adopt or not to adopt and the magnitude of the adoption when the technology is adopted (Wooldridge, 2002). If employing a Tobit model, we would approach the analysis as if all households had the same possibility to adopt the technology and households with no land allocated to HYVs simply did not want to adopt. Nevertheless, in rural areas, households are constrained differently. From the viewpoint of HYV-adoption, there can be households who are willing to adopt the technology, but cannot do so, because they are constrained by wealth or lack of access to timely extension services or HYV seeds. Considering these constraints and a Tobit model's aforementioned limitations, recent studies have chosen two-stage models over Tobit models (see Gebremedhin & Swinton, 2003; Croppenstedt et al., 2003; Shiferaw et al., 2008; Asfaw et al., 2010; Tambo & Abdoulaye, 2012). The DH model by Cragg (1971) is appropriate because it assumes

that rural households make two separate decisions. DH enables both steps of the adoption decision to be studied separately and acknowledges the possibility that decisions on adoption and the extent of adoption may be determined by different factors and potentially in different directions. We run a likelihood ratio test to compare Tobit and Cragg's DH model estimates (available on request), and results show that DH is the preferred model.

Rural households face two hurdles when adopting HYVs. In the first hurdle (1), they consider the adoption of HYV; in the second hurdle (2), they decide on the share of land allocated to the new varieties:

$$\left.\begin{matrix}(1)\ a^* \\ (2)\ d^*\end{matrix}\right\} = \beta_0 + wpdmi_i\,\beta_1 + femalerisk_i\,\beta_2 + wpdmi * femalerisk\,\beta_3 + x_{in}\beta_n + \varepsilon_i$$

Where a^* and d^* are latent variables and describe a household's decision to adopt the HYV of any crop and the share of their agricultural land cultivated with HYVs, respectively. a_i and d_i are observed decisions. x_{in} is a vector of member-, household- and zone-level characteristics. As hypothesized, we believe the level and significance of the effect of the main female's risk preference will depend on the level of female participation in decision-making within the household. In this regard, we interact the decision-making index (*WPDMI*) and female risk preference variable (*femalerisk*) and observe the effect in both hurdles. Moreover, we include other determinants mentioned in the section before to control for their effect in the regression. The model is estimated using the "churdle" command in STATA 15. We estimate the model with clustered standard errors at the village level to account for potential within village correlation.

3.2.6 Description of the sample

Table 3.1 presents the descriptive statistics of sample households. The vast majority (94%) of the households are headed by males. The average ages of main male and female members are 42 and 35, respectively. Average education is 1.2 years for main female decision-makers and 3.7 for male main decision makers. It is notable that only 39% and 64% of main females and males have formal education, respectively. An average household consists of six members. Of the sample households, 76% have access to extension services, while 15% have obtained credit during the past 12 months. Households reported an average per capita farm size of 0.24 ha and a total per capita income of 3,130 ETB. On average, households need to travel for 33 minutes to access all-weather roads. Of the sampled households, 39% reported that they had adopted HYVs on 38% of their land. The

average risk preference of the main female decision-makers is 5.6 and it is 6.8 for their male counterparts. Concerning female participation in decision-making, paired sample t-tests suggest that females have significantly more say in decisions regarding household purchases and livestock-related decisions than in other domains of decision-making. Moreover, decisions related to agricultural technology have the lowest female participation by far.

Table 3.1. Descriptive statistics of the sampled households

	Mean	SD
Socio-economic household characteristics		
Gender [1=male]	0.94	0.23
Main adult female age [years]	35.59	10.85
Main adult female education [years]	1.21	2.30
Main adult male age [years]	42.43	14.26
Main adult male education [years]	3.75	3.60
Female risk preference	5.59	2.31
Male risk preference	6.85	2.24
Household size	6.63	2.24
Extension [1=access]	0.76	0.43
Credit [1=obtained in past 12 months]	0.15	0.36
Per capita farm size [ha]	0.24	0.21
Per capita total income [ETB]	3132.72	11195.07
Distance to the nearest all-weather road [minutes]	33.22	38.63
HYV seed adoption [1=adoption]	0.39	0.49
HYV seed adoption intensity [% of land] *	38.39	21.14
Female participation in decision-making		
Crop production	0.28	0.24

Input use for crop	0.26	0.24
Crop harvest use	0.28	0.24
Livestock purchases	0.32	0.23
Income from livestock	0.33	0.24
Agricultural technology adoption	0.16	0.23
Agricultural and household asset purchases	0.38	0.17
N	248	

Note: * 98 observations

3.3 Results and discussion

3.3.1 Women's participation in decision-making and household wealth indices

PCA is employed to develop two indices that capture women's participation in household decision-making and the wealth status of the household. PCA and KMO estimates for decision-variables are reported in Table 3.2. Bartlett's test of sphericity indicates that the variables considered for factor analysis indeed share some common information. Proceeding with PCA, only one factor has an Eigenvalue greater than one and explains 69% of the variation in the decision-variables. All of the decision variables have expected positive factor loadings of more than 0.4. Overall, the KMO estimate and individual estimates of decision variables prove an adequate sampling for factor analysis. Successfully passing all validity tests, the generated index, WPDMI, proves to be significant in capturing the common information present in the decision-variable that is females' participation in intra-household decision-making.

Table 3.2. PCA and KMO estimates of decision variables

Decision related to…	Factor loading	KMO
Crop production	0.875	0.825
Input use for crop	0.879	0.875
Crop harvest use	0.859	0.874

Livestock purchases	0.866	0.759
Income from livestock	0.842	0.744
Agricultural technology adoption	0.767	0.911
Agricultural and household asset purchases	0.711	0.960
Bartlett's test of sphericity p=0.000		
Eigenvalue = 4.828		
$KMO_{overall}$ = 0.836		

Household wealth is proven to be an important determinant of the adoption decision of HYV seeds and a proxy for a household's risk bearing capacity. In order to generate meaningful estimates, the wealth status of the households need to be controlled for. Thus, we generate a wealth index to capture and control for its effect. We follow the approach suggested by Henry et al. (2003) and consider four types of indicators of household welfare: human resources, assets, food security and dwelling. Bartlett's test of sphericity indicates the presence of common information in all included variables. Three factors were estimated with an Eigenvalue greater than one. Evaluating the signs of factor loadings, the first factor that explains the highest share (33%) of the variation in the variables captures the wealth information shared in the analyzed variables. PCA and KMO results are presented in Table 3.3. Overall, the KMO result indicates adequate sampling. The wealth index passes all validity tests and proves to be good at presenting the common information that is household wealth status shared in household welfare indicators.

Table 3.3. PCA and KMO estimates of wealth indicators

	Factor loading	KMO
Highest education within household	0.593	0.716
Available labor within household	0.560	0.666
Total expenditure on clothing	0.628	0.805
Habitable rooms	0.640	0.790
Thatch roof	- 0.500	0.659
Kitchen	0.472	0.729
Food Variety Score (FVS)	0.597	0.629
Household Dietary Diversity Score (HDDS)	0.582	0.615
Mobile phone ownership	0.503	0.747
Number of different livestock units	0.620	0.841
Farm size	0.540	0.803
Bartlett's test of sphericity	p=0.000	
Eigenvalue	= 3.566	
$KMO_{overall}$	= 0.714	

3.3.2 Regression results

The DH model is employed to investigate the effect of female risk preferences on the adoption of HYVs. We assume that the effect of risk preference is conditional on the individual's participation in decision-making. Therefore, we follow instructions by Brambor et al. (2006) and include an interaction term for risk and WPDMI. As suggested by them, we include all constitutive terms,

which are the female risk variable, WPDMI, and their interaction in the model, as we have the conditional hypothesis that the effect of the main female's risk preference is dependent on the level of female participation in decision-making.

Table 3.4 presents the results from the DH model. We concentrate on the main variables of interest. The estimation results indicate that on the first hurdle, that is, whether HYVs are adopted in the first place, neither female nor male risk preferences have a significant effect on adoption. On the second hurdle, however, the results suggest that female risk preferences contribute significantly to the extent of adoption, that is, the share of the total agricultural land dedicated to HYVs. Moreover, the interaction term is significant, which signals the conditionality of the effect of female risk preference on the level of female participation in decision-making.

Table 3.4. Determinants of HYV adoption: Maximum likelihood estimates of the DH model

Variables	First hurdle adoption decision		Second hurdle intensity decision	
Member-level characteristics				
WPDMI	0.162	(0.249)	-17.312**	(6.748)
Female risk	-0.030	(0.040)	1.603	(1.039)
Female risk x WPDMI	-0.052	(0.043)	2.396*	(1.123)
Main female age	-0.059	(0.049)	1.020	(1.401)
Main female age^2	0.001	(0.001)	-0.012	(0.015)
Main female education	-0.013	(0.049)	-1.073	(1.457)
Main male risk	-0.072**	(0.035)	1.141	(1.042)
Main male age	-0.063	(0.048)	0.288	(1.018)
Main male age^2	0.000	(0.001)	-0.002	(0.010)

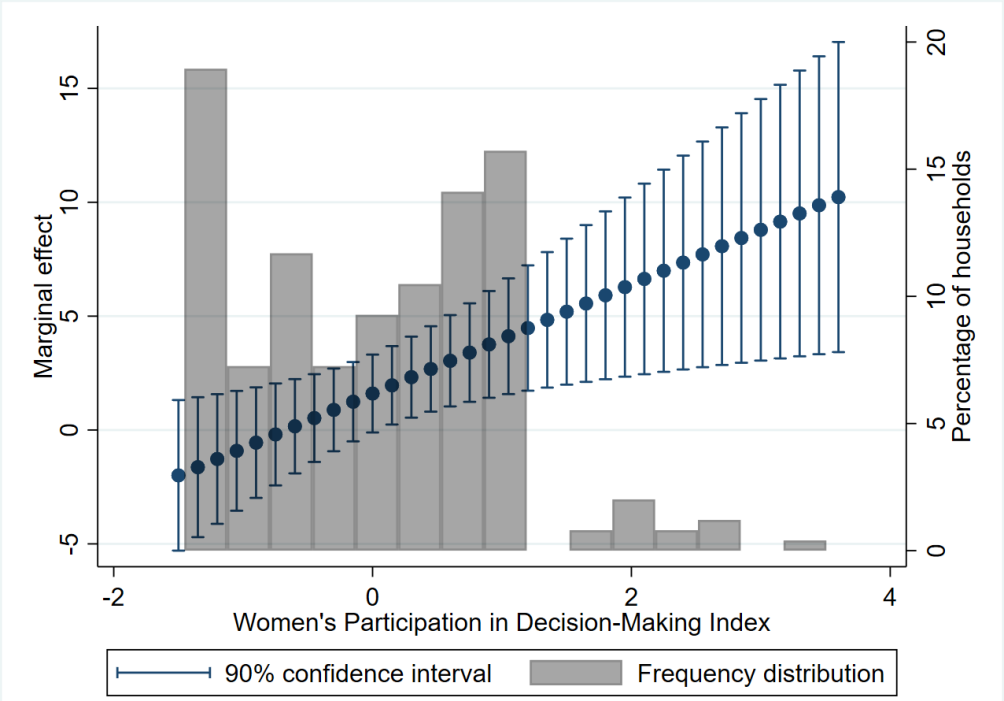
Main male education	-0.049	(0.036)	0.744	(0.855)
Household-level characteristics				
Wealth index	0.431***	(0.138)	-3.670	(4.156)
Wealth index^2	-0.180**	(0.076)	-0.722	(1.640)
Extension [1=access]	1.428***	(0.339)	4.267	(8.927)
Credit [1=obtained in past 12 months]	0.576*	(0.317)	-8.708	(5.639)
Maize production [1=Yes]	1.089***	(0.217)	-7.699	(5.560)
Number of females in the household	-0.176	(0.178)	6.116***	(2.120)
Distance to all-weather road	-0.006**	(0.002)	0.009	(0.056)
Observations	248			
Pseudo R2	0.123			
Log likelihood	-525.4			

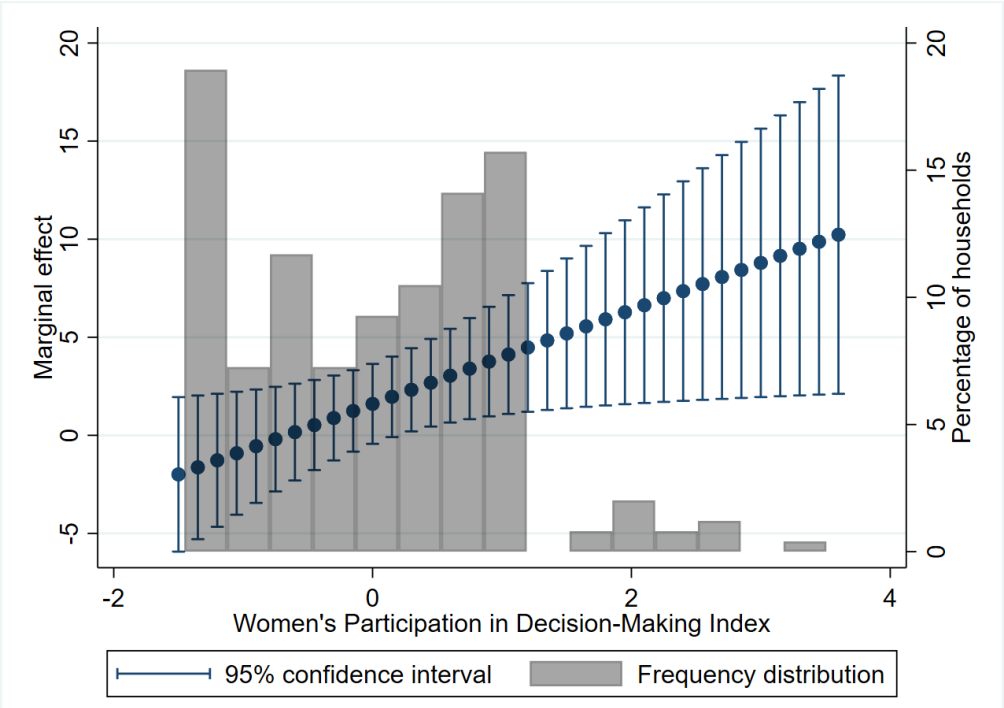
Note: Village level clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Due to space limitations, the results for the zone-level dummy variables are not shown in the table.

