Seed Security, Agrobiodiversity and Production Risk in Smallholder Agriculture in Eastern Ethiopia

Three Essays

Thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

by

Andrea Ruediger

Somerville College

Department of International Development
University of Oxford

Hilary Term 2017

Word Count: 76,877

For Elohim, Benjamin & Selma

Abstract

Seed Security, Agrobiodiversity and Production Risk
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Andrea Ruediger

University of Oxford, Somerville College
Doctor of Philosophy in International Development
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This doctoral thesis presents three original research papers investigating aspects of agricultural production in small-farming households in two regions of Ethiopia. While answering specific research questions, the articles are connected and motivated by an interest in essential themes of agricultural development: access to seed, the use and conservation of agrobiodiversity as well as strategies to manage production risk in smallholder agriculture.

The first article analyses patterns of agrobiodiversity in three communities with comparatively favourable farming conditions and good market access in the East Shewa zone of Eastern Ethiopia. Using original panel data of more than 300 households collected in 2011 and 2013, the study shows that the least vulnerable households grow a larger portfolio of food crops and wheat varieties. Based on these findings, the role of agrobiodiversity for ex ante risk management and alternative incentives for portfolio diversification are discussed.

The second article investigates the effects of a fungal crop disease on agricultural production of households in East Shewa using household level panel data during and after an epidemic outbreak of yellow rust in 2010/11. Findings suggest that while varietal diversity in wheat does not increase, roughly thirty percent of households make changes in their varietal portfolio and reduce wheat cultivation in response to the disease. Disease resistant varieties are only available to 16 percent of all households with preferential access to agricultural resources.

The third article presents a mixed methods study of a highly developed informal seed insurance network among subsistence-oriented small farmers in two communities in the West Hararghe zone of Ethiopia. Based on a survey and interviews with 150 farmers, we find that the vast majority of small farmers actively participate in informal seed assistance by giving or receiving small quantities of seed without compensation. We argue that the seed assistance through gifts is practiced to insure against hunger ex ante and facilitate access to crop genetic resources in a centre of crop origin and diversity.

Acknowledgements

I am sincerely thankful to my supervisors Douglas Gollin and Stefan Dercon for their guidance and support at various stages of my work. I feel privileged to have had the opportunity to learn from them. I am particularly grateful for their patience and their understanding as I was working on my thesis remotely and alongside other responsibilities.

To my examiners for the confirmation of status, Imane Chaara and Pam Berry, I am grateful for engaging deeply with my work and making this thesis truly an exercise in academic training, as hard as the months of revision of my confirmation paper were. For proof-reading and many helpful discussions about our shared interest in agricultural development, I also thank Frances Cossar.

I am grateful to the 574 farmers who participated in this study in Chefe Donsa, Ejere, Kokka, Schola and Asebot. I was very fortunate to share intense weeks of fieldwork in West Hararghe with my dedicated research assistants Girma Sori in 2013 and Badhadha Bizuna in 2011. They worked with me under difficult conditions, conducting interviews during Ramadan before the sun rose and after it had set. I am truly indebted to both of them. I am grateful to Melkamu Dumessa for translating the survey instrument. Many thanks also go to my wonderful team of enumerators in East Shewa: Fetene, Girma, Habib, Melkamu, Zerihoun, Rabbirra, Samuel and particularly Tesfaye Woldetsadik.

The fieldwork would not have been possible without the practical support of Care Ethiopia in Asebe Teferi and the Ethiopian Biodiversity Institute for fieldwork in East Shewa. A part of this research was conducted on a research fellowship with Bioversity International. I am particularly grateful to Elisabetta Gotor and Carlo Fadda for the opportunity to manage my first survey as well as for advice and support in Ethiopia. The financial support for this doctoral research and fieldwork from the Clarendon Fund, Somerville College and ODID/QEH is gratefully acknowledged.

For friendship and support during six months of fieldwork in Ethiopia in 2013, I am grateful to Silke Jolowicz, Frauke Frahm, Yonas Mekonen, Julianne and Toni Weis. For a loving and welcoming home away from home, I am grateful to my sister Susanne as well as Edda, Magda and Stefan

Most of all, I shall thank my husband Benjamin for the countless sacrifices he has made over all these years, for his support, belief and his enduring patience. You have certainly borne more than your fair share of the burden. For their fantastic support and encouragement as well as for many hours of babysitting, I am grateful to my parents Christa and Albrecht as well as my dear sister-in-law Sarah.

And finally, thank you to my dear daughter Selma for countless hours of joyful distraction, and for knowing that this work is important even when you cannot quite understand it.

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Introduction

This doctoral thesis presents three original research papers investigating aspects of agricultural production in small-farming households in two regions of Ethiopia. While answering specific research questions, the papers are connected and motivated by an interest in two essential themes of agricultural development: access to seed and strategies to manage production risk in smallholder agriculture, as well as by an interest in the use and conservation of agrobiodiversity[1]. This thesis offers original insights and new perspectives, especially on the uses of agrobiodiversity and the role of informal seed systems in smallholder agriculture, through rigorous analysis of primary data and a serious engagement with the respective literatures.

1. Overview

a. Paper 1: Patterns of agrobiodiversity

The first paper analyses patterns of food crop diversity and varietal diversity in wheat in three communities in the East Shewa zone of Eastern Ethiopia using original panel data of more than 300 households collected in 2011 and 2013. This paper is motivated by an interest in effective approaches to on-farm conservation of crop genetic resources in the centres of diversity.[2] Promoting and strengthening on-farm conservation, however, requires a thorough understanding of who diversifies and why, within and across communities. Recent econometric analyses of cereal and crop genetic diversity argued strongly for a risk management or insurance rationale as the essential driver of on-farm diversity (Baumgärtner, Quaas 2010, Bezabih, Sarr 2012, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2009, Di Falco, Bezabih et al. 2010). These contributions suggest that farmers who are most exposed to risk or most vulnerable have the greatest incentives to maintain a diverse crop and varietal portfolio. The evidence presented in this thesis, however, yields very limited evidence to support the idea that small farmers primarily diversify their crop and variety portfolio to spread production risk.

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[1]Defined in a holistic sense, agrobiodiversity encompasses "all aspects of biological diversity in areas of agricultural land use" from the diversity of soil organisms to animal and crop genetic resources (Stocking, Kaihura et al. 2003, p.5). In this thesis, we also use the term agrobiodiversity when referring more narrowly to the diversity of cultivated food crops and cultivated crop varieties or inter- and intraspecific diversity (Bellon 1996).

[2]The data was collected as part of a project implemented the by the CGIAR centre Bioversity International with the aim of improving small-farmers' capacity to cope with climate change by improving access to crop genetic resources. The author of this thesis was also the author of the evaluation report for this project and the principal investigator for the 2013 round of data collection. While the research interest is motivated by this affiliation, the research paper is, however, not directly linked to the aforementioned project.

This study argues for high fixed transaction costs, missing food markets and land availability as the main incentives for cultivating a diverse portfolio. We find that crop and varietal diversification is a production strategy of comparatively well-off households with larger land and livestock holdings and without immediate access to food markets. One important implication of this research for on-farm conservation is that not the most vulnerable farmers, but small farmers with limited market access and sufficient land seem to have higher incentives to maintain crop and varietal diversity.

b. Paper 2: The effects of wheat rust

Wheat is a staple crop in the highlands of Ethiopia, one of the regions with high vulnerability for stripe or yellow as well as stem rust epidemics of wheat, frequently causing substantial yield losses (Singh, Hodson et al. 2008, Wellings 2011). Empirical research on wheat rust in Ethiopia and beyond has largely focused, firstly, on creating awareness for the scale and threat of the disease, secondly, on the efficacy of disease control through resistant varieties and pesticides primarily in experimental settings as well as, thirdly, on genetic analysis for resistance breeding. Where access to conventional risk management and coping strategies is limited, however, farmers' de facto strategies in managing disease risk ex ante are of particular interest, which have not yet been systematically studied.

This study using original panel data analyses farmers' de facto responses to an epidemic outbreak of stripe or yellow rust in 2010/2011 and discusses them in terms of their potential to control or reduce the exposure to the disease. The study contributes to the literature by identifying and assessing farmers' response measures in a context of limited access to conventional rust control measures.

The analysis of how households' food crop and wheat variety portfolio or land use patterns change due to stripe rust confirms that the disease cannot be fully controlled by input-oriented, conventional disease management strategies. Especially the limited availability of resistant cultivars leads to an overreliance on pesticides of farmers who can afford them. Findings also suggest that limited access to modern as well as landrace wheat varieties creates incentives for small farmers to move out of wheat to reduce risk exposure.

c. Paper 3: Informal seed insurance

The study of solidarity networks or informal insurance institutions has become a major topic of development economics over the past decades (Fafchamps 1992b, Townsend 1994, Platteau 1997, Dercon 2005a). This paper contributes to this literature with an in-depth study of an extraordinarily highly developed informal insurance for seed, an essential agricultural resource in smallholder agriculture.

In rural communities with a majority Oromo population in the West Hararghe zone of Eastern Ethiopia, the vast majority of households are frequently involved in mutual seed assistance. Small quantities of seed are given without any form of cash, in-kind or service compensation and with no expectation of repay or return. While the importance and the exceptional extent of mutual seed assistance were mentioned in other sources, it has not yet been systematically studied (McGuire 2000, Mekbib 2006, McGuire 2008). The particular contribution of this study lies in going beyond the analysis of informal seed assistance as a seed source or channel, to relevant immaterial aspects of the mutual-aid practice such as norms regulating donations and receipts of seed, motivations and sanctions for non-compliance. Based on the analysis of material and immaterial dimensions of this informal social institution using an elaborate mixed methods approach, the study explores how mutual seed assistance is upheld in a context of high vulnerability.

The analysis suggests that the institutional design of mutual seed assistance, compared to other local practices of mutual aid, sets incentives to use this ex ante insurance instead of ex post food or cash assistance after harvest, which is given as a loan and is, thus, more costly. This finding is extremely relevant for the study of solidarity networks far beyond the specific local context. Moreover, we argue that the seed assistance through small gifts is practiced to facilitate access to crop genetic resources in the centre of origin and diversity for sorghum.

By clearly identifying the underlying principles of informal seed insurance, the study also explores how social changes or interventions can threaten the rationale of this informal institution. Thus, the paper also provides relevant insights for policy makers in fields of (emergency) seed aid and agricultural development.

2. Linkages between the three research papers

The agroeconomic research compiled in this thesis makes a contribution to the understanding of decision-making and resource allocation of small-farming households in Ethiopia and beyond.

a. Small farmers in Ethiopia

Ethiopia with the lowest urbanisation rate in Sub-Sahara Africa and over 80 percent of the population employed in agriculture, is a suitable and relevant context for studying questions of decision-making in small-farming households. The two study areas in East Shewa (Paper 1 & 2) and West Hararghe (Paper 3) also illustrate the diversity of smallholder livelihoods within one region of Ethiopia, emphasising the need for interventions which respond to these differences. While small farmers in West Hararghe are subsistence oriented with limited cash crop income through chat, the majority small farmers in East Shewa are actively participating in output markets and are more business oriented. The productivity gap between these different types of small farming

households is widening across and in the case of East Shewa also within regions (Hazell, Rahman 2014).

b. Seed security

The second paper analysing effects of a crop disease, highlights the importance of reliable access to seed of both modern, disease resistant varieties as well as traditional crop varieties in responding to disease. Farmers with access to non-market, semi-formal seed sources, such as seed banks or farmer-based seed multiplying enterprise are in a better position to manage the crop disease.

However, the first paper alerts to the fact that access to seed of traditional varieties is not a sufficient condition for small farmers to cultivate them. As traditional durum wheat varieties had disappeared from the study region and were reintroduced by conservation efforts through membership-based revolving seed banks, landraces now constitute an adoption puzzle. While some innovative and sensitised farmers adopt landraces and even find niche markets, a large share of farmers reject landraces partly due to a lack of information about market opportunities and management practices. Contrary to the limited adoption of modern, disease resistant varieties, low adoption rates of landraces cannot be merely understood as supply problems, but are rather linked to information asymmetries and risk attitudes.

The third paper, set in a different zone in the Oromiya region of Ethiopia, describes informal seed assistance as one aspect of a highly functional informal seed system. The comparison of the vastly different seed systems in the two study regions highlights the role of agricultural interventions in shaping local seed systems. The relatively high agricultural potential in the East Shewa zone has led to continuous interventions in agriculture over the past decades with lead to a disappearance of informal seed channels, while promoting productivity increases and market integration. In contrast to that, the West Hararghe zone is drought prone and the agricultural potential is much more limited. Consequently, interventions in agriculture in the region have been limited. While this is currently changing due to chronic food insecurity, the informal seed system is vibrant, and the community is the preferred seed source.

c. Agrobiodiversity

Farmers' seed systems are not only of interest for securing seed supply in small farming households, but also for the conservation of agrobiodiversity on farms (Almekinders 2001a).

Since the papers are set in a secondary centre of genetic diversity for durum wheat and barley and a primary centre of diversity and origin for sorghum, the three papers are strongly connected by

questions of conserving and using genetic diversity of these cereal crops in small-faming households.

Understanding farmers' incentives to maintain a diverse varietal and crop portfolio is essential for designing strategies for on-farm conversation (e.g. Brush 1995, Bellon 2004, Jackson, Pascual et al. 2007). The first paper not only contributes to this understanding with an empirical study, but also with a comprehensive and up-to-date review of the literature.

The second paper discusses a central hypothesis of the agroecological literature that more diverse farming systems are also more resilient. The example of cultivation of wheat landraces in East Shewa, however, illustrates the fine line between genetic erosion and functional diversity. Functionally diverse agroecosystems with high genetic diversity in wheat might allow farmers to select strategically for disease resistance among a range of landrace varieties and are also seen as less susceptible to epidemic disease outbreaks than monocultures. Furthermore, as crop domestication, evolution and adaptation historically took place on farms, a diverse agroecosystem is understood as the foundation for the dynamic adaptation of disease resistance (Almekinders, Louwaars et al. 1994).

While a substantial share of farmers in East Shewa cultivate a landrace durum wheat variety alongside modern bread wheat varieties, for diversity to be functional (in the sense outlined above) a higher level of genetic diversity would be required than is maintained on the vast majority of farms.

This debate around questions of resilience in agroecosystems aptly illustrates a new emphasis in the discussion of genetic erosion, i.e. the process of replacement of a genetically variable and diverse set of crop landraces by a few modern varieties (Harlan 1975). The challenge of responding to climate change in agricultural systems has sparked a renewed interest in the ecosystem services of agriculture beyond provisioning (and thus productivity) and thus in the role of *in-situ* conservation of genetic resources for building more resilient agroecosystems (Hayes, Wilhite et al. 2011, Thornton, Herrero et al. 2011, Parry 2014, Zeigler 2014).

The third paper illustrates the role of informal seed systems for the conservation of crop genetic diversity. Furthermore, the qualitative evidence shows that farmers in the study areas have an understanding of genetic resources as a public good, which must be conserved through collective effort, i.e. through fairly unrestricted sharing of small amounts of seed with neighbours and strangers alike. The more people have access to a variety and cultivate it, the lower is the probability of this variety being lost due to due to biotic or abiotic stresses.

The comparison of the two to study regions invites a discussion of trade-offs between conservation of crop genetic diversity and agricultural development, i.e. productivity growth. While West Hararghe has a highly developed mutual seed system and a substantially higher share of farmers cultivating landrace sorghum (than farmers cultivating landrace wheat in East Shewa), agricultural productivity and agricultural incomes are also much lower than in East Shewa. Given the differences in market integration and agricultural potential between the two regions, we would not want to imply any form of direct causation between the level of crop genetic diversity and agricultural productivity.

However, the analysis of mutual seed assistance in West Hararghe, clearly indicates that the high level of circulation of crop genetic resources in the community is based on redistributive norms and the perception of equal exposure to risk. The mutual insurance system which is central to maintaining crop genetic diversity is much less likely to be functional in communities with pronounced wealth differences, i.e. with stark differences in the probability to be seed insecure and in the capacity to cope with seed insecurity. Agricultural innovation leading to productivity growth, however, typically induces social change, including economic and social differentiation. Furthermore, modern agriculture relies on external agricultural inputs, which should go hand in hand with a development of formal input channels. As alternatives to the informal system emerge and are found to be reliable and trustworthy, farmers are less dependent on and have fewer incentives to invest informal channels. This illustrates some of the trade-offs between agricultural development and the on-farm conservation of genetic diversity, which is often linked to traditional social institutions.

d. Managing risk in smallholder agriculture

The purpose of many traditional, rural social institutions as well as plot and portfolio diversifications are primarily seen as means to smooth production and income and minimize risk in risk-prone smallholder agriculture (Alderman, Paxston 1992, Fafchamps 2003, Dercon 2005b). Scott has called this mode of smallholder production the “safety first principle” (1976, p.2).

Rain-fed subsistence or semi-commercial agropastoral production are dominant livelihood strategies in the Oromiya region of Ethiopia. Small-farming households in Ethiopia operate in a risk-prone environment with limited access to formal insurance or credit to buffer production risks. Rainfall variability, extreme weather events, crop pests and diseases frequently cause production shocks and affect households’ income and welfare. The effects of climate change intensify the risks small-farmers face. Therefore, all three research papers in this thesis are strongly linked by questions of risk management in small farming households.

The first paper examines the hypothesis that varietal and crop diversification in risk-prone environments is used primarily to spread production risk. Based on the empirical findings, the paper argues that while portfolio diversification can reduce the variability of income and reduce downside production risk, it does not mean that small farmers will diversify their portfolio to strategically exploit risk-spreading properties. By analysing patterns of food crop and wheat diversity across households, the paper proposes alternative motives beyond risk management that guide farmers' portfolio choice.

The second paper examines farmers' de facto management of disease risk, a source of production risk that has not been as systematically studied as moisture stress in the rich body of microeconomic studies examining farmers' risk management strategies. The empirical analysis indicated that for wheat production, diseases are perceived as the major crop stress and a highly relevant for portfolio choice. The paper aptly illustrates the challenges of intervening in a timely and efficient manner to support farmers in managing disease risks effectively in a developing country context.

The third paper investigates informal seed insurance as a traditional, social mechanism to manage risk, specifically to manage the risk of seed insecurity and consequently of production loss. The analysis of this informal social institution suggests that it can only emerge and be maintained when farmers perceive themselves as being equally exposed to risk and able to cope with risk. The rationale of assisting others without compensation, so one might be assisted in the future only works if the likelihood of requiring assistance is not highly different across the community.

As was shown in this section, the three papers in this thesis set in two different study areas in Ethiopia are thus highlighting different aspects of seed security, food crop and genetic diversity as well as production risk in smallholder agriculture.

3. Ethiopia: Smallholder agriculture in the centre of diversity

This thesis - investigating questions at the nexus of seed security, agrobiodiversity and risk management of smallholder farmers - is well situated in Ethiopia as a sub-Sahara African, low income country with a diverse agricultural sector and a large and growing rural population.[3]

Eastern Ethiopia was chosen to study questions related to the use and access to genetic resources and food crop diversity because it is one of the eight global centres of crop diversity and origin. Access to seed is particularly relevant in a context in which a variety of different crops is cultivated

[3]While the share of the rural population is steadily decreasing, the rural population has increased in total numbers from 42 million in 1990 to 80 million in 2015 (World Bank 2017).

across the country and global, commercial actors are less relevant for the formal seed market. Furthermore, given the remarkable geographical and agroecological diversity of Ethiopia, the studies presented here are conducted in culturally similar and geographically close, but still pronouncedly different contexts in terms of agricultural potential, interventions & systems as well as market integration. The comparison of findings across the two study sites highlights the importance of knowing the local context for sound agricultural development interventions. Finally, comparable to other contexts in rural Sub-Sahrara Africa, rain-fed subsistence or semi-commercial agropastoral production are dominant livelihood strategies in the Oromiya region of Ethiopia. Small-farming households in Ethiopia operate in a risk-prone environment with limited access to formal insurance or credit to buffer production risks. This context lends itself to studying questions of decision making and resource allocation under risk in small-farming households, which are of relevance beyond the specific households and communities which were studied.

a. Agriculture in Ethiopia

While the Ethiopian economy is rapidly transforming, the agricultural sector is still economically relevant with a share of agriculture in GDP of 42 percent in 2014 (World Bank 2017).[4] With 81 percent of the population living in rural areas and the vast majority being employed in agriculture, Ethiopia has one of the lowest rates of urbanisation in Sub-Saharan Africa.

Although the large-scale, commercial agricultural and horticultural sector is growing, small farmers account for 94 percent of the cultivated land in Ethiopia (Taffesse, Dorosh et al. 2011, Bachewe, Berhane et al. 2015). The number of smallholders grew from 11 million in 2004/5 to 15.3 million in 2013/14, while the share of arable land per capita is decreasing (Bachewe, Berhane et al. 2015).

Average agricultural productivity has increased at an exceptional rate over the last decade and cereal yields were the highest in East Africa with 23.3 quintiles per hectare in 2014 (World Bank 2017).[5] Total agricultural production in 2014 was 124 percent higher than in 2004/5, with an average annual growth in output of 9.4 percent over the last decade (Bachewe, Berhane et al. 2015). The expansion of cultivated land, an increase in labour, the adoption of inputs such as fertilizer and improved seeds as well as an increase in total factor productivity have been identified as drivers of this growth (Bachewe, Berhane et al. 2015). While land productivity is high, labour productivity, even if steadily increasing, remains lower than in other East African countries, such

[4]Almost a decade before that, in 1995, the share of agriculture in GDP was much more dominant with 55 percent.

[5]This estimate of cereal productivity is confirmed by IFPRI estimations of 21.5 quintals/ha in 2013/14 (Bachewe, Berhane et al. 2015). According to this indicator, land productivity has almost doubled since 1990, when average cereal output was 1,2 quintals/ha (World Bank 2017).

as Kenya, Tanzania or Rwanda, due to the comparatively high share of the population active in agriculture.[6]

A central feature of Ethiopian agriculture is its diversity, including considerable variations in seasonal rainfall and agro-ecological conditions. These range from high potential agriculture-livestock zones in humid highland regions like Arsi to low-potential semi-arid areas in Northern Tigray. Ethiopia is thus characterised by pronounced regional differences in productivity potential and actual productivity (Mann, Warner 2017).

A range of staple crops are cultivated in these diverse conditions. Tef, a cereal crop cultivated almost exclusively in Ethiopia, covers 21 percent of cultivated land in Ethiopia, followed by maize (14 percent), wheat (13 percent), sorghum (13 percent), barley (9 percent) and enset in the South of the country (Taffesse, Dorosh et al. 2011). Pulses, especially chickpea and lentils, are intercropped or grown in rotation with cereal crops and cover 12 percent of the cultivated area. The most important agricultural export crops are coffee as traditional cash crop, chat - a perishable, mild narcotic primarily exported to neighbouring countries and increasingly also oilseed (Bachewe, Berhane et al. 2015).

b. Risk & vulnerability in Ethiopian smallholder agriculture

Particularly small farmers outside the moisture reliable, humid zone, face considerable moisture stress. Ethiopia is known for the high frequency and vulnerability to droughts and for devastating famines in the past (World Bank 2008). Most recently, below average and erratic Belg rains in 2015 in Eastern Ethiopia have led to a large scale food emergency in the country's eastern regions and food aid interventions for 15 million people (FEWS NET 2015a, FEWS NET 2015b). Shocks such as droughts - which force farmers to deplete their assets - are shown to have persistent, negative effects on household consumption (Dercon 2004, Dercon, Hoddinott et al. 2012).

Recent research has confirmed that in densely populated areas, especially in the highlands, land constraints become increasingly binding and constitute a cause of rural poverty and increased vulnerability (Headey, Dereje et al. 2014). Arable land per capita is decreasing from 0.37 ha in 1980 to 0.16 ha in 2015 (World Bank 2017). The demographic development is also associated with more intensive farming practices, which exacerbates land degradation, especially through land erosion and soil depletion (Haileslassie, Priess et al. 2005).

[6]Out of 28 Sub-Saharan African countries included in the rural development report 2016, six have a lower agricultural value added per worker from 2010 to 2014 than Ethiopia (Burundi, Uganda, Malawi, Madagaskar, Cabo Verde, Guinea) (IFAD 2016). According estimations of the Food Policy Research Institute, Ethiopia had the second lowest labour productivity after the Gambia in all of Sub-Saharan Africa with US$ 296 per worker, i.e. agricultural gross production per economically active person in agriculture measured in constant 2004–2006 US dollars (IFPRI 2016).

Predicted effects of climate change, namely rising temperatures and changing rainfall patterns, have a high potential of increasing the vulnerability of small farmers in moisture stressed areas of Ethiopia (Conway, Schipper 2011, Aragie 2013). According to UNDP (2014) Ethiopia is potentially among the countries that will be most severely affected by climate change. While precipitation trends vary across different models, seasonal predictions point to a reduction of rainfall during planting season with significant negative effects for productivity at the end of the 21st century (World Bank 2008).

c. Abyssinian centre of crop origin and diversity

Ethiopia is a particularly relevant setting for this thesis as it is one of eight global centres of crop origin and diversity (Vavilov 1951, Engels, Hawkes et al. 1991, Brush 2004). In these gene centres, many of which are also set in geographically diverse and mountainous regions of the world, the crop genetic diversity is particularly high and some crops became domesticated.

For two cereal crops of particular interest to this thesis, tetraploid wheat and barley, the Ethiopian highlands are a secondary centre of diversity. A high diversity of landraces, but not of wild crop relatives is found, indicating that these crops were not domesticated in the region (Engels, Hawkes et al. 1991). For sorghum, a variable crop cultivated from below 400 meters up to 3,000 meters, Ethiopia is very likely the primary centre of crop origin and diversity (Engels, Hawkes et al. 1991).

As in many other gene centres, the genetic diversity is associated not only with geographical, but also with cultural and culinary diversity as well as elaborate agricultural practices (Brush 2004). Among other things, Ethiopia is well known for the long standing agricultural tradition of oxen ploughing, originally practiced by the Amhara, but now widely applied in Ethiopia as opposed to many other countries in Sub-Sahara Africa (McCann 1995).

d. Study sites in West Hararghe & East Shewa

While comprised of three papers, the thesis is using two datasets from two different zones in Eastern Ethiopia. The first two papers are set in East Shewa, while the third paper is set in West Hararghe, approximately 250km further east.

Both zones are in Oromia regional state with a majority Oromo population and Oromo as the dominant language, which comes from the cushitic branch of Afro-Asiatic languages. The Oromo, historically also called “Galla”, are the largest ethnic group in Ethiopia. The Oromo have a strong pastoralists tradition, but adopted many traditionally Amharic agricultural practices, e.g. oxen ploughing, over the last centuries (Baxter, Hultin et al. 1996).

While all study sites are situated in the major agricultural belt of Ethiopia called *weyna dega,* defined by an altitude between 1,500 and 2,300 meters, the sites in East Shewa are located in the

moist and the sites in West Hararghe are in the dry *weyna dega* (Hurni 1998, CSA, IFPRI et al. 2006, Chamberlin, Schmidt 2012).

East Shewa

The study sites in Gumbichu and Lome *woredas* are located only 80 to 120 kilometres southeast of Addis Ababa and with good access to a major highway and the country's main transport route connecting the capital to the port of Djibouti. The region around the capital is not only well connected, but also known for its relatively favourable conditions for rain-fed agriculture with fertile soils and a comparatively stable rainfall regime.[7] Additionally, the majority of farmers use modern inputs such as improved seeds and fertilizer. Consequently, productivity of small farmers is above the national average and also large-scale cash crop production through foreign investors (though predominantly in midland rather than the highland locations) is common.

The agricultural system in this region can be described as highly developed mixed agriculture in the grain-plough complex of the central and northern highlands, characterised by rotations of cereals, dominated by tef and wheat, and legumes, primarily chickpea and lentil (Westphal, Stevels 1975). The vast majority of small-farmers sells part of their cereal or pulses output on the market and thus generates cash income.[8] Transitory food insecurity occurs only rarely as a result of extreme weather events, which means that households in the region are generally food sufficient (MoA 2009).

West Hararghe

While the majority Oromo and minority Amhara population in East Shewa is Orthodox Christian, the most frequently practiced religion in West Hararghe is Islam (CSA, IFPRI et al. 2007).

The dominant livelihood in Mieso and Chiro *woredas* is also agro-pastoral small-scale farming, but under less favourable conditions with considerable moisture stress.[9] The agricultural system can be described as the sorghum-plough complex of the highland of Hararghe, with sorghum - as a drought-resistant crop - being cultivated by the vast majority of households, followed by maize as the second most important cereal crop (Westphal, Stevels 1975). Subsistence farming is complemented by the production of chat or khat as a cash crop. East and West Hararghe are the

[7]The highland site in East Shewa, Chefe Donsa, is also characterized by significantly more annual rainfall than the sites in West Hararghe. Von Braun et al. (1999) identify the high degree of rainfall variability rather than the average annual amount in some parts of Ethiopia, including the Hararghe zones, as a major production risk.

[8]Only eleven percent of households in the East Shewa household sample do not sell any of their output.

[9]A review of the biannual Food Security Outlooks of the Famine Early Warning Systems Network (FEWS) suggests that especially the Belg rains are unreliable and erratic, confirming the observation that a study of small-farmer production in the Hararghe zones makes already in 1998: "The variability of rainfall from year to year and its often uneven distribution during the growing seasons give place to a wide range of climatic hazards" (Klingele 1998).

main production areas for this mild narcotic drug which is consumed widely in Ethiopia as well as the neighbouring countries of Somalia and Djibouti (CSA, IFPRI et al. 2006). Given the lower agricultural potential and the dominance of subsistence agriculture, modern inputs are less widely available or applied.[10] With 1.6 ha on average, farm size in West Hararghe is significantly smaller than in East Shewa (2.3 ha) and also below national average of 1.81 ha (FAO 2017).[11]

A substantial share use the income from chat production and additional income generating activities to buy food during the rainy season and cover food shortages, even when not affected by drought (Berhane, Hoddinott et al. 2013). Both districts covered by the third paper have been primary intervention areas for the Productive Safety Net Programme for chronically food insecure households since it started in 2005 (FAO 2011, Van Domelen, Coll-Black 2012).

The doctoral research conducted in two pronouncedly different settings in the same Ethiopian region, illustrates how much knowledge and understanding of the local context matters for academic research as well as for policy interventions. The study sites capture some aspects of diversity in Ethiopian agriculture and agricultural livelihoods. Although this is not a comparative study, investigating access to seed, agrobiodiversity and risk in settings with high and low levels of market integration, under more or less favourable climatic conditions and with different levels of external intervention allows this thesis to speak to wider range of challenges in rural development.

4. Social science & agricultural development

The study of agriculture is inherently multidisciplinary as agricultural production is a physical process, studied in the realm of natural sciences, most notably in agronomy and increasingly in agroecology. Production, however, is managed on farms, which operate as businesses or, in the context of smallholder agriculture, are conceptualised as rural household economies (Duffy, Guertal et al. 1997).

a. Social science & study of agriculture

Agricultural production is one of the earliest subjects of study in economics. Early theorists of economics, e.g. Ricardo, Smith or Malthus, discussed theories of the firm, specialisation or prices in agricultural markets. Through the collection of farm statistics in agricultural censuses, early applications of statistics were developed in agricultural economics (Runge 2006).

Agronomists acknowledge the contributions of social scientists to the study of agricultural production. When breeding new crop varieties, for example, agronomists typically define yield

[10]Public breeding efforts for sorghum remain much lower than for wheat and tef (Bachewe, Berhane et al. 2015). This is one explanation for lower adoption rates of improved seeds in this region of Ethiopia

[11]According to national statistics 80% of small farming households cultivate less than 1ha in the densely populated highlands in the Hararghe zones, where 151 to 300 people lived per square kilometer in 2007 compared to national average in the same year of 81 (CSA, IFPRI et al. 2006, World Bank 2017).

only in a biological sense, but are unprepared to assess the profitability or value of an innovation to the agricultural producer (Duffy, Guertal et al. 1997)

The social sciences offer concepts and methods to analyse behaviour, decision-making, including resource allocation as well as institutions, all of which are central to the study of agri*culture*. Agricultural economics in particular has contributed to the study of "market expectations, behaviour under uncertainty, multimarket relationships for both products and factors, (…) technology adoption, public goods and property issues" (Gardner, Rausser 2001).

b. Challenges of interdisciplinary agricultural research

The rationale for agricultural research across disciplinary boundaries is intuitive and convincing. Based on extensive experience with cross-disciplinary research in rural development, Lowe (2006) argues that natural scientists often operate with simplistic conceptions of sociology or economics. Social scientists, on the other hand, often employ naïve models of environmental and technological systems.

Within the social sciences several disciplines have studied small-farming households with vastly different methodological and conceptual approaches, among them rural sociology, anthropology, political economy as well as development and agricultural economics. These strands of research are founded on distinct epistemological and ontological assumptions, i.e. accounts of knowledge and reality as well as varying behavioural assumptions. A prominent example, in which these differences were more explicitly discussed than usual, is the debate between Scott (1976) and Popkin (1979) on the rationale of social organisation in poor, rural communities. Disciplinary barriers can therefore be more pronounced between disciplines and research traditions *within* the social sciences than between natural sciences and social science disciplines with a positivist epistemology, especially economics (Lowe, Phillipson et al. 2013).

Over the past two decades, a growing interest and popularity of mixed method approaches could be observed, which also inspired the methodological approach of one of the papers in this thesis (Barrett 2001, Kanbur 2001, Ravallion 2001).