To present substantive findings with regard to the direction and level of effect of the main female decision-maker's risk preferences, we follow the suggestion of Brambor et al. (2006) and calculate the marginal effects of female risk preferences.

Table A4 in the appendices presents the calculated marginal effects and their standard errors at different levels of WPDMI. Results are sorted by an increasing order of WPDMI. It is observed that the marginal effect of the main female decision-maker's risk preferences is not significant at low levels of female participation in decision-making. We plot how the marginal effect of the female risk preference changes depending on the level of the women's participation in decision-making in Figure 3.1.

Plotted confidence intervals show that the effect only becomes and stays significant and positive after WPDMI is equal to 0.15 and 0.30, with 90% and 95% confidence, respectively. Thus, an increase in female risk preference has a positive effect on adoption intensity only above the average levels of WPDMI, and it covers around 50% of the households in the sample. The added histogram of WPDMI in the graph is important as it shows that real observations do fall within the significant range (Brambor et al., 2006). Moreover, full female decision-making power over almost all household decision-making processes (that is, the max of WPDMI) results in an approximately five-times greater effect than the average decision-making power (that is, the mean of WPDMI). A unit increase in the female risk preference variable is associated with a 10% increase in HYV adoption intensity at the highest observed female participation in decision-making. In short, there is no significant effect of the main female's risk preference at low levels of female participation in household decision-making. Consistent with the second part of our research hypothesis, there is a positive effect of an increase in the main female's risk preference on the extent of HYV adoption, thus the second part of the hypothesis holds true. Nevertheless, the main female's risk preference does not affect the incidence of HYV adoption, and thus, the first part of the hypothesis is not observed in the study area.


Marginal effect
-5
0
5
10
15
Percentage of households
0
5
10
15
20
-2
0
2
4
Women's Participation in Decision-Making Index
90% confidence interval
Frequency distribution


Marginal effect
-5
0
5
10
15
20
Percentage of households
0
5
10
15
20
-2
0
2
4
Women's Participation in Decision-Making Index
95% confidence interval
Frequency distribution

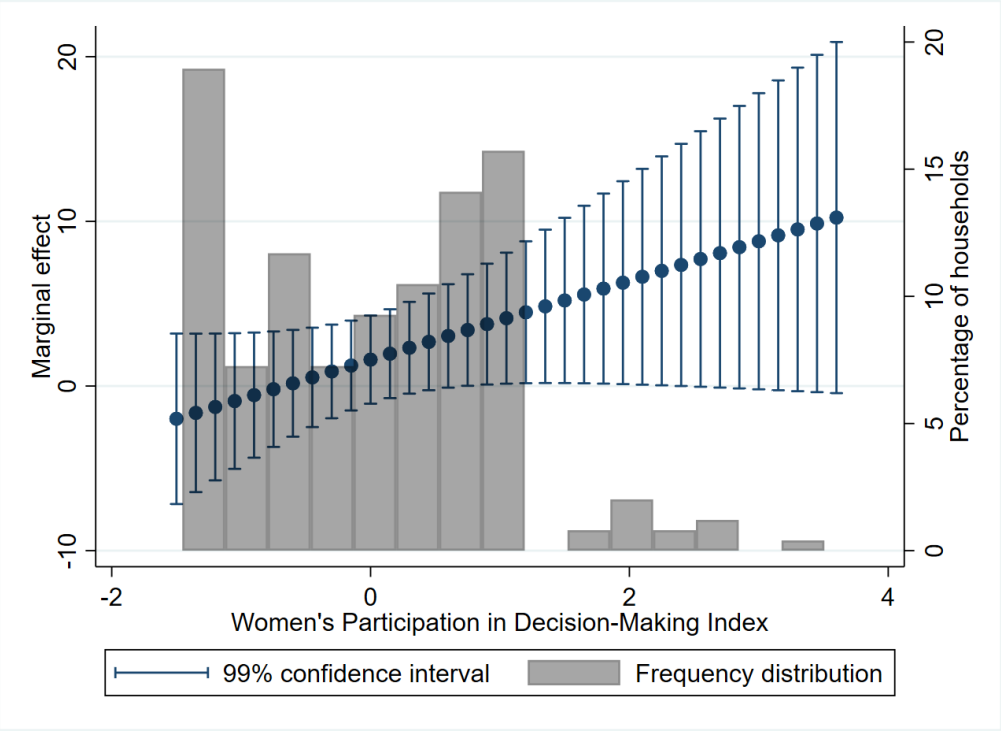


Figure 3.1. Change in the marginal effects of a main female's risk preferences on the extent of HYV adoption

With regard to the effect of other independent variables, Table A5 in the appendices presents the average marginal effects calculated for other independent variables from the DH model. It is observed that access to extension services has a positive impact on the adoption of HYVs. Households that have access to extension are on average 35% more likely to adopt. That effect is very large, however, there is no observed effect of extension on the share of land dedicated to HYV production. We also observe that credit access increases the probability of adoption by 14%. Consistent with the literature we find that the wealth of the household is a significant determinant of the adoption of HYVs. Wealth has no effect on the extent of adoption either. Although the effect is small, the distance to an all-weather road has a negative effect on the adoption of HYVs. This was expected because the time to the nearest all-weather road indicates the transaction costs households must bear to take their products to market or to purchase inputs. Thus, overall, access to extension services and the wealth status of the household are observed to be the most important determinants of the adoption of HYVs and the extent of the adoption is mostly dependent on the household decision-making process and risks preferences brought to it.

3.4 Conclusion

Considering the importance of farm- and farmer-level characteristics (Barrett et al., 2004), risks associated with the adoption of improved varieties, and gender matters in agricultural technology adoption (Doss, 1996), this study analyzed the effect of female risk preference on the (i) adoption and (ii) adoption intensity (that is, the share of land allocated) of HYVs. The analyses were built on the assumption that the extent of the effect of the main female's risk preference will depend on the women's participation in household decision-making. Thus, a positive effect of an increase in the main female's risk preferences on both the adoption and adoption intensity conditional on the women's participation level in decision-making was hypothesized.

The main female decision-maker's risk preference and female participation in decision-making (that is, WPDMI) were interacted in a DH model of HYV adoption. Regression results suggest that there is no effect of the main female's risk preferences on the first hurdle, that is, the adoption of HYV seeds. Thus, this finding rejects the first part of the study hypothesis. While adoption on the first hurdle is determined mainly by access and availability, the share of land allocated to a new variety subjectively (that is, from the farmer's perspective) creates uncertainty about the current food security status of the household, signifying the importance of risk preference. Furthermore, findings suggest that the main female decision-maker's risk preference significantly determines the extent of HYV adoption conditional on the level of female participation in decision-making. Risk-taking females will be more willing to risk current security for a higher potential income and better security in the future. A positive marginal effect of a higher risk preference was observed at the higher levels of female participation in decision-making. Thus, the second part of the hypothesis holds true.

The study has two shortcomings. Firstly, the bargaining power of the main female is assumed to be high when there are more women in decision-making processes. Because of the data limitations, we are not able to quantify the bargaining power differently and do the robustness check. Future research could benefit from employing a tool like Women's Empowerment in Agriculture Index (WEAI) (Alkire et al., 2013) to do a robustness check and a comparison with the approach we employed. Secondly, decision-making questions in rural surveys can be prone to biases as respondents may strategically report to adhere to social norms or development goals like gender equality (Jejeebhoy, 2002).

Overall, this paper contributes to the gender and technology adoption literature by linking female risk preferences with technology adoption, while distinguishing between different levels of female participation in intra-household decision-making. For future research, our findings highlight the importance of controlling and interacting gender dynamics in intra-household decision-making and risk preferences for a better understanding and estimation of farm- and farmer-level characteristics that determine the level of adoption of new seed varieties. Policy-makers would benefit from ex-ante qualitative research to understand the rural household's decision-making processes and individual's risk preferences, and thus, achieve better targeting of HYV dissemination. Moreover, the dissemination of new varieties should follow gender-inclusive social and economic development projects to achieve greater results.

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Chapter 4: Intra-household decision-making, production diversity, and dietary quality: a panel data analysis of Ethiopian rural households[5]

Abstract

Considering that rural poor are mostly subsistence farmers, it seems plausible that production diversity could lead to better nutrition for these farmers. The association between production and dietary diversity is complex, and this complexity demands rigorous empirical analyses and more attention to gendered aspects of intra-household decision-making. We employ panel data analyses of 363 Ethiopian smallholders surveyed in 2014 and 2016 to test for this phenomenon, and to explore the association of women's participation in decision-making with both production and consumption diversity. Results show that, diversification can be a strategy to improve the diets, but only of rural poor who have limited non-farm income, who are distant to the markets and mostly subsistence oriented. Moreover, female participation in decision-making associates with higher diversity both in terms of production and consumption, but it does not modify the magnitude of the association between production and dietary diversity. Our analyses contribute to the enriching literature on the linkage between production diversification and dietary diversity. We study this complex relationship in-depth and show that the gendered aspect of intra-household decision-making is an important covariate for both production diversity and dietary quality.

4.1 Introduction

Achieving zero hunger is the second goal of the Sustainable Development Goals (SDGs) of the United Nations Development Program (United Nations Development Programme, 2019). Although the increase in agricultural productivity and overall economic growth have contributed to the decline in the number of undernourished people, today, more than 820 million people still experience hunger and around two billion experience moderate food insecurity. The numbers are rising in the African continent. The most recent data suggest that roughly 260 million people in Africa are undernourished (FAO, IFAD, UNICEF, WFP & WHO, 2019). Sub-Saharan Africa is home to the poorest population in the world, many of whom experience alarmingly high nutritional

5 This chapter has been published as Sariyev, O., Loos, T. K., & Khor, L. Y. (2021). Intra-household decision-making, production diversity, and dietary quality: a panel data analysis of Ethiopian rural households. *Food Security*, *13*, 181–197. https://doi.org/10.1007/s12571-020-01098-9.

deficiencies (Ahmed et al., 2007; Barrett, 2010). African Union (AU) initiated African Regional Nutrition Strategy (ARNS) 2005-2015 which provided guidance to many African countries to improve nutrition. ARNS 2015-2025 is an extension of the earlier strategy which also emphasize the importance of nutrition sensitive agricultural transformation that provides food security for poor (AU, 2015).

Considering a high dependency of rural poor on agriculture, nutrition-sensitive agricultural research and programs have gained significant attention in the region. Considering that rural poor are mostly subsistence oriented, encouraging diversified farm production is perceived to be a promising strategy to achieve better dietary outcomes. Against this background, the association between production diversity and dietary diversity is tested in different settings. Recent impact evaluation studies show that nutrition sensitive agricultural programs have generally yielded positive outcomes, and observational studies have mostly identified production diversity and livestock ownership as most important determinants of dietary diversity (Ruel et al., 2018). Many studies report a positive association between on-farm diversification and the dietary status of rural households (Ecker, 2018; Islam et al., 2018; Jones et al., 2014; Koppmair et al., 2017; Pellegrini & Tasciotti, 2014), while some find mixed results depending on the country and measurement of dietary and diversification indicators (Sibhatu et al., 2015; Sibhatu & Qaim, 2018a). When significant, the low magnitude of the reported association in these studies creates doubt if the strategy of increasing dietary diversity through production diversification would be effective. A review of literature predominantly from Sub-Saharan Africa by Jones (2017a) indicates existing positive association between agricultural diversification and dietary diversity. However, the review also highlights that based on the reported magnitudes of association between production diversity and dietary diversity, it would require unrealistic increases in the number of species produced to have a meaningful change in dietary diversity. Sibhatu and Qaim (2018b) have very similar conclusion. They report that an average farmer in Sub-Saharan Africa would need to grow nine additional species to increase dietary diversity by one food group. Other factors like access to market and alternative livelihoods like non-farm income are observed to have larger effects than production diversification in many cases (Dixon et al., 2001; Jones, 2017a; Koppmair et al., 2017; Sibhatu et al., 2015). Moreover, the association between production diversity and dietary diversity is complex. Production diversity interacts with factors like availability of non-farm income, access to markets, and commercialization of the households. Therefore, the significance and magnitude

of the association are situation specific (Islam et al., 2018; Sibhatu et al., 2015). We look into this interaction in detail and estimate marginal effects of production diversity at different specifications. In this paper, we mainly address the question of complex association between production and dietary diversity. We adopt and employ an approach by Brambor et al. (2006) that can also be followed in future studies that aim to investigate the association between production and dietary diversity in detail.