Nevertheless, the barriers for truly interdisciplinary research remain very high due to fundamental epistemological and (consequently) methodological differences between and partly even within disciplines (Kanbur, Shaffer 2007, Lowe, Phillipson et al. 2013).[12] Interdisciplinarity, as opposed to

[12] To name just two examples of differences in foundational assumptions: sociology (similar to political science or international relations) is divided along epistemological lines into a hermeneutic-interpretative or constructivist (using primarily qualitative methods) and a (post-) positivist camp, employing mainly quantitative methodology. The increasing popularity of behavioural economics and consequently the rise of behavioural experiments can be interpreted as a foundational divide around behavioural assumptions in the discipline.

multi- or cross-disciplinarity, requires a dialogue of knowledge claims and disciplinary conventions (Lowe, Phillipson 2006). Therefore, research across disciplines in development studies or agricultural development is typically not interdisciplinary in a strict sense (Clark 2006). (Lowe, Phillipson et al. 2013)

The areas of research in this thesis are characterised by salient disciplinary differences. One example are the different approaches of ecology and economics to the study of agrobiodiversity in the first paper. Another example is the analysis of social institutions and cooperation (third paper) in anthropology and social-constructivist institutionalism on one side and in rationalist institutionalism and economics on the other. The respective literatures and concepts are discussed and considered in the papers, but the differences can ultimately not be bridged.

This thesis is explicitly based on an (post-)positivist (thus empiricist) epistemology and ontology. We also assume methodological individualism. Other behavioural assumptions can generally be described as rationalist.[13] In summary, while explicitly set in the foundational framework of economics, his thesis aspires to comprehensively consider the contributions made by different disciplines to the study subjects, without claiming to be fully interdisciplinary.

c. Choice of methods

Concerning the choice of methods within this general framework, it must be emphasised that the three research papers are stand-alone research projects with different target audiences, datasets and different methodological approaches.

The first two papers, which are set in East Shewa, are based on an original survey of more than 400 small farming households. These papers use quantitative methods, i.e. multivariate methods and summary statistics in a descriptive way. Additionally, some limited qualitative evidence is used as background information. The author of this thesis was the principal investigator for the second round of data collection in 2013, whereas the first round of panel data was collected in 2011 by a PhD student at Cambridge University in cooperation and funded by Bioversity International.

More precisely, the first paper analyses aggregate patterns of agrobiodiversity, which requires a primarily quantitative approach. Some qualitative evidence is presented selectively for the interpretation of observed patterns. In the second paper, some fully structured qualitative questions (developed in semi-structured pilot interviews) are used to generate hypotheses concerning farmers' responses to crop disease. Quantitative methods are most appropriate to assess actual changes in agricultural production across households.

[13]Further meta-theoretical considerations concerning the classification of behavioural assumptions of the models this thesis draws on as thinly or thickly rationalist are beyond the scope of this research (for a detailed discussion see Lehtinen, Kuorikoski 2007).

The third paper, set in West Hararghe, uses a mixed methods approach presenting descriptive summary statistics alongside extensive qualitative evidence (N=146) to conduct an institutional analysis. To analyse the elaborate practice of mutual seed assistance comprehensively, a mixed method approach was chosen to capture systematically quantifiable aspects (e.g. joint membership of donor and recipient in informal social networks) as well as not (reliably) quantifiable aspects, such as conditions for assistance. As discussed above, the datasets from the two study regions are distinct, but some relevant aspects are analysed in a comparative perspective in the conclusion to this thesis.

5. Research and international development

The research presented in this thesis was not only conducted at a department of international development, but it is also motivated by an interest and by the aim to contribute international development in a modest way. Development studies and development economics as (sub-) disciplines have, even when based on an empiricist account of knowledge, have an explicitly normative agenda (Loxley 2004, Clark 2006). This illustrates a commitment to applied research, which also characterises agricultural economics from its onset as an applied discipline with an agenda of providing service to the agricultural sector (Duffy, Guertal et al. 1997, Runge 2006).

Consequently, we will discuss possible implications of the research presented here for policy making in the conclusion to this thesis. Food security is one of the policy areas this thesis aims to contribute to through a better knowledge base and more nuanced understanding of seed provision. Better access to locally suitable, improved seed is widely acknowledged as a way to increase agricultural productivity and food security in semi-subsistence households (Rosegrant, Cline 2003, FAO 2014, Zeigler 2014)

This research is also of some relevance to the discussion of adaptation to climate change by small farmers. To name just one aspect, access to diverse plant genetic resources is seen as a basis for resilient cropping systems with a high adaptive capacity (FAO 2010, Jackson, Ford-Lloyd et al. 2014). In this context, it will also be necessary to address an issue that pervades current debates around these policy areas, namely, the question to what extent enhancing resilience and productivity in smallholder agriculture are complementary or conflicting goals.

All papers in this thesis are part of a large body of micro development studies investigating institutional and market failures in rural household economy (Dercon, Gollin 2014). Reflections on the policy implications of this research must be made in the awareness that these kinds of studies are ill-suited to contribute to a larger debate on the role of (smallholder) agriculture for poverty reduction, economic development (Pingali 2010, Christiaensen, Demery et al. 2011, Collier, Dercon 2013, Dercon, Gollin 2014).

Diversity beyond Risk Management. Patterns of Agrobiodiversity in Eastern Ethiopia

ABSTRACT

The diversification of the crop and varietal portfolio by small-farming households is commonly understood as a risk spreading mechanism or a natural insurance. However, this study of agrobiodiversity in the central highlands of Eastern Ethiopia, based on original panel data collected in 2011 and 2013, shows that the least vulnerable households grow a larger portfolio of crops and wheat varieties. This is consistent with the literature which identifies diversification as only one among several strategies for risk management. In a context of comparatively favourable farming conditions and high market integration, transaction costs and missing food markets for secondary crops offer far more plausible explanations for the observed patterns in crop and wheat diversity. We observe that relatively land abundant and well-off households add secondary cereals, like barley and maize, as well as legumes, such as haricot beans, to the standard portfolio mainly for home consumption. This study calls for a more differentiated analysis of the conditions under which crop portfolio diversification is the best and preferred strategy for risk management in rural household economies with limited market access.

INTRODUCTION

Crop genetic resources are essential for agricultural production and food security. However, the loss of diversity in plant genetic resources for food and agriculture (PGRFA) is substantial (FAO 2010). Genetic diversity of cultivated plants and their wild relatives is the basis for present and future plant breeding and crop development (Evenson, Gollin et al. 1998). Access to diverse germplasm allows farmers and plant breeders to develop and multiply varieties of major food crops which are resistant to crop disease, adapted to heterogeneous environments as well as to changing climatic conditions (Thrupp 1998).

Especially the global centres of crop origin and diversity, including the Abyssinian or Ethiopian centre, have long been recognized as pools of plant genetic resources for crop improvement (Vavilov 1951). By cultivating traditional varieties or landraces in these diversity hotspots farmers conserve genetic traits which are not only a resource for them to adapt to changing production conditions, but also a public good, if an impure one (Smale 2006b). The conservation of crop genetic resources *in situ* or on farms in response to genetic erosion has emerged as a paradigm in

the conservation literature and policy debate (Bellon 2004, Jackson, Pascual et al. 2007). Even if the costs and benefits of this form of conservation compared to *ex situ* germplasm collections in gene banks continue to be a subject of debate (Wood, Lenne´ 1997, Evenson, Gollin et al. 1998, Lenné, Wood 2011a).

On-farm conservation of crop-genetic resources in the centres of diversity is widely considered an important complementary response to the loss of agrobiodiversity. Promoting and strengthening on-farm conservation, however, requires a thorough understanding of which households diversify their crop and variety portfolio and why, within and across communities. Recent econometric analyses of cereal and crop genetic diversity argued strongly for a risk management or insurance rationale as the essential driver of on-farm diversity (Baumgärtner, Quaas 2010, Bezabih, Sarr 2012, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2009, Di Falco, Bezabih et al. 2010). This study of patterns of crop and varietal diversity in wheat in the Ethiopian highlands yields very limited evidence to support the idea that small farmers primarily diversify their crop and variety portfolio to spread production risk.

This study argues for high fixed transaction costs, missing food markets and land availability as the main incentives for cultivating a diverse portfolio. We find that crop and varietal diversification is a production strategy of comparatively well-off households with larger land and livestock holdings and without immediate access to food markets. One important implication of this research for on-farm conservation is that not the most vulnerable farmers, but small farmers with limited market access and sufficient land have higher incentives to maintain crop and varietal diversity.

Defined in a holistic sense, agrobiodiversity encompasses “all aspects of biological diversity in areas of agricultural land use” from the diversity of soil organisms to animal and crop genetic resources (Stocking, Kaihura et al. 2003, p.5). In this study, we focus on agrobiodiversity much more narrowly as the diversity of cultivated food crops and cultivated crop varieties or inter- and intraspecific diversity (Bellon 1996).

With this study of patterns of agrobiodiversity in the highlands of South-Eastern Ethiopia, we aim to contribute to a deeper understanding of factors of variation in diversity levels as well as of farmers’ incentives to cultivate a diverse portfolio of food crops and wheat varieties. We present findings from empirical analysis of original survey data and engage them with the literature.

This study contributes to both the academic and policy debate, firstly, by presenting findings of a panel analysis of varietal diversity in wheat, allowing for a more precise and less biased estimation of model coefficients and effects. This analysis is complemented by cross-section models of wheat

and food crop diversity using different diversity measures, which allows to assess the robustness of estimated effects across different specifications.

Secondly, the survey instrument was designed to guarantee an accurate measurement of wheat diversity, including extensive qualitative pre-tests to identify an exhaustive list of variety names and characteristics.

Thirdly, this study uses an elaborate composite measure of relative household wealth. Claims on the patterns of agrobiodiversity related resource endowments are consequently much better substantiated than in previous empirical work, relying largely on livestock indicators.

Fourthly, the analysis of patterns of crop and varietal diversity is extended to the Eastern part of the Central Ethiopian highlands in Oromiya regional state. This region differs in significant ways to the well-researched Northern regions of the highlands in Amhara and Tigray (e.g. with respect to market penetration or agro-ecological conditions). Moreover, the region is the centre of domestication and diversity of wheat and barley. Over the past two decades, considerable efforts have been undertaken to conserve agrobiodiversity *in situ* in this region, which is severely affected by genetic erosion. Thus, the findings are extremely relevant for future policy interventions.

Fifthly, we introduce measures for household participation in social networks into models of agrobiodiversity. These models were found to be significant for accessing plant genetic resources in related research in the region (Cavatassi, Lipper et al. 2011), but were not included in previous studies of agrobiodiversity in Ethiopia and beyond.

Finally, this study provides a comprehensive review of the literature on incentives for cultivating inter- and intraspecific diversity from different disciplinary backgrounds. Recent developments and conceptual advances in the field were not captured by previous reviews of this literature, which focused heavily on intraspecific diversity (Bellon 2004, Brush 2004). Specifically, the recently increasingly dominant agrobiodiversity for risk management hypothesis is discussed critically in light of the empirical findings.

In the following section, previous research on agrobiodiversity for on-farm conservation is systematically reviewed. We then introduce data sources and describe the economic, geographical and agricultural environment in which the study is set. Subsequently, research questions and the empirical strategy are presented. The results of the analysis are then discussed in the context of previous research on patterns of agrobiodiversity.

LITERATURE REVIEW

The last systematic and cross-disciplinary reviews of the literature in this vibrant and dynamic field of research have been conducted over a decade ago and focus heavily on diversity within, rather than across food crops (Brush 2004). Therefore, we attempt to provide a comprehensive literature review, starting with a description of the evolution of this literature and recent developments in the study of agrobiodiversity in the first section. In the second part, we systematically summarise research on different reasons for crop and varietal portfolio diversification.

1. Research for *in situ* conservation of agrobiodiversity

With the mandate of the Convention on Biological Diversity (CBD) in 1992 for on-farm or *in situ* conservation of agrobiodiversity, a wave of new empirical research emerges. These studies investigate patterns of cultivation of diverse crop varieties (e.g. Brush, Taylor et al. 1992, Bellon 1996), varietal choice (e.g. Smale, Bellon et al. 2001, Kruzich, Meng 2006) as well as strategies for the conservation of plant genetic resources on farms (e.g. Brush 1995, Bellon 2004, Jackson, Pascual et al. 2007). This rich body of literature on inter- and intraspecific diversity varies considerably in terms of the specific questions asked and the methodology applied, with disciplinary roots in ecology, conservation biology, anthropology, agronomy, geography as well as agricultural and development economics. More recently, the relationship between agrobiodiversity and climate change has become an increasingly important area and motivation of research in the field (Berry 2009, Baumgärtner, Quaas 2010, Jackson, Ford-Lloyd et al. 2014).

a. Analysis of varietal choice of small-farming households

One stream of studies investigates questions of varietal choice, i.e. an analysis of households' reasons and considerations for growing particular crop varieties (Brush 1992, Bellon 1996, Smale, Aguirre 1998, Smale, Bellon et al. 2001, Hintze, Renkow et al. 2003, Lacy, Cleveland et al. 2006, Edmeades, Phaneuf et al. 2008).

Understanding patterns and factors of landrace cultivation

Motivated by an interest in conserving germplasm diversity this research focuses especially on traditional varieties or landraces in their natural habitat or centres of crop diversity and domestication (Vavilov 1951).

Improved varieties typically have higher yield potential than traditional varieties, but are genetically more uniform. The process of replacement of a genetically variable and diverse set of crop landraces by a few modern varieties is called genetic erosion (Harlan 1975). While agricultural intensification - including introduction of modern crop varieties – as well as market integration are commonly understood as causes of genetic erosion, empirical evidence on the relationship is

complex (Wood, Lenne´ 1997). For example, tetraploid wheat landraces have disappeared and the ability to recall names of traditional varieties considerably decreased in some areas of the Ethiopian centre of diversity (Tsegaye, Berg 2007a). In Mexico, on the other hand, modern varieties are cultivated alongside traditional varieties in the case of maize (Van Heerwaarden, Van Eeuwijk et al. 2009).[14]

As established students of agrobiodiversity, Smale, Bellon et al. state that "[f]armers incentives to grow landraces are not well understood" (2001, p.201). This understanding, however, is essential for designing interventions to conserve landraces, i.e. genetic diversity, on-farm. Analyses of variety attributes and household characteristics associated with *de facto* landrace cultivation were consequently conducted in centres of origin for maize in Mexico (e.g. Smale, Bellon et al. 2001, Bellon, Hellin 2011), for potatoes in the Andes (e.g. Brush, Kesseli et al. 1995), for wheat in Turkey (e.g. Kruzich, Meng 2006) and for rice in Nepal (e.g. Wilby, Thomas 2007, Rijal 2010).

Adoption of modern varieties

Albeit often with a different angle and motivation, development economists have previously problematized the limited spread of modern crop varieties in a number developing country contexts (Smale M., Heisey P.W. et al. 1995, Hintze, Renkow et al. 2003, Feleke, Zegeye 2006, Wubeneh, Sanders 2006, Langyintuo, Mungoma 2008, Shiferaw, Kebede et al. 2008, Cavatassi, Lipper et al. 2011, Shiferaw, Kassie et al. 2014, Khonje, Manda et al. 2015).[15] Theses analyses are largely based on the conceptual framework of partial adoption of agricultural technologies (Feder, Just et al. 1985, Feder, Umali 1993, Doss 2006). Whereas research from the conservation angle asks why farmers cultivate landraces alongside modern varieties, the adoption literature aims to explain why many farmers continue to grow local or farmers' varieties instead of new varieties with higher yield potential. What relates the two literatures, however, is modelling (and subsequently the econometric specification) of varietal choice as a dichotomous decision of the household (1) to adopt modern varieties or (2) to cultivate landraces (Edmeades, Phaneuf et al. 2008). This conceptual approach is different to analyses of agrobiodiversity comparing land use choices, e.g. by using area-based diversity measures (see more below).

Varietal and agricultural portfolio choice

Reasons to grow a particular crop variety on the one hand and to maintain a certain set of varieties and crops on the other are closely linked and not always easy to separate. Varietal choice, defined as "[t]he decision of a farmer to maintain, incorporate or discard a variety from his/her repertoire

[14]A comprehensive discussion of literature on genetic erosion is beyond the scope of this paper. The selected references are used to illustrate the issue selectively.
[15]Only a small selection of studies analyzing the adoption of improved varieties is mentioned here. A full discussion of this literature is beyond the scope of the literature review.

of varieties of one crop" (Bellon 1996, p.27), is one element of agricultural portfolio choice of the small-farming household with implications for intraspecific and interspecific diversity.

b. Analysis of patterns of crop and varietal diversity

Beyond the research and policy interest in conserving landraces and thus germplasm, the analysis of agricultural biodiversity more generally is turning into a core area of research and policy intervention (Brookfield 2001, Brookfield 2002, Brookfield, Parsons et al. 2003, Kaihura, Stocking 2003, Jarvis, Padoch et al. 2007). While related research areas such as livestock or soil diversity are discussed elsewhere (e.g. Jarvis, Padoch et al. 2007), we focus on studies analysing the patterns of diversity of crops and crop varieties.

Summarizing factors of varietal diversity

Several attempts have been made to consolidate research efforts and summarize small-farmers' incentives to diversify their varietal portfolio (Bellon 2004, Brush 2004, Lenné, Wood 2011b). In his landmark book on crop diversity, Brush concludes that while the description and taxonomy of crop diversity and its evolution is elaborate, our understanding of "crop diversity in a dynamic context of environmental and social change [is] poorly developed" (2004, p.38). Brush broadly summarizes the factors for portfolio choice in the categories: (1) environment, (2) risk and (3) use, preference and markets (Brush 2004). In his summary, Bellon argues similarly that the choice of varietal portfolio is driven by "traits to suit specific production conditions, consumption preferences, or marketing requirements" (2004, p.161). In their summary of reasons for the cultivation of varietal diversity, ranging from agronomic to economic and culinary or end use factors, Lenné and Wood critically state that biological reasons for growing diversity have been studied significantly less than socio-economic, religious and culinary reasons (Lenné, Wood 2011b).

Varietal diversity beyond the centres of origin

While early research was strongly motivated by *in situ* conservation of diverse germplasm in the centres of crop diversity, more recent studies analysed diversity in areas outside these diversity hotspots (Smale M., Heisey P.W. et al. 1995, Smale, Hartell et al. 1998, Meng, Smale et al. 1999, Lipper, Cavatassi et al. 2012, Zawedde, Harris et al. 2014, Coromaldi, Pallante et al. 2015, Obayelu, Akintunde et al. 2015, Rahman, Chima 2016). These studies investigate hypotheses concerning (1) the relationship between market integration and levels of agrobiodiversity, (2) the use of agrobiodiversity for risk management and (3) productivity and crop diversity in small-farming households in developing countries (see more below).

Including crop diversity into the analysis

A number of more recent studies have extended the analysis of varietal diversity to cereal or food crop diversity at the household level as another aspect of agricultural diversity (Benin, Smale et al. 2004, 2005, Di Falco, Bezabih et al. 2010, Bezabih, Sarr 2012, Lipper, Cavatassi et al. 2012, Pandey 2015, Krishna, Pant et al. 2016, Rahman, Chima 2016). Van Dusen and Taylor (2005) argue that genetic erosion is not only caused by the competition between improved and traditional varieties, but also by competition between staple or traditional and newly introduced crops.

Crop and variety portfolio choice in the agricultural household model

As the study of agrobiodiversity broadened its scope beyond the centres of diversity and from the diversity of crop varieties to food crop diversity, it has also become more diverse in the conceptual and methodological approaches. Described as a "nascent literature" in the 2000s (Van Dusen, Taylor 2005, p.513), the conceptualisation of crop and variety portfolios as diversity outcomes in the agricultural household model has become a standard approach in the study of agrobiodiversity (Meng, Taylor et al. 1998, Benin, Smale et al. 2004, Van Dusen, Taylor 2005, Gebremedhin, Smale et al. 2006, Wilby, Thomas 2007, Di Falco, Bezabih et al. 2010, Bezabih, Sarr 2012, Krishna 2015, Rahman, Chima 2016).

Even if the underlying economic model is often not explicitly discussed, the estimation procedure increasingly follows the above mentioned studies (Isakson 2011, Zawedde, Harris et al. 2014, Obayelu, Akintunde et al. 2015, Rahman, Chima 2016). Whereas qualitative questions on relevant variety attributes or ranking exercises were used to analyse varietal and diversity choice in earlier studies, economic concepts and the econometric analysis have led to the prevailing use of household, market, farm characteristics and agro-ecological conditions as indicators for factors guiding varietal and food crop diversification.

Gauchan and Smale (2007) attempt a systematic comparison of the results of their analysis of rice diversity to other studies with a similar conceptual approach. The comparison suggests that findings across different contexts – in terms of the direction of the effect and the statistical significance - are not very robust. Although similar reasons to grow diversity have been identified across the literature and across regions, findings suggest that the determinants of portfolio choice and diversity outcomes remain very context specific.

2. Reasons for the diversification of the crop and varietal portfolio

Having reviewed the broad themes, motivations and developments in the study of patterns of inter- and intra-specific diversity, we now summarise arguments, studies and research findings related to specific reasons to diversify the crop and varietal portfolio. In particular, we review studies analysing (1) environmental/agro-ecological diversity, (2) risk management & agro-

ecosystem stability, (3) markets, (4) preferences, culture and social value and (5) productivity enhancement as factors of diversification.

a. *Agro-ecological & environmental diversity*

The argument that agrobiodiversity has evolved and is used as a response to agro-ecological diversity, i.e. varying topographic, soil and climatic conditions, is intuitive and well-established.

Regional level

Some of the cradles and hotspots of agrobiodiversity, such as Nepal, the Andes and the Ethiopian rift valley are characterized by exceptional agro-ecological heterogeneity due to the specific topography of mountain environments.[16] Regional analysis is particularly relevant to identify "eco-environmental clusters", i.e. which varieties and crops are cultivated in particular environments characterized by altitude, latitude and moisture (Brush 2004, p.87).

The relationship between environmental heterogeneity and agrobiodiversity has been analysed by comparing levels of diversity across different locations within one region or country at the village or regional level, as opposed to the household as the more common unit of analysis (Aguirre Gomez, Bellon et al. 2000, Gebremedhin, Smale et al. 2006, Orozco-Ramírez, Ross-Ibarra et al. 2016). Regional differences in infrastructure and market access, altitude and precipitation levels as well as in cultural factors complicate the systematic interpretation of regional differences (Aguirre Gomez, Bellon et al. 2000, Krishna, Pant et al. 2016). In their analysis of maize diversity in four Mexican communities in two agro-ecological zones and with two different majority populations, Orozco-Ramírez et al. (2016) aim to separate the environmental from the cultural effect on maize diversity.

In a multi-variate village-level analysis of inter- and intra-crop diversity in the Amhara and Tigray regions of Ethiopia, Gebremedhin et al. (2006) find a positive effect of altitude range within the village on wheat and maize diversity. Other indicators for environmental heterogeneity typically measured on a district or regional level (especially rainfall levels and variability and to a lesser extend soil types), however, are commonly used to measure risk exposure (see next section).

Household level: Diverse farming environments

At the household level, studies have captured the heterogeneity of farming environments using indicators for farm fragmentation, i.e. the number of and walking distance to plots, differences in fertility, soil type (often based on the colour of the soil) and slope of plots cultivated by one

[16]The concentration, i.e. the uneven spatial distribution and concentration of genetic diversity in certain areas of the world has long been an topic of research, but is not further discussed here (Vavilov 1951, Brush 2004).

household (Smale, Aguirre 1998, Benin, Smale et al. 2004, Van Dusen, Taylor 2005, Kruzich, Meng 2006, Di Falco, Chavas et al. 2007, Wilby, Thomas 2007, Di Falco, Chavas 2009, Cavatassi, Lipper et al. 2011, Isakson 2011, Velásquez-Milla, Casas et al. 2011, Bangwayo-Skeete, Bezabih et al. 2012, Chavas, Di Falco 2012a, Takeshima, Nagarajan 2012).

Similar to regional analysis, the use of irrigation and shares of fragmented, sloped, degraded or infertile land at the household level are not only indicating heterogeneity of farming conditions, but are also used as indicators for households' risk exposure.[17]

b. *Risk management & stability*

The argument that small-farmers maintain a diverse portfolio of food crops and crop varieties as a way to cope with the risk of agricultural production related to a range of biotic and abiotic stresses over time is widely recognized. More recently, the argument is gaining particular prominence in empirical studies in ecological and development economics.

Stability & resilience of diverse agro-ecosystems

From the ecological perspective, agrobiodiversity is seen to contribute to the stability and resilience of agricultural systems in the long run (Tripp 1996, Gaudin, Tolhurst et al. 2015). Even if the relationship between ecosystem diversity and stability remains a subject of debate (Kevin 2000, Hooper, Chapin III et al. 2005). In this context, stability is understood primarily as stability of yield over time (Tripp 1996).[18] Resilience in this context is understood as the "capacity [of the agroecosystem] to recover from disruptions of functions" (Jackson, Pascual et al. 2007).

As one factor of yield stability, increased resilience to crop pests and diseases is an important ecosystem services provided by agrobiodiversity, especially in low-input agriculture (Jarvis, Brown et al. 2007, Wilby, Thomas 2007).[19] In a review of empirical literature, Lenné and Wood (2011b) find evidence for lower disease severity when a diverse portfolio of crop varieties is cultivated on farm.

[17]Some studies found a positive association between farm fragmentation (often measured as the number of plots operated by the household) and biodiversity (Benin, Smale et al. 2004, Van Dusen, Taylor 2005). These studies interpret this finding as a use of diversity in repose to heterogeneous faming conditions on different plots.

[18]The previous section discusses yield stability over different environments, which is another aspect of agroecosystem stability.

[19]We refer here to different dimensions of agrobiodiversity. From the perspective of pest management, species diversity is known to contribute to resilience to pests (Wilby, Thomas 2007). In the case of disease management, genetic diversity of crops is seen as a more important factor of resilient low- input cropping systems (Jarvis, Brown et al. 2007).

The risk management rationale

Economists discuss related questions in the framework of small farmers' decision making – or, more specifically, of risk management - in a context of missing markets.

Different crops and crop varieties respond differently to abiotic stresses and shocks like drought, flooding or frost as well as to biotic stresses such as pests or diseases. To minimize production risk, the household grows a variety of crops - or several varieties of one staple crop - rather than specializing in the most productive ones. The household intends to reduce the fluctuation of or smooth output over time, thus mitigating the risk of total loss of harvest. Hence, agrobiodiversity is understood as a form of natural insurance in the absence of formal insurance and credit markets (Baumgärtner, Quaas 2010).

Empirical studies on the agrobiodiversity for risk management hypothesis

Recent econometric analyses of agrobiodiversity argued strongly for a risk management or natural insurance rationale as the essential driver of on-farm diversity (Di Falco, Chavas 2006, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2008, Di Falco, Chavas 2009, Di Falco, Bezabih et al. 2010, Bangwayo-Skeete, Bezabih et al. 2012, Bezabih, Falco 2012, Bezabih, Sarr 2012, Coromaldi, Pallante et al. 2015, Krishna, Pant et al. 2016).

A number of these empirical studies investigate the effect of agrobiodiversity on the variability of agricultural production across households and over time as an indicator of yield stability (Smale, Hartell et al. 1998, Widawsky, Rozelle 1998, Di Falco, Chavas 2006, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2008, Di Falco, Chavas 2009, Di Falco, Bezabih et al. 2010, Bangwayo-Skeete, Bezabih et al. 2012). Ecologists have repeatedly investigated the effect of species and genetic diversity on biomass production in experimental settings (Tilman 1999a, Tilman, Isbell et al. 2014). Transferring this approach to non-experimental settings, however, is problematic, especially when only cross-sectional data is available. Agrobiodiversity is treated as an input in the production function of the small farming household. Beyond problems related to small sample size, this empirical literature suffers from severe endogeneity bias, which is often not fully addressed.[20] Even if a number of these studies find downside risk or variability reducing effects of agrobiodiversity, they are not suited to show that small farmers strategically use agrobiodiversity to benefit from these effects.

A conceptually different and less problematic approach is the multivariate analysis of patterns of agrobiodiversity with a particular focus on indicators of risk exposure (and attitude). If the main

[20]See the discussion on productivity enhancing effects of agrobiodiversity for a more detailed conceptual critique of these models.

incentive for small farmers to grow a diverse portfolio of crops and crop varieties is to spread risk, we would expect variations in crop diversity to be significantly and positively related to variations in attitudes and exposure to risk.

Rainfall variability is typically used as a measure of exposure to co-variate risk for small-farming households (Dercon 2005b, Dercon, Christiaensen 2011). Two studies in the Ethiopian context combine rainfall with survey data and report positive effects of mean rainfall levels, but not variability, on crop diversity (Di Falco, Chavas 2009, Bezabih, Sarr 2012).

Beyond weather uncertainty, the level of degradation of farm land, fertility levels as well as plot slope are used as indicators of household-level risk exposure. Evidence from previous research tentatively suggests that households with more degraded and less fertile land diversify their crop portfolio more.[21]

Risk attitudes are much more difficult to measure or to approximate. Bezabih and Sarr (2012) attempt to capture risk attitudes directly, but cannot find conclusive evidence of the role of risk aversion in explaining crop diversity. Within a given community with similar agro-ecological conditions, and thus similar co-variate risks, we expect the relatively poor to be more risk averse and less able to use savings or assets to cope with the consequences of income shocks. Accordingly, Van Dusen and Taylor see “the level of household wealth, [as] a proxy for risk aversion, [and] exposure to risk” (2005, p.522). Similarly, Bezabih and Sarr argue that "farmers are more reluctant to engage in risky behaviour the lower their wealth levels” (2012, p.502).

Benin et al. (2004) as well as Bezabih and Sarr (2012) find that holdings of oxen or tropical livestock units respectively have significantly positive effects on crop diversity. Moreover, all studies in the region find land or farm size to be positively related to crop or varietal diversity (Benin, Smale et al. 2004, Di Falco, Bezabih et al. 2010, Bezabih, Sarr 2012). Benin et al. conclude that “those that are better off in land, labour, and livestock tend to maintain more crops and more varieties” (2004).

Contestations from development economics

Already during the 1980s, development economists studied aspects of household decision-making of small farmers in risk-prone settings from the adoption of agricultural technologies to marriage

[21]Findings on the sign and significance of these household level indicators are not consistent across different studies even in similar contexts. Of the studies reviewed, only Van Dusen and Taylor (2005) find a positive, significant association of multiple slopes with diversity in the milpa system. Bezabih and Sarr (2012) find a positive association between the number of infertile plots and crop diversity, whereas studies of cereal diversity in a similar context find mixed results only for diversity within certain crops (Benin, Smale et al. 2004, Gebremedhin, Smale et al. 2006). A number of studies suggest a positive relationship between erosion or land degradation and cereal or varietal diversity for specific crops (Benin, Smale et al. 2004 (for maize only), Gebremedhin, Smale et al. 2006, Di Falco, Chavas et al. 2007).

(Feder, Just et al. 1985, Rosenzweig, Stark 1989). In the 1990s, these insights were gathered in a common framework of understanding of (a) risk management and coping or (b) consumption and income smoothing in environments characterized by high environmental, economic, policy and idiosyncratic risks as well as missing credit and insurance markets (Alderman, Paxston 1992, Morduch 1995, Fafchamps 1999b, Dercon 2005b).

The conceptual distinction between ex ante and ex post strategies is particularly relevant for portfolio diversification. Ex ante, the household manages its exposure to risk by reducing the variability of income, often at the cost of lower return. Ex post, the household copes with the consequences of an income shock through the strategic allocation of scarce resources, the use of pre-cautionary savings or informal insurance mechanisms (Fafchamps 1999b, Dercon 2005b).

Diversifying the portfolio of crops and crop varieties grown by a household is identified as one ex-ante strategy among other options the household has to reduce exposure to risk (Fafchamps 1999b).

However, a number of other ex ante strategies for smoothing household income are discussed in the literature. Rural households also commonly diversify sources of income, which includes off-farm employment or business as well as different income-generating activities on the farm (Dercon, Krishnan 1996). Furthermore, households may choose to have several smaller plots in different locations rather than one large plot as a way to spread risk (Alderman, Paxston 1992, Morduch 1995). Intercropping is also commonly practiced as a diversification strategy (Fafchamps 1999b).

This brief discussion of the broader development economics literature on risk management of small-farmers suggests that agrobiodiversity may not always be the preferred and best strategy diversify household income or to mitigate the risk of agricultural production.

In a similar line of argument, Dercon and Krishnan (1996), in their analysis of income portfolios in rural Ethiopia and Tanzania, acknowledge the strong theoretical arguments for risk attitudes as drivers of income portfolio diversification. However, the study comes to the conclusion that other factors, such as entry constraints for certain income-generating activities, offer better explanations for variations in income diversification.

Contestations from the conservation literature

Similarly, a number of students of agrobiodiversity conservation argue that the functional value of diversity for coping with agricultural risks may be more of a “received wisdom” than a well substantiated fact (Wood, Lenné 2005, Jackson, Pascual et al. 2007). Brush describes a development in the literature from a diverse set of competing explanations to “crop diversity in

farmers' risk management strategies (…) as a primary explanation for the persistence of diversity"(Brush 2004, p.257).

c. *Markets*

While hypotheses on the relationship between environmental heterogeneity as well as agricultural risk and diversity are explicitly formulated, the debate around the role of input and output markets for agrobiodiversity is a much more contested. Does market integration accelerate genetic erosion or do markets provide incentives and opportunities for the conservation of landraces and marginal crops?

Market integration & loss of genetic diversity

It is a well-established narrative that genetic diversity of cultivated crops is best preserved in marginal environments with subsistence agriculture, in which the household produces mainly for home consumption and seed sourcing through the formal seed system and access to modern varieties is limited (Fafchamps 1992a, Brush 2004).[22] Access to input and output markets is perceived to foster specialization on high-value crops or varieties with higher yield potential, leading to the erosion of genetic diversity on farm. In line with this hypothesis, several studies have found a significant, positive relationship between distance to the next market and the cultivation of a diverse portfolio of food crops or crop varieties in Mexico, Peru and Ethiopia (Van Dusen, Taylor 2005, Winters, Hintze et al. 2005, Lipper, Cavatassi et al. 2012). Similarly, Isakson (2011) finds that Guatemalan small farmers who do not participate in output markets, have a significantly higher maize diversity than farmers selling a share of their harvest.