Production diversity is an ex-ante risk management strategy for risk-averse rural households (Just & Candler, 1985). In Ethiopia, conservation of landraces and crop biodiversity in the fields can mitigate negative impacts of different weather associated shocks, promote productivity improvements, and contribute to food security (Di Falco & Chavas, 2009). Like dietary diversity, farm production diversity is determined by various demographic, socio-economic and infrastructural factors like household demographics, wealth, access to market and other infrastructural and institutional services. A factor, gender, is linked to various aspects of rural livelihoods like adoption of agricultural technologies and practices (Fisher & Carr, 2015; Ndiritu et al., 2014), investment of generated income and credit (Carter et al., 2017; Garikipati, 2008) and food security (Galiè et al., 2019; Larson et al., 2019; Malapit et al., 2019; Sariyev et al., 2020; Sraboni et al., 2014). Moreover, recent observational studies that investigate agriculture and nutrition linkage find that livestock ownership and production diversity are prominent for dietary diversity, and women's empowerment can be an important mediator (Ruel et al., 2018). As both diversification of production and diets are decisions that are outcomes of household decision-making processes in which household members belonging to different gender and socio-demographic background may intensively participate, it is reasonable to investigate the effect of female participation in decision-making on both production and dietary diversity. To the best of our knowledge, this covariate has been widely overlooked in similar studies with the exception of Jones et al. (2014) who only investigate if the gender of the head and women's control of income modify the association between farm and dietary diversity. ARNS 2015-2025 highlights the importance of empowering women - increasing their nutrition knowledge, productive skills, control of productive resources, and participation in intra-household decision-making – to achieve sustainable nutrition outcomes (AU, 2015).

Considering the debatable link between production diversity and dietary diversity, the complexity of this association, and gendered preferences in decision-making that are likely to affect both

livelihood outcomes, there are two objectives that we pursue in this study. The first objective is to estimate the association between production diversification and household dietary diversity, and rigorously investigate the significance and magnitude of the association in various settings. Secondly, we examine the association of women's participation in decision-making with both production diversification and household dietary diversity, respectively. We contribute to the growing literature on the association between production diversity and dietary diversity; we explore the complexity of the association in detail, and investigate the importance of gendered aspects of intra-household decision-making with regards to both livelihood outcomes.

The paper proceeds with detailed information of the materials employed and methods used in section 4.2; section 4.3 presents, interprets and discusses regression results; section 4.4 concludes the paper and highlights policy implications of the findings.

4.2 Data and methods

4.2.1 Data

The analyses are built on data from 363 Ethiopian households surveyed in 2014 and 2016. This is a randomly chosen sub-sample of farmers from a nationally representative survey that was conducted by the International Food Policy Research Institute (IFPRI) for the Ethiopian Agricultural Transformation Agency (ATA) in 2012. This survey had a sample size of 3000 households in four main regions of Ethiopia[6]. Due to administrative and logistical constraints, our surveyed households were randomly chosen from the list of ATA survey farmers (i.e. 480 farmers) located in a radius of circa 150-200 km around the town of Hawassa. The area covers large parts of Southern Nations, Nationalities, and Peoples' (SNNP) and Oromia regions. Considering the diversity of agro-ecological zones, production systems, infrastructural endowments and market accessibility in the surveyed area, we believe that the findings from the sub-sample are suitable for drawing some wider conclusions. Although we have a balanced panel of 390 households, we limit the analyses to those 363 households where both genders are present, i.e. the cases where bargaining between genders may actually occur.

Enumeration was done by a team of trained enumerators using computer assisted personal interviews (CAPI). The questionnaire covered a wide array of household livelihood related characteristics including infrastructural and institutional access, adoption of agricultural

6 See Sawyer and Minot (2013) for more information regarding 2012 ATA baseline survey.

technologies, land endowment, crop production, asset ownership, food consumption and so forth. Regarding decision-making, considering that households make various decisions that affect their livelihoods, households were asked questions regarding their decision-making behavior in each relevant questionnaire section. In the following subsections, we describe the methods used to extract our main variables from the most relevant sections of questionnaire. We conclude this section by describing the econometric estimation strategies used in the analyses, the results of which are reported and discussed in the following section.

4.2.2 Production diversity measures

We use three measures to capture production diversity and to check for the robustness of its association with dietary diversity. The first measure of production diversity used in the analyses is the Simpson's Index of Diversification (SID) that captures both crop species richness and evenness in the farmer's cultivated area. SID is calculated as:

$$SID = 1 - \sum_{i=1}^{n} S_i^2 \tag{4.1}$$

where

$$S_i = {}^{a_{ih}}/_{A_h} \tag{4.2}$$

where a_{ih} reflects the area dedicated to the production of crop *i* and A_h is the total cultivated area by household *h*. Thus, S_i captures the proportion of area dedicated to the cultivation of crop *i* in the total cropped area. SID ranges between zero and one, with zero indicating that the household has no crop diversification and one meaning that the household has a completely diversified crop production in terms of richness and evenness. For example, a household that dedicates 75% of its cultivated area to one crop and 25% to another crop will have a lower SID score than another household who dedicates 50% to each crop, although they both grow the same number of crop species. In this measure of production diversity, we also capture the evenness concept of diversification. Thus, species grown in small plots like kitchen gardens are unlikely to lead to a meaningful change in the index. SID has been employed in recent similar studies (Jones et al., 2014; Linderhof et al., 2016; Mofya-Mukuka & Hichaambwa, 2018).

The second measure is generated by simply counting the number of different crop and livestock species produced by the farmers in the past 12 months before the interview. This measure has been widely used to investigate the association between production and dietary diversity in several

studies (Islam et al., 2018; Jones et al., 2014; Sibhatu et al., 2015; Sibhatu & Qaim 2018a). It has its limitations, as its dietary perspective is limited in cases where households produce inedible crops like cotton or where many crops that belong to the same food group are produced. That is why, we also calculate the food group production diversity (FGPD) in the households. We consider only nine food groups (i.e. cereals, pulses, tubers, vegetables, fruits, meat, fish, eggs, and milk products) for the third measure. Considering the difficulty of producing sweets, oils and fats, and spices by farmers, these groups are not considered in the indicator. Similar measures with varying specifications have been employed in recent studies (Chegere & Stage, 2020; Koppmair et al., 2017; Pellegrini & Tasciotti, 2014; Sibhatu & Qaim, 2018a).

These three measures are used in the analyses to check for the robustness of the conclusions about the determinants of production diversity and its association with dietary quality at the household level. It also enables us to compare the magnitude and significance of the association of the three measures with dietary quality. In addition, we can evaluate the economic significance of the different diversification strategies, since each of the measures we employ has different qualities, such as capturing the evenness of production in addition to richness (i.e. SID) and representing the direct contribution to diverse diets (i.e. production diversity by food groups).

4.2.3 Dietary quality measure

Dietary diversity can be defined by simply looking at the variety of foods consumed from major food groups (Krebs-Smith et al., 1987). To capture the dietary quality of the surveyed households, we calculate the household dietary diversity score (HDDS). HDDS is an indicator of economic access to food which describes the household's ability to access various food items (Kennedy et al., 2011). Diverse diets are associated with higher caloric availability at household level and better food access at an individual level (Hoddinott & Yohannes 2002). Considering its association with per capita income and energy availability, Ruel (2003) finds dietary diversity practical to capture food security status. Dietary diversity is further significantly associated with nutrient adequacy which is an aspect of dietary quality for individuals (Foote et al., 2004; Krebs-Smith et al., 1987). At household level, it is associated with many nutritional indicators like protein, fat, carbohydrates and different vitamins; and individual dietary diversity is associated with higher micronutrient intake (Fongar et al., 2019). Thus, dietary diversity is a good proxy of individual's dietary quality. Moreover, considering that individual and household level dietary diversity scores are observed to be correlated in different settings (Cisse-Egbuonye et al., 2017; Fongar et al., 2019; Koppmair et

al., 2017; Olney et al., 2009), it is safe to assume that HDDS is a good measure of a household's overall dietary quality.

Studies have used 24-h (e.g. Koppmair et al., 2017; M'Kaibi et al., 2017) and seven-day (e.g. Jones, 2017b; Jones et al., 2014; Sibhatu & Qaim, 2017) recall periods to capture dietary diversity. Regular fasting (i.e. not eating animal products on Wednesdays and Fridays) is practiced by some devoted Ethiopian Orthodox Christians. Considering this, seven-day recall that captures day-to-day variation in diets can be more relevant to capture dietary quality than the 24-h recall. Moreover, Sibhatu and Qaim (2018a) and Chegere and Stage (2020) highlighted tradeoffs associated with the two recall periods. Although, a seven-day recall is capable of capturing more of the daily variation in diets, it is also more likely to suffer from potential recall bias than the 24-h recall. Seven-day recall can capture foods that are consumed once or twice a week and are important for nutrition. These types of food are not likely to suffer recall biases. We opt to capture day-to-day variation in diets; HDDS is calculated from seven-day consumption recall data where food items are grouped into 12 food groups: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes, nuts and seeds; milk and milk products; oils and fats; sweets; spices, condiments and beverages. Considering that the contribution of the last three food groups to dietary quality is debatable and have been excluded in recent studies (Islam et al., 2018; Sibhatu et al., 2015), as a sensitivity test, we also run the analyses on dietary diversity based on nine food groups (HDDS9) that better reflect micronutrient adequacy (Kennedy et al., 2011).

4.2.4 Other covariates

Both production diversification and dietary diversity may be influenced by different socio-economic and demographic factors. On the demographic characteristics, we control for sex, age and years of formal education of the household head, along with the household size and dependency ratio in all our analyses, thereby capturing overall human capital endowment of households which, in turn, determines many livelihood outcomes.

In the first part of the analyses, the main determinants of production diversification are investigated. We review the literature by Rehima et al. (2013), Sichoongwe et al. (2014), Isnansetyo et al. (2017), Burchfield and La Poterie (2018), Mekuria and Mekonnen (2018), and Mofya-Mukuka and Hichaambwa (2018) to identify relevant covariates and include them to the estimations. We include cultivated land area, agricultural asset value, non-farm income and total livestock units owned as

household wealth indicators. Moreover, proximity to input and output markets may determine the diversification decision, thus we include time spent traveling to the nearest periodic market and input dealer. Considering the importance of institutional and technological endowments for rural livelihoods, access to an extension and the main information provided in the extension visits are included in an interaction term. On the technological aspects, the effect of irrigation and the adoption of crop rotation and intercropping practices are investigated.

In the second part of the analyses, we estimate the effect of the three production diversity measures on household dietary diversity (HDDS) where wealth indicators and market access variables from the first part remain, and a dummy indicating the receipt of remittance is added. Furthermore, the average share of crop harvest sold is calculated and added to control for the market orientation of the households. These variables are added based on the study objectives and review of existing literature (Hirvonen & Hoddinott, 2017; Islam et al., 2018; Koppmair et al., 2017; Pellegrini & Tasciotti, 2014; Sibhatu et al., 2015; Sibhatu & Qaim, 2018a).

The second objective of the study is to estimate the effect of female participation in decision-making on two outcome variables, production diversity and dietary diversity. We look into intra-household decision-making processes regarding crop production and household expenditure in production diversity and dietary diversity models, respectively. Decision regarding household expenditure is a proxy for female involvement in consumption decision. In each decision-making process, households are divided into three categories (i.e. sole, joint, none) according to the female involvement in respective decisions. Firstly, if the decision on at least one crop grown or one type of household expenditure is made by female only, a household is assigned to the "sole" category in the respective decision variables. The "joint" category includes remaining households in which decision-making on at least one crop grown or one type of household expenditure is made jointly by male and female. Finally, all remaining households falls into the category "none" which indicates that the respective decisions in the households were made by male only.

4.2.5 Estimation methods

Considering that the production diversity measures of simple species count and food group count are count variables, we employ fixed-effects Poisson model to estimate the determinants of production diversification. For the SID measure, which is a fractional variable ranging from zero to one, we run the pooled fractional probit (PFP) to have robust estimates (Papke & Wooldridge,

2008) and employ correlated random effects (CRE) by adding the time averages of all time-varying independent variables to control for unobserved heterogeneity (Mofya-Mukuka & Hichaambwa, 2018).

In the second part of the analysis, we estimate the determinants of household dietary diversity. Here, the main variables of interest are production diversity and women's participation in decision-making regarding household expenditures. The results from model specification tests, such as Breusch-Pagan and Hausman tests (available on request), suggest that pooled specification is more appropriate for our data. Nevertheless, we need to consider that farm diversification is also a decision that households make and it is likely to be affected by same unobservable household characteristics like skills, motivation, bond between family members and tradition to care for the well-being of the family that may also influence dietary quality. The results in pooled specification can be over or under estimated. To overcome these potential biases, we take the advantage of panel data and focus on changes within household over-time while controlling for time invariant unobservable household characteristics by employing fixed-effects model and adding a year dummy that controls for any unobserved special events (Islam et al., 2018; Muriithi & Matz, 2015). We report findings from both pooled and fixed-effects models. Our dependent variables, HDDS and HDDS9, are count variables and Poisson model is the most appropriate choice of estimation. When appropriate, we estimate the models with clustered standard errors[7] at the village level to account for within village correlation.