Transaction costs & failed markets

Distance to the next local market is commonly used as an indicator of the costs of transportation and information involved in participating in markets. The higher the cost of a household to access markets to sell output or to buy crops for consumption or to purchase inputs such as fertilizer and seeds, the more likely it is to produce for self-provision and thus to maintain a more diverse portfolio. When transaction costs are sufficiently high, a household may remain autarkic, in which case production and consumption decisions of small-farming households are not separable (de Janvry, Fafchamps et al. 1991, Omamo 1998a, Omamo 1998b, Key, Sadoulet et al. 2000, Renkow, Hallstrom et al. 2004).

[22]Whereas Brush (2004) reviews and criticizes the literature on poverty/ marginal agriculture and diversity (see especially pp. 260 -269 & pp. 48-53), Fafchamps (1992a) develops a theoretical model for crop portfolio choice by which he can show how small farmers grow a more diverse crop portfolio for self-provision even in the presence of food markets due to food price risk.

As argued by a number of studies, in a context of missing markets, diverse agricultural products are produced on farm, rather than purchased on food markets to satisfy household demand for dietary diversity or certain culinary purposes (Van Dusen, Taylor 2005, Isakson 2011).

Self-provisioning/Production of food or subsistence crops

A number of recent studies, however, have suggested that self-provisioning, i.e. primarily growing food or subsistence crops for home consumption instead of cash crops for sale, is a relevant factor for maintaining a diverse varietal or crop portfolio even for households in close proximity to markets (Arslan 2011, Hoffmann, Gatobu 2014, Krishna, Pant et al. 2016). This is consistent particularly with studies on maize diversity in the Mexican centre of diversity suggesting that landraces are cultivated alongside improved modern varieties and varietal diversity is maintained even in areas with very favourable market access and infrastructure (Brush, Tadesse et al. 2003, Perales R., Brush et al. 2003, Brush 2004, Bellon, Hellin 2011).

Niche market opportunities

Recent studies on the role of market integration for the cultivation of traditional varieties have challenged the view of landrace cultivation as a low-return, “safety-first” strategy (Scott 1976). This research highlights niche market opportunities for traditional varieties which achieved premium prices on local markets (Keleman, Rañó et al. 2009, Hellin, Dixon et al. 2011, Keleman, Hellin et al. 2013).

This is echoed by findings from Sub-Sahara Africa. In Chad, households’ market participation is related to an increased probability to cultivate of underutilized crops like minor millets (Takeshima, Nagarajan 2012). Participation in output markets in Kenya is suggested have a positive effect on pigeon pea diversity (Lipper, Cavatassi et al. 2012). The analysis of patterns of market participation suggests that households producing for the market have a significantly better food security status than non-participants, confirming the well-established hypothesis that “only wealthier farmers are willing and able to grow cash crops” in a context of high food price risk (Fafchamps 1992a, p.90).

It is important to note that studies identifying niche market and thus premium price opportunities, differ significantly from the dominant understanding of traditional variety or marginal crop cultivation as a low return strategy, involving opportunity costs compared to specialization scenario (Wale 2008).

d. *Preferences, social values & culture*

The role of dietary preferences, cultural and culinary factors for growing a certain set of crops and varieties seems intuitively relevant.

Dietary preferences & portfolio choice from the utilitarian perspective

From a utilitarian perspective, assuming fully functional food markets, we would expect small farmers to optimize their crop and varietal portfolio, specialising on the production of cash crops and varieties with high return and buying lower return food crops, which are preferred for consumption.

In a context of market failure, however, in which small-farming households optimize production choice, but households' consumption and production decisions are not (fully) separable, we expect households' consumption preferences (which are also shaped by cultural factors and social norms) to influence portfolio choice (de Janvry, Fafchamps et al. 1991).

In their experiment on maize purchase and sales in western Kenya, Hoffmann and Gatobu (2014) can show how imperfect information on unobservable qualities (taste and contamination with a fungus), i.e. a form of market failure, incentivize self-provision and disincentives small farmers from using of food markets.

Culinary preferences and traditions, thus, have a role in the rational choice model of the small-farming household. Some juxtapose studies based on this model with ethno-ecological research exploring cultural variables in crop choice and perceive them as incompatible (Skarbø 2014). Irrespective of the position in this debate, it remains a methodological challenge to determine the importance of cultural and social norms for agrobiodiversity conservation relative to other factors.

Quality, culinary & consumption preferences

A range of empirical studies on varietal choice emphasise the role of quality, taste and culinary preferences for the cultivation of certain crop varieties: In Nepal, certain rice landraces are cultivated for their superior taste and are used for ritual dishes, hence identifying food tradition as a factor for the conservation rice landraces (Rijal 2010, Krishna, Pant et al. 2016). Taste is also the second most frequently mentioned reason to adopt a new sweet potato variety in Uganda (Zawedde, Harris et al. 2014).

In a detailed study of uses for traditional durum wheat varieties in Ethiopia, Tsegaye and Berg (2007b) show that landraces are used for traditional dishes, for which improved bread wheat varieties are unsuitable. A number of these dishes are specifically served for social occasions emphasizing the social value of traditional varieties. Brush comes to the conclusion that "consumption factors are particularly important in farmer conservation" in his study of landrace cultivation in the Andean potato agriculture (1992, p.161).

Arslan and Taylor (2009) and Aslan (2011) aim to capture the additional, non-market value of traditional maize varieties over improved maize with the concept of shadow prices in a context of missing food markets for these varieties.

Culture & culinary traditions

Brush comprehensively discusses the role of culture as "one element among many forces" in the evolution and conservation diversity of domesticated crops in the three centres of diversity (Brush 2004). A number of gene centres are characterised at once by dietary, geographic, cultural diversity as well as agrobiodiversity. As argued above, culture can play a role in shaping dietary preferences and creating specialized uses and thus demand for certain food crops and landrace varieties. This is discussed by a few recent studies analysing differences in landrace cultivation between ethnic groups and based on cultural variables, such as dress and language (Skarbø 2014, Orozco-Ramírez, Ross-Ibarra et al. 2016).

e. *Productivity enhancement*

One the one hand, the adoption of modern, genetically less diverse, varieties has significantly increased agricultural productivity, even if there are substantial regional variations (Evenson, Gollin 2003). Moreover, it has often been remarked that *de facto* hotspots of global agrobiodiversity, where genetically diverse varieties continue to be cultivated, are often less developed regions of the world, like Nepal, Ethiopia or the Peruvian and Ecuadorian Andes, in terms of human development and economic growth indicators (e.g. Barrett, Travis et al. 2011). This has led to a debate around the link between development, poverty and (agro)biodiversity (Lipton, Longhurst 1985, Barrett, Travis et al. 2011, Palmer, Di Falco 2012).[23]

On the other hand, a fundamental hypothesis of ecology is that more diverse ecosystems are also more productive (Tilman 1999a, Tilman, Isbell et al. 2014). In the case of agricultural systems, large scale field experiments of intercropping of different crops (as opposed to monoculture) in China have confirmed the productivity enhancement hypothesis (Li, He et al. 2009).

The two debates appear to make opposing statements about the returns of diverse crop and varietal portfolios. It is, however, not trivial to compare statements based on the comparative performance of traditional and improved crop varieties to statements about the productivity of ecosystems with high and low functional species diversity.

A number of non-experimental studies have examined the relationship between varietal diversity and crop diversity and productivity using survey data and econometric methodology (Smale,

[23]The debate of the environmentalist paradox, i.e. the fact that increases in human well-being coincide with a loss of biodiversity, is complex and goes far beyond questions of agrobiodiversity and the scope of this paper.

Hartell et al. 1998, Widawsky, Rozelle 1998, Di Falco, Chavas 2006, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2008, Bangwayo-Skeete, Bezabih et al. 2012, Chavas, Di Falco 2012a). Some of these studies find a productivity enhancing effect of diversity for wheat in Italy (Di Falco, Chavas 2006, Di Falco, Chavas 2008), for wheat in Ethiopia (Di Falco, Chavas et al. 2007), for barley in Ethiopia (Di Falco, Chavas 2009) as well as for crop diversity in Ethiopia (Di Falco, Bezabih et al. 2010, Bangwayo-Skeete, Bezabih et al. 2012, Chavas, Di Falco 2012a).

It remains to be determined by further (ideally (quasi-)experimental) research whether these significant, positive statistical effects of agrobiodiversity on productivity can be interpreted as productivity enhancing effects in small farming systems. Classical inputs of agricultural production such as land, labour and oxen as well as environmental factors (such as rainfall or soil type) are exogenous (especially in contexts like Ethiopia with limited land and rural labour markets). Crop and varietal choice, however, is highly endogenous. Even if most studies present endogeneity tests for these econometric models, from the point of view of economic theory and intuition, diversity cannot easily be viewed as an exogenous input factor.

3. Summary

A rich and diverse body of literature developed over the past three decades investigating patterns and incentives for the cultivation of diverse portfolios of food crops and crop varieties.

a. *Approaches from ecology & agricultural economics to agrobiodiversity*

The field is strongly influenced by the two disciplinary traditions of ecology and economics, which have shaped the terminology and the conceptual approaches to agrobiodiversity conservation.

(Agro-)Ecology

The ecosystem perspective on agrobiodiversity stresses the functional values of agricultural diversity, moving far beyond the diversity of food crops and crop varieties. Agricultural biodiversity is understood to support agricultural production, among other things, through nutrient cycling, soil conservation and formation, pest control, pollination and other ecosystem services with direct value to the farmer and the environment (Lenné, Wood 2011b).

Even if the mechanisms are still subject of debate, highly diverse agro-ecosystems are understood to be more stable, resilient and productive (Ceroni, Liu et al. 2010). From the perspective of agro-ecology, agricultural diversification is not only a sustainable, but also a high return strategy, especially in tropical agriculture (Te Pas, Rees 2014).[24]

[24] Here, we refer to the widely accepted hypothesis that organic agriculture (which is inherently more biodiverse) has the same or even higher yield potential than conventional agriculture in the tropics, whereas average productivity of organic agriculture is lower in temperate regions.

(Development & agricultural) Economics

The economic analysis of food crop and varietal diversity is a more recent phenomenon (Meng, Smale et al. 1998). More important than the methodological contribution, is the conceptualisation of crop and varietal portfolios in the framework of optimizing behaviour and rational decision-making in the rural household economy.

The household is the unit at which decisions and actions concerning the conservation of crop genetic diversity are taken and the agro-ecosystem is managed. This provides the framework for an analysis of the relative importance of economic, environmental and social factors influencing diversity choice within and across communities or regions.

In the context of missing or imperfect markets, however, diversification of the crop and variety portfolio as a subsistence strategy - as opposed to the specialisation in an optimal set of high-return crops - is seen as a low return strategy.

b. *Drivers of diversity*

Having reviewed literature investigating incentives and motives for small-farming households to maintain a (genetically) diverse portfolio of crops and/or varieties, we find that they can be summarized in five broad categories: environmental heterogeneity, risk & stability, markets, dietary preferences and productivity enhancement.

More recently, the view of agrobiodiversity as a means to spread risk has become increasingly dominant. Studies using agrobiodiversity as an input of agricultural production of small farming households, find significant effects of crop or varietal diversity on the variance of production or on downside production risks. These non-experimental findings, however, have to be interpreted with caution and are not fully consistent with studies analysing patterns of diversity.

Given the heterogeneity of farming systems and regional contexts, we can neither expect to definitively identify factors driving agrobiodiversity nor their relative importance across different contexts (Lenné, Wood 2011b). Niche market opportunities, environmental conditions, access to markets and agricultural technology, culinary preferences (shaped also by cultural traditions) vary greatly and shape portfolio choice in different ways.

Therefore, we must aim for a more systematic understanding of the circumstances and conditions under which certain incentives guide small farmers' choice of diversity. This understanding is the basis for successfully designing interventions to conserve agrobiodiversity on farm.

In this study, we analyse patterns of variation in inter- and intraspecific diversity in a context of relatively stable farming conditions and a comparatively high degree of market integration in the mid- and highlands of South-East Ethiopia. In this context, we will ask what characterises

households cultivating a diverse portfolio of food crops or crop varieties. Moreover, we will discuss whether observed patterns of agrobiodiversity suggest particular reasons.

STUDY BACKGROUND & DATA

The three study sites are located in *Lome* and *Gumbichu woredas* (disticts), approximately eighty to one hundred kilometres east of the Ethiopian capital Addis Ababa in the East Shewa zone of Oromia regional state. In 2011, 313 households in nine village communities (*gandas*) were surveyed to collect baseline data. In a second survey in May & June 2013, 301 households were re-surveyed and 127 additional households were added to the sample (N=428). Both surveys were conducted in cooperation with the CGIAR centre Bioversity International and the Ethiopian Institute for Biodiversity Conservation.[25] The study sites in midland (*Kokka*), mid-highland (*Ejere*) and highland (*Chefe*) locations were initially chosen to investigate agrobiodiversity, and specifically the cultivation of landraces, under different agro-ecological conditions related to differences in altitude. Random sampling of households within these three sites in 2011 and re-sampling in 2013 was done using complete lists of households provided by local authorities.

1. Agro-ecological conditions & livelihoods

Ethiopia is a low-income country dependent predominantly on rain-fed agricultural production and prone to weather shocks (Dercon 2004). However, Ethiopia is also characterized by a remarkable diversity of geographic and agro-ecological conditions as well as livelihoods (not to mention the ethnic, religious and cultural diversity).[26]

East Shewa zone has a relatively favourable location in terms of the proximity to the capital and the access to road infrastructure as well as the farming conditions. All three sites are located in the moisture reliable cereal production zone with a short (*Belg*) and a longer (*Meher*) rainy and production season (Hurni 1998, Taffesse, Dorosh et al. 2011). The average and median land holdings of 2.25 ha per household in this sample are more than double the national average of 1.05 ha as well as the regional average of 1.15 ha (Nega, Adenew et al. 2003). Land degradation, among other factors due to deforestation and low vegetation cover, is a visible challenge for communities in East Shewa as well as for the rest of the country (Taddese 2001). This explains partly why 14.05 percent of all plots cultivated by households in the sample have low fertility and only 37.7 percent are rated as very fertile. While the majority of farmers rely entirely on seasonal rainfall, almost one quarter (23.8 percent) uses irrigation on at least one of plots cultivated household.

These comparatively advantageous conditions in the Ethiopian context also translate into higher productivity. Compared to the national average of 16.9 quintals per hectare in 2011, farmers in the

[25]The author of this paper was the principal investigator only for the second-round survey. The panel analysis is therefore limited by differences in the questionnaires in both rounds (see below).
[26]For an overview of livelihood zones see (Famine Early Warning Systems Network (FEWS NET) 2009)

sample produce 19.3 quintals of wheat per hectare, i.e. twenty percent above average (Taffesse, Dorosh et al. 2011). Tef, barley and maize outputs are also above national average. Despite the region being well-connected to urban centres, the majority of the population is still deeply dependent on agriculture. Only one third of all households have any form of off-farm income from business, renting out land, off-farm employment, benefits or remittances.[27]

However, due to the land size, productivity and location most households are not exclusively producing for subsistence. Agricultural production can generally be described as "semi-commercialized" (Thijssen, De Boef et al. 2012). Only eleven percent (N=50) of the households in the sample sold none of their crops on the market during the year prior to the survey. Wheat is a staple crop in the area, grown by 95 percent of households and sold by roughly half. The most commercialized crops are lentil and chickpea, which are sold by more than 70 percent of the households growing legumes.

2. Genetic erosion and conservation efforts in a diversity hotspot

The central highlands of Ethiopia are considered one of the centres of diversity for cultivated plants, with a particularly genetic diversity of durum wheat and barley (Engels, Hawkes et al. 1991). Furthermore, the region is well known in the policy and academic community for a pioneering approach to *in situ* conservation of agrobiodiversity through community gene banks (CGBs) implemented with funds of the Global Environmental Facility. These membership-based revolving seed banks - mainly for landrace varieties - operate in two of the three study sites (*Ejere* & *Chefe*) since the mid-1990s. Both CGBs are revolving seed banks, in which farmers acquire a share by bringing 20 to 25kg of their own seed into bank and making a small financial contribution to cover the administrative costs. The membership entitles a farmer to take out one seed loan per year, usually for one crop and variety, which has to be repaid in kind after the harvest and with an interest of 20 percent.

Despite the conservation efforts 60 percent of the wheat-growing households in the sample grow only one high-yielding modern wheat variety. This is testimony to the success of the agricultural policies of the Ministry for Agriculture (MoA) promoting high-input agriculture and the modern varieties, which has been identified as one of the drivers of the substantial genetic erosion in the area (Teklu, Hammer 2006, Tsegaye, Berg 2007a).

[27]The most common sources of income are business (15.9%) and land rental (10%). The average annual income from business is 3,945 Birr (US$ 195).

THEORETICAL FRAMEWORK & EMPIRICAL STRATEGY

This study analyses patterns of agrobiodiversity in a specific region and context of Ethiopia. It thereby aims to contribute to a differentiated understanding of incentives for the diversification of the crop and varietal portfolio of small-farming households. The research questions guiding the analysis are: Which households diversify their crop and wheat portfolio? What motives for cultivating a diverse portfolio of food crops and wheat varieties can be identified?

1. Theoretical Framework

The conceptual framework for analysing crop and wheat diversity is based on the theory of the farm household model (Singh, Squire et al. 1986). In this model, the household farm maximizes its utility over a set of consumption goods generated by crop and variety portfolio and quantities it produces, purchased consumption goods as well as leisure. Descriptive evidence clearly indicates that small-farming households in East Shewa while selling part of their harvest, produce and consume the crops and varieties grown. The revised agricultural household model emphasises that in the absence of markets and in the presence of high transaction costs, consumption and production decisions are not separable (Janvry, Fafchamps et al. 1991). This model is particularly relevant for discussing the role of consumption preferences of rural households in portfolio choice.

A version of the farm household model applied to the study of on-farm conservation of crop and varietal diversity was developed and estimated by Van Dusen (2000). A number of applied economic analyses of inter-and intraspecific diversity have followed this approach (Benin, Smale et al. 2006; Birol, Smale et al. 2006; Edmeades, Smale et al. 2006; Gauchan, Smale et al. 2006; Winters, Hintze et al. 2006). Since the theoretical model followed here has been formally developed and stated elsewhere (e.g. Benin, Smale et al. 2003, Van Dusen 2006), we refrain from a formal statement of the model here.

2. Empirical Strategy

Estimating the effect of agrobiodiversity, as an input in the agricultural production function, on the mean, variance or skewness of overall output, is not considered a viable empirical strategy for this study. As the crop and varietal portfolio is chosen by the household, diversity is an endogenous variable. The households' preferences, e.g. its preference for diversity, are not directly observable or measured and influence both the input and the output variable, leading to a biased coefficient estimate. Instrumental variables to deal with this endogeneity bias in agricultural production functions are not available. Although frequently used, walking distance to the next market distance is unlikely to impact output only through the choice of varieties, as it will also affect the use of

other inputs and other potentially endogenous variables, hence the conditions for a valid instrument are violated.

We therefore choose a different, but well-established approach to investigate patterns of agrobiodiversity by using diversity measures as dependent variable in a model of household diversity choice (Brush, Taylor et al. 1992, Benin, Smale et al. 2004, Van Dusen, Taylor 2005, Gebremedhin, Smale et al. 2006, Di Falco, Bezabih et al. 2010, Bezabih, Sarr 2012).

The 2013 cross-section data is used to identify patterns of agrobiodiversity related to a set of household, farm, location, social network and market characteristics. These were chosen as indicators for relevant factors of diversity choice identified in the literature. In a second step, panel methods are applied to obtain more efficient and unbiased results on the effect of the explanatory variables on wheat diversity.[28]

Furthermore, a small number of qualitative, semi-structured interviews (N=30) were conducted in 2013 with beneficiaries of a project with the aim to reintroduce landrace wheat varieties in the study areas.[29] These interviews gave some insights into the uses, characteristics and performance of landrace wheat varieties compared to modern wheat varieties. Where relevant to interpret the findings, we draw on this qualitative evidence.

3. Dependent variables

For the classification of crop varieties and crops, the survey relied entirely on farmers' taxonomy based on characteristics such as phenotype or use qualities. Relying on farmer identification rather than on pedigree analysis implies that we have no reliable information of the actual level of genetic diversity maintained, especially when mainly improved varieties are grown. While the diversity of genotypes might be overestimated with this approach, farmers' classification of varieties has been shown to be relatively consistent and corresponding to a functional diversity (Sadiki, Jarvis et al. 2010).

Based on crop and variety names, agrobiodiversity on the household level is captured by several diversity measures for interspecific diversity (crop diversity) and intraspecific diversity (varietal diversity in wheat).

[28]The range of indicators for relevant explanatory variables is more limited in the panel data set. For crop diversity, we cannot use area-based measures of food crops diversity due to the limited availability of data from 2011. Results for the panel analysis of crop diversity are displayed in the appendix. For these reasons, the panel analysis is primarily used to check the robustness of highly significant variables in the cross-section models.

[29]For more information on the Seeds for Needs project, please see Bioversity International's website: http://www.bioversityinternational.org/seeds-for-needs/

Shannon-Wiener Index

$$SHANNON = -\sum \alpha_i \ln(\alpha_i),$$
$$SHANNON \geq 0$$

Herfindahl-Hirschmann Index

$$HERFIN = \sum \alpha_i^2$$

α_i ... area share on which crop i or wheat variety i is cultivated by household in 2012/13

The Shannon-Wiener Index (SHANNON) captures both richness and abundance as a composite measure of area shares allocated to individual wheat varieties or crops. The Shannon-Wiener index was originally used in information theory and is now widely used to evaluate species diversity in ecological systems. Also called an evenness index, it makes no assumptions about the shape of the underlying distribution in species abundance. A higher value of this index indicates a higher degree of diversity. A household growing only one wheat variety would score zero on the Shannon Index.

The Herfindahl-Hirschmann Index (HERFIN) is less commonly used to measure agrobiodiversity, but can be interpreted more intuitively. The index was introduced in the study of agrobiodiversity by Smale et al. (1998). It was initially developed as an aggregate measure to compare the level of competitiveness (i.e. the number of companies and their market shares) across markets. As a measure of spatial concentration, the index weights varieties or crops covering greater area more than crops or varieties to which only a small area is allocated. The index ranges from zero to one. Zero indicates the highest possible degree of diversity with many crops or varieties being grown on small areas of land. A value of one indicates a farmer growing only one wheat variety or crop.[30]

Despite their more limited information content, simple crop count and variety count measures are also used as they allow for an intuitive interpretation of the quantitative effect of the model coefficients on crop or variety richness.

Table 1: Descriptive Statistics Dependent Variables[31]

Variable Name	Description	Mean	Std Dev	Min	Max
Crop Diversity					
Crop Count	Number of crops grown	4.63	1.59	0	11
ShannonC	Shannon-Wiener index for crop diversity	1.39	0.38	0	2.36
HerfinC	Herfindahl-Hirschmann index for crop div	0.31	0.14	0.11	1
Wheat Diversity					
Wheat Count	Number of wheat varieties grown	1.45	0.87	0	4
ShannonV	Shannon-Wiener index for wheat diversity	0.28	0.41	0	1.39
HerfinV	Herfindahl-Hirschmann index for wheat div	0.82	0.26	0.25	1

4. Independent variables

The choice of independent variables is guided by the factors identified in the literature for cultivating a diverse portfolio: environmental heterogeneity, agricultural production risk, markets

[30]Please note that the two indices have opposite directions: an increase in diversity will result in an increase of the value of the *Shannon-Wiener* index and a decrease of the value of the *Herfindahl-Hirschmann* index.
[31]Please also refer to the Appendix table 21, figures 5 & 6 for more information on the distribution of the dependent variables and on summary statistics for the panel dataset.

and dietary preferences. For the reasons given in the introduction to this section, investigating the productivity enhancing effects of diversity is not straightforward. While productivity as a highly endogenous variable cannot be plausibly included as an independent variable in this model of diversity choice, we analyse and discuss the returns to diversifying the wheat or crop portfolio throughout the finding and discussion section.

Environmental heterogeneity & household-level risk exposure

As indicators of environmental heterogeneity, we use location dummies, which correspond to three different altitudes and thus agro-ecological conditions for the cultivation of crops and varieties. At the household level, we use the number of plots operated by the household as indicator for farm fragmentation and heterogeneity. As a response to environmental heterogeneity, we expect the effect of farm fragmentation on diversity to be positive.

Proxies for farm-level variations in risk exposure used here, i.e. the share of sloped and fertile land as well as the use of irrigation. If risk considerations drive portfolio diversification, we expect households with more sloped, less fertile and less irrigated land to have higher levels of diversity.

It must be noted that these are imperfect indicators for idiosyncratic exposure to production risk. Previous studies have shown, for example, that the association between slope and intraspecific diversity is opposite for different crops, such as maize and tef (Benin, Smale et al. 2004). Variations in diversity could, thus, also be an indicator of the suitability of crops and varieties for certain conditions, i.e. of environmental heterogeneity. Other plausible indicators for exposure to aggregate or idiosyncratic production risks, such as moisture stress or disease risk are not available in this context.

Household assets & wealth

Household assets, such as land and oxen holdings as well as household size (as a rough indicator of labour availability), capture the resources or inputs of the household for agricultural production. Land and livestock are also indicators of the household's wealth, especially considering that livestock is used as a form of saving in the absence of financial markets. (Dercon 1998). Other studies of agrobiodiversity typically use *only* oxen or tropical livestock units as an indicator of household wealth (Benin, Smale et al. 2004, Isakson 2011, Bezabih, Sarr 2012). This is particularly problematic in the Ethiopia, the land of the plough, where oxen are a more widely used agricultural input than in other African countries (McCann 1995).

To capture household wealth more accurately, a composite measure capturing the value of all livestock holdings and relevant property items (e.g. mattress, bicycle or mobile phone). Following Van Dusen & Taylor (2005), we understand wealth as a proxy for risk aversion and the household's ability to cope with risk. The relationship between wealth and risk attitudes is an issue of debate.

Nevertheless, wealth is frequently used as a proxy for risk aversion also on other fields of agricultural and development economics (Bellemare, Brown 2010). Following the agrobiodiversity for risk management hypothesis, we would expect more risk averse households, i.e. relatively poorer households, to cultivate a more diverse crop and variety portfolio.

Off-farm income, which is only used as a dummy and only added in the wheat diversity models, is an additional indicator for attitudes towards production risks. A household with a source of off-farm income and thus a more diverse income portfolio than household that only engages in agricultural activity is expected to be willing to take more risk, i.e. to cultivate lower levels of agrobiodiversity.

Market participation

To capture the role of market integration for diversity, we use walking distance to the next market as a proxy for transaction costs. We expect households facing higher transaction costs to be grow a more diverse portfolio. We also use the share of harvest sold as a measure of the level of market production or commercialisation.[32] We expect that high the levels of market production are related to lower levels of diversity due to specialisation on the most profitable varieties and crops.

Social networks & links

Since there is strong evidence for the role of social networks for seed-sourcing and access to plant genetic resources in other parts of Ethiopia, we add composite measures of bonding and linking social capital to the analysis (McGuire 2008, Cavatassi, Lipper et al. 2011). Membership in one of community gene banks is an additional indicator of access to diverse plant genetic resources.

Dietary preferences are generally not observable. As discussed above culture is often a factor shaping culinary practices and dietary preferences. We therefore introduce a dummy for the head of the household being ethnic Oromo or Amhara (baseline). To differentiate the effect of market distance on agrobiodiversity for relatively wealthier and poorer households, we also introduce an interaction term in the models.

[32]The commercialisation variable, i.e. share of harvest, is subject to endogeneity: the household made its crop and varietal and land allocation choice before the harvest and the sale of output. To ensure that the endogeneity does not severely bias the coefficient estimates, the models were all run without the commercialisation measures. The results were not significantly different. The commercialization measure is still included as a more general indicator for the level of market production of the household. Other studies have suggested that market integration leads to a loss of diversity (Brush, Tadesse et al. 2003, Van Dusen, Taylor 2005). Therefore, it is important to add this control to the model.

Table 2: Overview & summary statistics of independent and control variables

Please note: Right-hand side variables differ slightly in the panel & cross-section analyses, (P) denotes Panel

Variable Name	Description	Mean	SD	Min	Max
1. Agro-ecological conditions/location					
Kokka	Midland site (*Lome woreda*)	0.12	/	0	1
Ejere	Mid-Highland site (*Lome woreda*)	0.65	/	0	1
Chefe	Highland site (*Gumbichu woreda*)	0.22	/	0	1
Ganda 1-9	Dummies for the nine village communities (*gandas*)	/	/	0	1
2. Farm characteristics: risk exposure and environmental heterogeneity					
Nb. of plots	Number of farm plots operated by the households	4.11	2.43	0	25
Slope	Share of plots with moderate or steep slope	0.55	0.42	0	1
Irrigation	Dummy for farmland (partially) irrigated	0.24	/	0	1
Fertility	Share of plots with good fertility	0.38	0.37	0	1
3. Household assets: agricultural resource endowments and household wealth					
Livestock & Property[33]	Value of livestock holdings & property in thousand Birr (*without depreciation & valued at estimated market prices*)	42,6	45,5	8	684
Off-farm income	Off-farm income by at least one hh member (Dummy)	0.19	0.39	0	1
Livestock (P)	Value of livestock holdings at 2013 prices in tsd. Birr	34,2	18,7	0	116
Land size	Total of land operated by household in hectares	2.25	1.47	0	11
Number of children	Number of children currently living in the household	5.85	2.14	1	13
Household Size (P)	Number of persons living in the household	6.15	2.52	1	20
4. Market participation indicators					
Market distance[34]	Walking distance to next market in minutes	42.60	33.27	2	255
Share of wheat harvest sold	Share of the total wheat harvest which was sold by the household	0.13	0.19	0	1
Share of crops sold	Share of crops which were sold by the household	0.51	0.30	0	1
5. Household characteristics: dietary preferences					
Oromo	Ethnic Oromo (=1)/ Ethnic Amhara (=0)	.801	/	0	1
6. Social networks/links: Access to plant genetic resources					
CGB	Community Gene Bank membership	0.29	/	0	1
Model Farmer (P)	Household receives agricultural resources & training through the government model farmer programme	0.28	0.45	0	1
Bonding Social Capital	Aggregate measure for membership/leadership in informal social institutions[35]	2.20	1.02	0	6
Linking Social Capital	Aggregate measure for links to, positions and membership in formal social institutions[36]	1.83	1.50	0	6
Social Capital (P)	Aggregate measure of social capital[37]	2.02	0.90	0	5

[33]Further analysis has shown that due to the distribution of the livestock & property variable the error distribution is not normal. The untransformed variable is highly skewed to the left with a high number of outliers (N>20) at the upper end of the distribution. Consequently, as noted in table 2, the livestock & property variable is being log transformed. In order to avoid co-linearity problems (as wealth and land holdings are highly correlated, r=0.497) the land variable remains linear.

[34]An outlier analysis using a boxplot indicated that only three observations are above 120 min or two hours walking distance, i.e. outside the 1.5 inter-quartile-range of the upper quartile.

[35]Included informal social institutions are: *idir* (funeral association), *guza/debo* (labor sharing arrangement), *iqub* (savings association), *afoosha* (women's self-help association), *maqa* (oxen pairing arrangement) and *egni* (oxen-labour exchange arrangement). For more information on risk and input sharing institutions see also (Aspen 1993, De Weerdt, Fafchamps 2011).

[36]This measure captures the household's membership and association with formal organizations, which link the household to governmental or other agencies (such as NGOs). Included organizations are: farmer's cooperatives, seed producing cooperative (Biftu), local government, Ethio-Organic Seed Action (EOSA), the Food and Agriculture Organizations of the United Nations (FAO). The measure also incorporates whether anyone in the household is considered a model farmer by the MoA.

[37]This variable includes: membership and leadership in an idir group, membership in a cooperative, a seed multiplying organization and a position in local government.

5. Estimation procedure

Crop and varietal diversity are treated as an outcome variable in this paper. As discussed in the literature review, the empirical approach chosen in this as well as in other studies of agrobiodiversity in Ethiopia and beyond, allows insights into the uses and the incentives of crop and varietal diversification.

a. Cross section models

The models were chosen with respect to the three different dependent variables and their respective characteristics and distribution.

Poisson & regression models for count variables

Poisson regression models are used for the crop count and wheat variety count with non-negative integer values. An analysis of the distribution of both crop and wheat count indicates that the data is not overdispersed, i.e. the standard deviation is not significantly larger than the mean. Thus, the poisson distribution and the poisson regression are appropriate choices. For poisson models we report model coefficients (rather than average or partial effects) as they can be conveniently interpreted as semi-elasticities (or percentage changes in the dependent variable per unit increase in the independent variable).

The results from ordinary least squared estimation (OLS) for crop diversity are also displayed for reference as the distribution of observations is less skewed for crop than for varietal diversity and OLS estimates are consequently less biased.

Tobit models for index variables

In specifications using the indices we choose models which account for the specific, i.e. non-normal, distribution of the dependent variables. In the case of the Shannon-Wiener index zero – i.e. the score for non-diverse households growing only one crop or variety - is the lower limit of the distribution. The dependent variable thus has a skewed distribution with non-negative observations with a mass at zero in the case of wheat diversity (see below). In the case of crop diversity, the distribution is not clumped at zero, but is heteroskedastic and slightly skewed to the left.