4.3 Results and discussion

4.3.1 Sample characteristics

We start the analyses by firstly summarizing the households in Table 4.1. There has been a significant increase in average number of crop and livestock species produced from the first survey round to the second. A significant increase is also observed in the average number of food groups produced. On average, households are observed to produce seven species that belong to three food groups. Mean dietary diversity significantly improved in the second round, which, however, is not

7 The are 29 clusters. To check for any potential over-rejection of null effect size, we employ procedure described in Cameron et al. (2008). We do so using clusterbs command in STATA 15 by Menger (2015). We run the model with 5000 bootstrap iterations. Overall, results do not change.

the case when considering only 9 food groups. Looking into intra-household decision-making, from the first to the second round, there has been a significant increase in the average share of households where males decide regarding expenditures. This share has significantly fallen for the cases where only females are the decision makers. In the decision domains for both crop production and household expenditures, households mostly fall into the joint decision-making category. Average landholding, total livestock unit, and expenditure on durables and services have increased indicating improvements in the wealth statuses of the sampled households over the years. Moreover, on average, we observe significant increases in commercialization and adoption of crop rotation or intercropping practices. All these improvements may be associated with an observed increase in mean dietary diversity. We examine this association after studying the main determinants of production diversification.

Table 4.1. Summary statistics

Variables	Description	Year: 2014	Year: 2016	Mean difference
Diversity indicators				
SID	Simpson's Index of Diversification.	0.54 (0.20)	0.56 (0.21)	0.01
Species count	Number of different crops and livestock species produced per HH in past 12 months.	7.16 (2.83)	7.75 (3.02)	0.58***
FGPD	Food group production diversity. Number of different food crops and animal products produced belonging to different food groups. Maximum of 9 food groups considered.	2.65 (1.16)	3.83 (1.30)	1.18***
HDDS	Household dietary diversity score.	6.36 (1.68)	6.71 (1.51)	0.35**

HDDS9	Household dietary diversity score based on nine food groups that better reflect micronutrient adequacy.	4.23 (1.38)	4.21 (1.34)	-0.02
Decision-making variables				
Decision-making regarding crop grown – None	=1 if there was no female participation in decision-making regarding any crop grown.	0.27 (0.44)	0.31 (0.46)	0.04
Decision-making regarding crop grown - Joint	=1 if there was a joint decision-making regarding at least one crop grown.	0.64 (0.48)	0.58 (0.49)	-0.06
Decision-making regarding crop grown - Sole	=1 if female solely made decision on at least one crop grown.	0.09 (0.29)	0.12 (0.32)	0.03
Decision-making regarding household expenditure - None	=1 if there was no female participation in decision-making regarding any type of HH purchases.	0.03 (0.16)	0.14 (0.34)	0.11***
Decision-making regarding household expenditure - Joint	=1 if there was a joint decision-making regarding at least one type of HH purchases.	0.56 (0.50)	0.57 (0.49)	0.01
Decision-making regarding household expenditure - Sole	=1 if female solely made decision on at least one type of HH purchases.	0.41 (0.49)	0.29 (0.45)	-0.12***
Other household level socio-economic indicators				
Household (HH) head sex	= 1 if the HH head is Female.	0.14 (0.35)	0.15 (0.36)	0.01

HH head age	Age of the HH head (years).	44.20 (13.59)	47.26 (13.03)	3.06***
HH head edu	Years of formal schooling for the HH head (years).	3.23 (3.56)	3.20 (3.57)	-0.03
HH size	Number of HH members.	6.46 (2.19)	6.54 (2.26)	0.09
Landholding	Total land area of parcels owned or rented.	1.43 (1.17)	1.66 (1.55)	0.23**
Cultivated land	Total cultivated land area	1.32 (1.08)	1.56 (1.46)	0.24**
Market distance	Travel time; minutes it takes to get to the nearest periodic market.	52.40 (45.05)	47.27 (39.96)	-5.14
Agricultural asset value	Value of agricultural assets owned (1000 Ethiopian Birr (ETB)).	0.60 (1.46)	0.80 (1.69)	0.20
Non-farm income	Income from non-farm activities in past 12 months (1000 ETB).	2.60 (6.81)	3.62 (7.81)	1.02
Expenditure on durables and services	Total expenditure on durables and services in the past 30 days (1000 ETB).	0.13 (0.01)	0.22 (0.02)	0.09***
Total livestock unit	Total livestock unit owned. Factors are: cattle = 0.7, sheep and goats = 0.1, chicken = 0.01. (Harvest Choice, 2011)	3.89 (4.34)	4.69 (4.71)	0.80**
Extension	= 1 if HH received extension in past 12 months.	0.70 (0.46)	0.69 (0.46)	-0.01
Rotation/Intercropping	HH is aware of and employs crop rotation and/or intercropping practices.	0.48 (0.50)	0.69 (0.46)	0.21***

Share sold	Average share of crop harvest sold (%) in past 12 months. Calculated for each crop grown and averaged at household level.	27.99 (22.59)	32.09 (23.79)	4.10**
Remittance	=1 if HH received any remittance in past 12 months.	0.08 (0.28)	0.10 (0.30)	0.02

Note: Standard deviations in parenthesis. Average exchange rates: in 2014, 1 USD ≈ 19.7 ETB; in 2016, 1 USD ≈ 21.8 ETB (Exchange Rates UK 2019); *** p<0.01, ** p<0.05, * p<0.1

4.3.2 Diversity in farm production

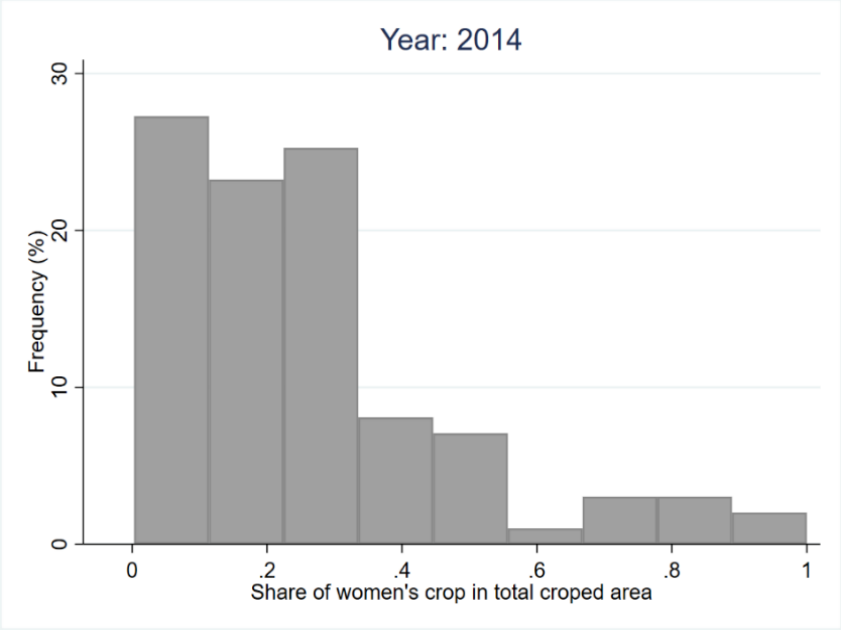
Table 4.2 reports the results from regression analyses where we estimate the determinants of production diversification at household level. Employing three measures of production diversification as left-hand-side variables (LHV), we run PFP with CRE and fixed-effects models. Results indicate that area dedicated to crop production and adoption of crop rotation or intercropping practices associate with richness and evenness of cultivated crop species (i.e. SID) and the number of different crop and livestock species produced (i.e. species count). We also observe a negative association of non-farm income with these two outcome variables. This means that the households who are more dependent on agriculture are probably more motivated to diversify their agricultural production as an ex-ante risk management strategy. Moreover, involvement of women, be it sole or jointly, in decision-making processes regarding crop grown significantly and positively associates with the number of species and food groups produced. We do not observe any significant association when concentrating on SID that captures both the evenness and richness of crop species. This could be due to women being involved in the decision-making on a small part of the total cropped area, such as on the crops grown in the kitchen gardens. This changes the number of crops and crop groups grown, but, since kitchen gardens are relatively small, their contribution to SID is diluted. Figure 4.1 depicts the extent of crops where the decision to grow them is made solely by women (hereafter referred to as women's crop). In 50% and 62% of the cases, women's crops are grown in less than one-fifth of the total cultivated area in 2014 and 2016, respectively.

Table 4.2. Production diversification: PFP with CRE and fixed-effects model estimates

Variables	PFP with CRE	Fixed-effects	
	LHV: SID	LHV: Species count	LHV: FGPD
Decision-making regarding crop grown – Joint	0.068	0.096***	0.149***
	(0.060)	(0.032)	(0.042)
Decision-making regarding crop grown – Sole	0.029	0.135**	0.163**
	(0.099)	(0.061)	(0.071)
Input distance	-0.000	-0.000	0.000
	(0.001)	(0.000)	(0.001)
Market distance	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
Agricultural asset value (1000 ETB)	-0.011	0.004	0.009
	(0.016)	(0.011)	(0.010)
Cultivated land (ha)	0.064**	0.046***	0.020
	(0.027)	(0.013)	(0.018)
Total livestock unit	0.014	0.029***	0.014**
	(0.009)	(0.006)	(0.007)
Non-farm income (1000 ETB)	-0.007**	-0.005**	-0.002
	(0.003)	(0.002)	(0.002)
Expenditure on durables and services (1000 ETB)	0.154**	0.113***	0.046
	(0.060)	(0.036)	(0.041)
Rotation/Intercropping	0.154**	0.113***	0.046
	(0.060)	(0.036)	(0.041)
Irrigation	0.035	0.257***	0.062
	(0.145)	(0.083)	(0.092)

Extension	0.076	-0.018	0.010
	(0.082)	(0.045)	(0.053)
[Extension] x [Main information – crop management]	0.084	0.048	0.057
	(0.059)	(0.034)	(0.044)
Observations	726	726	726
Wald χ^2	141.45**	109.61***	279.88***

Note: Robust standard errors in parenthesis. Estimation controls for head sex, head age, head education, HH size, dependency ratio, and year 2016 that are not reported due to space limitations. *** p<0.01, ** p<0.05, * p<0.1



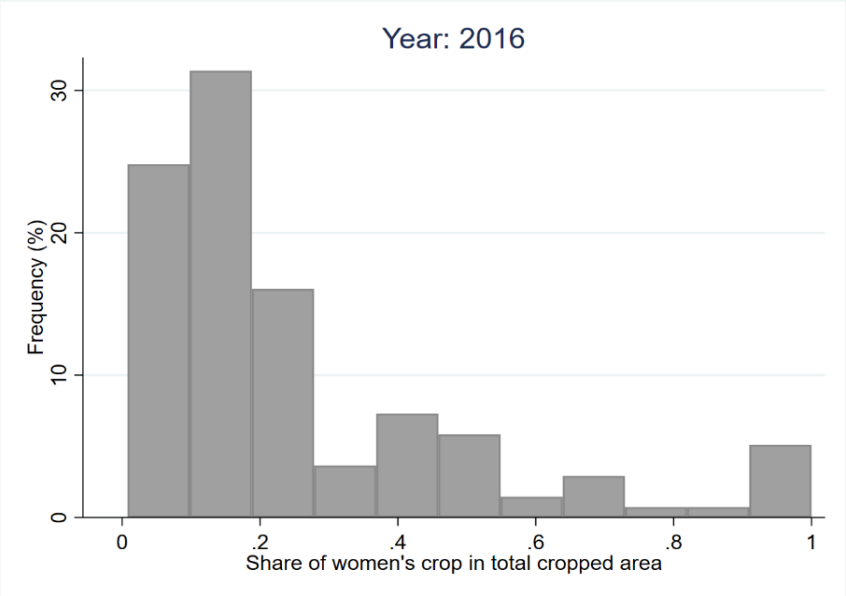


Figure 4.1. Frequency histogram: Share of women's crop (i.e., solely decided by women) in total cropped area for households that fall into sole female decision category

4.3.3 Production diversity, decision-making, and dietary quality

Table 4.3 shows the estimation results of pooled and fixed-effects Poisson models where our main right-hand-side (RHS) variables of interest are production diversity measures and women's decision-making regarding purchased food. Left-hand-side (LHS) variable is HDDS. We also employ HDDS9 as LHS variable and report results in Table A6. All production diversity measures are positively associated with HDDS in both pooled and fixed-effects specifications. In pooled specification, we observe that an increase in the number of species produced is associated with a 1.5% increase in the number of food groups consumed. Increasing the production by one food group is associated with a 3.4% increase in HDDS. In the fixed-effects specification, a unit increase in the number of species and food groups produced are associated with 1.1% and 2.1% higher HDDS, respectively. Overall, the magnitudes are very small. The magnitude of women's participation in decision-making regarding household expenditures is generally much larger than that of production diversity measures. We observe that decision-making regarding household expenditures made jointly and by women only are associated with around 9% and 13% increases in HDDS, respectively. The results are similar when restricting diet diversity to nine food groups (see Table A6). Moreover, wealth indicators significantly and positively associate with dietary quality. Overall, we observe that wealth and women's participation in decision-making are robust determinants of dietary diversity. Market distance and commercialization are significantly

associated with dietary quality in pooled specification, but not when concentrating on changes within households over time.

Table 4.3. Dietary quality: Pooled and fixed-effects Poisson model estimates

Variables	Pooled Models			Fixed Models		
	RHS: SID	RHS: Species count	RHS: FGPD	RHS: SID	RHS: Species count	RHS: FGPD
Production diversity	0.130**	0.015***	0.034***	0.126*	0.011**	0.021*
	(0.053)	(0.003)	(0.006)	(0.075)	(0.005)	(0.011)
Decision-making regarding household expenditure – Joint	0.063*	0.058*	0.063*	0.098**	0.103**	0.104**
	(0.037)	(0.035)	(0.036)	(0.048)	(0.047)	(0.047)
Decision-making regarding household expenditure – Sole	0.111***	0.103***	0.111***	0.129**	0.130**	0.136***
	(0.041)	(0.038)	(0.040)	(0.051)	(0.051)	(0.051)
Landholding	0.002	-0.000	0.004	0.007	0.005	0.008
	(0.007)	(0.007)	(0.007)	(0.012)	(0.011)	(0.011)
Total livestock unit	0.011***	0.010***	0.010***	0.011**	0.009*	0.010**
	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)
Non-farm income (1000 ETB)	0.004***	0.004***	0.004***	0.003*	0.003**	0.003*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Expenditure on durables and services (1000 ETB)	0.103***	0.089***	0.082***	0.075**	0.061*	0.060*
	(0.024)	(0.024)	(0.026)	(0.037)	(0.036)	(0.036)
Remittance	0.041	0.034	0.033	0.044	0.042	0.044
	(0.026)	(0.024)	(0.026)	(0.044)	(0.045)	(0.044)
Market distance	-0.001**	-0.001**	-0.001**	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share sold	0.001**	0.001**	0.001*	0.001	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Observations	726	726	726	726	726	726

Wald χ^2	727.89**	536.75**	641.70**	48.33***	53.08***	51.88***

Note: Village level clustered and robust standard errors in parenthesis for pooled and fixed-effects models, respectively. Estimation controls for head sex, head age, head education, HH size, dependency ratio and year 2016 that are not reported due to space limitations. *** p<0.01, ** p<0.05, * p<0.1

The magnitudes of association between different production diversity measures and dietary quality are small. Furthermore, diversification interacts with other household characteristics that modify these magnitudes. For example, if we compare a household with high non-farm income who is less dependent on agriculture with a household with no or very low non-farm income, production diversification can be more significant for the latter in terms of dietary quality. The same can be hypothesized when comparing mostly market-oriented household with highly subsistence-oriented households. This conditionality of the association demands the analysis to be extended before meaningful conclusions with better credibility can be reached.

4.3.4 Extended model of association between production and dietary diversity

The association of production diversity with dietary diversity is conditional on household characteristics. For example, the benefit of diversification for households that are highly market-oriented or that specialized in the production of specific crop or livestock is questionable. Considering the importance of a household's market orientation, we extend the model by adding an interaction term of the production diversity measures with market participation, which is captured by the average share of crop product sold. Household consumption is rarely attributable to only on-farm production. Considering that households in close distances to the markets have possibilities to also diversify their diets by purchasing from markets, it is plausible to hypothesize a larger magnitude of association between production diversity and dietary diversity for households that are further away from the markets. Moreover, the level of non-farm income can define the significance of on-farm production diversity for dietary quality. Diversification can reflect more gains in dietary diversity for households with limited or no income options outside agricultural production. Thus, we further interact market distance and non-farm income, respectively, with diversity measures. Moreover, considering the foregone benefits from specialization in already highly diversified farms, we include a square of the diversity terms into the analyses. We extend our model to have a clearer understanding of the association between production and dietary diversity.

Table 4.4 reports the estimation results of the extended model of dietary quality. It is important to highlight that we cannot make any immediate conclusions from Table 4.4. Insignificant coefficient of interaction term neither means that there is no interaction nor the interaction term should be dropped. The coefficient of interaction term should neither be interpreted as marginal effect nor assumed as meaningful conditional effect. This effect can be of opposite sign, significant and insignificant depending on the actual values of interacting variables (Ai & Norton, 2003; Brambor et al., 2006). Although the coefficients of interaction terms are insignificant, it is possible that the marginal effect of production diversity is significant for a range of the other terms that are interacted with production diversity measures. The opposite is also true.

Table 4.4. Extended model of dietary quality: Fixed-effects Poisson model estimates

Variables	Fixed-effects models		
	SID	Species count	FGPD
Production diversity	-0.367	0.015	0.078**
	(0.250)	(0.016)	(0.036)
Production diversity square	0.531**	-0.000	-0.009*
	(0.256)	(0.001)	(0.005)
[Production diversity] x [non-farm income]	-0.007	-0.000	0.000
	(0.009)	(0.001)	(0.001)
[Production diversity] x [share sold]	-0.002	-0.000**	-0.000
	(0.002)	(0.000)	(0.000)
[Production diversity] x [market distance]	0.003**	0.000**	0.000**
	(0.001)	(0.000)	(0.000)
Market distance	-0.002**	-0.002**	-0.001*
	(0.001)	(0.001)	(0.001)
Share sold	0.001	0.003**	0.001
	(0.001)	(0.001)	(0.001)
Non-farm income	0.008	0.007	0.002
	(0.006)	(0.006)	(0.004)

Decision-making regarding household expenditure – Joint	0.096**	0.103**	0.106**
	(0.047)	(0.045)	(0.047)
Decision-making regarding household expenditure – Sole	0.126**	0.132***	0.135***
	(0.050)	(0.049)	(0.050)
Observations	726	726	726
Wald χ^2	66.00***	75.73***	67.81***

Note: Robust standard errors in parenthesis. Estimation controls for head sex, head age, head education, HH size, dependency ratio, total livestock unit, landholding, monthly expenditure on durables and services, remittance and year 2016 that are not reported due to space limitations. *** p<0.01, ** p<0.05, * p<0.1

We follow the recommendation of Brambor et al. (2006) and calculate the marginal effect of production diversity indicators along with respective standard errors on HDDS in meaningful ranges of the modifying terms. Figure 4.2 depicts how the marginal effect of SID on dietary diversity changes depending on the values of non-farm income, market distance and share of harvest sold. It is also important to know how the study population falls within the reported ranges. Thus, we visualize the distribution of the households as histogram in the background. The marginal effect intervals (i.e. whiskers) that include zero implies that there is no statistical significance. The figure shows that SID is positively associated with dietary diversity when there is no or low non-farm income. The association becomes statistically insignificant above non-farm income of 10000 ETB per year. In very close distances to the market, SID shows no association with dietary diversity. The magnitude of the association is larger when market is distant. Moreover, we find no significant association between SID and dietary diversity for highly market-oriented farmers.

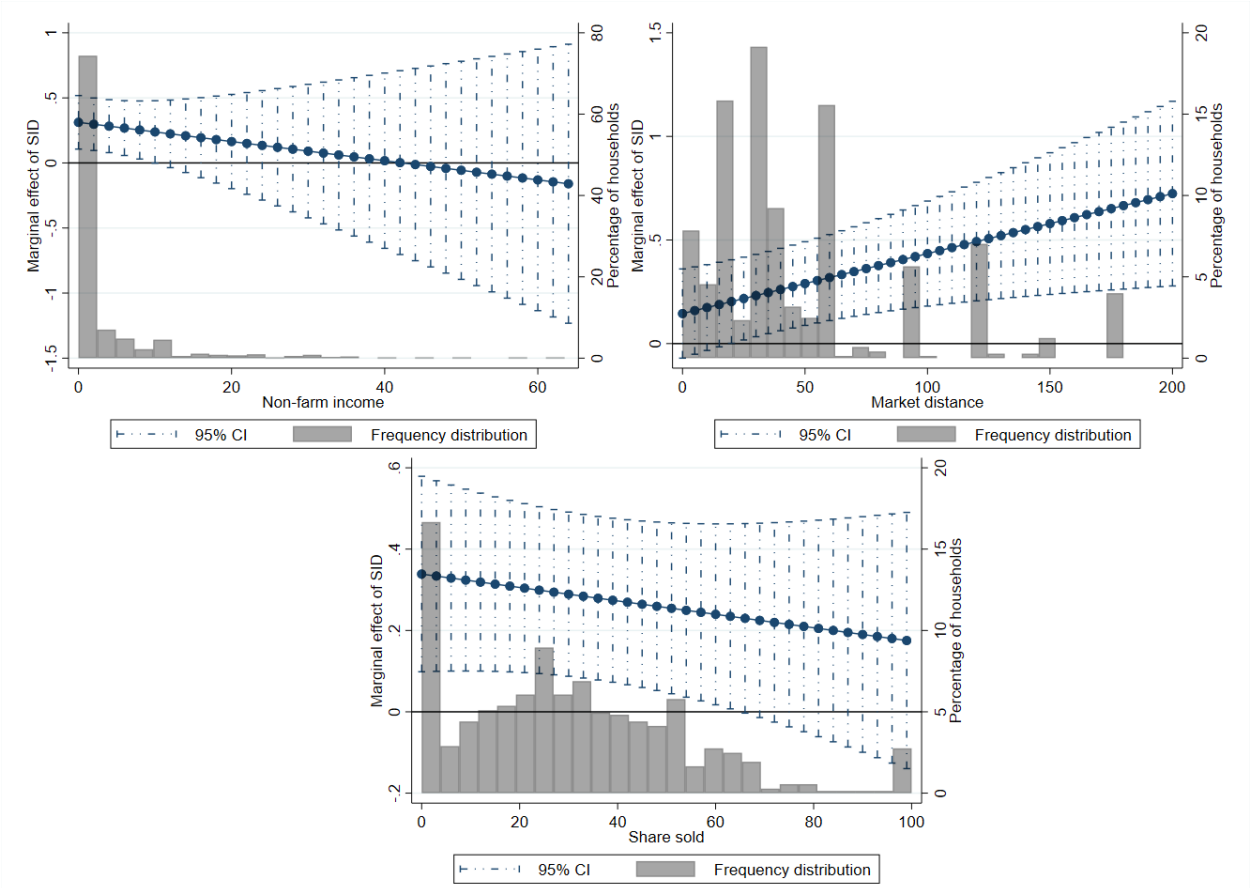


Figure 4.2. The marginal effects of SID on HDDS along values of non-farm income, market distance, and share sold

A unit change in SID means full diversification, thus magnitudes of the association between production diversity and dietary quality can be interpreted more easily for the species count and food group count measures. We depict how the marginal effects of species count and FGPD on HDDS change depending on the values of non-farm income, market distance and share of the harvest sold in Figure 4.3 and Figure 4.4, respectively. We find significant association between species count and dietary quality when the closest market is distant, household is mostly subsistence oriented, and there is no or very low non-farm income. Within the 95% confidence interval (CI), a unit increase in species count associates, at highest, with consuming around 0.09 more food groups. In other words, an average farmer (i.e. in terms of other covariates than market distance) would need to grow eleven more species on top of already produced seven species to increase the dietary diversity by one unit. The literature has somewhat similar findings; Chegere and Stage (2020) find that an average household in Tanzania would need to produce nine more species to increase dietary diversity by one more food group. Moreover, meta- analysis by Sibhatu

and Qaim (2018b) also finds that in Sub-Saharan Africa, an average farmer would need to diversify the farm by nine more crop or livestock species in order to boost dietary diversity by one food group.

An increase in one food group produced is associated with better dietary diversity up to non-farm income of 14000 ETB per year, and even then, the magnitude is very small (i.e. 0.06 at highest). Extending production by one additional food group is associated, at highest, with consuming 0.14 more food groups. We find that producing another crop or livestock or increasing production by one food group is associated with higher diet diversity for farmers that consume 50 to 70 percent of their production. This means that for mostly market-oriented farmers, there is no direct potential gain in dietary diversity from further diversification. The results are similar when HDDS is replaced by the HDDS9 specification (see Table A7, Figure A1 and Figure A2). We also interacted production diversity measures with decision-making variables to check if gendered decision-making aspects modify the magnitude of the association between production and dietary diversity. Overall, there is no significant modification to the extended model. In spite of the fact that women's sole or joint decision-making related to household expenditures is better for dietary diversity than sole male decision-making, it does not modify the association between production diversity and dietary quality. This finding is similar to the finding from Malawi by Jones et al. (2014).