The Herfindahl-Hirschmann index is constructed to range between zero and one. Similar to the Shannon-Wiener Index, the distribution (especially for varietal diversity) has a high number of observations at one, i.e. no diversity.

Ordinary-least-squared (OLS) estimation with censored or constrained dependent variables results in inconsistent and biased coefficient estimates as the linearity assumption for the residuals of the OLS regression is violated and the conditional expected values can be negative in a linear estimation (Wooldridge 2002). Linear regression models cannot distinguish between non-linear

naught observations and the normal distribution of continuous values above the threshold. The standard censored Tobit model is typically used to deal with censored or truncated data (Hill, Griffiths et al. 2012).

The tobit model estimates coefficients using an unobserved latent (uncensored) dependent variable rather than the observed, censored values of y. In order to interpret the coefficients and estimate the effects of the independent variables on the actual rather than the latent variable, we compute and display the conditional marginal effects at the sample average for all dependent variables.

Standard errors & standardisation

The households are located in three sites (midland, mid-highland and highland) with different agro-ecological conditions which could very plausibly affect agrobiodiversity at the site-level, meaning that the residuals are not independently distributed. Consequently, we analyse intracluster correlation for sites (using both the site indicator (3 locations) and the more specific village (*ganda*) indicator) and diversity measures. We find a significant intracluster correlation for wheat diversity (intracluster correlation coefficient: 0.40), but not for crop diversity (intracluster correlation coefficient: 0.03). Relatively high variance between clusters, indicating a cluster effect, biases the estimation of residuals and standard errors, often leading to "over-rejection"(Hill, Griffiths et al. 2012).

Clustering standard errors in this model with a low number of clusters (3 or 9) leads to over-specification as we have more independent variables than clusters and not enough degrees of freedom for the estimation. All specifications are run with site-level dummies, either with dummies corresponding to the three agroecological zones or with the nine village-level dummies. To correct for heteroscedasticity in the area-based measures of diversity, we use and display robust standard errors in all models. Estimating standard errors by bootstrapping yields very similar results.

For standardization we use beta coefficients, which are displayed for selected models in all output tables. To obtain the beta coefficients all variables in the model are transformed to have a mean of zero and a standard deviation of one. Standardized coefficients allow to compare the relative importance of dependent variables as well as an evaluation of the magnitude of effects. One unit change in the dependent variable x can be interpreted as a standard deviation unit change in y.

b. Accounting for the zero-inflated distribution of wheat diversity

The large proportion of households growing only one wheat variety (257 out of 394) and thus scores zero on the Shannon-Wiener index. This estimation problem requires a careful choice of a limited dependent variable model. Humphreys (2013) argues that the model choice is dependent

on whether the zeros are "genuine". This is the case when the participation (whether to diversify or not) and the consumption (how many varieties to grow) do not differ in the meaningful way. Hence, we need to determine whether households choose not to diversify on a varietal level or whether it is a corner solution due to limited access or other contextual factors that prevent the household from growing more than one wheat variety.

Participation decision: analysing the choice of non-diverse households

An analysis of the varieties grown by non-diverse households, points to different trends in the highland (Chefe) and the midland (Ejere) site. While 94.5 percent of non-diverse households in the midland site grow the same modern variety (called *Kubsa*), the most popular variety in the highland region is grown by only 26.2 percent of non-diverse households. Six varieties are grown by ten percent or more of the households in Chefe. In summary, non-diverse households in the highland site have access to a range of varieties, but choose to grow only one. In Ejere, on the other hand, growing only one variety is very likely a corner solution. With respect to these findings a two-part model for varietal diversity in wheat (with the Shannon-Wiener Index as dependent variable) is also presented.

Analysing zero-inflated count data

There are a number of econometric approaches to analysing zero-inflated count data. There is some agreement that the zero-inflated poisson or negative binominal regression and hurdle models are useful options for count data. In our case, the poisson regression is the correct model for analysing the number of wheat varieties grown, which is not inflated at zero, but has a large share of observations at y=1 (61.0 percent). Since the data does not suffer from over dispersion, a poisson distribution is thus a good fit for the dependent variable.

Analysing semi-continuous data

There is more debate around the correct model for fitting semi-continuous dependent variables, like the Shannon-Wiener Index. In this paper, we do not adopt a sample selection model (Heckman 1974). A Heckman procedure requires a valid instrument to correctly specify the model, which is not available in this context. Membership in one of semi-formal seed multiplying networks could serve as instrument if households were randomly selected to be a member of the gene bank or of the seed business Birftu. If membership or selection were random and therefore access to more diverse wheat varieties were also randomly assigned in the absence of a fully functional seed market, membership would be correlated with decision to diversify, but not with the level of diversity within the group of members. Since membership is not random, but strategic a suitable instrument is unavailable, we follow Min & Agresti (2002) in their recommendation of a two-stage model developed by Duan et al. (Duan, Manning et al. 1983, Manning, Duan et al. 1987).

The model assumes that different stochastic processes underlie the sample inclusion and level of the positive response. Therefore, we implement (1) a probit model for the participation or diversification choice ($y_i = 0/ y_i \neq 0$) with a dummy variable for diversity (i.e. household cultivating more than one wheat variety) as dependent variable and (2) an OLS for the level of diversity where the dependent variable is log-transformed to adjust the skewed distribution ($y_i | y_i > 0$). It must be noted, however, that this econometric model is based on the strong assumption that the error terms for the two parts of the model are independently distributed. While the discussion above indicates that in one of the study areas and participation and consumption decision differ, it is not reasonable to assume that the unobservable factors that explain participation are independent of the factors that explain the level of diversity. Given that this assumption is violated, the results must be interpreted with caution.

Both models are run with the same set of explanatory variables.[38] The coefficients of the log-linear model were not re-transformed and can thus be interpreted as semi-elasticities (i.e. the percentage change in the dependent variable related to a one-unit increase in the independent variable).

c. Panel models

The econometric models discussed thus far are used to identify patters of diversity in 2013 cross-section data with an elaborate set of farm, household, market and location characteristics. A subsample of 303 households has already been surveyed in 2011, thus allowing for a dynamic analysis of changes in wheat and crop diversity between 2011 and 2013.

Panel data allows the use of household fixed effects in order to take into account unobserved time-invariant confounding effects which can bias the estimation of cross-section models. The panel dimension of the dataset is thus exploited to obtain more precise and unbiased as well as robust estimates for the influence of farm and household characteristics on wheat diversity.

We present models for panel data alongside the cross-section specifications as they are more narrowly specified (due to data availability in 2011) and have a smaller number of observations. Due to the short panel, we cannot estimate effects of variables which do change very little over the two-year period between the two surveys as there is too little variation.

Choice of panel models

Similar to the cross-section specifications, we run different panel models for the different measures of wheat diversity. The results of the Hausman specification test (see appendix) indicates

[38]This model is also recommended in the STATA Journal entry on the Heckman procedure as an attractive alternative as the Heckman two-stage model as very high requirements for the model to be correctly specified (StataCorp 2015). In our case, the lack of valid instruments is a challenge for the application of sample selection models.

that the fixed effects model yields more consistent, efficient and unbiased estimates for models of wheat diversity. Consequently, we report findings from fixed effects regressions with robust standard errors for the two indices and for the diversity dummy (modelling only the household's choice to diversify, but not the level of diversity). We use a poisson fixed effects model for wheat count as dependent variable.

Due to rationale of fixed effects models, effects of explanatory variables with limited variation over time (e.g. membership in community gene banks or market distance) cannot be estimated.

Finally, the results of the panel analysis of crop diversity are presented in the appendix. Only the crop count variable could be used for the panel models due to limited data on land allocation to crops in the first round. We present results from the fixed and random effects specification following the results from the Hausman test (see appendix).

6. Limitations of the econometric approach

The methodological choices made in this study were carefully reflected. Nevertheless, some limitations must be acknowledged before moving to the interpretation of the results.

a. Population validity

This study has been conducted in three districts located in the East Shewa zone of Ethiopia. The study sites are comparable to, albeit not representative of, other moisture-reliable mid- and highland locations with comparatively good market access in the country, in which tef, barley and wheat are cultivated. As respondents were randomly sampled within the communities, the study presents representative results only for the communities which were surveyed. There are, however, few representative studies covering the variety of livelihood systems and agro-ecological conditions in Ethiopia.

b. Construct validity

This study of agrobiodiversity uses variety names as the basis for measuring varietal diversity in wheat. Variety names do not capture how genetically similar or different two varieties are. The preferred method is genetic sequencing, which has, however, high financial and technical barriers to implementation. The vast majority of diversity studies cited here therefore relies on the approach chosen here.

c. Internal validity

We briefly discuss a number of potential sources of systematic error, which could influence the patterns of variation in agrobiodiversity we observe (Antonakis, Bendahan et al. 2010).

Reverse causation, i.e. the temporal precedence of wealth over biodiversity or simultaneity, i.e. feedback loops between agrobiodiversity and wealth are particularly relevant potential sources of bias in this context, as the literature review has already shown. Throughout the discussion of the

findings, we therefore analyse whether the diversification of the varietal and crop portfolio can be considered a high-return strategy, potentially indicating a reverse direction of the observed association.

Through random sampling in the three study sites with a very high response rate of the sampled households, we control for selection bias. Between the two survey rounds, only 10 households dropped out for reasons that do not indicate systematic non-participation.

Throughout the analysis, we observed a very high correlation between certain independent variables, i.e. between the value of livestock and property as indicator of wealth, land size and social capital indicators. This indicates a potential bias resulting from collinearity. In response and as a way to check the robustness of the findings more generally, we conducted a sensitivity analysis to probe whether results change with functional form of certain variables or specification (Leamer 1985).

Endogeneity bias, especially resulting from omitted variables, is partly addressed through the panel analysis. Nevertheless, relevant factors which can plausibly influence production choice in a context of missing markets and change over time, such as dietary preferences, are not included because they are not measurable.

d. Conclusions for inference

Although we reflected on and aimed to control for sources of bias in the econometric modelling of factors of agrobiodiversity, we do not claim that the econometric models are fully identified. We interpret findings in a descriptive manner. Consequently, do not draw inference on underlying causal relationships.

FINDINGS

1. Patterns of food crop diversity

Households cultivated between one and eleven food crops, including cereals (wheat, teff, barley, maize), legumes (chickpea, lentil, fava and haricot beans), vegetables and fruit (tomatoes, onions, melons, cabbage), with an average of 4.6 crops cultivated.[39] 29.5 percent of households cultivated four crops.

Results of the multivariate cross-section analysis of patterns of household-level food crop diversity, based on OLS, censored and poisson regressions, are presented in table 3 below.[40]

a. The role of farm & household size, wealth & market distance

Larger land holdings and a higher value of livestock and household property are associated with higher food crop diversity. The effects are consistently positive and highly statistically significant across all four econometric specifications.[41]

Furthermore, walking distance to the next market is also positively associated with food crop diversity, suggesting that households facing high transactions costs cultivate a more diverse crop portfolio. Walking distance to the next market proves to be a very robust factor, even in specifications including more specific sub-village level location dummies (not displayed) rather than site dummies which are proxies for agro-ecological differences. Hence, the variable does not merely act as a proxy for differences in locations.

The number of children living in the household is significantly and positively associated with crop diversity in three specifications. This effect can be interpreted as the role the on-farm labour supply for maintaining a diverse crop portfolio (especially in a context of limited agricultural wage labour markets). Positive and significant effects of the availability of labour as well as the proportion of males in the household on crop level diversity have been shown in other regions of Ethiopia (Benin, Smale et al. 2004, Di Falco, Bezabih et al. 2010).

[39]See the Appendix and Table 21 for more information on the distribution of crop diversity.
[40]Since some data is missing for relevant variables, observations are lost and the models in table 2 are estimated with different sample sizes. To ensure that the different coefficient estimates are not due to the different samples, all models were run with the smallest sample (N=392). The results were not significantly different from the ones displayed above.
[41]Due to the construction of the Herfindhal-Hirschman index (model 4) - which ranges between 0 (very diverse) and 1 (no diversity) – negative signs of the regression coefficients indicate a positive relationship with the diversity measures.

Table 3: Multivariate Analysis Crop Diversity (2013 Cross Section)

VARIABLES	(1) Crop Count OLS (beta)[a]	(2) Crop Count Poisson[c]	(3) Shannon Idx Tobit (beta)[a b]
Ejere: mid-highland site	0.015	0.058	0.097
	(0.004)	(0.066)	(0.122)
Chefe: highland site	-0.658**	-0.050	-0.049
	(-0.175)	(0.067)	(-0.053)
Number of plots	0.074**	0.017***	0.006
	(0.111)	(0.006)	(0.040)
Share of sloped land	-0.374**	-0.090**	-0.080*
	(-0.101)	(0.041)	(-0.089)
Irrigation (Dummy)	0.214	0.043	0.035
	(0.058)	(0.043)	(0.039)
Share of fertile land	-0.037	-0.009	-0.007
	(-0.009)	(0.038)	(-0.007)
Log value of livestock & property, Birr	0.294***	0.099***	0.116***
	(0.176)	(0.035)	(0.283)
Land holdings, ha	0.264***	0.049***	0.055***
	(0.263)	(0.011)	(0.227)
Number of children	0.090***	0.022***	0.019**
	(0.139)	(0.006)	(0.123)
Walking distance to next market,hrs	2.998**	0.915***	1.177***
	(1.068)	(0.354)	(1.746)
Walking distance, squared	-0.428***	-0.090***	-0.081***
	(-0.395)	(0.027)	(-0.312)
Interaction: (Value livestock & property)*(Walking Distance)	-0.133	-0.055*	-0.082**
	(-0.493)	(0.032)	(-1.260)
Share of crops sold	-0.086	-0.024	-0.047
	(-0.016)	(0.052)	(-0.036)
Oromo (baseline: Amhara)	0.073	0.037	0.066
	(0.019)	(0.036)	(0.070)
Member community gene bank	0.217	0.062**	0.041
	(0.063)	(0.031)	(0.050)
Bonding social capital	-0.010	0.000	-0.002
	(-0.006)	(0.014)	(-0.006)
Linking social capital	0.090	0.017	0.000
	(0.086)	(0.011)	(0.000)
_se			0.320***
			(0.011)
Constant	0.278	0.092	-0.287
	(.)	(0.376)	(0.295)
Observations	418	418	414
(Pseudo) R-squared	0.378	0.056	0.352

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

Likelihood Ratio (LR) Chi-Square test is highly significant for all ML models: (2) – (4)

[a] Normalized beta coefficients in parentheses

[b] Coefficients are marginal effects at mean values

[c] Robust Standard errors in parentheses

[d] Standard errors in parentheses

Interpretation of the quantitative effects

In order to evaluate and compare the quantitative effects of the highly significant explanatory variables, standardized coefficients were calculated for all econometric models and displayed for specifications (1) and (3).

A standard deviation increase in the value of livestock and property is estimated to result in a 0.18 standard deviation increase in crop diversity or a predicted increase from the mean by 0.22 or 0.35 crops using the OLS and Poisson model respectively (at mean of walking distance).

An increase in land by one standard deviation is estimated to result in a 0.26 increase in standard deviation of crop diversity or an increase in crop diversity by 0.38 crops. Based on the poisson regression results, an increase in land by one hectare is estimated to increase diversity by 0.25 crops.

Finally, food crop diversity is estimated to increase by 1.07 standard deviations if the walking distance to the next market increases by one standard deviation. Taking the squared term and the interaction effect into account, we find that at the mean value of the wealth indicator, a 33 min (standard deviation) increase in walking distance from the mean (0.7 hrs) is predicted to lead to an increase in diversity by 0.42 or 0.53 crops, using the poisson estimation.

The estimated and predicted quantitative effects of changes in land, wealth and market distance on food crop diversity are relatively small. Market distance has the largest and most significant effect per standard deviation increase, approximately double the effect of livestock and property value on diversity at mean values of other variables. The quantitatively large and highly significant effect of market distance on crop diversification is consistent across specifications.

Interpretation of the interaction term

The negative and significant coefficient on the interaction term for household wealth and market distance indicates that the effect of wealth on diversity is lower among households further away from markets. However, the quantitative effect of the interaction is small in comparison to the estimated main effects of market distance and wealth on diversity, which continue to be significant and positive. Joint significance tests for the main and interaction effects were performed.[42] While the null hypothesis of the sum of coefficients being zero was rejected for the test for market distance, it could not be rejected for the wealth indicator. This indicates that the effect of wealth on crop diversification is not significant for marginal or remote farmers.

[42]We performed a post-estimation significance tests on the sum of the coefficient of the interaction term and the coefficient of the two factors without interaction.

This still raises the question which other incentives for diversification relatively wealthier households have to grow a diverse crop portfolio, which will be discussed in more detail below.

b. The role of farm and location characteristics

Farm-level characteristics indicating risk exposure as well as indicators for environmental heterogeneity are not statistically related to greater food crop diversity across all specifications, especially when looking at the more elaborate, area-based measures of diversity and not the crop count measure.

The only significant coefficient in models of area-based measures of crop diversity is the share of sloped land. The sign of the coefficient is negative, indicating that households with less sloped land are more crop diverse. Notably, also the signs of the irrigation and fertility coefficients - although not statistically significant - are also opposite to the hypothesised effect.

When analysing indicators of environmental heterogeneity, we find that households operating more plots, i.e. with greater heterogeneity, are associated with a higher number of crops grown, but not with greater relative abundance. Location in the highland site, Chefe, tends to be associated with lower inter-specific diversity (but higher intraspecific diversity, see below) compared to the midland site Kokka.

c. Access to plant genetic resources

Except for specification (3) - suggesting a positive association between membership in a gene bank and the number of food crops grown - coefficients of social capital and community gene bank membership are not statistically significant. The results suggest that access to plant genetic resources through social networks and the seed bank is not a relevant factor in explaining variations in food crop diversity in this context.

Nevertheless, more diverse households obtain new seed to a large extent through community gene banks (see also table 3 below). Further analysis clearly shows that members of the seed banks have significantly more land, livestock and household property than non-members.[43] Gene bank membership might therefore act as an intervening variable in the relationship between agricultural resource endowments and crop diversity.[44] In specifications with an additional interaction term for

[43]See Appendix, Table 25 for an overview correlation coefficients of selected explanatory variables. Group comparison tests show that CGB members are wealthier on a 10 percent significance level (members' livestock & property value is 6,500 Birr higher than non-members (with a sample average of 43,000 Birr)). Secondly, tests confirm that members have significantly (5% significance level) more land (0.4 hectares more than non-members (with a sample average of 2.5). Thirdly, it can be shown that CGB members have significantly more (1% significance level) linking social capital than non-members (0.9 more with a sample average of 1.83).

[44]Moreover, models using diversity indices as dependent variable also take the land allocated to certain crops into account rather than merely the number of crops grown by the household. Food and cover crops often

CGB membership and wealth indicator, we find that the main effect of wealth on diversity remains highly significant and positive, CBG membership is also significant, positive and large in the specifications with area based diversity measures (3) and (4). The significant, but small negative coefficient on the interaction term indicates that the average marginal wealth effect for members is positive, but smaller than for non-members (-37.3 percent for model (3)).[45]

d. Findings from panel analysis of crop diversity

The results of fixed and random effects poisson regression (see appendix, table 22) exploiting the panel dimension of the data - using only the crop count as dependent variable and smaller and less elaborate set of indicators for the explanatory variables - generally confirm the patterns presented above, with the exception of the interaction term, which is not significant. Variables with limited variation over time (e.g. CGB membership and land holdings) are not significant in the fixed effects model. Notably, the more limited social capital variable is significant and positive in both specifications.[46]

e. Diversifying the crop portfolio for consumption purposes

The detailed analysis of the crop portfolio grown by households with high and low crop diversity will shed more light on the incentives underlying the results of the household level analysis of patterns of food crop diversity.

The most frequently grown crops in this region of Ethiopia are wheat (94.9 percent), tef (89.0 percent), chickpea (82.0 percent) and lentil (67.2 percent). Households in the lowest quartile of crop diversity distribution, grow on average 3 crops, with the majority of households growing wheat, tef and chickpea and 38.6 percent of all households growing lentil (see figure 1).

The role of crop portfolio choice in optimizing farming return is often understood as an example for economies of scope, i.e. efficiencies created by variety, rather than scale (Pope, Prescott 1980). The combination of wheat, tef, lentil and chickpea in an optimal set of crops in this region, clearly has synergy effects especially for managing soil nitrogen for tef and wheat cultivation by rotating the cereals with nitrogen fixing legumes.

An analysis of average sample prices and productivity of all crops shows that the crops in the standard portfolio (wheat, tef, chickpea, lentil) are not only the most commonly grown crops, but

obtained through the community seed bank, such as lathyrus, fenugreek or fava bean are grown on significantly smaller plots than the more commonly grown crops.

[45]We did not include this interaction effect in the output tables as it makes the interpretation of the wealth effect and particular the conceptually more relevant interaction between wealth and walking distance more complicated. Joint significance tests for the main and interaction effects were performed. The hypothesis that coefficients are simultaneously equal to zero was rejected, i.e. the interaction is statistically significant.

[46]The social capital variable in the panel combines elements of bonding and linking capital, e.g. membership in informal institutions and positions in local government etc.

also the crops with the highest gross value per hectare.[47] Clearly, this measure can only serve a rough indicator of profitability, since a full profit calculation would require an analysis of inputs for the production of all crops. However, the comparatively high profitability of these crops is also reflected in the fact that they are the most frequently sold crops, especially chickpea and lentil as highly commercialized crops, which are sold by over seventy percent of households.[48]

Figure 1: Comparison of crop portfolios

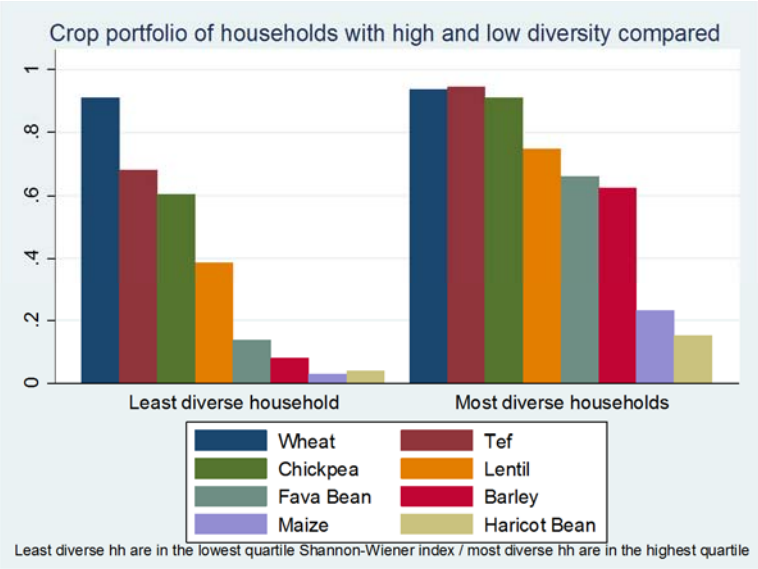


Figure 1 [49] illustrates that highly crop diverse household - growing 6.2 crops on average - move beyond the standard portfolio by adding secondary cereals, such as barley or maize and pulses, such as fava or haricot bean to their food crop portfolio. The additional crops grown by crop diverse households are predominantly for home use rather than for sale. [50] Qualitative interviews and anecdotal information indicate that barley and fava bean are grown for specific culinary purposes. Barley is commonly used for malting and serves as a basis for an alcoholic drink called *tallah*, whereas fava bean is the main ingredient for a well-known, popular breakfast dish called *ful medames*. Furthermore, barley as one of the less commercialised crops is known to be widely used and appreciated for traditional dishes (Eticha, Berghofer et al. 2009, Sopade, Shewayrga 2011, Mohammed, Seleshi et al. 2016).

The analysis of profitability and commercialization of crops provides some evidence that households add less profitable cereals and pulses to their portfolio primarily for consumption purposes. This raises the question why households would grow less profitable crops for

[47]Tef ist estimated to have the highest gross value per hectare (16,800 Birr), followed by wheat (11,200 Birr). Chickpea and lentil achieve an average gross value of 10,640 Birr and 10,400 Birr respectively. The estimated gross value of maize and barley is less than half of the more profitable cereals (5,600 & 3,500 Birr respectively). Similarly, fava and haricot beans have a significantly lower gross value than the two most popular legumes (5,600 & 3,200 Birr respectively).

[48]74.6 percent of households growing the crop sell chickpea and 71.4 percent sell lentil. Roughly half of all tef and wheat growers sell a proportion of their produce. Compared to these figures the proportion of households selling barley (20.6%), fava beans (31%) and maize (31.1%) is significantly lower.

[49]The y-axis of this figure shows the share of households growing the respective crop.

[50] See previous footnote for a comparison of commercialization.

consumption rather than buying them on the market while specializing on the most profitable crops.

f. The role of transaction costs & food market failure

The highly significant association between distance to markets and food crop diversity also points to the role of missing or failing markets.

The vast majority of households grows chickpea (82.0 percent) and sells it (74.6 percent). Chickpea has developed into the primary cash crop in the region (see more in section 3) for households with very good access to markets as well as for households facing higher transaction costs. We find no difference in the share of households selling the crop, comparing households within short walking distance to the market (lowest quartile) and with households which are (over) one hour away from the next market (highest quartile).

Tef, on the other hand, as the crop with the highest gross value per unit land, is sold significantly more by households farther away from the market (57.1 percent) than by households close to the market (35.5 percent). The data presented here provides little evidence to interpret this slightly puzzling finding. One possible explanation might be differently developed marketing structures for tef as a traditional cash crop and chickpea as a more recent cash crop. Another plausible explanation is that off-farm income opportunities are better closer to market centres, thus reducing incentives to sell crops which are also consumed in the household. For all other crops, we find no significant difference in the share of households selling it or the number of households selling the respective crop is too small to make a meaningful comparison.

This analysis provides some evidence that households which are relatively far away from markets, frequently use markets to sell output, especially cash crops. Transaction costs, e.g. for transport and access to market information, for these markets are not too high to inhibit participation.

Thus, while we find that households farther away from markets tend to cultivate a more diverse food crop portfolio, they also actively participate in output markets. This draws attention to the role of food markets and the cultivation of food or subsistence crops in explaining these patterns. In line with the evidence that crop diverse households grow additional crops primarily for consumption purposes, we find that households with (over) one-hour walking distance to the next market grow significantly more barley (+ 19.3 percent), fava bean (+ 32.4 percent), spices like fenugreek (+ 19.3 percent), but also more tef (+ 15.5 percent) than households within 15 minutes of the next market.[51]

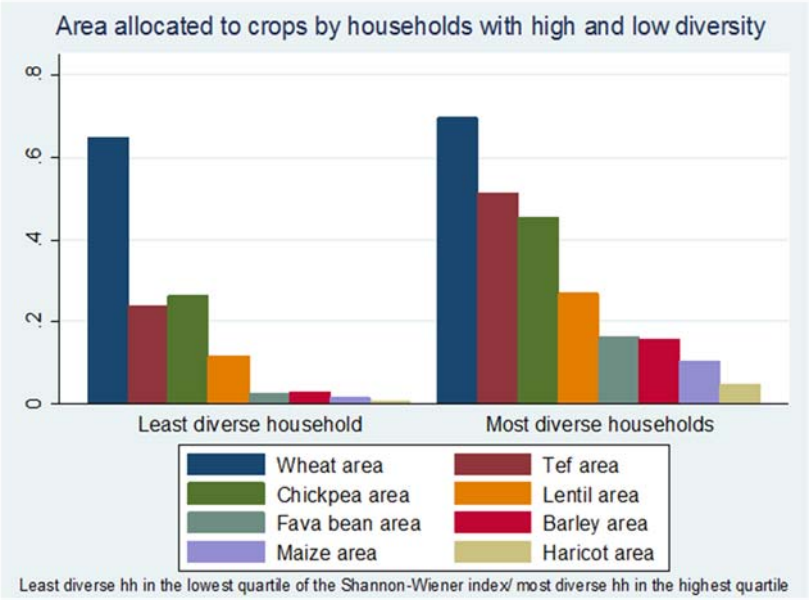
[51]In this comparison, we excluded households from the midland location Kokka, which are mostly located very close to the market and some of the cereal and pulse crops are not commonly cultivated in this locaiton. The results from the multivariate analysis, however, do not change when the Kokka location is excluded. The

These findings suggest that households further away from markets cultivate more food crops for subsistence rather than using food markets to cover consumption needs.

g. Land as a constraint for crop diversification

Figure 2 illustrates that the least diverse households allocate on average a similar area to wheat as the primary staple crop in the region as the most diverse households, but significantly less area to all other crops. This suggests differences in land availability in the two groups and land constraints as a factor for cultivating a diverse crop portfolio and thus echoes the findings from the multivariate analysis.

Figure 2: Comparison of crop areas



While highly diverse households cultivate on average 3.0 hectares, less diverse households operate only 1.6 hectares on average. Diverse households grow more crops, spread them more evenly than less diverse households, but they also allocate larger areas (in absolute terms) of their land to the profitable standard crop portfolio.

While least diverse households allocate on average 1.26 hectares to wheat, tef, chickpea and lentil, most diverse households allocate significantly more land (+0.67 hectares) to the standard crop portfolio, but a significantly smaller share of land (-14.9 percent). This challenges the hypothesis that larger farmers will dedicate a larger share of land to cash crops than small farmers who are more subsistence-oriented (Fafchamps 1992a).[52]

Compared with the standard portfolio, considerably smaller areas on average (of less than 0.2 hectares) are allocated to the less profitable, minor cereals and legumes by diverse households.[53]

group comparison shows that households also grow more wheat (+ 6.4 percent). However, there is no significant difference in the cultivation of the most commercialized crops lentil and chickpea.

[52]The association between land holdings and the share of land allocated to the four crops is negative and statistically significant. It also significant for all four crops individually, including chickpea and lentil, which can undoubtedly be described as a cash crop.

[53]The mean area allocated to wheat (0.83 ha), teff (0.47 ha), lentil (0.62 ha), chickpea (0.53 ha) across all households is significantly higher than the mean area allocated to barley (0.22 ha) or fava beans (0.22 ha).

Furthermore, we find that across all cereal and pulse crops, the vast majority of households do not allocate less than half a timmad (approximately 0.125 ha) to a crop. This suggests a land threshold for the cultivation of an additional crop.

In line with a number of other studies, however, we find that larger farms tend to be more crop diverse (Brush, Kesseli et al. 1995, Benin, Smale et al. 2004, Di Falco, Bezabih et al. 2010, Isakson 2011, Bezabih, Sarr 2012).

h. Summary of the findings

The multivariate analysis suggests that households which are further away from markets diversify their crop portfolio most by adding secondary cereal and pulse crops to their portfolio which are grown primarily for home consumption.[54]

In line with other studies of crop diversity we also find that households which are relatively wealthier, i.e. with larger endowments of land, livestock and labour, and farther from markets cultivate a more diverse food crop portfolio (Smale, King 2005). This effect, however seems to be smaller the further away households are from markets. The wealth effect is thus negligible for remote households.

While the markets for cash crops (as well as for crops which are grown both for consumption and sale such as tef and wheat) are well developed and the vast majority of small farmers participate in these markets, the market for minor food crops such as barley, fava and haricot bean appears to be much thinner. The farther the household is from the next market, the lower appears to be the probability of the household to be a (net) buyer of these food crops.

Based on these findings, it appears plausible that in this specific context of comparatively high integration into cash crop markets and limited production risk, diversification of the crop portfolio is a production strategy motivated by limited access to food markets and to some extend by consumption preferences of farmers who can afford to diversify.

2. Patterns of varietal diversity in wheat

While 65 percent of households cultivated only one wheat variety, wheat diverse households cultivated up to six varieties in 2011 and four in 2013 (see appendix, figure 6). In this section, we analyse patterns of variation in wheat diversity.