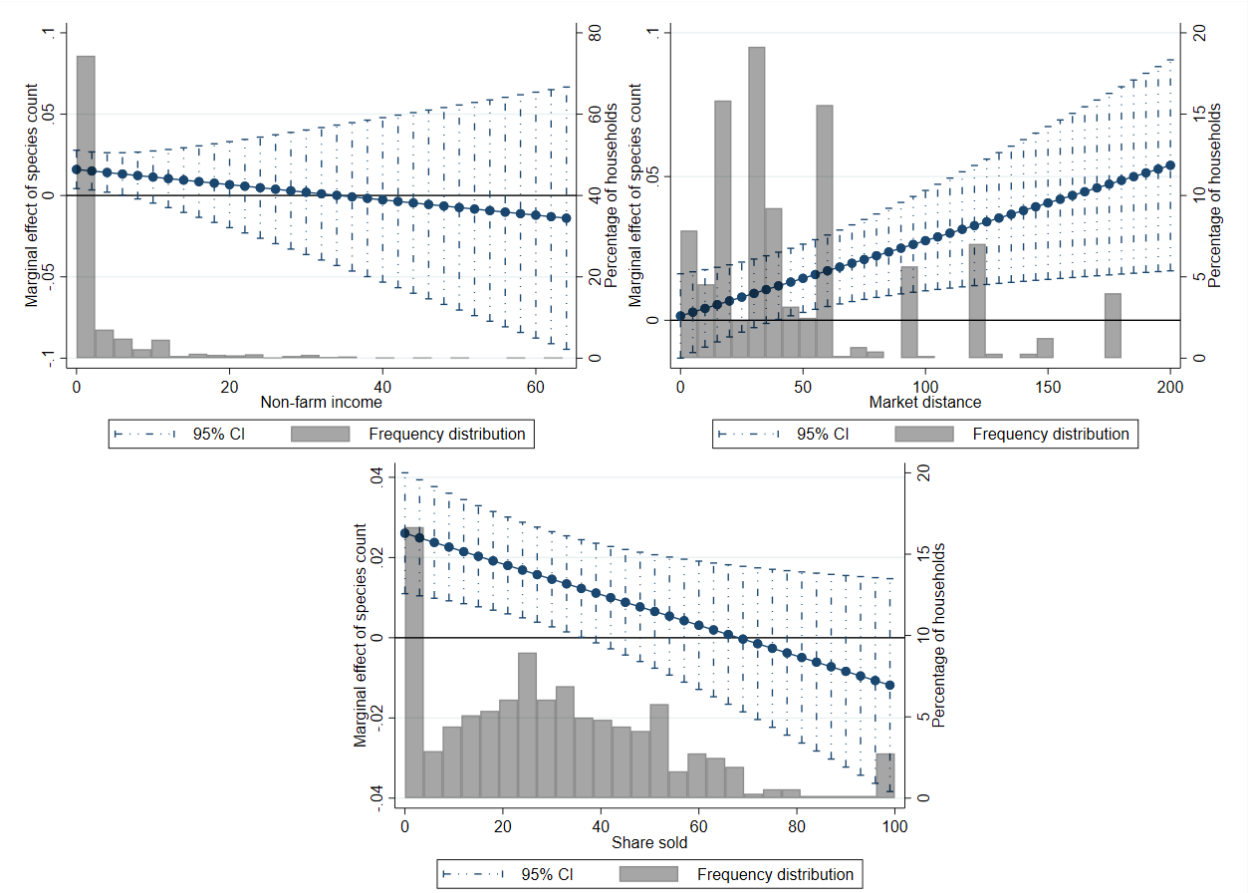


Figure 4.3. The marginal effects of species count on HDDS along values of non-farm income, market distance, and share sold

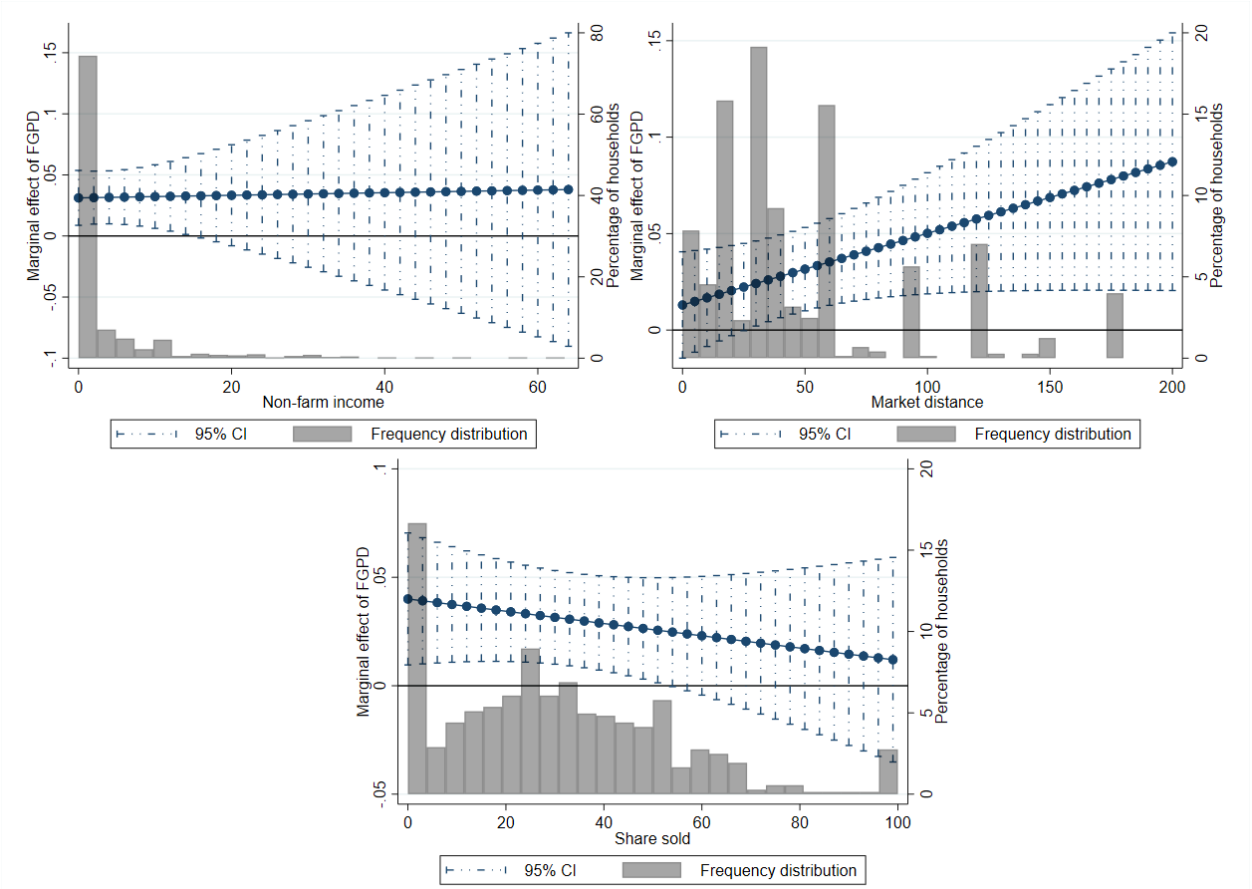


Figure 4.4. The marginal effects of FGPD on HDDS along values of non-farm income, market distance, and share sold

4.4 Conclusions and policy implications

Nutrition-sensitive agricultural research and programs have gained much attention in recent years which is justified considering that all forms of undernutrition can be widely observed in the poorest rural smallholders whose livelihoods, to a great extent, depend on agriculture. One example of such programs and research may include activities related to on-farm diversification that is believed to contribute to the diets of rural poor. So far, research has found mixed results and significance of this association seems to be case specific.

Using panel data from Ethiopian rural households, we concentrated on production diversity at household level and looked into its association with dietary quality. Considering that this association is complex and likely to be significantly influenced by the availability of non-farm income, distance to markets and market orientation of the households, we employed regression models with interaction terms to gain more insight into the analysis. Doing so, we also highlighted

the more detailed method of interpreting the results. Furthermore, as both production and dietary diversification are decisions made by households, we examine if female participation in decision-making is linked to both livelihood outcomes, and if it can modify the magnitude of the association between production and dietary diversity.

We added year dummies in household fixed-effect regression to be able to capture the effect of any special event that might have occurred from first to the second round of the survey and would affect all households equally. Nevertheless, the analyses are limited in controlling for time-variant unobservable heterogeneity that could bias the estimations. Thus, the results are cautiously interpreted as associations.

We found that the size of the cultivated area and adoption of crop rotation or intercropping practices are linked to household level production diversity. While non-farm income was negatively associated with species count and SID that captures both the evenness and richness of crop species, female participation in decision-making variables regarding the crops produced were associated with a higher species counts and food groups produced. In addition, female participation in decision-making was also associated with better dietary quality. On the relationship between production diversity and dietary quality, we found that diversification can be a strategy to improve diet of rural poor who is highly and directly dependent on agricultural income, who lives far from the markets, and is mostly subsistence oriented. Yet, even in these cases the viability of achieving better dietary quality through production diversification is highly questionable, as the low magnitudes of the association mean that unrealistic changes in production diversification would be required. Moreover, in respective domains, households with women's participation in decision-making are associated with higher production and dietary diversity than those with sole male decision-making. However, it does not modify the association between production and dietary diversity.

We highlighted in this article an important covariate, which is gendered aspects of intra-household decision-making, for production diversity and dietary quality. We also highlighted the in-depth interpretation of the results when using interaction terms. Researchers should employ this in-depth approach to better assist practitioners. Furthermore, although we observe positive association between production diversity and dietary quality, this association is highly case specific. Development programs aiming to contribute to food security could adopt production diversification strategy only in rural areas with very limited market access and a lack of non-farm income

possibilities; but even then, its viability is questionable. We find strong association between dietary diversity and female decision-making power and wealth indicators. Therefore, gender-inclusive social and economic development policies together with infrastructural and market development projects that contribute to household wealth and women's empowerment are recommended, as they are more promising than on-farm diversification in increasing the dietary quality.

Future literature could contribute to our knowledge base by concentrating more on district level production diversity that is likely to determine the market diversity and affordability at district level. Moreover, association between diversity in the district markets and district level food security should be rigorously investigated.

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Chapter 5: Discussion and conclusions

The number of undernourished people has been rising in recent years. In 2018, more than 820 million people around the globe suffered from hunger. Moreover, around 1.3 billion people lack regular access to sufficient and nutritious food. Undernourishment and extreme poverty are highly correlated (FAO, IFAD, UNICEF, WFP, & WHO, 2019), and almost 80% of the extreme poor live in rural areas (Castañeda et al., 2018). Rural households produce food for direct consumption and for market sale that generates income to be used for food and non-food purchases from markets. Thus, both food security and healthy household environments determine nutritional outcomes for the poor and are significantly dependent on agricultural and rural development. This was visualized in the conceptual framework of this dissertation, which is based on the agricultural and nutritional framework. This framework depicts numerous multidirectional linkages. The selected linkages for analyses were highlighted in the conceptual framework. Overall, this dissertation mainly dealt with the gender dynamics in intra-household decision-making as an important socio-economic factor at the household level. Gender bias in domestic decision-making, decision-makers' risk preferences, and their effect on agricultural production choices, and thus, livelihood outcomes are investigated. Moreover, considering the significant dependency of the rural poor on agriculture and their mostly subsistence orientation, nutrition-sensitive agricultural development programs have recently gained considerable attention. Against this background, production diversification was examined as a promising strategy to diversify rural diets.

5.1 Summary of the main findings

Considering the concentration of the literature on women's empowerment outcomes in social settings in which women are disadvantaged, in Chapter 2, we examined the implications of women's empowerment in a social context in which females historically enjoyed equality and even favoritism. The main objective was to study women's participation in intra-household decision-making and its implications on household-level dietary quality. The Kingdom of Bhutan was selected as the research region considering the prevalent vestiges of polyandry and matrilineal succession in some nomadic ethnic groups during the early years of this century. Moreover, by the end of the 20th century, women were reported to own more land than men, which presumably creates opportunities and supports their empowerment (FAO, 2000; Kotikula, 2013; ThingsAsian,

2002). Land is a very important resource, and nowadays, Bhutanese households have moved toward more gender equality in land inheritance. In addition to the main objective, in Chapter 2, we were interested in Bhutanese women's participation in various domains of domestic decision-making. Moreover, we examined the association between women's participation in decision-making and their land ownership status.

Mixed methods research was employed to study female participation in crucial intra-household decision-making processes of Bhutanese households and to estimate the association between female engagement in domestic decision-making and household-level dietary diversity that was captured by food variety and household-level dietary diversity scores. The quantitative data were collected from 213 households in November 2017. These households were randomly selected from two central western regions of Bhutan. To capture women's participation levels in decision-making, we adopted the approach suggested by Sariyev et al. (2020). In-depth interviews were conducted to be able to freely discuss and understand households' decision-making behavior in various decision domains.

Descriptive statistics showed that Bhutanese women do often participate in domestic decision-making. This was also a finding from in-depth interviews. Most of the sampled households reported joint land ownership. We employed a non-parametric Wilcoxon rank-sum test (Wilcoxon, 1945) to check for relationships between three land ownership statuses and women's participation in various domains of domestic decision-making. Results indicated that the distribution of women's participation in decision-making (WPDM) measures were statistically different in different land ownership statuses and throughout various decision domains. We found high probabilities (77% to 87%) of greater female participation throughout various decision domains in households where a female owns the largest parcel than in households where a male owns the largest parcel. The probabilities of greater female participation in the female ownership category versus the joint ownership category range from 54% to 79% throughout the decision domains. Thus, as hypothesized, an association was observed between land ownership status and women's participation in decision-making.

PCA was employed to capture the common information shared in seven WPDM variables representing various domains of domestic decision-making and to generate an index that was used to examine implications of women's participation in domestic decision-making on household-level dietary quality. It was estimated that the association between the index and dietary quality is

nonlinear. There was a positive association at the low levels of female participation in decision-making, while after some threshold level this association was negative. We transformed the original WPDM variables to develop an index capturing gender equality in decision-making. A positive association between gender equality and dietary quality was estimated. The results suggest that, in Bhutanese households, female or male domination in domestic decision-making would be associated with low dietary quality at the household level. Our finding is in line with the findings of studies from societies in which females are disadvantaged (Malapit et al., 2015; Malapit et al., 2019; Quisumbing & McClafferty, 2006; Sraboni et al., 2014), but most importantly, it signifies context specificity of the relationship between women's empowerment and nutrition. Nutrition programs are advised to employ ex-ante qualitative research to study the society and their norms in order to design a program that sustainably achieves the objectives. The results indicated that, in line with the fifth sustainable development goal of the United Nations, social programs should target gender equality and not merely women's empowerment; however, the latter is very relevant in discriminative societies.

In Chapter 3, we examined female risk preferences as an interacting socio-economic factor in the agriculture-nutrition linkage from the agricultural technology adoption perspective. The chapter concentrated on the adoption of high-yielding varieties in Ethiopia where, unlike in Bhutan, females are very much disadvantaged in terms of access to productive resources. HYVs have had significant gains for the poor (Datt & Ravallion, 1998; Evenson & Gollin, 2003; Hazell, 2009); nevertheless, like any newly introduced technology, they are likely to face resistance in the field. On Ethiopian farms, the adoption of a new technology is a risky decision that is mainly determined by the farmers' wealth, knowledge, and risk preference (Admassie & Ayele, 2010; Kebede et al., 1990). Studies show that risk averse farmers are less like to adopt new technologies (Brick & Visser, 2015; Jianjun et al., 2015; Jumare et al., 2018; Liu, 2013), and females are more risk averse than men in most environments (Croson & Gneezy, 2009; Eckel & Grossman, 2003; Embrey & Fox, 1997). Moreover, in terms of gender and varietal adoption, the literature is not uniform, and there are contradicting findings (Ndiritu et al., 2014; Simtowe et al., 2016).

Motivated by the aforementioned contradicting findings, Chapter 3 studied the effect of the main female decision-maker's risk preference on the adoption of high-yielding varieties (HYVs), hypothesizing the conditionality of its effect on the dominance of female preferences declared in intra-household decision-making. The dominance of female preferences in domestic decision-

making was captured by employing the same methodology used in Chapter 2, that is, by generating the women's participation in decision-making index (WPDMI). The main female's risk preference was elicited by a risk game. WPDMI and risk preference were interacted in Cragg's DH model to examine the effect of female risk preference on the incidence and extent of HYV adoption. The results indicated that neither female nor male risk preferences determine the incidence of HYV adoption. On the other side, the main female's risk preference was found to determine the extent of the adoption, that is, the share of land dedicated to HYV production. As hypothesized, this effect was conditional on the dominance of the female preferences declared in domestic decision-making; a positive marginal effect of a higher risk preference on the extent of HYV adoption was observed at the higher levels of female participation in decision-making. The results showed that while the incidence of HYV adoption is determined mainly by access and availability, the extent of it, from the farmer's perspective, creates uncertainty regarding the household's immediate food security status, signifying the importance of risk preference. A risk-taking female is more likely to risk her short-term food security status for potentially higher gains in the long term. For practitioners, these findings emphasize the importance of ex-ante analyses of decision-making processes and the associated risk preferences for better targeting and sustainability; for academics, they highlight the importance of capturing decision-making and risk preferences along with access and availability indicators to better understand and evaluate farm- and farmer-level determinants of varietal adoption. HYV dissemination is likely to yield more sustainable outcomes when followed or merged with gender-inclusive, rural empowerment projects.

Chapter 4 concentrated on the direct link between agricultural production and nutrition that is through the consumption of own farm produce. Considering that the rural poor are mostly subsistence oriented, nutrition-sensitive, agricultural programs have considered production diversification as a promising strategy to diversify rural households' diets. Many retrospective studies found a positive association between production and dietary diversity (Chegere & Stage, 2020; Ecker, 2018; Islam et al., 2018; Jones et al., 2014; Koppmair et al., 2017). However, the magnitudes of the association reported in these studies have very recently raised questions regarding the viability of this strategy. Considering that the association between agricultural production and dietary diversity is altered by many factors like non-farm income options, market access and orientation, in this chapter, we examined in depth the association, concentrating on the interactions. Moreover, considering that diversification of both production and consumption are

outcomes of intra-household decision-making processes, it is reasonable to investigate female participation in decisions as an interacting socio-economic factor. To the best of our knowledge, this factor has not been previously investigated. Thus, in this chapter, we treated production and consumption decisions separately and investigated how female participation in decision-making contributes to the two livelihood outcomes, and if it directly modified the association between crop production and dietary quality. We employed various measures of production diversity and dietary quality to check for robustness of the association in different specifications.

The results indicated that agricultural practices like crop rotation or intercropping are positively associated with production diversity in terms of both richness and evenness of cultivated crop species and the number of different livestock and crop species. A negative association was found between non-farm income and these diversity measures. This indicates that the households that are more dependent on agriculture are more motivated to diversify their agricultural production as an ex-ante risk management strategy. Women's participation in decision-making regarding crops grown was positively associated with production diversity in terms of the number of species and number of food groups produced. We did not observe any association when both richness and evenness (i.e., in terms of area dedicated to production) of crop species were considered. This was due to the fact that women were involved in decision-making on small plots, such as kitchen gardens. Kitchen gardens are relatively small; they contribute to the number of different crop species produced, however, their contribution is diluted when both richness and evenness are considered.

We estimated a significant association between production and dietary diversity. However, this association was very case sensitive, and the magnitudes were low. The results indicated that production diversification can be a strategy to improve the diets of the rural population that are highly dependent on agricultural production, live far from markets, and are mostly subsistence oriented. Nevertheless, even in these cases, the viability of this strategy is highly questionable since the results predicted that an average farmer in the sample should grow 11 more crop or livestock species on top of the seven species they are already producing in order to increase dietary diversity by one food group. Moreover, women's participation in decision-making regarding household expenditures was positively associated with household-level dietary quality. Overall, women's participation in decision-making was found to contribute to both production and dietary diversity, but it did not modify the association between these two livelihood aspects. Wealth indicators were

strongly associated with dietary diversity indicators. The results highlight that gender-inclusive socio-economic development policies and programs together with infrastructural and market development projects that contribute to household wealth and women's empowerment are more promising strategies than production diversification in terms of nutrition in rural areas. The literature also argues that nutrition knowledge (Chegere & Stage, 2020; Murty et al., 2016) and infrastructural and market development (Koppmair et al., 2017; Sibhatu & Qaim, 2018) are more promising strategies for nutrition than farm diversification.

5.2 Limitations and recommendations for future research

In addition to the specific limitations relating to the individual research questions analyzed in Chapters 2, 3, and 4, this dissertation has few overall limitations. The dissertation mainly concentrated on intra-household decision-making in Bhutanese and Ethiopian households. The data collected in these countries reflects the answers to the structured questions regarding intra-household decision-making by the most informed household member, who is mostly the household head. In their study of domestic decision-making in Bangladesh, Ambler et al. (2019) find that systematic differences exist in the responses to such structured questions depending on who answers the question. This discrepancy can potentially lead to ill-defined conclusions. An alternative option could be to interview multiple members within a household to check for discrepancies, however, the treatment of these discrepancies remains an unresolved gap in the literature. It was beyond the objectives of this dissertation to check and study such discrepancies, but by focusing on this gap, future research would make a significant contribution to the literature. It is also important to study what is embedded in these discrepancies (Doss et al., 2020). Moreover, the analyses concentrate on who makes the decisions; recent work by Bernard et al. (2020) in Northern Senegal shows that information regarding who makes the decisions can be complemented with information about why that individual or couple are the decision-maker(s) to yield more insightful conclusions. The analyses in this dissertation did not consider why the specific individuals make the decisions. Nevertheless, the findings from Northern Senegal can be case specific and depend on the family structures in the research region. Future research could replicate this method in Ethiopia and Bhutan and compare with the findings from this dissertation.

This dissertation concentrated on the decision-making aspect of women's empowerment. The Women's Empowerment in Agriculture Index (WEAI) (Alkire et al., 2013) that is widely employed in large development programs differentiates between five domains of women's empowerment in

agriculture: production, resource, income, leadership, and time. Malapit and Quisumbing (2015) and Ruel et al. (2018) argue that different aspects of empowerment are likely to affect different nutritional outcomes. Overall, this dissertation studied gains in production and consumption from women's empowerment in intra-household decision-making that relate largely to production and income, and partially to the resource domain of WEAI. Future research can contribute to the literature by focusing on dimensions like ownership or access to productive resources, time use, and leadership to investigate to which aspect of nutrition they mostly link. Moreover, the analyses employed various dietary diversity indicators as proxies for dietary quality at the household level. It was not possible to consider all four dimensions of food security. The relevance of the employed dietary diversity indicators to measure household-level dietary quality were discussed throughout the dissertation. Nevertheless, distinguishing between nutrient-rich foods could have provided additional useful information regarding the nutrition status of the sampled households. Moreover, in the agriculture-nutrition linkage, this dissertation did not look into non-food expenditure and the associated health aspect of nutrition. Although most Bhutanese households have access to toilets and water, access to improved sanitation and knowledge and practice of hygiene rules, like handwashing with a soap, are not as high (Atwood et al., 2014). Anemia and stunting are widely observed in Bhutan. Sanitation and hygiene practices, like handwashing, were linked to reduced incidences of diarrhea and the associated likelihood of stunting (Bhutta et al., 2008). Moreover, rates of access to improved sanitation and practice of basic hygiene habits are also low in Ethiopia (UNICEF Ethiopia, 2020). However, any analyses of the outcomes of such problems or strategies to alleviate their severe consequences were beyond the scope of this dissertation.

5.3 Concluding remarks

The main contribution of this dissertation is that policies and programs that contribute to gender equality will support the profound potential of agricultural and rural development to improve nutrition. This dissertation mainly concentrated on the gendered nature of domestic decision-making and its corresponding socio-economic factors as important components of agriculture-nutrition linkages. The analyses of each research question specifically incorporated relevant domains of intra-household decision-making since decision-making behavior in one domain cannot be assumed to be indicative of how a household operates in all other domains (Bernard et al., 2020; Sariyev et al., 2020). Overall, it can be concluded that extensive knowledge of a society and its culture is needed to ensure that this interacting socio-economic aspect is correctly considered and

approached in order to yield sustainable positive outcomes. Empowering women in contexts in which they are disadvantaged can influence both their risk-taking behavior and participation in domestic decision-making where households' livelihood strategies are determined. This fact can be considered in varietal dissemination strategies in order to achieve high and sustainable dissemination rates. Moreover, supporting women's voices in household- and farming-related decisions is a promising strategy to sustain the linkage between agriculture and nutrition. Applying the gender lens in nutrition-sensitive agricultural interventions and gender-sensitive rural development programs promises sustainable nutritional outcomes in the agriculture-nutrition framework.

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Appendices

Table A1. Comparison of WPDM between land ownership types (i.e., male, female, and jointly owned lands)

Land ownership	Male vs Female			Female vs Joint			Male vs Joint		
	Male	Female	Sig.	Female	Joint	Sig.	Male	Joint	Sig
Two-sample Wilcoxon rank-sum test. Null hypothesis:	$WPDM_{maleland}=WPDM_{femaleland}$			$WPDM_{femaleland}=WPDM_{jointland}$;			$WPDM_{maleland}=WPDM_{jointland}$;		
Observed rank sum									
Asset purchases	1010.5	1200.5	***	2452	11913		1611	14860	***
Crops grown	1017.5	1193.5	***	3123.5	11241.5	***	2812.5	13658.5	***
Food purchases	1010.5	1200.5	***	2934.5	11430.5	***	2267.5	14203.5	***
Harvest use	1007.5	1203.5	***	3030.5	11334.5	***	2729	13742	***
Income use	1057	1154	***	2784	11581	**	2689.5	13781.5	***
Input use	1022.5	1188.5	***	2766	11599	**	2338.5	14132.5	***
Land use	911.5	1299.5	***	3409.5	10955.5	***	2258	14213	***
Expected rank sum	1306.5	904.5		2295	12070		3549	12922	

Note: *** p<0.01, ** p<0.05, * p<0.1

Table A2. Pairwise correlation of decision variables

WPDM regarding	Asset purchases	Crops grown	Food purchases	Harvest use	Income use	Input use	Land use
Asset purchases	1.000						
Crops grown	0.467***	1.000					
Food purchases	0.498***	0.365***	1.000				
Harvest use	0.451***	0.921***	0.365***	1.000			
Income use	0.437***	0.708***	0.230***	0.755***	1.000		
Input use	0.537***	0.818***	0.417***	0.837***	0.710***	1.000	
Land use	0.501***	0.688***	0.364***	0.651***	0.554***	0.665***	1.000

Note: *** p<0.01, ** p<0.05, * p<0.1

Table A3. Factor loadings and KMO values of GED variables

GED regarding…	Factor loading	KMO
Asset purchases	0.6978	0.9172
Crops grown	0.8671	0.8377
Food purchases	0.6178	0.8993
Harvest use	0.8744	0.7874
Income use	0.8088	0.9045
Input use	0.8965	0.9075
Land use	0.7487	0.8961
Eigenvalue = 4.4034		

$KMO_{overall}$	= 0.8694

Note: *** p<0.01, ** p<0.05, * p<0.1

Table A4. Marginal effects of female risk preferences at different levels of WPDMI on HYV's adoption intensity

WPDMI at	Marginal effect of female risk	WPDMI at	Marginal effect of female risk
-1.5	-1.992	1.2	4.478*
	(1.789)		(2.291)
-1.35	-1.632	1.35	4.837**
	(1.651)		(2.454)
-1.2	-1.273	1.5	5.197**
	(1.523)		(2.620)
-1.05	-0.913	1.65	5.556**
	(1.408)		(2.788)
-0.9	-0.554	1.8	5.915**
	(1.310)		(2.959)
-0.75	-0.195	1.95	6.275**
	(1.232)		(3.131)
-0.6	0.165	2.1	6.634**
	(1.180)		(3.305)
-0.45	0.524	2.25	6.994**
	(1.154)		(3.480)
-0.3	0.884	2.4	7.353**
	(1.158)		(3.656)