Table 4: Multivariate Analysis Wheat Diversity (2013 Cross section)

VARIABLES	(1) Wheat Count Poisson[c]	(2) Herfindhal Idx Tobit (beta)[a b]	(3) STAGE I Div Dummy Probit[c]	(4) STAGE II Shannon Idx, ln OLS[c]
Village Dummies [d]	***	***	***	*/**
Number of plots	0.020**	-0.024*	0.134***	-0.004
	(0.008)	(-0.228)	(0.049)	(0.011)
Share of sloped land	-0.084	0.079	-0.162	-0.172***
	(0.056)	(0.131)	(0.227)	(0.065)
Irrigation (Dummy)	-0.147**	0.077	-0.126	-0.158**
	(0.059)	(0.123)	(0.265)	(0.078)
Share of fertile land	-0.084	0.113	-0.361	-0.069
	(0.055)	(0.165)	(0.233)	(0.074)
Log value of livestock & property, Birr	0.168***	-0.181***	0.590***	0.059
	(0.044)	(-0.562)	(0.180)	(0.064)
Off-farm income (dummy)	-0.207***	0.225***	-0.673**	-0.066
	(0.061)	(0.336)	(0.282)	(0.116)
Land holdings, ha	-0.015	0.018	-0.049	-0.045*
	(0.019)	(0.112)	(0.082)	(0.026)
Number of children	0.011	-0.015	0.020	0.011
	(0.009)	(-0.147)	(0.041)	(0.011)
Walking distance to next market, hrs	0.285***	-0.324**	0.904**	0.300
	(0.087)	(-0.734)	(0.402)	(0.212)
Walking distance, squared	-0.084***	0.089	-0.223**	-0.191*
	(0.025)	(0.541)	(0.113)	(0.097)
Share of wheat harvest sold	0.083	0.064	-0.226	0.043
	(0.117)	(0.048)	(0.504)	(0.146)
Oromo (baseline: Amhara)	-0.061	0.139*	-0.436*	-0.095
	(0.051)	(0.227)	(0.239)	(0.094)
Interaction: (Value livestock & property)*(CGB Membership)	-0.056	0.198**	-0.750**	0.251**
	(0.066)	(3.781)	(0.318)	(0.112)
Member community gene bank	0.622	-2.089**	7.764**	-2.512**
	(0.698)	(-3.773)	(3.339)	(1.190)
Bonding social capital	0.027	-0.038	0.087	0.023
	(0.022)	(-0.158)	(0.093)	(0.023)
Linking social capital	0.038**	-0.042*	0.143**	0.004
	(0.016)	(-0.242)	(0.066)	(0.021)
_se		0.382***		
		(2.205)		
Constant	-2.023***	3.826***	-9.022***	-1.412*
	(0.455)	(.)	(1.895)	(0.713)
Observations	391	366	338	120
(Pseudo) R-squared	0.099	0.426	0.372	0.426

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

Likelihood Ratio (LR) Chi-Square test is highly significant for all ML models: (1) – (3)

[a] Normalized beta coefficients in parentheses

[b] Coefficients are marginal effects at mean values

[c] Robust standard errors in parentheses

[d] Coefficients of the 8 village dummies are not displayed, baseline: midland village

Summary: Models (1)-(3) six coeff highly significant & positive (***) & Model (4) seven coeff significant & positive (*/**/***)

Table 5: Panel Analysis Wheat Diversity

VARIABLES	(1) Wheat Count Poisson FE [b]	(2) Shannon Idx Fixed Effects [b]	(3) Herfindhal Idx FE (beta) [a]	(4) Div Dummy Fixed Effects [b]
Land holdings, ha	0.043**	0.025*	-0.017*	0.030
	(0.020)	(0.014)	(-0.102)	(0.019)
Log value of livestock	0.115*	0.056**	-0.032*	0.105**
	(0.064)	(0.028)	(-0.127)	(0.053)
Off-farm income (dummy)	0.006	-0.006	-0.021	-0.025
	(0.052)	(0.037)	(-0.037)	(0.059)
Nb. of household members	0.012	0.006	-0.002	-0.007
	(0.016)	(0.010)	(-0.019)	(0.014)
Walking distance to next market, hrs	0.083	-0.027	0.043	-0.050
	(0.116)	(0.081)	(0.099)	(0.117)
Walking distance, squared	-0.047	-0.011	0.000	-0.011
	(0.033)	(0.023)	(0.001)	(0.034)
Member community gene bank	0.071	0.001	-0.013	0.072
	(0.063)	(0.052)	(-0.024)	(0.071)
Model Farmer	0.156***	0.093**	0.025*	0.162***
	(0.059)	(0.044)	(0.086)	(0.061)
Constant		-0.477*	1.169***	-0.850
		(0.274)	(.)	(0.521)
Observations	594	585	585	575
(Pseudo) R-squared		0.074	0.052	0.087
Number of HHID	297	301	301	297

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

[a] Normalized beta coefficients in parentheses

[b] Robust standard errors in parentheses

The results of the cross-section analysis of wheat diversity are presented in table 4 above. Since area based wheat diversity measures could be calculated for both rounds, we also show results of the panel analysis (see table 5). The panel analysis includes a dummy variable for model farmer rather than the social capital variable as the combination of bonding and linking social capital produced estimated which were not easy to interpret.[55]

a. The role of farm size, wealth and market distance for wheat diversity

Similar to patterns of crop diversity, the coefficient on the value of livestock and property is statistically significant and positive across all cross-section and panel specifications (except for the second stage of the two-part model (4), see below).[56] This suggests that relatively wealthier households do not only to grow a larger portfolio of crops, but also more wheat varieties.

[55]The model farmer dummy was the only significant social capital indicator when the specification was run with all 6 variables which are summarized as social capital in the panel version.

[56]Not all variables from the cross-sectional analysis were available for the panel specifications. The indicators used to capture explanatory variables also differ to some degree for the panel analysis due to the different data structure in the first round survey.

The standardized coefficient of the wealth variable is much larger than for crop diversity. A standard deviation increase in the livestock & property variable is predicted to increase wheat diversity by 0.56 standard deviations or by 0.21 varieties at the sample mean of market distance (accounting for the interaction).

Since the continuous off-farm income variable is very noisy (and consequently not significant in specifications for crop and wheat diversity), we use a dummy, which has a negative and statistically significant coefficient in the cross-section specifications for wheat (but not for crop) diversity. Households with at least one source of off-farm income are predicted to grow 0.23 wheat varieties less on average than households without off-farm income.

Results from the panel, but not the cross-section analysis, indicate – in line with findings for crop diversity – that land abundant farmers cultivate a more diverse wheat portfolio. However, the quantitative effect is small and smaller than the effect of livestock, when comparing the standardized coefficients (table 3, model (3)).

Furthermore, walking distance to the next market is also positively associated with wheat diversity, suggesting that households facing high transactions costs cultivate a more diverse wheat portfolio. Wheat diversity is estimated to increase by 0.18 varieties if the walking distance to the next market increases by one standard deviation (or by 33 minutes) at mean wealth. The significant negative coefficient on the squared term suggests that the relationship between diversity and market distance is not linear, but concave. Thus, an increase in the household's distance to the next market has smaller effects on wheat diversity the more remote the household already is.

We find that the patterns of variation in wheat diversity, especially related to household wealth, land holdings and market distance are generally consistent with the findings from crop diversity. Household size as a possible indicator of labour availability, however, is not significantly related to wheat diversity.

b. The role of farm and location characteristics

Not surprisingly, location matters more for wheat diversity since the conditions for growing wheat and particular varieties differ significantly across agro-ecologies, but also within one agro-ecological zone. This is the reason why location dummies for sub-villages or *gandas* are used in the varietal diversity models rather than the site level location dummies which correspond to different agro-ecological zones (Chefe, Kokka and Ejere).

Beyond significant differences across locations, the positive and significant coefficient on the number of plots (as an indicator of farm fragmentation) across three cross-section specifications, (1) to (3), suggests a role of environmental heterogeneity for diversifying the wheat portfolio.

Variables capturing (un)favourable farming conditions, as proxies for farm-level risk exposure, are generally not significantly related to wheat diversity with the exception of the positive coefficient on irrigation in the first specification.

c. Access to plant genetic resources

Findings from the cross-section (and to a lesser degree from panel) analysis point to the significant role of access to plant genetic resources for cultivating a diverse wheat portfolio.[58] The fact that linking rather than bonding social capital is significantly related to wheat diversity, supports the observation that the informal seed sector is not very highly developed in this region of Ethiopia and seed is commonly sourced through formal channels, especially the extension services (see table 6).

Table 6: Seed sources of diverse and non-diverse households

Seed Source	**Households growing one wheat variety,** in % N=261[57]	**Households growing more than one variety**, in % N=144
Extension service	37.9%**	28.8%**
Saved	34.2%***	18.7%***
Local market	15.3%	15.6%
Community seed bank	9.0%***	28.0%***
Bought from other farmer	2.0%	3.4%
NGO/aid agency	1.0%*	3.2%*
Exchanged	0.6%*	2.4%*
Received as gift	0.0%	0.0%

Proportions different at *** p<0.01, ** 0.01<p<0.05, * 0.05<p<0.1

In the econometric models for wheat diversity, we test and control for an interaction between wealth and membership in a Community Gene Bank for wheat diversity given the high correlation of the two variables. The main effect and the interaction term are both significant, but have opposite signs, indicating that membership in the CGB has a higher effect on wheat diversity for farmers at lower levels of wealth. The point estimates in specification (3) suggest that the wealth effect for community gene bank members is actually very small and negative, but the CGB effect is very large, especially in specifications (2) and (3). [59]

While the effect of an increase in wealth from the first to the ninth centile is predicted to increase wheat diversity by 0.138 units of the Shannon-Wiener Index for non CGB members, no change is predicted for gene bank members.

[58]Since fixed effects are removed in the panel analysis and the variation in dummy variables like gene bank membership over a two-year period (i.e. in a short panel) is small, an insignificant coefficient does not imply that there is no effect, but that it is a fixed effect.

[59]$HERFINV_i = -2.089 - 0.181*wealth_i + 0.198*wealth_i*1 + b_k x_x + e_i$ for CGB=1// the coefficient is +0.017, i.e. a negative effect on wheat diversity in a specification with the Herfindhal Index as independent variable. Joint significance tests for the main and interaction effects were performed. The hypothesis that coefficients are simultaneously equal to zero was rejected, i.e. the interaction is statistically significant.

Further analysis of seed sourcing patterns (see table 6) supports this finding as 28 percent of diverse households obtain wheat seeds from the community gene bank, whereas only nine percent of non-diverse households use this source.

Households growing more than one variety rely significantly less on extension services and private stocks. The extension service is still the most important source for both groups. The significant positive coefficient of linking social capital is driven by households participating in the model farmer programme as the panel analysis confirms. This emphasises the role of formal channels and access to seeds as a highly relevant factor in explaining variations in wheat diversity.

Overall, informal seed sourcing, through seed gifts, exchange or farmer-to-farmer sales, plays only a marginal role in this region of Ethiopia. This illustrates why bonding social capital is not significantly associated with wheat diversity.

d. Two-part model of wheat diversity

We move on to an interpretation of the results of the two-part model with the stage one modelling the decision to diversify with a probit model (3) and the stage two capturing the level of diversity with a log-linear regression (4). We find that the probit model yields similar results to models (1) and (2). The patterns of diversity within diversified households, however, appear distinctly different. This indicates that the poisson and tobit specification capture primarily the household's choice to diversify its wheat portfolio or not.

The small sample size and the fact that the variation in wheat diversity levels is not very high (see appendix, figure 6), means that the levels model is not very informative. The share of sloped land, irrigation and land holdings are negatively associated with diversity levels of households growing more than one variety.

Notably, the variable which has shown very robust effect throughout all other specifications, the value of livestock and property, is not significantly associated with the level of wheat diversity. Diverse household are significantly wealthier on average (+18 percent). This suggests that wealth is relevant for the decision to diversify the wheat portfolio, but other factors guide the choice of the level of diversity.

Gene bank membership has (the only significant) positive effect on the level of diversity. This emphasises, again, the role of non-market institutions for seed supply and the role access to genetic resources for wheat diversity.

e. Landrace cultivation & wheat diversity

When analysing the wheat varieties grown by diverse households, we find that they grow significantly more landraces than households specialised in one variety. Only 3.9 percent of non-diverse households (N=229) cultivate landraces, compared to 53.3 percent of wheat diverse

households (N=120). Growing landraces alongside improved varieties is a cultivation pattern observed in a number of other contexts, especially in other centres of crop genetic diversity (Brush 1992, Meng, Taylor et al. 1998, Bellon, Hellin 2011).

If we analyse landrace cultivation as a common way to diversify the wheat portfolio, we find that -given the high standard deviation in output- the difference in productivity of landraces and modern varieties is not significant. The most popular and dominant improved variety *Kubsa* (grown by 53 percent of all households) is, however, significantly more productive on average than all other varieties (+ 1.4 quintiles/ha, mean: 19.68 quintiles/ha). Tinkur Sinde, on the other hand, is a popular purple seeded landrace variety, grown by 35 percent of households cultivating landraces (N=136), which was repeatedly mentioned in qualitative interviews for its superior use qualities.[60] With a mean productivity of 17.67 quintiles per hectare it has a significantly lower productivity than the most popular improved variety (-10.2 percent).

The significantly lower share of households selling Tinkur Sinde (-17.5 percent) and other landrace varieties (-21.9 percent) and the lower share of harvest sold compared to improved varieties, suggests that landraces are primarily grown for home use and not for sale.[61] Moreover, average land allocated to Tinkur Sinde (-0.24 ha) and other landraces (-0.34 ha) is significantly smaller than the mean area allocated to other varieties with a mean area of 0.7 ha.

In qualitative interviews respondents stressed the superior qualities of the landrace varieties for cooking compared to improved wheat varieties. While the grain is also used for staple foods like bread and *injera* (flat, soft pancakes from sour dough), it is most popular for a dish called *kinche,* for which the durum wheat is cooked seasoned and crushed to pieces. It is also used for similar dishes based on cooked durum wheat like *nifro* or *muk*. Many beneficiaries seem to grow these varieties specifically for the preparation of these dishes. The purple durum wheat varieties are used for malting, to produce local beer (*tallah*) or liquor (*hararke*). (Tsegaye, Berg 2007b).

Summarizing the findings of landrace cultivation as one common option to diversify the wheat portfolio, we find - analogous to crop diversity - that landraces are grown on significantly smaller plots of land, are sold less frequently and in smaller volumes than improved varieties, indicating their role as secondary crops, grown primarily for consumption purposes.

[60]Since the variety name is a description of the dark colour of the seed and the seed was reintroduced in this area, it is likely that the name refers to more than one landrace variety

[61]Share of harvest sold for LR (excl. Tinkur): 12.2 percent/other: 19.6 percent // Share of harvest sold for Tinkur Sinde: 16.3 percent / other: 19.2 percent (not statistically significant)

f. Niche market opportunities as incentive for landrace cultivation

The analysis of reported prices for the different wheat varieties, shows that Tinkur Sinde achieves a premium price of 737 Birr/quintile on the wheat market, which is 16.2 percent higher than the average reported price for other varieties. This finding goes hand in hand with the evidence from market surveys and qualitative interviews. A market survey of the local markets in Chefe and Ejere suggested that there is no price difference for traditional and improved varieties, referring primarily to white landrace varieties.

In interviews, however, farmers reported repeatedly that they had achieved very high prices for the dark coloured tetraploid or durum wheat, especially at the farm gate. Due to its superior quality, taste and its specific culinary uses, the demand for durum wheat is high.[62] While white coloured landrace wheat varieties can also be visually distinguished from bread wheat (due to a lower starch content), the purple varieties are easily identifiable as durum wheat. Consequently, information asymmetries between buyer and merchant - which have repeatedly been identified as a reason for market failure in local seed (and grain) markets (Lipper, Anderson et al. 2010) - are not a barrier in achieving and maintaining premium prices in this context.

This evidence suggests that the re-introduction of landraces could create new niche market opportunities, thus setting incentives for small farmers to diversify their wheat portfolio and to conserve diverse genetic resources on farm.

g. Landrace cultivation & the adoption of agricultural technology

The case of durum wheat landrace cultivation in the Ethiopian centre of diversity appears to be pronouncedly different from the very well-studied case of maize landrace cultivation in Mexico, where landraces continue to be cultivated in some regions despite adverse price incentives and a high degree of market integration (Arslan 2011, Bellon, Hellin 2011). As described above, durum wheat landraces had disappeared from at least one of the sites studied here (Ejere), but were re-introduced through *in situ* conservation interventions.

Qualitative interviews with small-farmers growing traditional varieties with and without previous experience in landrace cultivation as well as with several stakeholders of the community gene banks indicate that the challenges of landrace cultivation can be understood as a problem of agricultural technology adoption or diffusion (Feder, Umali 1993). The majority of small farmers who had previously grown only one bread wheat variety, were disappointed with the performance of landraces, used the same inputs as the modern varieties (despite lower fertilizer requirements)

[62]Brush, Taylor and Bellon ((1992) report similar findings in their study of Andean potato diversity.

and showed very negative attitudes towards the marketability of landraces. Over half of the respondents in this group were not interested in continuing the cultivation of landraces.

Farmers with previous exposure to traditional varieties, generally expressed different views about the positive traits of the landrace variety (e.g. higher drought tolerance, frost resistance, better taste) despite the lower performance. They also adopted more appropriate management techniques and emphasized market opportunities.

We might argue that these differences reflect different attitudes or preferences of adopters and non-adopters. Misconceptions about marketability and inappropriate management, however, point to the availability of information as a barrier to assessing the risks and benefits of the technology and to adopting it. Farmers in the first group are less familiar with landraces and thus have a higher degree of uncertainty.

A full discussion of landrace cultivation as a problem of agricultural technology adoption is beyond the scope of this paper. Nevertheless, some concepts of the adoption literature are briefly outlined to provide possible interpretations of wheat diversity patterns.

Firstly, farm size is found to be a significant factor for the adoption of a new technology, especially in the early stages. Even a divisible technology such as a new variety is only adopted beyond a minimal critical farm size or threshold (Feder 1980).

Secondly, innovators or early adopters of a new technology are typically less risk averse. As argued above, we understand wealth (measured by the value of livestock and property) as a proxy of absolute risk aversion. Wealthier farmers are thus more likely to adopt a new technology.

Thirdly, relatively better-off farmers are more likely to be members of the community gene banks through which this technology is diffused. As discussed above, membership in the gene bank involves a (small) initial investment. This could be understood as the fixed cost of adopting landraces in a context in which the informal seed system (and thus the spread of varieties through other channels) is very limited, creating a barrier for smaller, relatively poorer farmers to adopt.

h. Summary of the findings

In summary, the cross-section and panel analysis of wheat diversity confirms central findings from the crop level analysis: distance to market, larger livestock, property (and land) holdings are associated with higher levels of diversity. Livestock endowments and household property as indicators of wealth are, however, more relevant in explaining the decision grow more than one variety than in explaining variations in the level of diversity of wheat diverse households.

Landrace cultivation is a popular option for diversifying a household's wheat portfolio. Based on productivity and commercialisation indicators for landraces and their specialized uses in the household, we argue that they are grown primarily for consumption purposes. Nevertheless, there is some evidence to suggest that niche market opportunities are developing for landraces. We would expect to observe an additional increase in the cultivation and commercialisation of these varieties in response to price incentives.

DISCUSSION

Focussing in on the findings on patterns of food crop diversity, we discuss the central findings of this study, in the light of five possible explanations for patterns in agrobiodiversity which are proposed in the literature. We begin with a discussion of the hypothesis that agrobiodiversity is used by small farmers to manage risk. Secondly, we discuss whether the observed association between relative wealth and diversification might be related to higher returns from maintaining a diversified crop and variety portfolio. Thirdly, we analyse the role of fixed transaction costs related to the remoteness of households. Fourthly, we highlight the role of missing markets and high shadow prices for certain food crops. Finally, we discuss the association of crop diversity and farm size with respect to fixed costs related to crop cultivation.

1. Agrobiodiversity for risk management

As has been argued extensively, the argument has been put forward in the literature that small farmers use a diverse portfolio of crops and crop varieties primarily to smooth production and reduce downside production risk.

Literature

The majority of studies supporting this hypothesis investigate the relationship between agrobiodiversity and the mean, variance and skewness of output (e.g. Di Falco, Chavas et al. 2007)**.** A number of studies with a similar conceptual approach as was applied in this study, provide some evidence that farmers diversify to spread production risk (Van Dusen, Taylor 2005, Bezabih, Sarr 2012).

Evidence

We would expect variations in crop diversity to be significantly and positively related to variations in attitudes and the capacity to cope with as well as with exposure to risk.

Under the assumption that poorer households have a lower capacity to cope with shocks *ex post* and are thus more risk averse than wealthier households, findings suggest that more risk averse households cultivate a less diverse crop and variety portfolio. A positive relationship between crop and varietal diversity and livestock holdings as an indicator of households' wealth has been found in previous studies (Benin, Smale et al. 2004, Smale, King 2005, Bezabih, Sarr 2012).

Moreover, the findings presented here provide little evidence that crop or wheat diversity is associated with comparatively unfavourable farming conditions, indicating higher risk exposure.[63]

[63]The significant negative coefficient on the irrigation dummy in cross-section models (1) and (4) of wheat diversity (see table 4 above) is the only effect that is consistent with hypothesized effect: When irrigation is available, the household is subjected less to moisture stress and thus less expose to rainfall risks. If risk considerations motivate diversity choice, households using irrigation should have lower levels of wheat diversity.

We find that intra-and interspecific diversity tend to be lower on moderately and steeply sloped land. This association could, however, be interpreted in alternative ways, i.e. with respect to the suitability of certain crops for sloped or flat land. For example, crops which require more moisture are less suitable for sloped land due to water run-off.

Plot diversification is also a possible alternative *ex ante* risk management strategy in small farmer agriculture as well as an indicator of higher heterogeneity in farming conditions. The significant and positive association between the number of plots operated and crop diversity can thus be interpreted as a portfolio response to heterogeneous production conditions.[64] If portfolio and plot diversification were used as alternative strategies to spread production risk, we would expect to find a negative relationship.

The finding that households with sources of off-farm income tend to grow a less diverse portfolio, is consistent with risk managing behaviour since income diversification represents an alternative risk management and income smoothing strategy. Significant negative coefficient on the irrigation dummy is also consistent with the hypothesized effect. When irrigation is available, the household is able to manage moisture stress and is thus less exposed to rainfall risks.[65]

Conclusion

In this study context, with relatively favourable farming conditions in the Ethiopian context and a comparatively high degree of market participation, we find limited evidence that crop or wheat diversity is being used to manage production risk.

How can we relate this statement to studies which firmly established this hypothesis in the field by analysing agrobiodiversity as an input in the agricultural production function? Even if we can correctly identify and estimate the risk reducing effects of crop or varietal diversity - by smoothing the variability of farm output or by reducing downside risk - it does not mean that farmers grow a diverse portfolio to make use of these effects.[66] From the perspective of decision-making in the rural household economy, the risk reducing effects of diversity are considered alongside a range of other factors in optimizing portfolio choice under certain constraints.

2. Reverse Causality

The same empirical literature has made the case that agrobiodiversity enhances agricultural productivity and is, thus, a high-return strategy.

[64]See table 3, specification (1) and (2) & table 4, specification (1) and (3)
[65]See cross-section models (1) and (4) of wheat diversity in table 4
[66]Analogously, the factually better yield performance of modern varieties under small farming conditions does not necessarily imply that small farmers will cultivate them.

Literature

The hypothesis is based experimental studies in ecology (e.g. Tilman 1999a, Li, He et al. 2009). Studies using survey methods find similar effects, albeit without using experimental or quasi-experimental econometric methods, such as propensity score matching (e.g. Bangwayo-Skeete, Bezabih et al. 2012, Chavas, Di Falco 2012a).

Evidence

Following this argument, the observed association between wealth and food crop and wheat diversity can be interpreted differently: households are wealthy because they diversify their portfolio.

We argue that the optimal or standard crop portfolio, grown by the majority of households comprises wheat, tef, chickpea and, to a lesser extent, lentil in this particular study context. The idea of a standard portfolio is based on models in agricultural economics for choosing the optimal agricultural output mix, for example to optimize input use (Just, Pope 2001). Evidence suggests that these are the most profitable crops (based on the limited indicator of gross value per hectare) as well as the most commercialized crops, comparing the share of households selling the crops.[67]

Additional food crops grown by more crop diverse households (such as fava bean, haricot bean, barley, maize) are secondary or marginal crops in the region and are primarily grown for consumption. We find that these crops have a significantly lower gross value per hectare and a significantly smaller share of land is allocated to these crops.[68]

Conclusion

Crop diverse households add less profitable, secondary crops to their portfolio, which they primarily cultivate for consumption. This does not suggest that crop diversity is a high return strategy.

3. Fixed Transaction Costs

High transaction costs, especially transportation and opportunity costs of accessing markets, set incentives for the production of food or subsistence versus cash crops for households further away from markets (e.g. Key, Sadoulet et al. 2000). For a household far away from markets, facing high

[67]To give some intuition why this combination of crops can be considered an optimal mix: There are two cereal crop (of which tef is very labour intensive & wheat tends to require more chemical inputs) and two pulses, which have a nitrogen fixing quality and are grown in rotation.

[68]The findings for wheat diversity point in a similar direction. The role of niche market opportunities might already make landrace cultivation, which are often cultivated by wheat diverse households, a profitable production strategy for some households and potentially in the future.

transaction costs, production and consumption (and insurance) decisions cannot be separated (de Janvry, Fafchamps et al. 1991).

Literature

In line with this argument several studies have found suggest that a diverse crop and varietal portfolio is maintained where transactions costs are high and market participation is low (Brush, Taylor et al. 1992, Van Dusen, Taylor 2005, Winters, Hintze et al. 2005, Isakson 2011, Lipper, Cavatassi et al. 2012).

Evidence

We expect households facing higher transaction costs to participate less in markets, grow more crops and wheat varieties for home consumption and have higher levels of agrobiodiversity.

Across all specifications, we find that a highly significant and positive association between walking distance to the next market and food crop or wheat diversity respectively. This indicates that transaction costs are an important factor in explaining variations in agrobiodiversity in the study area.

In this context of comparatively intensified smallholder agriculture and a high degree of market participation, it is not straightforward to distinguish between cash and food crops. Wheat, for example, as the most important crop in the region, is sold by most household, but only in small volumes. We discuss the standard portfolio (wheat, tef, chickpea and lentil) and the secondary crops (barley and fava or maize and haricot) along the lines of cash and food crops, because the literature often relies on this distinction (e.g. Fafchamps 1992a).[69]

In line with the transaction cost argument, we find that remote households grow significantly more crops, which are primarily used for home consumption. Barley is cultivated by 22.5 percent of households close to the market, but by 42.4 percent of household farther away.[70] Similarly, fava bean is cultivated by 15.3 percent of households close and 54.2 percent of households close to markets.

On the other hand, however, remote households also actively participate in output markets. For lentil, chickpea and wheat there is no significant difference in the share of households selling crops for households closest to or furthest from markets. More puzzling, significantly more households further away from markets sell tef.[71] It must be noted, however, that no information on

[69]We make this distinction based on the share of households who are selling any share of their output of any of these crops.
[70]Here we are comparing households in the lowest and the highest quartile of the distance distribution.
[71]23 percent more households which are further away from markets, sell any share of their tef output.

consumption and thus no information on the use of markets to buy food as well as on the volume (except for wheat) sold on the market is available.

Conclusion

The conclusion that remote households cultivate a more diverse portfolio of food crops, despite their active participation in output markets is somewhat puzzling. Fixed transaction costs related to distance should apply equally to buying and selling goods, which are storable. We would expect farmers who participate in output markets to specialise on an optimal cash crop portfolio and buy food crops. High fixed transaction costs are but one explanation for market failure. We therefore explore other, possibly crop-specific reasons for missing markets.

4. Missing markets & high shadow prices for food crops

Markets for particular crops may missing or failing and shadow prices for particular food crops or crop varieties might be high, but unobserved (Arslan, Taylor 2009, Arslan 2011). Farmers are willing to accept lower returns, i.e. pay a productivity premium, to cultivate and consume these crops when markets for these crops are failing.

Literature

The literature provides some intuitions and empirical examples as to why food markets might fail. Firstly, a limited spatial market integration for food crops can lead to high food price risk, i.e. the co-variation of production risk and local prices (Fafchamps 1992a, Bellemare, Barrett et al. 2013). Secondly, there might be an unobserved value of self-provisioning, related to informational asymmetries leading to market failure (Hoffmann, Gatobu 2014). Thirdly, high shadow prices have been observed for local crop varieties with superior use qualities, particularly in semi-subsistence households (Arslan, Taylor 2009, Arslan 2011, Taylor, Lybbert 2015).

Evidence

As shown above, the additional crops cultivated by more households with a more diverse portfolio are less frequently sold, have a lower gross value per hectare and are used for traditional dishes.[72] As also discussed above, primary qualitative information as well as secondary information highlight that landrace durum wheat is frequently used for a range of traditional dishes, indicating a consumption preference for these varieties (Tsegaye, Berg 2007a). Furthermore, barley as one of the less commercialised crops is known to be widely used and appreciated for traditional dishes (Eticha, Berghofer et al. 2009, Sopade, Shewayrga 2011, Mohammed, Seleshi et al. 2016). This

[72] These crops are also grown on smaller areas if the household is not selling it, with very substantial differences (of up to 50 percent in mean area) for maize and haricot.

provides some suggestive evidence that that there is a preference for consuming these crops related local culinary practices and farmers are willing to pay a productivity premium to grow these crops.

Furthermore, secondary crops, such as fava bean, barley and maize, are grown significantly more (by more than fifty percent) by wealthier and more land abundant households, who still allocate a larger total area to the more commercial crops, but have on average a lower land productivity (for wheat). This indicated that farmers who can afford to grow these crops, i.e. who have sufficient land and are wealthy enough to pay a productivity premium for cultivating these crops, i.e. to accept the loss in return from specialisation.

The argument that regional market integration is a factor causing high food price risk in the region is not very plausible in this specific context. Adama and Debre Zeit as regional market centres are close and the local markets are well connected to these regional centres via roads.

Conclusion

We have some suggestive evidence that additional, secondary crops are food crops cultivated for consumption by households close to and far from markets, indicating some degree of market failure. Plausible reasons for thinner markets for these crops as suggested by the literature, however, cannot be given based on the available data and the secondary literature. Diversification of the crop portfolio by adding these secondary crops appears to by production strategy of farmers who are removed from food markets and relatively land abundant and wealthy farmers, who can afford to grow these crops to satisfy their preference for dietary diversity in a context of missing markets.

5. Missing markets & high shadow prices for food crops

The results of this study confirm the overwhelmingly consistent empirical finding that larger farms in developing countries are more crop diverse (Benin, Smale et al. 2004, Di Falco, Bezabih et al. 2010, Bezabih, Sarr 2012).

Literature

Theoretical arguments for this finding are surprisingly rare in the numerous studies of agrobiodiversity in developing country contexts. Economies of scope in agriculture are one approach to understanding the relationship between farm size and portfolio diversification (Pope, Prescott 1980, Chavas, Di Falco 2012b, Hitayezu, Zegeye et al. 2016). Because of diminishing returns to scale in agriculture (especially with lumpy inputs or missing input, especially labour, markets), optimization of agricultural production is often achieved through diversification.

A slightly different argument that has its root in the technology adoption literature points to the fixed cost related to the cultivation of an additional crop (Feder 1980, Feder, Just et al. 1985). In this context, fixed costs can be seen as related to the management (e.g. sowing, ploughing, weeding and harvesting at particular times) of an additional crop. Unless a farmer can allocate a certain area to the crop, the farmer might not find it feasible to adopt it.

Evidence

Findings suggest such a minimum area allocated to one crop, as farmers do typically not allocate less than half a timmad (approx. 0.125 ha) to a crop. Across all food crops, there are only 5 cases in which farmers report to have allocated less than half a timmad to a crop.

Moreover, we find that the same share of land is allocated to the four most profitable crops on larger as on smaller farms (of approximately 85 percent), but more crops are cultivated overall on larger farms. This might suggest that on larger farms there is sufficient land left to cultivate additional crops beyond allocating the largest share of land to the standard portfolio.

Qualitative evidence also suggests that small amounts of seed (of approximately 3kg) of a new landrace variety in the study area was not given to men, but to women in an intervention. Women consistently argued that they would be more likely to multiply and grow the seed than men, who would not consider such a small amount of seed, which can cover only on a small area, worth cultivating or investing in. This anecdotal evidence also supports the idea of a minimum threshold.

Conclusion

The cultivation of an additional crop or variety seems to incur a fixed cost in this specific study context, in which intercropping is not practiced, leading to a land threshold of approximately 0.125 ha. This study suggests that in semi-commercialised smallholder agriculture with binding land constraints, land availability limits the number of crops and crop varieties cultivated.

CONCLUSION

In this study, we analyse patterns of food crop and wheat diversity in three communities located in the Central Highlands of Ethiopia. We find that transaction costs, failure in specific food markets as well as fixed costs related to the adoption of crops and varieties offer plausible, even if not exhaustive, explanations of the observed variations in agrobiodiversity.

The patterns of identified in this specific region of Ethiopia echo findings - particularly concerning the role of farm size, household wealth and market distance - of previous studies in Ethiopia and beyond (Smale, King 2005). However, they provide little evidence towards the hypothesis that risk management and expected productivity increases are highly relevant incentives for cultivating a diverse portfolio in this context characterised by comparatively high moisture reliability and market integration.

This study contributes to the empirical literature with relevant insights into patterns and incentives for the diversification of the crop and varietal portfolio of small farming households which are, among other things, relevant for targeted efforts to conserve agrobiodiversity. An important conceptual contribution is made by emphasising the distinction between the potentially risk-reducing effects of agrobiodiversity on the one hand and small farmers' incentives to cultivate a diverse portfolio on the other hand. Put differently, showing that agrobiodiversity reduces production risks is not sufficient to argue that farmers will strategically use it for this purpose.

An aim of further research in this area should therefore be to model and then empirically estimate the conditions under which varietal or crop diversification is the preferred strategy of a small farming household to manage risk.

Furthermore, the claims concerning the productivity-enhancing effects of agrobiodiversity are extremely relevant for promoting sustainable agriculture, but they are not sufficiently substantiated at this point. Quasi-experimental or ideally experimental research designs should be used to replicate the findings and address the inherent endogeneity problems of the empirical models. Moreover, the interaction between exogenous input factors, especially farm size, and agrobiodiversity for agricultural productivity should be further explored.[73]

This study leaves some questions unanswered concerning the role of market failure in explaining patters of agrobiodiversity. We find suggestive evidence that while farmers actively participate in

[73] In an explorative study of wheat productivity, we find the same significant and positive relationship between varietal diversity and land productivity that is described in other studies. But when an interaction term between wheat diversity and land is introduced, the main effect of wheat diversity becomes changes signs, while still being statistically significant. This points to a highly heterogeneous relationship with important implications for the interpretation of the role diversity for productivity.

output markets, they cultivate certain crops for home consumption irrespective of the transaction costs they face, indicating failure in food markets. Further qualitative evidence, data on household consumption as well as price information for local markets would be necessary to sufficiently explore possible reasons for the failure in food markets and their relationship to de facto conservation.

Implications of this study for the conservation of agrobiodiversity are further discussed in the conclusion to this thesis.

The Effects of Wheat Rust on Agricultural Production of Small-Farming Households in East Shewa, Ethiopia

ABSTRACT

The fungal diseases commonly referred to as wheat rust have been identified as a serious threat to global wheat production. As in other wheat growing areas of the world, the outbreak of yellow rust in Ethiopia reached epidemic scale in 2010/11. Based on original panel data of over 300 affected households from 2011 and 2013, this paper analyses the effects of the disease on agricultural production in the East Shewa zone of Eastern Ethiopia. While varietal diversity in wheat does not increase, roughly thirty percent of households make changes in their varietal portfolio and reduce wheat cultivation in response to the disease. However, disease resistant varieties are only available to sixteen percent of all households with preferential access to agricultural resources. Particularly, non-diverse households growing only one improved, but susceptible wheat variety have very limited response options and reduce their wheat cultivation. The findings of this study in a diversity hotspot for durum wheat confirm the threat that wheat rust poses to wheat cultivation, wheat genetic diversity and critically reviews policy responses.

INTRODUCTION

Wheat is one of the most important cereal crops with 716 million tonnes produced in 2013 worldwide (FAOSTAT 2015). Half of the global wheat output is produced in developing countries. With an estimated annual production of 4 million tonnes, Ethiopia is the largest producer of wheat in Sub-Saharan Africa (FAOSTAT 2015).

Wheat rust was identified as the most important threat to global wheat production (Wellings 2011, Chaves, Martinelli et al. 2013). The earliest, archaeological evidence for stem rust infection in wheat dates back to pre-biblical times (Kislev 1982). The disease affects all major wheat growing regions, of which eastern Africa is one. The infestation with one of the three types of the fungal disease - leaf rust, stem rust or stripe rust – results in a significant reduction in grain size and quality. Harvest losses of up to seventy percent due to wheat rust epidemics have been recorded in the US already in the early twentieth century (McIntosh, Wellings et al. 1995). Wheat rust continues to pose a threat to food security on a global scale as the cereal crop was the primary

source of calories for over two billion and the primary protein source for four billion people in 2010 (Chaves, Martinelli et al. 2013).

Ethiopia is one of the regions with high vulnerability for stripe or yellow as well as stem rust epidemics (Singh, Hodson et al. 2008, Wellings 2011). In 2010/11 the worst yellow or stripe rust epidemic of the past two decades broke out. A virulent new strain, called Yr27, highly susceptible popular cultivars in Ethiopia and favourable, i.e. wet and relatively cool, weather conditions at the start of the growing season led to the epidemic (Abeyo, Hodson et al. 2013, Mesay, Bedada et al. 2014). An estimated six hundred thousand hectares (43 percent of all area cultivated with wheat in Ethiopia) were affected and yield losses were substantial, ranging from sixty to one hundred percent (Taffesse, Dorosh et al. 2011, Abeyo, Hodson et al. 2013)

Empirical research on wheat rust in Ethiopia and beyond has largely focused, firstly, on creating awareness for the scale and threat of the disease, secondly, on the efficacy of disease control through resistant varieties and pesticides primarily in experimental settings as well as, thirdly, on genetic analysis for resistance breeding. Where access to conventional risk management and coping strategies is limited, however, farmers de facto strategies in managing disease risk ex ante are of particular interest, which have not yet been systematically studied.

This study using original panel data offers unique insights into farmers' responses to the epidemic outbreak of stripe or yellow rust in 2010/2011 in the Central Highlands of Eastern Ethiopia. The study contributes to the literature, by identifying farmers' response measures in a context of limited access to conventional rust control measures. These responses are then analysed in terms of their potential to control the disease or reduce the exposure to the disease.

The analysis how households' food crop and wheat variety portfolio or land use patterns change due to stripe rust, confirms that the disease cannot be fully controlled by input-oriented, conventional disease management strategies. Especially the limited availability of resistant cultivars leads to an overreliance on pesticides of farmers who can afford them. Findings also suggest that limited access to modern as well as landrace wheat varieties creates incentives for small farmers to move out of wheat to reduce risk exposure.

Crop diseases and pests are discussed as one of a number of risks of agricultural production, including drought, frost, flooding, livestock diseases and pests (Morduch 1995, Fafchamps 2003, Dercon 2005b, Duflo 2006). However, research in this field has focused largely on rainfall variability as a source of production risk, aiming to identify household strategies and capacities to manage risk ex ante and to cope with risk ex post (e.g. Porter 2012, Macours 2013). Pest epidemics are similar to moisture stress as they present an aggregate risk, often affecting whole communities or regions (Fafchamps 1999b, Dercon 2005b). Disease epidemics, however, are crop specific and thus

the severity of shock depends on the importance of the crop in a household's portfolio. Moreover, disease management involves a dynamic and continuous effort as both the pathogen and the resistance or susceptibility of the host evolves over time.

For farmers in the study area, wheat rust poses a greater risk than moisture stress to the cultivation of wheat, as the primary staple crop (see below). Ex ante risk management of production shocks caused by crop diseases and pests, however, have not yet been systematically analysed in the discipline. This study presents a relevant contribution to this discussion. Recently, the role of agrobiodiversity in preventing pest epidemics has been highlighted (Jarvis, Brown et al. 2007, Legrève, Duveiller 2010, Lin 2011, Webber, Kahiluoto et al. 2014, Lamichhane, Barzman et al. 2015). The study is set in one of the global centres of crop origin and diversity for wheat, in which genetically diverse wheat landraces are being cultivated and efforts of conserve wheat genetic resources on-farm are ongoing (Tsegaye, Berg 2007a, Bezabih 2008). A previous rust epidemic has, however, contributed to severe genetic erosion, i.e. the loss of traditional durum wheat varieties (Negatu, Mwangi et al. 1994, Tsegaye, Berg 2007a). The analysis of changes in the varietal portfolio due to the recent rust epidemic offers the opportunity to explore the role of crop diversity in disease management as well as the consequences of increased disease severity and incidence for landrace conservation.

In the next section, we will review the literature on wheat rust management as well as responses to comparable shocks to agricultural production. This will be followed by a discussion of the study background, the data and the empirical strategy. We then present households' responses to the wheat rust epidemic, with a particular focus on changes in the wheat portfolio and changes in the land allocation to wheat. The findings are consequently discussed to highlight challenges of conventional rust management strategies, the role of crop and variety abandonment for risk management as well as the role of agrobiodiversity in preventing wheat rust.

LITERATURE REVIEW

1. Strategies to control wheat rust

The considerable challenges in responding to the threat rust diseases pose to wheat cultivation are related to a number of specific aspects of the epidemiology of the disease. Firstly, the dissemination of the spores of the rust fungi over very long distances in the air and in water leads to a rapid spread of the pathogen on large spatial scales (Singh, Huerta-Espino et al. 2002). Secondly, the disease can remain dormant for long periods of time in the form of overwintering spores, which survive, for example, on wheat stubbles. Under certain environmental conditions (i.e. high humidity and cold temperatures), the dormancy period is interrupted, starting a new infection cycle (Singh, Huerta-Espino et al. 2002). In wet and cool seasons - such as the long 2010 rainy season (*Meher*) in Ethiopia - leaf rust fungi have optimal conditions to germinate and grow (Abeyo, Hodson et al. 2013). Finally, the specific life cycle of rust pathogens is conducive to genetic mutation, leading to the rapid emergence of new virulent races (Singh, Huerta-Espino et al. 2002). A prominent example is the new and particularly aggressive new strain of stem rust, called Ug99, which spread quickly from Uganda to Eastern and Northern Africa leading to another (stem) rust epidemic in Ethiopia in 2013/14 (Singh, Hodson et al. 2008, Abeyo, Hodson et al. 2013).

a. Breeding and dissemination of resistant cultivars

The three types of wheat rust have been extensively studied within plant sciences. Given the easy dissemination and the high survival rate of the pathogens, breeding of rust resistant varieties is the primary focus of empirical research as well as interventions to prevent wheat rust epidemics (Heisey, Smale et al. 1997, Singh, Huerta-Espino et al. 2004, Chaves, Martinelli et al. 2013, Chen 2014).[74] The dissemination and the role of rust resistant varieties in responding to the recent epidemic in Ethiopia was the principal subject of agronomic research following the outbreak (Abeyo, Hodson et al. 2013, ICARDA 2013, Mesay, Bedada et al. 2014, Tegene, Abdusalam et al. 2014).

b. Chemical control through fungicide application

Results of a controlled field study in the Bale Mountains of Ethiopia indicate that high-frequency fungicide application is an effective, reactive strategy to control the disease, especially when resistant varieties are not immediately available to farmers to prevent an outbreak (Hailu, Fininsa 2007). The efficacy of chemical control measures to manage rust diseases has been well

[74]The most notable research initiative to develop rust resistant varieties is the Borlaug Global Rust Initiative, led by Cornell University and funded by the Bill and Melinda Gates Foundation (BMGF, http://www.globalrust.org). In addition, a scaling project has been funded by USAID and BMGF to make newly bread cultivars available in Ethiopia (http://www.cimmyt.org/project-profile/ethiopia-wheat-rust-scaling/).

established (Singh, Huerta-Espino et al. 2004, Chen 2014). However, chemical control implies significant costs for small-farming households and requires a high capacity of local extension services or highly functional markets to make these inputs available. Fungicide application is therefore not the dominant response strategy developing countries and has limited feasibility for resource-poor farmers (Heisey, Smale et al. 1997, Marasas, Smale et al. 2003, Orr 2003)

c. Alternatives to resistance breeding and chemical control?

Breeding for resistance and fungicide application are the most frequently discussed crop protection measures in the literature on wheat rust. Hence, current approaches to manage wheat rust are highly input-oriented. Moreover, proposed measures are firmly rooted in a modern, green revolution approach to agriculture, which requires, among other things, the regular replacement of improved wheat varieties to maintain performance qualities as well as disease resistance (Heisey, Smale et al. 1997).

In developing countries and especially the Sub-Saharan context, in which mainly small farmers grow wheat and respond to disease, access to and resources to buy inputs are limited (Orr 2003). This is also illustrated by this study. More than in developed countries, small farmers are highly dependent on external interventions to make use of these crop protection measures, e.g. in terms of international funding and technical support for breeding locally adapted, resistant varieties.

This raises the question whether there are alternative means, especially at the level of farm and crop management, for farmers to manage rust diseases. In order to answer this question, we widen the perspective to other, comparable risks to agricultural production. What alternative options to respond or adapt to other pests - and to a lesser extend to weather related shocks - are discussed and might be applicable to rust management?

2. Strategies to manage pest risk

On the one hand, advances in the management of pests - including bacterial, viral and fungal plant diseases as well as weeds and animal pests - are often related to new technologies. As a result, the challenge of dissemination and information for farmers in developing countries is being critically discussed (Lucas 2011). On the other hand, especially the rise of organic farming has promoted a debate around ecological approaches to pest management, many of which are based on traditional farming practices and are designed to minimize synthetic inputs.

a. Integrated disease management

Particularly relevant to this discussion is the concept of integrated pest management (IPM), which developed as an attempt to diversify pest and disease management strategies in response to the over-reliance on pesticides during the “chemical area” (Perrin 1997) or the “pesticide wave”

(Zadoks 2003). Integrated pest management is defined as an ecologically and economically sound way to integrate chemical, biological and host resistance approaches as well as agronomic practices to manage diseases, pests and weeds (Way, van Emden 2000). An IPM strategy will typically be crop and disease specific and include a disease risk analysis. The debate is ongoing whether IPM is an alternative to chemical control (Altieri 1993a, Tilman 1999b, Abrol, Shankar 2012) or a way to reduce the application of synthetic pesticides for environmental reasons (Perrin 1997, Way, van Emden 2000, Oerke, Dehne 2004). Irrespective of the position in this debate, it resulted in a renewed appreciation of traditional knowledge and traditional agricultural practices, ranging from intercropping to trap crops (Perrin 1976, Altieri, Nicholls 2004).

b. Strategic, tactical and control measures for crop protection

Helpful for the identification of alternative disease management measures is the categorization put forward by Koehl (2006) between preventive strategic and tactical measures on the one hand and reactive control measures on the other.

In reacting to an occurring pest, chemical, biological or physical measures can be taken to control it. Beyond pesticide application, the use of natural enemies or pheromones as a biological control measures or the manual removal of insects or of affected parts of the plant are examples for alternative reactive responses (Altieri, Nicholls 2004, Abrol, Shankar 2012).

Tactical preventive measures at the crop level include the alteration of the timing of sowing, the use of disease resistant cultivars, the removal of crop residues carrying pathogens or the treatment of affected seeds (Koehl 2006).

Strategic preventive measures are taken at the level of farm management and farming practices. They go beyond the specific susceptible crop or crop variety. They include reduced tillage, crop rotation, physical barriers around plots, the diversification of landscape or cultivated crops (Stirling, Hellin et al. 2014).

Coming back to rust management, this classification of crop protection measures shows that rust management has been discussed mainly from a control (i.e. pesticides) and a preventive tactical (i.e. resistance breeding) perspective, but that a discussion of strategic measures is lacking. Especially in the more recent literature on pest dynamics under climate change, the strategic systemic approach to crop protection in general has received more attention and will be discussed in the next section.

c. Barriers to integrated wheat rust management

The plethora of pest management measures discussed in the (ecological) IPM literature might suggest that there many alternative or complementary strategies to chemical control and

resistance breeding in managing wheat rust. Monitoring and forecasting of rust epidemics has been one additional IPM measure which has been applied in major wheat cultivating areas in the developed world and is now being implemented for developing countries (Line 1993, Stirling, Hellin et al. 2014).[75] Wheat rust management decision guides also recommend a number of complementary preventive measures, including the removal of infected crop residues, the removal of alternate host plants (barberry, barley and volunteer wheat) and moderate fertilizer use (Baidya, Paudel et al. 2015, Sileshi, Ero et al. 2015). These practical guides also stress that there are no "green" alternatives to chemical rust control.

Before breeding programmes for rust resistance developed in the mid twentieth century, the disease caused considerable crop loss in all major wheat growing regions (Dubin, Brennen 2009). The specific characteristics of the rust pathosystem described above (e.g. long-distance dispersal and the long-term survival of dormant spores) considerably limit alternative options for rust management. Scholars across disciplines agree that resistance breeding remains the most important rust management mechanism (Marasas, Smale et al. 2003, Legrève, Duveiller 2010, Chakraborty, Newton 2011, Chaves, Martinelli et al. 2013, Stirling, Hellin et al. 2014). This conclusion is also drawn for organic farming, even if breeding efforts for organic seeds are more limited (Vanloqueren, Baret 2008).

3. Managing pests under climate change

It is a well-established fact that climate change poses new challenges for agricultural production and consequently for food security, especially in tropical and sub-tropical regions (Hayes, Wilhite et al. 2011, Thornton, Herrero et al. 2011, Parry 2014, Zeigler 2014). Besides the higher frequency of extreme weather events, changes in precipitation and higher temperatures, the increase in occurrence of pests is one of the pathways through which climate change is predicted to impact crop production (Reynolds, Ortiz 2010) . A number of recent publications have specifically reviewed evidence to identify how pests will evolve and affect agriculture under climate change (Legrève, Duveiller 2010, Chakraborty, Newton 2011, Garrett, Forbes et al. 2011, Luck, Spackman et al. 2011, Lamichhane, Barzman et al. 2015, Reddy 2015).

a. Unclear predictions for disease evolution under climate change

While there is some agreement that insect pests will occur more frequently under climate change, predictions for plant diseases and rusts in particular are more uncertain and could well be positive for some regions (Legrève, Duveiller 2010, Stirling, Hellin et al. 2014).

[75]The global rust monitoring of the International Maize and Improvement Center (CIMMYT) is the most prominent example: http://rusttracker.cimmyt.org/

Climate change is likely to affect all three dimensions of the plant disease triangle simultaneously: a virulent pathogen, a susceptible host and a favourable environment, which greatly complicates predictions (Legrève, Duveiller 2010). The most immediate effect will be on the environmental conditions for disease outbreak, e.g. high humidity in the case of fungal diseases for infection or higher temperatures for overwintering spores. However, there is evidence that the temperature optima profiles for rust races are already changing, i.e. that the pathogen is adapting to changing temperatures (Thach, Ali et al. 2016). Moreover, the effectiveness of current resistance genes may vary with temperature (Stirling, Hellin et al. 2014).

The complex interaction of climate change effects on wheat rust is only one aspect that causes uncertainty. The increased occurrence of stripe and stem rust epidemics over the past decades is closely linked to agricultural intensification and global movement leading to a wider dispersion of new races (Oerke, Dehne 2004, Savary, Ficke et al. 2012). The effects of intensification, globalisation and climate change on rust or more generally disease occurrence cannot be disentangled.

b. Adaptation to climate and disease risks

The simultaneity of effects and complexity of disease dynamics are reasons why the discussion of adaptation to biotic stresses (including diseases) under climate change is characterized by a systemic and more strategic approach. Adaptation in agricultural systems is understood both as the improved management of agricultural risks and the adaptation to progressive (climate) change (Fuhrer, Gregory 2014).

Notably, strategies to adapt to climate change or to disease risk under climate change do not differ in significant ways from approaches towards sustainable agriculture or sustainable agricultural intensification, especially for low-input agricultural systems. Sustainable or agro-ecological farming practices are inherently more systemic, taking the entire agro-ecosystem – including nutrient, water and energy cycles – into account (Altieri, Farrell 1995). Farming practices such as soil protection and conservation, crop rotation and intercropping, reduced tillage, on-farm water management, soil nutrient and crop residue management or biological pest control are some of the repeatedly mentioned, specific measures (Legrève, Duveiller 2010, Rosenzweig, Hillel 2010, Thornton, Herrero et al. 2011, Fuhrer, Gregory 2014, Stirling, Hellin et al. 2014).

4. Agricultural diversity & adaptation to production risk

One expression of this more systemic and strategic approach in responding to disease risk is that the overall adaptive capacity of the farming system comes into focus. This offers a preventive strategic perspective on rust management that has been missing from the scholarly and policy debate.

a. Diversity as a key to resilience & disease prevention

Increasingly simple or "primitive" (Perrin 1997) agroecosystems with a small number of species, e.g. food and cash crops, are known to be more vulnerable to pathogen and pest attack (Oerke, Dehne 2004). In recent contributions on disease dynamics as well as in the literature on sustainable agriculture more generally, diversity (on serval levels: landscape, species, genetic, agricultural livelihoods) is seen as a key component of resilient or robust farming systems (Altieri 1999, Gurr, Wratten et al. 2003, Cavatassi, Hopkins et al. 2006, Jarvis, Brown et al. 2007, Berry 2009, Lin 2011). While the evidence for reduced incidence of pests in diverse agro-ecosystems is more robust for animal pests than for plant diseases, a reduction in vulnerability to disease is widely understood as an ecosystem service related to agricultural diversity (Altieri, Nicholls 2004, Jarvis, Brown et al. 2007, Wilby, Thomas 2007). This builds on the fundamental finding from plant epidemiology that the incidence and number diseases increase proportionallyto host abundance (Lin 2011).

Although on a different scale, leading experts of international rust resistance breeding also identify diversity as a key to managing rust. They argue that the genetic make-up of current resistant wheat varieties is too uniform and consequently that resistant cultivars must be diversified, e.g. by a genetic combination of resistance genes (Singh, William et al. 2004). Ideally, a farmer should also grow more than one rust resistant variety (with different resistance genes) and he should also alternate the use of different fungicides to avoid resistance in the pathogen (Chakraborty, Newton 2011, Baidya, Paudel et al. 2015). These recommendations for more durable rust resistance are even more challenging to implement in a context of resource and access constraints.

Therefore, discussing agrobiodiversity more generally (which may well include diversity of resistant cultivars) as a preventive strategic response to disease risk is particularly relevant. Genetic, species and landscape diversification are strategies that can be implemented in smallholder agriculture as they require only a limited amount of inputs and no continuous external support. The question whether more diverse smallholder systems can be productive in the short and medium term at a level that meets the demands of a growing population, is a question of fierce debate and goes beyond the scope of this paper.

b. Dimensions of diversity for pest management

In organic farming the importance of diversity for pest control and prevention is discussed over time and in space. Food crop rotation is an important means of achieving diversity in commercial organic farming and particularly relevant for controlling soil borne diseases (Lampkin 2002). Fallowing as well as the manipulation of sowing and harvesting dates are other examples of temporal diversity.

Intercropping and mixed cropping are examples of diversity in space often practiced in traditional agricultural systems and are particularly relevant for controlling insect pests (Altieri 1993b). The use of varietal mixtures, i.e. a combination of different suitable varieties grown alongside each other, is one of the most relevant ecological farming practices for controlling fungal diseases. Research suggests that the multiplication and dissemination of spores is lower when varietal mixtures are used, which, incidentally, is also a traditional farming practice (Lampkin 2002).

Diversity of farm plot location and landscapes or traditional polycultures are examples of other strategic dimensions of agricultural diversity with implications for pest prevention, which we will not discuss in detail here (Nicholls, Altieri 2007, Rossing, Modernel et al. 2014)

c. The role of genetic diversity

Genetic diversity and - considering the study background in one of the centres of crop diversity – the role of landraces is particularly relevant. There are two distinct research areas and interests when it comes to wheat landraces and wheat rust.

Ex situ genetic diversity for resistance breeding

Conventional breeding is based on existing crop genetic resources. Wheat landraces from Ethiopia and beyond, conserved in ex situ collections, have been and continue to be a source of resistance genes for rust resistance breeding (Negassa 1986, Teklu, Hammer 2009, Bansal, Arief et al. 2013, Daetwyler, Bansal et al. 2014, Ford-Lloyd, Engels et al. 2014, Zeigler 2014).

In-situ genetic diversity for farmer selection

On the other hand, conserving crop genetic diversity also in the field or in situ is seen as a strategy to directly improve farmers adaptive capacity (Lin 2011, Bellon, Van Etten 2014, Ford-Lloyd, Engels et al. 2014). Farmer selection of genotypes which perform well under different stresses is the way crop genetic resources have been conserved, have evolved and adapted to environmental and other changes for millennia (Jarvis, Brown et al. 2007). The historical analysis of crop genotypes and pathogens suggests that plant host resistance and diseases co-evolved (Jarvis, Brown et al. 2007). Allowing for evolutionary dynamics, including the evolution of host resistance to new pathogens, to continue is one central arguments for the in situ conservation of traditional crop varieties (Bellon, Van Etten 2014). Given the pace of climate change, it is uncertain how evolutionary dynamics will evolve and how feasible farmer selection will be, given that fitness of local landraces will be reduced by climate change (Bellon, Van Etten 2014, Ford-Lloyd, Engels et al. 2014).

One example for the role landraces in rust control is Bioversity International's project in Northern Ethiopia. Wheat landraces which are resistant to stem rust is are currently being tested locally, (re) introduced and disseminated through a community gene bank scheme.[76]

Genetic diversity to break the boom & bust cycle of monoculture

Maintaining a diverse genetic base with varieties at different levels of resistance is not a means to fully prevent disease outbreak like the cultivation of a single resistant variety. It is rather a means for "a more stable disease management than a monoculture allows", which is based, among other things, on barrier effects and interaction between different pathogen races (Jarvis, Brown et al. 2007, p.292). The resistance of improved varieties, especially when cultivated in monoculture, typically breaks down after five to six years leading to a so-called boom and bust cycle (Dubin, Brennen 2009). The role of genetic diversity in reducing the severity of a fungal disease of rice has been confirmed in controlled experiments (Zhu, Chen et al. 2000).

Landrace cultivation between genetic erosion and adaptive change

Evidence suggests that the dynamics leading to disease control are only effective above a certain level of genetic variation at the household and the community level (e.g. in local seed banks or circulated through the informal seed system). The cultivation of one popular landrace variety alongside an improved variety might be at the "borderline between adaptive change and genetic erosion" (Ford-Lloyd, Engels et al. 2014, p. 33).

An example for this difficult balance is a previous rust epidemic in the study area in 1977, which is reported to have led to a complete failure of tetraploid wheat since the remaining landraces were highly susceptible to rust (Negatu, Mwangi et al. 1994, Tsegaye, Berg 2007a). This was a major contributing factor to the severe genetic erosion in the area, i.e. the loss of genetically diverse traditional or landrace varieties. Through in situ or on-farm conservation efforts throughout Ethiopia – the centre of origin and domestication of durum wheat and other cultivated crops – wheat landraces have been re-introduced through community gene banks (Tsegaye, Berg 2007a).

d. Managing risk through crop abandonment

An agro-ecosystem, in which diverse crop genetic resources are maintained, will not only allow farmers to adapt by switching varieties, but also provide viable options to change crop types (Webber, Kahiluoto et al. 2014). The example above shows that crop varieties often disappear as a result of disease epidemic. In the case of inadequate disease management, also the cultivation of the affected crop can become economically unviable (Oerke, Dehne 2004) and the abandonment of food or cash crop by households or in entire regions can be the result (Legrève, Duveiller 2010).

[76] For more information see: http://www.bioversityinternational.org/news/detail/can-ancient-ethiopian-wheat-varieties-provide-resistance-to-stem-rust/

It is important to note that the abandonment of a crop due to disease-related crop loss is an example for failed pest management, but it can be an example for successful risk management. The aim of risk management strategies is to reduce exposure to risk and consequently to reduce the variability of agricultural output (Fafchamps 1999b, Dercon 2005b).

5. Summary & contribution

Intensification is understood to be one of the major contributing factors to increased incidence and severity of rust epidemics. Especially in the recent literature on pest dynamics under climate change, agrobiodiversity - as a fundamental principle of sustainable or agroecological farming – has been emphasised as a potential strategic preventive measure to manage plant diseases and increase the resilience of agroecosystems. Genetic diversity in wheat is thereby of particular relevance for the management of wheat rust. However, this literature review has also shown that the cultivation of resistant wheat varieties remains the central tactical measure in preventing wheat rust epidemics, highlighting in turn the policy challenge of equitable access for small farmers in developing countries.

Empirical research on wheat rust in Ethiopia and beyond has largely focused (1) on creating awareness for the scale and threat of the disease, (2) on the efficacy of disease control through resistant varieties and pesticides, primarily in experimental settings, as well as (3) on genetic analysis for resistance breeding.

This study analyses de facto responses to a wheat rust epidemic in a context of smallholder agriculture in a developing country and in one of the centres of wheat genetic diversity based on survey panel data. The study contributes to the literature, firstly, by identifying farmers' response measures in a context of limited access to conventional rust control measures. These responses can then be analysed in terms of their potential to control the disease or reduce the exposure to the disease. Secondly, we discuss whether wheat rust continues to pose a threat to the conservation of genetic diversity or whether landrace cultivation and varietal diversity can contribute to making small farmers' cropping systems more robust to wheat rust. Thirdly, we discuss policy challenges related to the access to rust resistant wheat varieties in a context of limited functionality of the formal and informal seed system.

STUDY BACKGROUND & DATA

1. Study background

The three study sites *Kokka, Ejere* and *Chefe Donsa* are *kebeles* (villages) located at different elevations were chosen to represent different agro-ecological conditions for wheat cultivation: midland, mid-highland and highland. The sites are located in *Gumbichu* and *Lome woredas* (districts) in the East Shewa zone of Oromia regional state, seventy to one hundred kilometres southeast of the Ethiopian capital Addis Ababa and close to the highway, which connects the capital to the port of Djibouti. Consequently, households in the study sites have favourable access to markets. 81.7 percent of households are located within one-hour walking distance to the next market.

The three *kebeles* are characterized by annual rainfall of 900 to 1,300mm with a short (*Belg*) and a main rainy season (*Meher*) (Seboka, Desalegn 2012, Shiferaw, Tura 2012).[77] The elevation of the study sites ranges from approximately 1,800 to 2,400 masl. Despite lower annual rainfall than in other highly productive cereal production areas of the country, the study sites are characterized as part of moisture reliable highland cereal zone or as part of the Moist *Weyna Dega* agro-ecology (Hurni 1998, Chamberlin, Pender et al. 2006, Chamberlin, Schmidt 2012).

The overwhelming majority of households in the sample are small-farmers with average land holdings of 2.3 ha, used for mixed agriculture and livestock production. Agricultural production can be described as 'semi-commercialized' as the majority of sample households sell part of their cereal or pulse production on local markets (Seboka, Desalegn 2012). Only eleven percent of households reported to produce exclusively for subsistence. The most popular cereal crops are wheat and tef, grown by over ninety percent of sample households. Barley (35.5 percent) and maize (12.3 percent) are less commonly cultivated. Pulses, especially chickpea (84.5 percent) and lentil (68.9 percent), are grown in rotation with cereal crops and produced to a large extent for the market with over 75 percent of chickpea growing households having sold part of their output in 2013. Vegetables and fruit such as tomatoes, onion, garlic and cabbage are usually grown for home use, except for the Kokka site (at a comparatively low elevation of 1,800 masl), which is widely known for its horticultural production, particularly melon, as well as for the large-scale production of flowers and strawberries and other cash crops on plantations.

Wheat is the most important staple crop in the region with 96 percent of households cultivating it. Nationally, tef and maize are the dominant cereal crops both in terms of cultivated land and output (Taffesse, Dorosh et al. 2011). Sorghum cultivation, although grown in a different agro-

[77] Rainfall data was also confirmed by the data compiled in the Climate Knowledge Change Portal: http://sdwebx.worldbank.org/climateportal/index.cfm

ecological zone, is comparable to wheat on a national scale with an average of 1.4 million hectares of cultivated area and 22 million quintals harvested between 2004 and 2007 (Taffesse, Dorosh et al. 2011). Wheat productivity of the sample households in 2013 of 19.3 quintals per hectare was circa twenty percent above the national average of 16.9 quintals per hectare in 2011 (Taffesse, Dorosh et al. 2011). Tef, barley and maize outputs in 2013 were also above the national average.

Wheat is not only the most important crop and highly productive in the study area, it also originates in the region. The Ethiopian central highlands are one of eight global centres of origin, characterized by a unique genetic diversity of durum or tetraploid wheat (Engels, Hawkes et al. 1991). In recent decades, however, genetic erosion has rapidly progressed which is most plausibly linked to the wide-spread adoption of only one or few - genetically similar – high-yielding wheat varieties bred by the national agricultural research institutions and spread through extension services (Teklu, Hammer 2006, Tsegaye, Berg 2007a). In two of the study sites revolving seed banks have been established to re-introduce and conserve genetic resources in this diversity hotspot (Bezabih 2008).

Almost thirty percent of all households in the sample are members of a Community Gene Bank (CGB) and have access mainly to traditional varieties for major crops, with a particular focus on wheat and barley. Despite the presence of the seed banks, the extension service continues to play the dominant role for seed sourcing. Two thirds of all wheat varieties grown in 2013 were bought from the extension service.[78] A quarter of households used saved seeds, 19.6 percent sourced through the CGB and only 15 percent bought seeds from local markets. The informal seed system plays only a negligible role in the region as compared to other parts of the country (McGuire 2000, Mekbib 2006, Thijssen, Bishaw et al. 2008).[79] Out of 685 reported cases of wheat and barley grown by 428 households during the 2012 season, only 13 (less than 3 percent) were sourced through exchange or gifts.

2. Data collection and structure

This study is based on two household surveys, conducted in May/June 2011 and May/June 2013 with the support of Bioversity International and the Ethiopian Biodiversity Institute (EBI).

During the first survey round, 313 households were surveyed in nine *gandas* (sub-villages) in the three study sites or *kebeles*. Respondents were sampled randomly using sub-village level household lists. Three *gandas* (sub-villages) were picked randomly from each *kebele* (village). The *kebeles* were consciously chosen to represent a midland (Kokka, ca. 1,800 masl), mid-highland

[78]In this analysis we refer to 685 reported varieties grown by the 428 households in the 2013 sample.
[79]See Mekbib (2006) and McGuire (2008)for examples from West Haraghe, where informal seed exchange is the primary seed source.

(Ejere, over 2,100 masl) and highland (Chefe, over 2,300 masl) locations, covering different agro-ecological conditions for wheat cultivation. Moreover, community gene banks (CGB, see above) have been active in two of the three study sites since the 1990s. Through random sampling, members and non-members of the gene banks in locations with and without in situ conservation efforts were included in the sample.

The second-round survey included 428 households. 303 households from the first round were re-surveyed in 2013[80] and 125 households were added by random sampling from *ganda* (sub-village) household lists to systematically increase the size of the sample.[81] Interviewees in both rounds were usually heads of household.

For data analysis in this paper we use mainly the panel data set (N=303), including only households which were surveyed in both rounds. In the analysis below, some observations are lost due to missing data for relevant variables. The 2013 cross-section (N=428) dataset is only exceptionally used, when panel data is not available for the indicators of interest, e.g. pesticide use and land rentals.

The survey instruments covered household composition, assets (including livestock and land holdings), crop and variety choice, production, sales etc., involvement in social networks, intra-household decision making as well as an assessment of production conditions in the previous seasons. The first-round questionnaire was developed based on and accompanied by qualitative data collection (semi-structured interviews and focus groups). Questionnaires were translated into the local languages: Amharic and *Afaan Oromo*. Interviews were conducted by experienced enumerators in the native language of the respondent. Answers were recorded on paper.

The 2013 survey was also accompanied by qualitative data collection. 30 farmers were interviewed using semi-structured interview guides and live interpretation to explore attitudes towards and experiences with wheat landrace cultivation. Nine key informant interviews were conducted in addition to that with committee members and chairpersons of the community gene banks, the seed multiplying enterprise *Birftu* as well as with development assistants and *woreda* (district) officials. Qualitative interviews were used to gather background information and to triangulate

[80]The ten households missing from the 2013 round had either moved away (N=4), passed away (N=1), were not willing to be interviewed again (N=2) or were traveling at the time of the survey (N=3).

[81]The author of this study acted as principal investigator for the second-round survey in 2013. The sample was systematically increased in the second round to allow for a larger sample for a planned third wave of data collection. The baseline survey was collected by Dr. Stella Nordhagen (Cambridge University, Bioversity International). Given that there were different principal investigators and research objectives, the survey instruments in both rounds differ to some degree. Some of the questions of particular interest to this study, were not asked in 2011 (e.g. on fungicide use or the abandonment of wheat varieties).

findings, particularly with regards to landrace cultivation and conservation as well as seed system analysis. However, qualitative data are not explicitly analysed in this paper.