-0.15	1.243	2.55	7.712**
	(1.192)		(3.833)
0	1.602	2.7	8.072**
	(1.252)		(4.011)
0.15	1.962	2.85	8.431**
	(1.337)		(4.189)
0.3	2.321	3	8.791**
	(1.440)		(4.368)
0.45	2.681*	3.15	9.150**
	(1.559)		(4.548)
0.6	3.040*	3.3	9.510**
	(1.690)		(4.728)
0.75	3.400*	3.45	9.869**
	(1.830)		(4.909)
0.9	3.759*	3.6	10.228**
	(1.978)		(5.090)
1.05	4.118*		
	(2.132)		

Delta-method standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A5. Average marginal effects of other independent variables on HYV's adoption intensity

	First hurdle Adoption		Second hurdle intensity	
Main female age	-0.015	(0.014)	1.020	(1.243)
Main female age^2	0.000	(0.000)	-0.012	(0.014)

Main female education	-0.003	(0.013)	-1.073	(1.159)
Main male risk	-0.018	(0.012)	1.140	(1.191)
Main male age	-0.016	(0.012)	0.288	(0.872)
Main male age^2	0.000	(0.000)	-0.002	(0.009)
Main male education	-0.012	(0.009)	0.744	(0.903)
Number of females in household	-0.044	(0.036)	6.116	(4.018)
Wealth index	0.107***	(0.033)	-3.670	(3.499)
Wealth index^2	-0.045**	(0.021)	-0.722	(2.010)
Extension [1-access]	0.355***	(0.067)	4.267	(8.377)
Credit [1-obtained in last 12 months]	0.143**	(0.066)	-8.708	(6.205)
Maize production [1- Yes]	0.271***	(0.048)	-7.699	(5.901)
Distance to all-weather road	-0.001**	(0.001)	0.009	(0.061)
Bale	-0.074	(0.104)	-7.728	(9.402)
Guji	0.204*	(0.104)	8.856	(7.145)
WestArsi	0.072	(0.083)	-2.356	(9.726)
KembataTimbaro	0.166	(0.112)	-12.579	(10.395)
Sidama	0.130	(0.081)	-19.660**	(9.383)
Gedeo	-0.094	(0.085)	-27.798***	(8.039)
Wolayita	0.172	(0.109)	6.869	(11.353)
GamoGofa	0.149	(0.108)	13.984	(10.783)

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A6. Dietary quality (HDDS9): Pooled and fixed-effects Poisson model estimates

Variables	Pooled Model			Fixed Effects Model		
	SID	Species count	FGDS	SID	Species count	FGPD
Production diversity	0.139***	0.020***	0.051***	0.126	0.015**	0.033**
	(0.054)	(0.004)	(0.009)	(0.099)	(0.007)	(0.014)
Decision-making regarding household expenditure – Joint	0.107**	0.099**	0.105**	0.109*	0.111*	0.112*
	(0.049)	(0.047)	(0.049)	(0.066)	(0.064)	(0.065)
Decision-making regarding household expenditure – Sole	0.153***	0.141***	0.151***	0.122*	0.118*	0.126*
	(0.053)	(0.051)	(0.052)	(0.070)	(0.069)	(0.069)
Landholding	-0.005	-0.008	-0.002	0.012	0.009	0.013
	(0.008)	(0.008)	(0.009)	(0.018)	(0.017)	(0.017)
Total livestock unit	0.014***	0.012***	0.013***	0.013*	0.011	0.012
	(0.002)	(0.002)	(0.002)	(0.008)	(0.007)	(0.007)
Non-farm income (1000 ETB)	0.004***	0.005***	0.004***	0.004*	0.004*	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Expenditure on durables and services (1000 ETB)	0.131***	0.114***	0.101***	0.097**	0.079*	0.076*
	(0.032)	(0.034)	(0.036)	(0.045)	(0.045)	(0.045)
Remittance	0.040	0.031	0.027	0.057	0.054	0.058
	(0.033)	(0.030)	(0.032)	(0.059)	(0.060)	(0.058)
Market distance	-0.000	-0.000	-0.001*	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share sold	0.001*	0.001	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	726	726	726	726	726	726

Wald χ^2	432.38***	414.23***	432.84***	30.08**	37.23***	38.16***

Note: Village level clustered and robust standard errors in parenthesis for pooled and fixed-effects models, respectively. Estimation controls for head sex, head age, head education, HH size, dependency ratio, and year 2016 that are not reported due to space limitations. *** p<0.01, ** p<0.05, * p<0.1

Table A7. Extended model of dietary quality (HDDS9): Fixed-effects Poisson model estimates

Variables	Fixed-effects model		
	SID	Species count	FGPD
Production diversity	-0.573*	0.017	0.109**
	(0.315)	(0.020)	(0.047)
Production diversity square	0.803**	0.000	-0.012*
	(0.342)	(0.001)	(0.006)
[Production diversity] x [non-farm income]	-0.010	-0.001	0.001
	(0.012)	(0.001)	(0.001)
[Production diversity] x [share sold]	-0.002	-0.000*	-0.000
	(0.003)	(0.000)	(0.000)
[Production diversity] x [market distance]	0.003*	0.000**	0.000*
	(0.002)	(0.000)	(0.000)
Market distance	-0.002*	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)
Share sold	0.001	0.003	0.002
	(0.001)	(0.002)	(0.002)
Non-farm income	0.010	0.012	0.001
	(0.008)	(0.008)	(0.005)

Decision-making regarding household expenditure – Joint	0.107*	0.110*	0.111*
	(0.065)	(0.063)	(0.064)
Decision-making regarding household expenditure – Sole	0.118*	0.120*	0.122*
	(0.069)	(0.067)	(0.068)
Observations	726	726	726
Wald χ^2	41.04**	55.65***	52.43***

Note: Robust standard errors in parenthesis. Estimation controls for head sex, head age, head education, HH size, dependency ratio, total livestock unit, landholding, expenditure on durables and services, remittance, and year 2016 that are not reported due to space limitations. *** p<0.01, ** p<0.05, * p<0.1

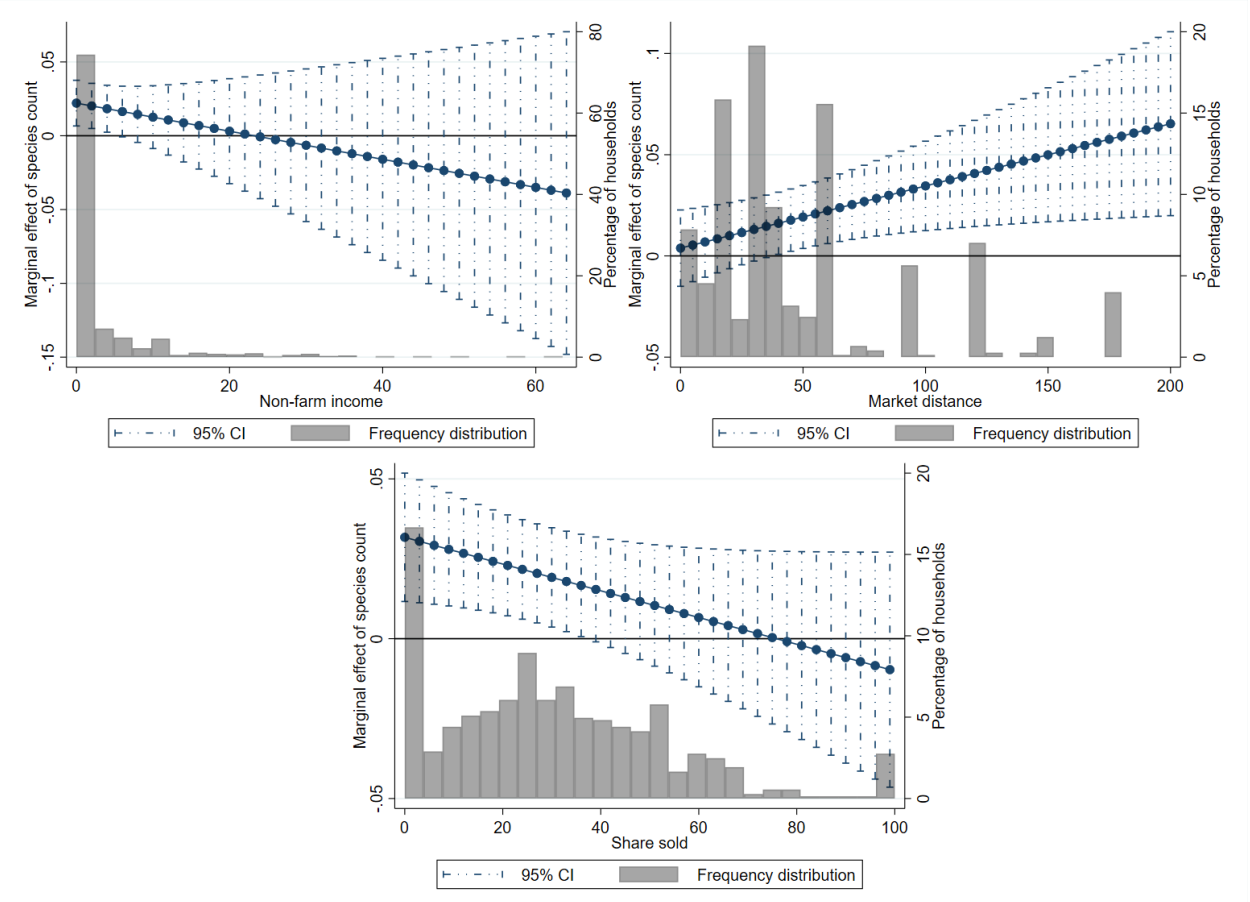

Figure A1. The marginal effects of species count on HDDS9 along values of non-farm income, market distance, and share sold

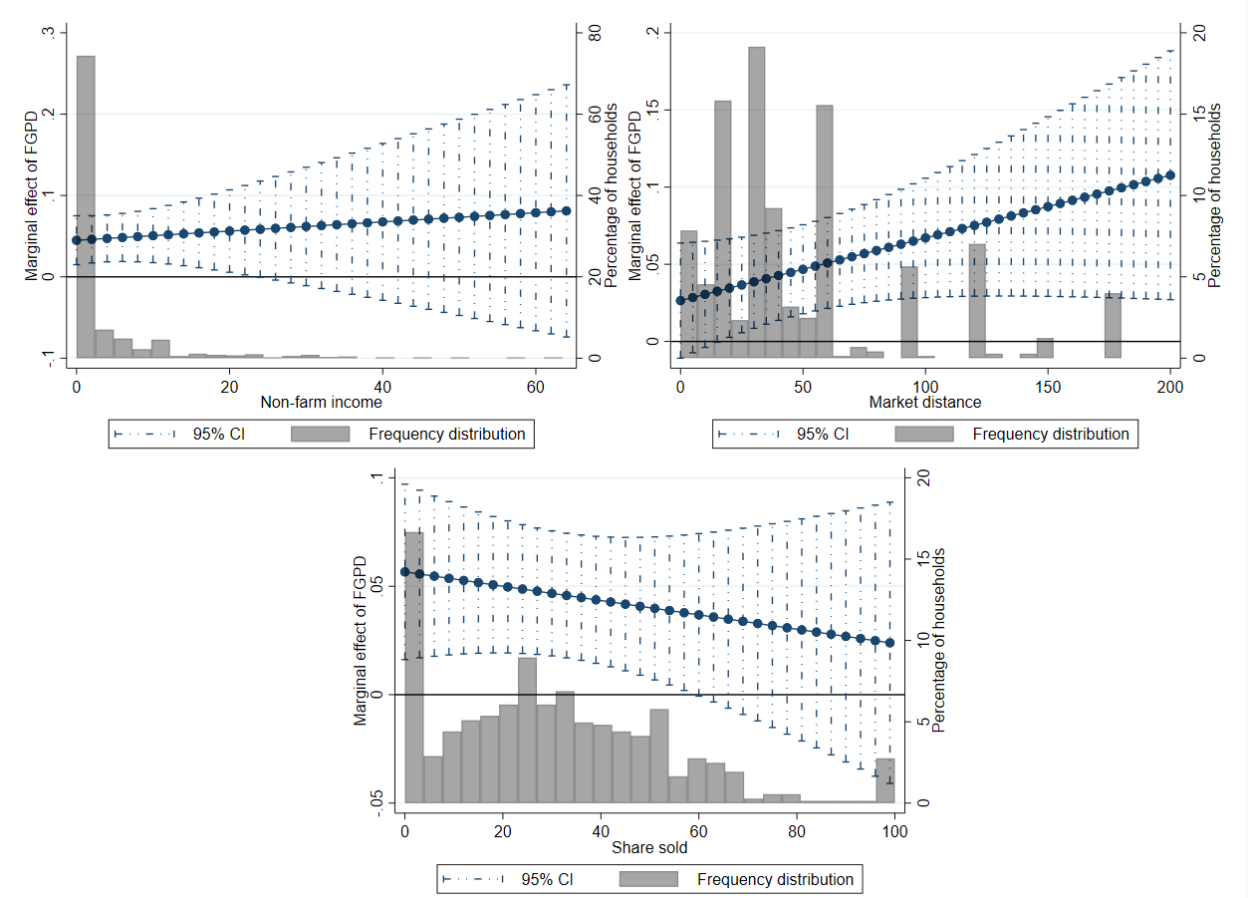

Figure A2. The marginal effects of FGPD on HDDS9 along values of non-farm income, market distance, and share sold