3. Limitations of the data

Given the specific context of data collection and the fact that the principal investigators of the two survey rounds differed, the panel data has a number of limitations which affect the analysis. Although the phrasing of key questions and units is consistent in the survey instruments for both rounds, a number of questions were asked slightly differently by the enumerators in the two rounds (see below), which was noted during data analysis when the survey was finalized.

During the first survey round, enumerators only captured the answers respondents gave to specific questions concerning difficulties in wheat cultivation and rust responses. Enumerators in the second round, however, read answer categories out loud, leading to systematically different results for some parts of the survey instrument (see particularly table 9 & 10). As a result of this measurement error, we observe a systematic over-reporting of difficulties in growing wheat and response strategies to wheat rust in 2013. The careful interpretation of the findings (see below) accounts for the measurement error and still offers highly relevant insights This systematic difference only concerns the specific questions discussed above and not the entire survey instrument.

Furthermore, while respondents in the first round listed all crops grown on their farm, they only reported the cultivated area and harvest of the *three most important crops* as well as for all wheat and barley varieties. In the second round, respondents were asked for an estimation of the cultivated area and harvest of *all* crops and all wheat and barley varieties grown by the household to allow for an accurate measurement of varietal and crop diversity. These differences explain why certain steps of data analysis could not be implemented. In this study, we analyse the relationship between wheat cultivation (under disease stress) and the cultivation of other major crops, particularly tef, barley, lentil and chickpea. Responding to the data limitations, we avoid measures based on area and productivity for these crops wherever possible (using dummies for crop cultivation instead, for which we have complete information). Where area-based measures are used, it must be noted that the analysis excludes households for which the respective crop is secondary. Since tef is cultivated by over 90 percent of all households, we believe that the resulting bias is minor. To account for the difference, we only include households with available data for both rounds.

Despite these limitations, the insights this original dataset offers are highly valuable for our understanding farmers' responses to stripe rust. The data offer a particularly high level of detail on wheat production and rust responses. Furthermore, the data are unique as they offer insights in small farmers' production during and after a rust outbreak.

EMPIRICAL STRATEGY

In this study, we aim to understand how small-farmers in three communities in East Shewa change their agricultural production in response to the wheat rust outbreak of 2010/2011 and to what extent classic disease control measures, such as fungicide application and disease resistant varieties are available and adopted.

As discussed above, this non-experimental study draws only on loosely related previous empirical research in its conceptual approach. Therefore, the empirical strategy and the presentation of findings are structured in a way that combines the formulation hypotheses with testing of hypothesis (under some limitations). Firstly, we use fully structured categorical self-reporting questions based on pre-survey qualitative data collection to identify possible responses to wheat rust and assess the severity of the disease compared to other challenges of wheat cultivation.

Secondly, based on the analysis of self-reporting questions, hypotheses concerning changes in the wheat and crop portfolio due to rust exposure are formulated and further investigated using descriptive summary, bivariate and multivariate methods to analyse factual changes in a range of relevant production indicators. We apply econometric methods exploiting the dynamic dimension of the panel dataset in addition to descriptive summary statistics to identify patterns in portfolio change and particularly to describe the role of wheat rust for variations in outcome variables. Although we reflected on and aimed to control for sources of bias (especially endogeneity) in the econometric modelling of the relationship between wheat rust and portfolio change, we do not claim that the econometric models are fully identified. We interpret findings in a descriptive manner and do not claim inference on underlying causal relationships.

1. Dependent variables

Table 7 below provides an overview of the variables used in the multivariate analysis used to describe patterns of changes in the wheat portfolio (see table 14).

Indicators of changes in wheat cultivation show that both the mean land on which wheat is grown as well as the average share of land allocated to wheat have decreased significantly from 2011 to 2013 by 0.12 hectares or 4.7 percent on average. Using the (change in) share of land allocated to wheat as dependent variable in the multivariate analysis is appropriate as the primary interest is in dynamic differences, i.e. changes within households over time rather than changes across households.

Table 7: Overview summary statistics for dependent variables

Variable description	N		Mean		Std Dev	Min	Max
	'11	'13	'11	'13			
Net number of varieties adopted and abandoned from 2011 to 2013[82]	278		-0.01		0.67	-3	3
Land allocated to wheat *(in hectares)*	301	300	0.93**	0.81**	0.64	0	7
Share of land allocated to wheat	301	301	0.45***	0.39***	0.01	0	1
Change in share of land allocated to wheat	301		-0.05***		0.29	-1	0.75

Differences are significant on a (**) 5% or (***) 1% significance level respectively.

2. Independent variables

The independent variables for all three multivariate models are summarized below (table 8). In order to analyse the role of wheat rust in changes of households' wheat portfolio and in households' allocation to wheat, we must control for a range of factors which typically drive portfolio choice or optimal relative land allocation.

a. Agricultural resource endowments & wealth

Agricultural production is primarily determined by small farmers' endowments (and access) to inputs: land, labour and capital, which are measured or proxied by land size, household size and livestock under the reasonable assumptions of limited labour markets and of primarily non-mechanised agriculture. These production indicators are used as control variables for farm heterogeneity. The value of total livestock holdings (as opposed to the male cattle count) serves also an indicator of household wealth. Wealthier farmers are expected to have a higher capacity to adopt market-based options for plant protection, such as fungicides or new wheat varieties (under availability constraints).

b. Access to plant genetic resources

Access to plant genetic resources (PGR) is a central enabling factor for portfolio diversification and the households' decision to shift production from wheat to other crops. In a context, in which the informal seed systems is negligible and the seed market of minor importance, other access options become more relevant: membership in a community gene bank, a seed multiplying enterprise or, most importantly for access to disease resistant varieties, the government's model farmer scheme, which provides inputs (seed, fertilizer etc.) and training to a selected group of innovative farmers. We expect farmers with better access to PGR to have a higher net adoption of new wheat varieties, to allocate more land to wheat and to have a higher probability to be in the non-rust affected group.

Table 8: Descriptive statistics for independent variables
(for households included in both survey rounds, N=602)

Variable	Description	Mean/Share	Std Dev	Min	Max
Wheat Rust Exposure					
Rust Problem	Dummy for rust problems[83]	0.87	/	0	1
No Rust 2013	Dummy variable for households no longer reporting rust problems in '13	0.23	/	0	1
Household Assets & Characteristics					
Household size	Number of minors and adults living in the household	6.30	2.56	1	20
Land	Land cultivated by the household in hectares	2.21	1.37	0	7.5
Heads of cattle	Heads of male cattle owned (incl. oxen)	2.83	1.57	0	10
Value Livestock[84]	Value of livestock holdings at 2013 median prices, Birr	34,151.88	18,651.23	0	116,050
Crop and Variety Portfolio					
Wheat Count	Number of wheat varieties grown	1.33	0.79	0	6
Crop Count	Number of crops grown	4.80	1.56	0	10
Rust Resistant (N=585)[85]	Number of rust resistant varieties grown	0.09	0.32	0	2
Landraces (N=585)	Dummy for cultivation of wheat landraces	0.14	/	0	1
Chickpea	Dummy for cultivation of chickpea	0.85	/	0	1
Lentil	Dummy for cultivation of lentil	0.70	/	0	1
Tef	Dummy for cultivation of tef	0.92	/	0	1
Barley	Dummy for cultivation of barley	0.38	/	0	1
Tef Area (N=509)[86]	Share of land allocated to tef	0.48	0.46	0	3
Market integration					
Market distance[87]	Walking distance in minutes	44.54	34.96	2	180
Commercialisation (N=546)[88]	Share of wheat harvest sold (in %)	0.17	0.20	0	1

[83]Some observations were lost due to a small number of households not growing wheat (N=15 in 2013 and N= 5) for which the question is not applicable.

[84] Further analysis has shown that due to the distribution of the livestock variable the error distribution is not normal. The untransformed variable is skewed to the left with a number of outliers (N>20) at the upper end of the distribution. Consequently, the livestock variable is being log transformed when used in the multivariate analysis.

[85]The number of observations is lower for these variables because not all households were able to clearly identify all varieties grown.

[86]The number of observations is lower for this indicator (which is only used in selected specification) because households in survey round I were only asked to report planted area and output for the three most important crops. Survey II has information on the area and production of all crops planted (see limitations)

[87] An outlier analysis using a boxplot indicated that only two observations are above 120 min or two hours walking distance, i.e. outside the 1.5 inter-quartile-range of the upper quartile.

[88]The number of observations for this variable is lower because of missing data for the amount of harvest sold for each wheat variety planted. Many respondents reported that they did not recall the exact amount

Table (ctd.): Descriptive statistics for independent variables

Variable	Description	Mean/Share	Std Dev	Min	Max
Access to plant genetic resources					
Gene Bank	Membership in a Community Gene Bank (CGB)	0.31	/	0	1
Model Farmer	Household participates in the government 'model farmer' scheme	0.30	/	0	1
Seed Enterprise	Membership in a farmer-based seed multiplying enterprise (Birftu)	0.15	/	0	1
Alternative rust response indicators (available for 2013 only, N=301)					
Fungicide (only '13)	Dummy for use of fungicide	0.57	/	0	1
Rent Dummy (only '13)	Dummy for any land rented out	0.12	/	0	1
Rent Size (only '13)	Size of land plot rented out, ha	0.09	0.30	0	2.25
Agro-ecological conditions/locations					
Kokka	Midland site (*Lome woreda*)	0.34	/	0	1
Ejere	Mid-highland site (*Lome woreda*)	0.32	/	0	1
Chefe	Highland site (*Gumbichu woreda*)	0.34	/	0	1

c. Agricultural portfolio indicators

We also use a range of indicators, such as crop dummies, crop area, wheat and crop count variables, to capture the portfolio composition and potential trade-offs between wheat and other major crops. The hypothesised effect of portfolio indicators varies: we would expect an inverse relationship between the cultivation of cereal crops (esp. tef and wheat) and no effect for pulses, which are grown in rotation with cereals. Pulses are, however, much more commercialised than cereal crops (see above), which might have implications for relative land allocation. We would also expect more wheat diverse farmers to reduce the share of land allocated to wheat less as they have options to specialise on less rust susceptible varieties within their portfolio.

d. Market integration

Access to markets is proxied by the walking distance of the household to the next market. The share of wheat output sold is an indicator of the level of market production in wheat. The portfolio choice of small farmers cultivating crops mainly for subsistence or for the markets is often found to be different (Fafchamps 1992a). We use market indicators as a control for systematic differences in portfolio choice related to market integration.

Indicators of rust response strategies that go beyond portfolio choice, such as fungicide application and renting out land, are only available for the second-round survey.

that was sold (especially when it was only a small amount). Moreover, the small number of farmers who reported to have sold a larger amount than they harvested are not included.

3. Multivariate methods

The analysis of changes in the household portfolio of wheat varieties from 2011 to 2013 (table 14) is based on an ordinary least squares regression model using first differences of all independent variables and village dummies to control location specific variations. The dependent variable is the net number of varieties adopted or abandoned (see table 12 for more information) between the surveys and is similar, but not equal to the change in the wheat count variable. Since the dependent variable is a change in a count variable (i.e. with negative integer values, a mass and mean at zero, with a balanced distribution), the poisson model is not applicable.[89] Consequently, we use an OLS model with robust standards errors to correct for the implicit heteroscedasticity of the error terms. Although variables were jointly significant in most specifications, only few coefficient estimates were significant, albeit relatively consistent across different specifications. The results of the first difference specification are presented in this paper, which allows to control for unobserved heterogeneity between households by removing household fixed effects and accounts for the fact that the explanatory variable of interest – the change in reported problems with rust – is a dynamic indicator. Other explanatory and control variables included in the model for explaining change in the wheat portfolio are exogenous, including indicators of access to PGR and agricultural resource endowments.

[89]The non-linear poisson fixed effects regression can also not be used because the dependent variable is a composite variable based on count variables for the adoption and abandonment of wheat varieties. The variable, which very accurately measures net adoption is not available for both rounds. Fixed effects poisson models using the wheat count variable as dependent variable was implemented as a control and yielded similar results, but the size of the estimated coefficients differed.

FINDINGS

In this section, findings on farmers' responses to the wheat rust outbreak are presented, starting with categorical self-reporting questions on the severity of and reactions to the disease. We then move on to an analysis of changes in wheat diversity and the varietal portfolio. Based on the analysis of household level land allocation to wheat, we discuss shifts in cultivation patterns, which allows for more differentiated insights into responses of more or less well-endowed households. Finally, we present findings on fungicide use and land rentals.

1. Analysis of self-reporting questions on challenges and rust responses

Table 9 gives an overview of difficulties farmers report with growing wheat in both survey rounds. The fact that farmers report significantly more problems in 2013 is very likely due to a systematic difference in the way the question was asked in the two survey rounds (see also a discussion of limitations of the data above). Nevertheless, these figures serve to show how severe the wheat rust outbreak was in 2010/11 and how much it affected the majority of farmers in the field sites. Only 11 out of 296 respondents who answered this question in 2011, do not report any problems with the disease. In 2013, more households report a lack of fertilizer than wheat rust problems.

Table 9: Reported difficulties in growing wheat[90]

Difficulty	Share of households in '11, %	Share of households in '13, %
Not enough land	13.9	55.5
Poor soil	0.3	35.6
Not enough seed	10.5	54.3
Not the right seed	2.4	51.2
Hard to store seed	0.3	36.0
Lack of fertilizer	11.1	89.6
Pests	5.4	58.5
Wheat rust	96.3	77.5
Other disease	0.7	17.0
Weather/Rain	24.3	64.1

All differences are statistically significant at a 1% level

Nevertheless, rust continues to be the second most frequently mentioned problem in 2013. Moreover, farmers' answers also highlight other challenges of agricultural production in the central highlands of Ethiopia: moisture stress and limited access to agricultural resources such as seeds and fertilizer, which are usually provided through the government extension services.

Table 10: Responses to wheat rust[91]

Changes	Share of hh in '11, %	Share of hh in '13, %
No changes	6.8	40.0
Plant other modern wheat varieties	65.5	40.6
Plant other landrace wheat varieties	6.8	54.5
Grow more chickpea or lentil	3.7	36.1
Grow more of other crops	2.0	10.1
Use more inputs (incl. fungicide)	46.6	63.0
Rent out land	0.3	10.1

All differences are statistically significant at a 1% level

[90] The results are displayed for households included in both survey rounds (N=296 for 2011 & N=289 for 2013). Households not growing wheat were not asked (N=4 in 2011 and N=10 in 2013). The data is missing for one household in the first round and for two households in round two.
[91] The sample sizes for this table are the same as for table 3 (see footnote 12).

Farmers describe a range of responses to the stripe rust (see table 10). Planting a different (i.e. resistant) modern variety and applying fungicide are by far the most frequent responses in 2011. These similarities in farmers' responses to the academic discussion on wheat rust epidemics - focussing on conventional input-oriented crop protection strategies - could be a testimony to the effect of decades of agricultural policy interventions aiming to increase productivity through a green revolution approach, implemented through extension services and heavily funded by international donors in regions with high agricultural potential (McCann 1995).[92]

When re-interviewed two years after the peak of the rust epidemic, realizing that the access to inputs for plant protection remains very limited, farmers' responses to the disease are more diverse. Many report to grow more landrace wheat varieties or to increase cultivation of other crops, thus reducing the household's wheat production. All 13 households which abandon wheat from 2011 to 2013 report problems with wheat rust in the first round.

In 2011, when the outbreak is most acute, only a small minority of farmers reports to make no changes in response to the disease. Forty percent of households in 2013 continue to farm as they used to. On the one hand, this reflects that fewer farmers are affected by the disease in 2013 and thus make no more changes in response to or to prevent the disease. On the other hand, it means that farmers have already reacted and changed production in response to the effects and the risk of the disease in previous years.

2. Group comparison: indicators for rust response options

In order to explore further the factual and relative relevance of response strategies listed by farmers, table 11 gives an overview of indicators for different reactions to the disease, derived from farmers' answers discussed above. It compares these indicators for farmers who reported problems with rust in 2011, but not in 2013 to farmers who continue to experience problems with wheat rust. Even if the group variable is subject to measurement error, it serves as a basis for determining whether farmers experience fewer rust problems either as a result of successful disease management or of reduced exposure to the disease.

Although the statistical differences based on group comparisons have to be interpreted with caution, the results suggest that farmers in the group without rust problems are no longer affected by the disease rather than having managed it.

To conclude that these farmers have successfully controlled the disease, we should find that farmers in the group without rust problems grow significantly more resistant varieties (1), grow

[92]See the last chapter of his book for a discussion of agricultural policies from 1960s onward

Table 11: Comparison - Households with & w/o rust problems in '13

	HH reporting no rust problem '13		HH reporting rust in '11 & '13		
	N	Value (1)	N	Value (0)	
REPONSE OPTION 1: Changes in the wheat portfolio & cultivation					
Resistant varieties (dummy)	64	0.094	217	0.184	**
Landraces (dummy)	64	0.146	217	0.133	
Improved, susceptible varieties					
Wheat area	65	0.732	221	0.807	
Change in wheat area	65	-0.058	220	-0.086	
RESPONSE OPTION 2: Changes in the crop portfolio & cultivation					
Crop count	65	4.431	220	4.614	
Δ Crop count	65	-0.646	220	-0.590	
Tef	65	0.892 (N=58)	221	0.923 (N=201)	
Tef area	63	0.393	211	0.458	
Δ Tef area	45	-0.144	169	-0.053	*
Chickpea	65	0.846 (N=55)	221	0.851 (N=188)	
Chickpea area	59	0.424	203	0.538	**
Δ Chickpea area	55	-0.198	180	-0.094	*
RESPONSE OPTION 3: Fungicide application					
Fungicide (dummy)	64	0.563 (N=36)	217	0.608 (N=132)	
RESPONSE OPTION 4: Renting out land					
Land rental (dummy)	65	0.077 (N=5)	221	0.122 (N=27)	
Land rental (ha)	65	0.054	221	0.097	*
Resource endowments					
Land (ha)	65	2.170	221	2.221	
Δ Land (ha)	65	-0.102	221	-0.078	
Livestock Value (Birr)	65	32,590	221	34,092	
Δ Livestock Value (Birr)	65	844.9	221	-2,272	*

Differences in mean or proportion significant at a 10% (*), 5%(**) or 1%(***) level

relatively more tef or chickpea to replace wheat (2), use more fungicides (3) or rent out significantly more land (4).

None of the indicators for the four response options, identified based on the self-reporting questions, points towards successful disease management by adopting one or several of these responses. To the contrary, the statistically significant differences indicate that households which are no longer experiencing rust problems grow comparatively less disease resistant varieties, less chickpea or tef and rent out less land than households which are still affected by the disease in 2013. Note that households in this group have increased the total value of their livestock holdings significantly compared to the rust affected group. This difference might indicate that small farmers use their assets to self-insure against the risk of agricultural production. It is well documented that small farmers sell livestock to smooth their income when an income shock occurs, e.g. though production losses due to this disease or extreme weather events (Dercon 2005b). In this context, we would expect farmers to sell livestock in order to buy wheat for consumption or to compensate for the loss of income from wheat sales.

In summary, four broad categories of farmers' responses to wheat rust were identified in this section. This descriptive bivariate analysis tentatively suggests that despite responding to the disease in a number of ways, farmers continue to identify rust as a major challenge in wheat cultivation. In the following, further findings for each of the response categories is presented,

starting with an analysis of changes in the wheat portfolio. Farmers identified most frequently the adoption of alternative modern and traditional varieties as a reaction to the disease outbreak.

3. Changes in wheat diversity & varietal portfolio

Qualitative interviews and informal conversations indicated that many farmers chose to abandon modern wheat varieties which were most susceptible to the rust while new rust resistant varieties were not immediately available. We, thus, investigate whether the rust outbreak had an effect on wheat diversity in the communities.

a. Changes in wheat diversity & varietal turnover

Using both a simple variety count as well the Shannon-Wiener diversity index to measure varietal diversity in wheat, we find that the level of wheat diversity did not change on a statistically significant level from 2011 to 2013. In both years, households in the sample grow on average 1.3 wheat varieties. In 2013, 26.9 percent of sample households grow more than one wheat variety and only 6.3 and 2.3 percent of households cultivate three or four varieties respectively. The values for 2011 are not significantly different.

While varietal diversity at the aggregate level is not affected by the rust outbreak, a differentiated analysis of household level changes of the varieties grown (based on variety names), points to substantial turnover in the varietal portfolio. Table 12 shows that thirty percent of households, which grow wheat and can identify all varieties cultivated on their farms in both rounds, abandoned at least one wheat variety between the two survey rounds and adopted at least one wheat variety, which was not previously grown. The table also shows that households who adopted new varieties (i.e. mainly resistant improved varieties and to a lesser extend landraces) are not necessarily the ones, who abandoned varieties, suggesting that there are is a considerable number of both net adopters and net losers of wheat varieties. While wheat diversity did not change on the aggregate level, the table points to a substantial variation in household level changes in varietal diversity, which is further analysed below.

b. Reasons for abandoning wheat varieties

Data generated through a different set of semi-structured, self-reporting questions concerning the abandonment of wheat and barley varieties, offers some insights into farmers' reasons to stop cultivating a particular variety, thereby going beyond the recent wheat rust epidemic. Sixty percent of all sample households report to have abandoned a wheat variety at some point in their farming life. Based on responses from these households, we summarize and categorize reasons in table 13. The answer categories presented in the table follow farmers' answers and are therefore not discrete, but indubitably interrelated. Since the infection with wheat rust depends on specific

weather conditions, farmers are able to assess the performance of their varieties with and without disease stress.

Performance related reasons are most important in farmers' decisions to more away from a particular variety. Abandonment is also frequently motivated by the inadequate response of varieties to biotic and abiotic stresses, including moisture stress and pests. Wheat rust is by far the most important stress-related reason to abandon a variety and overall the second most frequently mentioned reason to drop a variety. This underlines that wheat rust constitutes a major threat to wheat cultivation compared to other biotic and abiotic stresses in the region.

c. Multi-variate analysis of wheat portfolio change

We further explore the role of wheat rust in household-level variations in varietal diversity, while controlling for other relevant factors, using a multivariate analysis of patterns of portfolio change. As discussed above, we choose a parsimonious first difference model with strictly exogenous independent variables, including proxies for household endowments, access to plant genetic resources as well as an indicator of rust exposure (presented in table 14 below). The outcome variable captures household level varietal change by combining the variables for household level wheat abandonment and adoption (see table 12).

We find that a change in rust exposure is significantly and positively associated with changes in the household wheat portfolio. A household which has previously not reported problems with wheat rust is estimated to increase the number of varieties it cultivates by 0.16 on average when it is hit by wheat rust.

Findings from table 12 suggest that this small net increase in varietal diversity is mainly related to the adoption of disease resistant varieties.

Table 12: Number of wheat varieties abandoned or newly adopted from '11 to '13

Abandoned \ Adopted	0		1		2		3		4		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0	161	57.50	33[a]	11.79	3	1.07	0	0.00	0	0.00	197	**70.36**
1	33	11.79	20	7.14	6	2.14	1	0.36	1	0.36	61	**21.79**
2	1	0.36	12	4.29	6	2.14	0	0.00	0	0.00	19	**6.79**
3	1	0.36	0	0.00	1	0.36	0	0.00	0	0.00	2	**0.71**
4	0	0.00	0	0.00	0	0.00	1	0.36	0	0.00	1	**0.36**
Total	196	**70.00**	65[b]	**23.21**	16[c]	**5.71**	2	**0.71**	1	**0.36**	280[d]	100.0

[a] *of these 19 hh adopted resistant varieties & 4 hh adopted landraces*
[b] *of these 31 hh adopted resistant varieties & 5 hh adopted landraces*
[c] *of these 13 hh adopted resistant varieties & 3 hh adopted landraces*
[d] *of these 10 hh adopted and 17 hh abandoned landraces*

Table 13: Summary of reasons for abandoning wheat varieties

(Farmers reported up to two reasons for each abandoned variety)

	No.	%
Susceptibility to wheat rust	167	29.07
Low or decreasing yield	259	43.53
Replaced by high yielding variety	116	19.50
Performance under moisture stress	20	3.36
Susceptibility to pests (insects)	7	1.18
Susceptibility to frost	6	1.01
Other (weed, wind, climate change, long time to mature, seed loss, marketability)	20	3.36
TOTAL	595	100

Most frequently abandoned varieties: Enkoy (N=90, esp. due to rust), Israel (N=75), Arendeto (landrace, N=45), Galerma (N=39, esp. due to rust), Sereto (N=35), Gerardo (N=26), Pavon 76 (N=21), Kubsa (N=20, esp. due to rust)

Table 14:First difference model - wheat variety change

VARIABLES	(1) DV: Net no. of varieties adopted/abandoned First Difference OLS[a]
Δ Land holdings, ha	0.030
	(0.053)
Δ Log value of livestock	0.158***
	(0.040)
Δ No. of household members	0.038*
	(0.022)
Δ Model farmer (dummy)	0.095
	(0.085)
Δ Member seed multiplying enterprise	0.068
	(0.086)
Δ Member community gene bank	0.034
	(0.072)
Δ Rust problem (dummy)	0.157*
	(0.089)
Constant	0.157*
	(0.080)
Observations	279
R-squared	0.203

[a] *Regression included also 9 sub-village dummies (not displayed). The village effects were not statistically significant*

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

Characteristics of households with access to resistant varieties

Further analysis shows that households (N=46) cultivating rust resistant varieties have significantly and substantially higher livestock (plus 32.8 percent) and land holdings (plus 25.2 percent) as well as significantly more social capital (plus 22.4 percent).[93] This strongly suggests that relatively better-off farmers have better access to the highly sought after resistant varieties, which are not available on local markets, but are primarily distributed through the extension service.

Furthermore, as a result of the multivariate analysis (table 14) we find that livestock endowments and household size are positively and significantly associated with wheat portfolio change. Going beyond access to rust resistant varieties, this confirms findings from previous research in the Ethiopian highlands, showing that relatively wealthier farmers maintain a more diverse varietal (and crop) portfolio (Benin, Smale et al. 2004, Bezabih, Sarr 2012).[94]

Pathways to accessing to resistant varieties

In this section, we further explore the implications of the finding that households with access to resistant varieties have significantly more social capital compared to households which do not cultivate rust resistant varieties. The composite social capital variable also captures a number of ways to gain access to seed, including community gene bank membership, participation in the model farmer programme as well as in the seed multiplying seed cooperative *Birftu*. In the case of *Birftu*, the model farmer programme and a position in local government, we find that households with access to these institutions or programmes, grow significantly more resistant varieties households without access. To illustrate this further: out of the seven households in the sample growing two disease resistant varieties, six are members of *Birftu* and four are model farmers.[95]

Furthermore, participation in the model farmer programme proved to be significantly and positively associated to the adoption of new varieties in models looking exclusively at adoption.[96]

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[93]We include only households which were surveyed in both rounds and compare 2013 values of these indicators. Absolute mean values are land size in hectares: 2.45 (hh cultivates no resistant varieties) vs. 3.06 (hh cultivates resistant varieties); estimated livestock value in tsd Birr: 31,653 (no res var) vs. 42,048 (res var); average number of membership/position in formal or informal institutions: 1.83 (no res var) vs. 2.24 (res var). All differences are significant on 1% level.

[94]Benin et al. (2004) as well as Bezabih and Sarr (2012) find that holdings of oxen or tropical livestock units respectively have significantly positive effects on crop diversity. Benin et al. conclude that "those that are better off in land, labour, and livestock tend to maintain more crops and more varieties" (2004, p.207). The relationship between household endowments and agrobiodiversity is discussed in detail in a different paper in this doctoral thesis.

[95]We include only households which were surveyed in both rounds and compare 2013 values of these indicators. Absolute mean values are land size in hectares: 2.45 (hh cultivates no resistant varieties) vs. 3.06 (hh cultivates resistant varieties); estimated livestock value in tsd Birr: 31,653 (no res var) vs. 42,048 (res var); average number of membership/position in formal or informal institutions: 1.83 (no res var) vs. 2.24 (res var). All differences are significant on 1% level.

[96]The results of this analysis are shown in the appendix, table 25 The dependent variable was the number of adopted varieties, not taking into account the varieties dropped by the household in the same period (as

This points to the role of governmental support in the provision of agricultural resources. Roughly thirty percent of all farmers in the sample participated in this scheme, which aims to diffuse new agricultural technologies by granting innovative farmers or 'early adopters' preferential access to resources and training (Lefort 2012).

Findings on the strategic role of specific seed sourcing channels (model farmer scheme, farmer based seed enterprises and to a lesser extend also community gene banks) as well as the inequitable distribution of rust resistant varieties have highly relevant implications for the design of seed interventions also in other contexts. The implications of membership-based seed sourcing channels for the most vulnerable and resource-poor households are already being critically discussed (Tripp 2001b, Tripp 2001a, Ricciardi 2015). This analysis suggests that farmers changed their portfolio of wheat varieties in response to the wheat rust epidemic of 2010/11. Moreover, the analysis emphasizes the role of formal, non-market institutions for accessing (disease resistant) plant genetic materials in a context of limited seed market development and a marginal role of the informal seed system.

Table 15: Overview of varieties grown
(Households included in both rounds, N=602)

Variety Name	Release date	Wheat Type	MV/ LR	No. of hh '11	No. of hh '13
Kubsa	1995	Bread	MV	256**	231**
Galema?	1995	Bread	MV	35**	20**
Gerardo	1976	Durum	MV	14	14
Pavon 76	1982	Bread	MV	11***	0***
Ejerso	2005	Durum	MV	7	2
Lelisso	2002	Durum	MV	6*	1*
Cocorit	1976	Durum	MV	3	8
Dashen	1984	Bread	MV	2	0
Digalu (RES)	2005	Bread	MV	1***	30***
Yerer	2002	Durum	MV	1	4
Dando (RES)	2010	Bread	MV	0***	17***
Ude	2002	Durum	MV	0	2
Kakaba (RES)	2010	Bread	MV	0**	6**
Enkoy	1974	Bread	MV	0	0
Tinkur Sinde[97]	/	Durum	LR	47*	31*
Traditional[98]	/	Durum	LR	2	6
Israel	/	Bread	LR	1	0
Other[99]	/	/	/	4***	36***
Don't' know	/	/	/	10	7

d. Varietal analysis

Further analysis of the wheat varieties cultivated (see table 15), reveals that - there were changes in the wheat variety portfolio

opposed to the model in table 14). Participation in the model farmer scheme was a robust significant factor in this analysis.

[97] *Tinkur Sinde* is well documented as a popular purple seeded landrace variety (Negatu, Mwangi et al. 1994, Hailye, Verkuijl et al. 1998, Tesema 2006, Tsegaye, Berg 2007a). Respondents either used the variety name or the phrase "famadi guracha" (i.e. black wheat)

[98] Varieties in this category were most frequently called *Abasha* or *Abashi* (i.e. traditional or ancestral). Four other known landrace tetraploid wheat varieties, were reported only once or twice and included in this category: *Arendeto, Galano, Abashi Gula, Tikur Bukura* (Negatu, Mwangi et al. 1994, Tsegaye, Berg 2007a)

[99] Seven other variety names which could not be identified and were only mentioned by one or two respondents: *Jaferson, Wendea, Biratmalk, Aminge, Adja, Bukakie, Serto*. These two varieties could be identified through the Ethiopian variety registry, but were grown by only one household: *Ginchi, Wetera*. In the 2013 sample 33 households grew a different variety than the ones listed in table 15, but the variety names were not reported.

between 2011 and 2013. Nevertheless, the popularity and predominance of one modern variety called *Kubsa,* as the most frequently grown variety in the study area, remains unchanged by the rust outbreak. Released in 1995 and distributed through the government extension service, *Kubsa* has become one of the most popular cultivars in the Ethiopian highlands. Its disease resistance, however, has reduced and it has become vulnerable to new yellow as well as stem rust races (CIMMYT 2014, Tegene, Abdusalam et al. 2014). Only four percent of non-diverse households (i.e. growing only one wheat variety) abandon *Kubsa* while 21 percent of wheat diverse households decide to stop growing the popular bread wheat cultivar. This significant difference suggests that households growing exclusively this susceptible variety do not have the option to switch to a different variety due to limited availability.[100]

A number of less frequently grown, older improved varieties such as *Pavon 76* disappeared completely. As discussed above, the replacement of older improved varieties with new varieties with better performance and higher resistance to diseases and pests is an important component of green revolution agriculture (Heisey, Smale et al. 1997). It is therefore not surprising that the vast majority of abandoned varieties (see table 13) are modern varieties which have a lower performance and have a high susceptibility to wheat rust. Only one previously popular landrace variety called *Arendeto* has been abandoned by a substantial number of households previous to the survey, as findings from table 13 suggest (Tsegaye, Berg 2007a).

Changes in the cultivation of improved varieties

Recently developed bread wheats became more popular since the last survey (see table 15). *Dando, Digalu* and *Kakaba* were bred over the past years by the Ethiopian Institute for Agricultural Research (EIAR) with high disease resistance (Mesay, Bedada et al. 2014, Tegene, Abdusalam et al. 2014). Two years after the yellow rust outbreak 16.2 percent (46 out of 284 wheat-growing households in 2013) are cultivating rust resistant varieties. For improved bread wheats we can observe a clear trend to abandon older varieties and adopt new rust resistant varieties in the context of disease outbreak, leading to substantial changes in the varietal portfolio.

Changes in the cultivation of traditional varieties

While farmers identify the cultivation of landraces as a possible disease response strategy (see above), the share of households growing landraces reduced by three percent to 12.7 percent in 2013. For landrace cultivation, especially for the purple seeded landrace varieties, we observe

[100]In 2013 217 (83.46 percent) of 260 non-diverse households grow exclusively *Kubsa*. It must be considered that farmers might choose not to switch to other varieties, especially to landraces. Data collected through semi-structured interviews with farmer who had grown a new landrace variety, suggested strongly that farmers without previous experience with landraces, had more reservations and were more critical in the assessment of the performance of the landrace variety.

much more variation than for improved bread varieties which are either abandoned or adopted by the majority of households changing their cultivation of these varieties. For example, while 26 households abandon one popular traditional variety (called *Tinkur Sinde*), 13 households newly adopt it, leading to a net reduction in the cultivation of this variety. This variation could be interpreted as a trial and error method testing the susceptibility and performance of landrace cultivars.

As discussed above, this ambivalence concerning the potential of landraces in mitigating effects of wheat rust is also reflected in the academic literature. While a number of wheat surveys find that traditional varieties are susceptible to yellow stripe rust in particular (Negatu, Mwangi et al. 1994, Tegene, Abdusalam et al. 2014), ecologists argue that landraces have a higher adaptability to disease due to their more diverse genetic make-up (Wale 2012). A number of durum landraces are found to be resistant to particular rust pathogens, leading to a continued interest in identifying resistance genes in landraces for formal breeding (Negassa 1986, Teklu, Hammer 2009, Bansal, Arief et al. 2013, Daetwyler, Bansal et al. 2014).

With respect to the interpretation of the results presented here, the variation in landrace adoption and abandonment could also be an indicator that several landraces are summarized under the variety name *Tinkur Sinde*, which can be translated as 'black seed'. Without genetic or phenotypic analysis, it cannot be determined whether some landraces grown in the study region indeed have rust resistant properties and thus constitute a viable strategy to directly reduce the exposure to the disease.

In summary, the analysis of the varietal portfolio reveals that farmers without access to resistant varieties, especially those growing exclusively the most popular, but susceptible cultivar *Kubsa*, have very limited options to switch to a different wheat variety. In the next section, we analyse whether this translates into a decline in wheat cultivation between 2011 and 2013.

4. Changes in land allocation to wheat

As shown above, the area allocated to wheat has reduced significantly between the two survey rounds by an average of 0.12 hectares or 4.6 percent per household while average landholdings remained at 2.2 ha. With an average wheat area of 1.16 ha, households using one of the three resistant varieties, allocate over 51 percent more land to wheat than households without access to these varieties. These changes might suggest that farmers reduce their wheat cultivation and replace it by other crops to reduce their exposure to the disease.

5. Other responses: renting out land and fungicide use

In 2013 88.7 percent of households do not rent out any land. The 48 households which do, rent out a median share of 0.5 ha. Although a comparison to 2011 is not possible, these figures indicate – confirming the findings from the self-reporting questions presented at the beginning of this section – that renting out land in response to the disease is not a response which the majority of farmers chose.

Fungicide application is the most commonly chosen immediate response to a rust outbreak and, as discussed above, an effective strategy to control the disease. The weekly application, which is the prerequisite of complete disease control and the maintenance of full yield potential, implies substantial costs for a small farming household. While only relatively wealthier farmers can afford this input, it can also be argued that the prevented losses in wheat harvest might allow farmers to increase their assets if they are net sellers of wheat (which a large share of households factually are). Both arguments can make a contribution to explaining why those sixty percent of households which are using fungicides in 2013 have significantly larger livestock (plus 13 percent) and land holdings (plus 17 percent) than non-users. As opposed to resistant varieties, qualitative interviews and informal conversations indicated that pesticides are available on the local market.

As the analysis of disease resistant varieties already suggested, access to agricultural resources in the study sites is not only a question of availability and affordability, but also of households' social networks. Fungicide users in 2013 have significantly higher bonding social capital, i.e. they are organized in significantly more informal, horizontal community institutions than non-users. Moreover, while 36 percent of fungicide users are model farmers, significantly less, i.e. 20 percent of non-users participate in the scheme.

In summary, the access to fungicides for rust control is much better than to seed for disease resistant varieties and thus fungicide application is a more commonly adopted approach. Access to and use of both agricultural resources is better for relatively wealthy and better-connected households.

DISCUSSION

In this section, we will discuss how the empirical findings relate to the broader discussion of rust and disease management in small farming households in developing countries. More specifically, we discuss challenges of the conventional rust management approach in the study context. Furthermore, we critically discuss the role of variety or crop abandonment in reducing exposure to rust. Finally, the contribution of agricultural diversity to rust management is reconsidered in the light of the findings.

1. Challenges of conventional rust management

Farmers' preferred disease response strategies in the study area are largely consistent with the scholarly debate around rust management, especially when considering the responses for the first round of the survey in 2011. The preference for alternative (resistant) wheat varieties and chemical control is clearly related to the fact that, among all the response strategies listed by farmers, these appear to be the only strategies to effectively avoid crop loss due to the disease while continuing to cultivate wheat.

It must be considered, however, that interventions to intensify agriculture have been implemented in this region for decades (McCann 1995). In a number of ways, exemplified by the marginal role of the informal seed system or by the high share of farmers applying pesticides, farming practices in the area cannot be described as traditional agriculture. Therefore, it appears plausible to assume that farmers' approach to disease control has also been shaped by the concepts of high-input, modern agriculture (Orr 2003).

a. Challenges of pesticide use

While fungicides in the study area are accessible and affordable for the majority of households, the use of resistant varieties is limited to a small share of well-connected, comparatively well-off households. Modern crop protection, however, aims to minimize the use of chemical disease control for environmental reasons and to reduce the risk of resistance to pesticides in pathogens (Way, van Emden 2000, Oerke, Dehne 2004, OECD 2016). A consequence of the limited availability of resistant varieties, which must be considered with critical awareness, is the danger of excessive pesticide use with its well-documented, negative consequences for the environment and human health, e.g. through pesticide residues in food and water (Gesesew, Woldemichael et al. 2016, Mekonen, Argaw et al. 2016, Negatu 2016). Furthermore, the use of pesticides involves costs for households, which has been shown to create a barrier for poorer households to use the technology and to be a cause of debt in rural Ethiopia (Williamson 2003).

b. Challenges of inequitable access to resistant varieties

Findings strongly suggest that access to disease resistant varieties is not only limited, but also inequitable. Farmers who are relatively better-off and better connected to government agencies - be it through the model farmer program or because they hold positions in local government - are the ones cultivating resistant varieties. This confirms findings from previous studies in Ethiopia concerning selective access to improved seeds (Asfaw, Shiferaw et al. 2011). By providing resistant varieties to households, which already have preferential access to agricultural resources, the social fabric of these rural communities can be affected and growing wealth differences might be reinforced. In a situation of high demand for and low supply of rust resistant varieties, it would seem sensible to target the poorer households first with the aim to improve food security and to protect the savings of the poorest from depletion.[101]

Considering the features of the seed system - especially the marginal role of informal seed supply channels - as well as the observed seed sourcing patterns in the study sites, new varieties, which are given only to a selected number of households, are unlikely to spread widely and quickly.

A notable exception from this finding of inequitable access is related to the local seed multiplying cooperative *Birftu*. Members of this semi-formal institution, with exclusive and very limited membership, grow in some cases even both of the newly introduced, resistant cultivars. Providing seed cooperative members with seed to multiply locally could lead to a wider dissemination of the varieties through the local market.

Nevertheless, this study in a well-connected part of the country, in terms of market penetration and road infrastructure, serves as an illustration of the limited capacity of seed supply through governmental extension services. Access to improved seed is very likely to be even more limited in other parts of the country. A call for strengthening other channels of the formal and informal seed system and investing in decentral solutions for sustainable and diverse access to seed comes also from advocates for improved emergency seed aid (McGuire, Sperling 2008, Sperling, McGuire 2010).[102]

c. Challenges of maintaining rust resistance

Resistance breeding is the main approach the Ethiopian government pursues in reaction to the evolving threat of wheat rust with support of the international community. This study finds that less than one fifth of households cultivate resistant varieties two years after a severe outbreak and

[101] For further discussion of the role of pre-cautionary savings and productive assets (such as livestock, which is commonly used for saving and smoothing consumption) in addressing chronic poverty see e.g. (Dercon 2005b, Dercon, Hoddinott et al. 2012).

[102] The characteristics of the local seed system as well as policy recommendations for seed sector development and seed interventions are discussed in more detail in the conclusion chapter.

three years after the release of new varieties. Moreover, one of the two resistant varieties released in 2010 in response to the stripe rust epidemic, called *Digalu*, proved to be highly susceptible to stem rust, leading to major crop losses during the stem rust outbreaks in 2013/14 and 2014/15 (Abeyo, Hodson et al. 2013).

This illustrates vividly that breeding and disseminating disease resistant varieties is not a one-off effort, but an evolving process which requires a consistently high technical capacity. Rust resistant varieties must not only be available, but farmers must be willing and able to replace varieties at a rate that will prevent epidemics in the future (Heisey, Smale et al. 1997).

2. The role of crop and variety abandonment in reducing risk

Alternative disease response strategies proposed and applied by farmers, such as renting out land or increasing cultivation of other pulse and cereal crops cannot be described as disease management. While these measures do not reduce the loss in wheat production to the disease, they reduce the risk of exposure to rust, i.e. they are a form of risk management beyond disease management.

The decrease in livestock holdings of disease affected households suggests that farmers cope with the income shock by selling livestock to smooth household consumption. Evidence further suggests that in order to reduce the risk of income loss due to another rust outbreak, households decrease wheat cultivation and rent out land. A number of households (N=13) did not only reduce the area allocated to wheat, but abandoned wheat cultivation altogether. This supports the conclusion that wheat rusts pose a threat to wheat cultivation, which is of particular relevance in one of the centers of genetic diversity of wheat (Singh, Hodson et al. 2008).

One question that arises from this finding is whether the abandonment of a wheat variety and particularly of a crop type reduces the variability of agricultural output in the long-term. However, this is a question which can only be sufficiently answered empirically. While the productivity of a wheat variety susceptible to wheat rust can be high in years when the disease does not break out, rust risk causes a higher, unpredictable variability of income. On the other hand, a loss of a variety or a crop represents a loss in agrobiodiversity. With fewer varieties and crops grown the overall risk of production losses due to biotic and abiotic stresses might very plausibly increase.

3. Food crop and crop genetic diversity in rust response & prevention

This study does not provide conclusive insights on the question whether the diversification of the agroecosystem leads to improvements in rust prevention. Nevertheless, the shifts in the wheat portfolio due to rust – which were not only from susceptible to resistant varieties - and shifts to alternative crops illustrates that – in the absence of (cost-)effective disease management – farmers

rely on access to alternative varieties or suitable alternative crops in their response to rust. Access to alternative wheat varieties and crops can most easily be granted through on-farm availability of these alternative varieties and crops (i.e. agrobiodiversity), but the findings also point to the potential of markets, community-level non-market institutions and national extension and international aid in providing access to diverse genetic resources.

Especially households growing only one susceptible modern cultivar, however, do not seem to have the choice to switch varieties due to the restrictions of the local seed system. This illustrates the role of farm-level diversity in providing that choice and highlights the role of access to crop genetic resources, especially in a situation, in which only a quarter of households cultivate more than one variety of wheat.

Notably, overall wheat diversity did not increase in response to the disease outbreak and the share of households cultivating landraces decreased slightly. While farmers were searching for alternative varieties and crop types to manage disease risk, they did not choose to diversify on an aggregate level or put differently, increasing varietal diversity was not a significant de facto response strategy.

Moreover, findings on changes in landrace cultivation confirm the discussion in the literature concerning the fragile balance between genetic erosion and adaptive change through genetic diversity. While the rust outbreak did not result in large scale abandonment or loss of landraces, landraces did also not represent a viable alternative leading to significantly increased adoption on the aggregate level. We observe households abandoning and adopting landraces in a context of disease stress. Nevertheless, the initial level of landrace adoption and thus genetic diversity was low, in the community – with less than one fifth of households growing landraces - and at the household level – with the vast majority of households cultivating one traditional variety.

This discussion illustrates the considerable challenge of building robust cropping systems under climate change. The lack of varietal diversity due to genetic erosion in the region is a contributing factor to the quick dissemination of the disease as well as its epidemic proportions (Lamichhane, Barzman et al. 2015). On the other hand, findings suggest that diversifying the varietal portfolio using the plant genetic resources available in the community does not constitute an effective strategy to minimize disease exposure and risk at the household level.

4. Areas for further research

Some of the questions raised in this study can only be definitively answered by further research efforts.

In order to generate more robust evidence on the role of agricultural diversity, going beyond crop genetic diversity, for rust incidence and scope, studies based on experimental or quasi-experimental evidence are necessary. Moreover, contemporary examples for farmer selection of resistant genotypes would be useful in arguing for and exploring further the role of in situ conservation of landraces in rust management.

Within crop sciences, and particularly crop protection, options for integrated pest management (IPM) for wheat rust in developing country contexts should be discussed systematically. Ideally this should include an analysis of rust management practices before the green revolution as well as in areas with less intensified wheat production.

Finally, crop diseases and pests are conceptualized as one of a number of agricultural risks, including also drought, frost, flooding, livestock diseases and pests, which affect the production and the income of a rural household (Townsend 1995, Fafchamps 2003, Dercon 2005b, Duflo 2006). As this study illustrates, crop diseases when occurring at an epidemic scale are comparable to other aggregate - rather than idiosyncratic - risks such as moisture stress (Fafchamps 1999b, Dercon 2005b). However, research in this field has focused largely on rainfall variability as a source of production risk, aiming to identify household strategies and capacities to manage risk ex ante and to cope with risk ex post (Porter 2012, Macours 2013). Ex ante risk management of production shocks caused by crop diseases and pests, however, have not yet been systematically analysed in the discipline.

CONCLUSIONS

This study illustrates the challenges wheat rust epidemics create for small-farming households in developing countries with limited access to conventional disease control measures. The need to respond effectively to the increasing incidence and severity of the disease is highlighted by the fact that newly bred and disseminated stripe rust resistant varieties in the study area proved to be highly susceptible to stem rust infection in the following years.

This study also points to the dangers of increasing pesticide use to control wheat rust in the absence of effective preventive measures. Pathways to intensification of small-holder agriculture in Ethiopia and beyond must therefore incorporate integrated disease management. Since conventional intensification has increased the risk of exposure to wheat rust worldwide, rust responses in smallholder agriculture should, therefore, contribute to alternative, more sustainable approaches to intensification. Increasing diversity of agro-ecosystems in several dimensions, including a sufficient level of crop genetic diversity, appears to be a particularly plausible alternative with the potential to also address other challenges of agricultural development in the region, such as soil conservation.

Highly inequitable access to disease resistant varieties, provided by the government, emphasises the need for pro-poor approaches to agricultural interventions. Supporting specifically resource-poor farmers with very low varietal and genetic diversity in wheat in managing wheat rust (and other biotic and abiotic stresses) can make an important contribution to food security, social coherence and prevent households from falling (deeper) into poverty traps.

In a context of limited functionality of seed markets and the informal seed system, the role of formal, (non-market) institutions becomes instrumental in providing access to plant genetic resources. This study illustrates that seed banks and seed enterprises become important alternative channels for the multiplication, dissemination, quality control and storage of seeds.

An Institutional Analysis of Informal Seed Assistance in West Haraghe, Ethiopia

ABSTRACT

Solidarity networks or informal insurance institutions have become a major subject of study in development economics over the past decades (Fafchamps 1992b, Townsend 1994, Platteau 1997, Dercon 2005a). We present a mixed-methods study of a highly developed informal seed insurance network among subsistence-oriented small-farmers in one highland and one midland district in the West Hararghe zone of Eastern Ethiopia. Based on a survey and interviews with 146 farmers, we find that the overwhelming majority of small farmers actively participate in informal seed assistance by giving or receiving small quantities of seed without cash or in-kind compensation, especially in planting seasons after a drought. Denial of seed is highly exceptional and only reported in communities in which off-farm seed is supplied by a wealthy local benefactor. The analysis suggests that the institutional design of informal seed assistance, compared to other practices of mutual aid, sets incentives to use this ex ante insurance instead of ex post food or cash assistance after harvest. Moreover, we argue that the seed assistance through gifts is practiced to facilitate access to crop genetic resources in a centre of crop origin and diversity.

INTRODUCTION: Seed Gifts between Insurance and Enigma

Seed is an essential input for production in small-farming households, also described as “farmers’ most precious resource” (Tripp 2001b, p. 1). Especially under conditions of environmental stress, including periodic drought, secure access to seed is central to improving food security and to the livelihood of vulnerable, rural households (Almekinders, Louwaars et al. 1994, Scowcroft, Polak Scowcroft 1999, McGuire, Sperling 2008). Highly developed informal seed systems play an important role in securing access to seed and maintaining a high level of crop-genetic diversity in the West Hararghe zone of Eastern Ethiopia and beyond (McGuire 2000, Mekbib 2006, McGuire 2008).

At the heart of the local seed system is the practice of seed assistance. Off-farm seed supply in the form free gifts, given and received without any offer or expectation of compensation, is the most important source of seed. Formal channels such as the market or the government extension service play only a secondary role (McGuire 2000, Mekbib 2006). This study - conducted in 2010 and 2013 in chronically food insecure village communities in one lowland and one highland community (*kebele*) in West Hararghe - shows that the vast majority of rural households actively

participate in seed assistance as donors or recipients of seed in the aftermath of severe drought as well as under less stressed conditions.[103]

In such contexts of high vulnerability, traditional safety nets for insuring collectively against risk - in this case seed insecurity - have been identified as research area of outstanding academic and practical relevance (Ahmad, Dreze et al. 1991, Platteau 1991, Fafchamps 2003, Dercon 2005b). Not least because policies, which seek to strengthen existing informal, mutual-help institutions, potentially face fewer "long-run sustainability and dependency problems" (Dercon, Krishnan 2005, p. 305).

Informal seed assistance is one of a number of highly developed solidarity networks in rural Oromo communities, including also informal labour and oxen sharing institutions (Aspen 1993, Tesema 1996). Seed assistance, however, is exceptional as it is given as a gift (rather than as loan or in exchange). Farmers understand seed assistance not primarily as a form of informal group insurance, but rather as a universal, moral obligation of all Oromo to mutual solidarity.

Gift-giving as social phenomenon in pre-industrial and modern societies has fascinated generations of social scientists. Godelier calls this fascination "the enigma of the gift"(1999, p. 1). The two essential aspects of the puzzle are the seemingly universal patterns of gift exchanges on the one hand and on the other hand the vastly diverse forms gift-giving takes. Marcel Mauss, as one of the earliest comparative scholars of gift-giving, was intrigued by the observation that apparently disinterested and voluntary gifts consistently evoke the obligation to reciprocate (1954[1924]). Hence, the practice of gift-giving - presented as pure and altruistic, but "in fact obligatory and self-interested" – is underpinned by what Mauss calls a contract or law (Marcel 1954[1924], p. 1).

It is precisely this analytical interest in the "contract" - i.e. rules and norms governing informal seed assistance, which motivates this study. Thus, the main research question of this study can be formulated as follows:

How is the informal social institution of seed assistance upheld in a context of high vulnerability?

[103]Mieso & Chiro Zuria *woredas*, including Asebot and Schola *kebeles,* have been primary intervention areas for the Productive Safety Net Programme for chronically food insecure households since it started in 2005 (FAO 2011, Van Domelen, Coll-Black 2012). A review of 26 Food Security Outlooks of the Famine Early Warning Systems Network (FEWS) from 2009 to 2017 suggests that especially the Belg rains are unreliable and erratic in this region of Ethiopia. In consequence, most parts of the West Hararghe zone is classified as "crisis" on the acute food insecurity scale (level 3 out of 5) in more than half of the reports or as "stressed" (level 2), with "emergency" situations (level 4) in 2016. Source: http://www.fews.net/east-africa/ethiopia

This study - an in-depth institutional analysis based on mixed methods approach - will thereby respond to "a growing interest in the empirical analysis of informal risk-sharing and in the modelling of sustainability and consequences of these arrangements" (Dercon 2005b, p. 20)).

So far, seed gifts and exchange in West Hararghe and beyond was primarily analysed as one aspect of seed systems analysis conducted by agronomists (Almekinders, Louwaars et al. 1994, Hailye, Verkuijl et al. 1998, McGuire 2000, Almekinders, Louwaars 2002, Mekbib 2006, Thijssen, Bishaw et al. 2008, Mekbib 2008a, Bishaw, Struik et al. 2010, CRS, EWNRA, ISSD, ORDA, REST 2016). While these analyses are of considerable descriptive value, their analytic interest lies mainly in the comparison and relevance of different seed sources.

However, these studies only make a limited contribution to analysing the rationale, the institutional design and the sustainability of informal seed assistance. McGuire's contribution is one notable exception motivated by the understanding that "seed systems are also social systems, […] affected by local norms and social relationships. Few studies consider these social dimensions" (McGuire 2008, p. 217). In the same way Tripp emphasises the need for an institutional approach to seed provision, which "considers the ways, in which individuals and groups […] establish rules to guide their transaction and structure incentives to achieve particular purposes" (Tripp 2001b, p. 2).

By analysing seed assistance from a seed systems perspective, i.e. primarily as a material practice, the elaborate norms and cultural understanding of seed assistance have been neglected. References to culture feature so prominently in farmers' narratives of seed assistance that an institutional analysis must acknowledge and discuss them. This study is based on a household survey and qualitative interviews with 146 randomly sampled farmers in five villages (*gandas*) in two districts (*woredas*) in different agro-ecological settings. It combines descriptive quantitative with qualitative data analysis to fully capture both the material practice as well as the rules, norms and rationalisations underpinning the practice.

Understanding how seed assistance through gifts is upheld and how effective it is in providing for the acutely seed insecure, has relevant implications for seed aid and food security interventions. Firstly, it will allow developing better policies for participatory seed production, distribution and aid (Mulatu, Belete 2001, Mekbib 2006). Sperling, Cooper et al. stress the inadequacies of the currently most commonly used approach to seed aid: "Direct distribution of seed […] may undermine the functioning of local seed systems and therefore aggravate seed security problems" (2008, p. 602). Secondly, a better understanding enables us to identify more clearly whether and why groups in the community might be excluded from assistance, which in turn will facilitate better

targeted interventions (Goldstein, Janvry et al. 2005, McGuire, Sperling 2008, Ricciardi 2015). Thirdly, a deeper understanding of the institutional design will improve the capacity to assess how the institution will respond to the increasing demographic and environmental pressure that the region is facing (Samberg, Shennan et al. 2013).

Paper Outline

The following section introduces the concept of informal social institutions for the analysis of seed assistance. The conceptual framework of informal insurance is presented, drawing both on anthropological and micro-economic literature. section 3 outlines the methodological approach and introduced the study background in some detail.

Findings are presented in two sections. Section 4 describes the practice of seed assistance, including an analysis of quantifiable indicators of characteristics and the relationship between donors and recipients of seed. The findings presented in section 5 move beyond the contributions of previous studies. The section presents findings from qualitative data analysis concerning motivations, conditions and compensation for seed assistance as well as sanctions for seed denial. Moreover, it analyses the explicit and implicit norms underlying seed assistance as well as the symbolic understanding of seed.

Based on these findings, section 6 offers a rigorous analysis of seed assistance as social institution with a focus on its enforcement mechanism. The institutional features, which set apart seed assistance from other risk sharing institutions among the Oromo, are emphasised.

The final section summarizes the contributions made to the understanding of seed assistance and identifies further research needs.

CONCEPTUAL FRAMEWORK

In this section, (1) informal seed assistance is framed and defined as a social institution. Furthermore, (2) the theoretical framework is developed based on approaches and concepts from game theory and social anthropology.

1. Framing the research object

The framing of seed assistance matters crucially for how we analyse and understand it. Framing it as 'diffusion channel' for seed results in a different analytical focus than calling it 'gift', 'solidarity network', 'a risk sharing arrangement', 'informal contract', 'reciprocal exchange' or 'insurance'. This study aims for a comprehensive analysis with a focus on the immaterial aspects as well as on explaining how the practice is upheld under conditions of vulnerability and scarcity.

Framing seed assistance as a social institution, calls for the application of a diverse set of analytical tools from different disciplines within the social sciences (from micro-economics, international relations and social anthropology most notably). These tools have not yet been systematically applied in this context. Within that frame of analysis other possible perspectives can be accommodated. Gift-giving, for example, is one possible mode of transaction in this institution. Moreover, the set of rules and norms at its core represent an informal agreement or contract as Mauss called it (1954[1924]). A social or solidarity network describes the relationships and connections constitutive to the institution. Insurance and risk sharing (Posner 1980, Fafchamps 1992b); sociality and social reproduction (Godelier 1999, Sahlins 2004 [1974]); solidarity and subsistence ethics (Scott 1976) are common descriptions of the purpose or essence of reciprocal practices. In the proposed analytical frame, they become subject of inquiry and not an attribute, which defines the course of analysis.

a. Defining social institutions

Building on Krasner's definition of regimes, an institution is defined as coherent "sets of implicit and explicit principles, norms and rules and decision-making procedures around which actors' expectations converge..." (1983, p.2). Following Finnemore and Sikkink, we distinguish between norms, as a single standard or rule of behaviour and institutions, which "emphasize the way in which behavioural rules are structured together and interrelate" (1998, p. 891).

b. Defining principles and norms as concepts in institutional analysis

The two central concepts in Krasner's definition are norms and principles. Given the informal character of this institution, rules and decision-making procedures, which are typically of a more formal nature, are less relevant here.

Finnemore and Sikkink's discussion of core principles (which is coherent with Krasner's definition of the concept), is particularly insightful for the case at hand. Constitutive to an institution is a shared understanding, which finds its expression in principles, e.g. universalism or individualism. They argue that "norms underpinned by these principles will be more successful" (Finnemore, Sikkink 1998, p. 907).

An institutional analysis will thus begin by analysing (culturally contingent or identity based) core principles and then move to of norms, defined as single standards of behaviour (see discussion section below).

c. Institutional design as analytical concept

While concepts such as core principles and norms are relevant and valuable tools for a systematic analysis of seed assistance, they are of little explanatory value for the research questions in and of themselves. The next section will, thus, introduce a theoretical framework for explaining the sustainability of seed assistance through gifts by drawing mainly on game-theoretic conceptualisations of informal risk-sharing and complementing it with anthropological approaches to the analysis of gift-giving.

2. Theoretical Framework

As argued in the introduction, gift-giving remains an enigma because it appears similar in very different contexts and is yet so vastly diverse in its forms. Marcel Mauss (1954[1924]) captures the generality of phenomenon by identifying three universal obligations: to give, to receive and to reciprocate. Scott (1976) sees at its core a universal moral norm of reciprocity. Studying gift-giving in a particular context thus means to come to terms both with the generality of gift exchange as social phenomenon and the specific form it assumes. This theoretical framework attempts to accomplish this in bridging the culturalist-rationalist divide by which the literature on gift-giving and risk sharing is so profoundly shaped. In particular, this framework advances the 'insurance principle' as the general rationale upholding risk-sharing agreements in the form of ex ante input or ex post consumption sharing (Platteau 1997).

While first formulated by anthropologists, the formalization of the idea by economists as equilibrium solution of an iterated game under conditions of high vulnerability has developed into a complex model of informal risk-sharing agreements with considerable explanatory power. Despite the increasing complexity in modelling informal insurance, there is a clear understanding of "the indeterminacy of the theory" of risk sharing agreements with incentive problems, which can theoretically account for a wide range of institutional designs (Fafchamps 1992b, p. 150). We follow the conceptualisation of a social institution as an equilibrium of a repeated game, which is

stable and self-perpetuating as proposed in the New Institutional Economics literature (e.g. Ostrom 2005). Analytical concepts from anthropology are then introduced to capture and systematically analyse the contingency, the specific form the equilibrium solution has assumed.

a. Explaining the principle- Informal insurance institutions as contingent equilibria of an iterated cooperation game

Posner - as one of the first economists to engage with the findings presented by Scott and others from a strictly rationalist perspective - finds that substantivists have given "valuable, if unsystematic, insights in the economic function of those institutions" (Posner 1980, p.2).

Posner is thereby building on a powerful and widely restated intuition first formulated by Evan-Prichard:

> "It is scarcity and not sufficiency that make people generous, since everybody is thereby insured against hunger (…) in a community where everyone is likely to find himself in difficulties from time to time (…) he who is in need today receives help from him who may be in need tomorrow" (Evans-Pritchard 1940, p.85).

Reciprocity among self-interested actors is thus sustained through a "quid pro quo" principle, which can be summarised as follows: "I help you today because I expect you to help me tomorrow" (Cox, Fafchamps 2007b, p.3725). Posner thus concludes that obligatory sharing and norms of generosity function as "a substitute for formal insurance" (1980, p.15). Platteau (1997), however, critically emphasises that the underlying principle of these arrangement is balanced reciprocity, rather than insurance as insurance usually implies that there are winners and losers of risk-sharing.

Evans-Pritchard's emphasis of scarcity as the basis for mutual help resonates with the rationalist conception of vulnerability or subsistence conditions as a central, structural premise influencing decision making in poor, rural communities. Duflo (2006) describes this vulnerability as an environment characterised by uncertain weather conditions, by the risk of crop failure, price volatility, illness and other potential income shocks. Being close to subsistence is what makes these risks particularly distressing to the poor (Duflo 2006).

In the absence of a state to provide welfare services and without functioning markets for credit and insurance, households adopt a number of forward-looking strategies in response to risk under conditions of high vulnerability, such as asset strategies (self-insurance), consumption or income smoothing, e.g. risk spreading through crop, plot or income diversification as well as the participation in informal risk-sharing and safety nets (Fafchamps 2003, Dercon 2005b). Informal cash or in-kind gifts, exchanges and loans are thus seen as a set of possible rational risk-spreading

or coping mechanisms. These strategies become particularly relevant when self-insurance strategies are limited in the absence of suitable assets as agricultural produce often has only limited storability and livestock savings suffer from high covariate risks (Dercon 2005b).

The Rationale of full insurance and self-enforcement

The formalization of the insurance principle in the framework of repeated games provides a more concise understanding of how the insurance principle works.

Mutual assistance is conceptualized as a strategic game played among non-altruistic, risk adverse actors maximizing their expected utility, with similar (idiosyncratic) risk probabilities and the actors' production being independent. This is a typical Prisoner's Dilemma situation, which has a non-cooperative outcome (or autarky as the only Nash-equilibrium) when only played once. While both actors would benefit from cooperation by mutually sharing risk, in the absence of enforcement, both do not cooperate, i.e. defect (Axelrod 1984, Kimball 1988, Foster, Rosenzweig 2001).

If the game is repeated with infinite iterations under the so-called "shadow of the future", however, a cooperative outcome can emerge because the players are not only calculating their contemporaneous benefit or cost - which would result defection in the current game, but also the utility from continued cooperation, compared against defection or autarky in the future, i.e. reliance on self-insurance and risk spreading mechanisms at the household level (Axelrod 1984).

Coate and Ravallion argue that cooperation can be sustained in a "suitably risky environment" (1993, p.2). This means that vulnerability influences the cost of non-cooperation, which could threaten survival, and the preference for future security over current benefits. Kimball (1988) can show that even when assuming high degrees of risk aversion and high discount rates (of future returns) the expected gains for an individual farmer of sharing are higher than from individual risk spreading. Thus, "[s]olidarity networks should emerge quite naturally in societies that are vulnerable to starvation" (Fafchamps 1992b, p.150). An arrangement is expected to be self-enforcing, i.e. it does not require an external enforcing entity, if exclusion constitutes a "credible threat". This means both (1) that an actor is excluded from the risk-sharing group in case of non-cooperation and (2) that "short-run benefits from opportunistic behaviour are smaller than long-run benefits from cooperation" (Fafchamps 1992b, p.146).

Empirical studies have shown, however, that although some communities practice a remarkable degree of risk-sharing (see Townsend 1994), the model of full insurance is statistically rejected (Mace 1991, Udry 1994, Bardhan, Udry 1999, Fafchamps, Lund 2003).

Incentive problems in collective insurance

This empirical finding of incomplete insurance is related to the fact that collective risk management has incentive problems common to all forms of collective action (Platteau 1991). Ray (1998) distinguishes incentive problems arising from limited information (adverse selection and moral hazard) and from limited enforcement (i.e. limited commitment). More recent efforts in the risk-sharing literature have responded to the realisation that "problems such as commitment and enforceability should be incorporated as standard fixtures in the modelling landscape" (Cox, Fafchamps 2007b, p.3777). Only a small number of relevant approaches to modelling and testing models of insurance with incentive problems are discussed here.

Limited group formation

More recent contributions have shown that opposed to the idea of Townsend's (1994) "village economy", insurance is often provided in sub-groups as Fafchamps (1992b) argues or, more precisely, in networks of linked actors, in which the smallest unit of analysis is a dyad (Bloch, Genicot et al. 2007, Fafchamps, Gubert 2007a). Since monitoring commitment and effort is costly, it is easier to implement in personal relationships - in which monitoring costs fall over time - as opposed to an entire community.

In repeated interaction it is thus easier to establish trust, defined as "correct expectations about the actions of other people that have a bearing on one's own choice of action when that action must be chosen before one can monitor the actions of those others" (Dasgupta 1988, p. 51). Interpersonal trust is found to be essential in supplementing weak institutions, which are subject to incentive problems (Fafchamps, Gubert 2007a).

Ex ante solidarity

A number of recent contributions have enhanced our understanding about the particular incentive problems associated with different kinds of shock, such as health problems or death of a family member (Fafchamps, Lund 2003, Dercon, De Weerdt et al. 2006, De Weerdt, Fafchamps 2011).

Fafchamps (1992b) as well as the contributions on quasi-credit discussed below offer important insights about incentive problems of different ways to insure the same risk. Highly relevant for this study is thereby the notion of ex ante solidarity, which is defined as mutual assistance in production factors (labour, oxen, machinery etc.) rather than output to prevent hunger and starvation. This form of insurance gives fewer incentives for moral hazard since actors can capture the entire marginal product of their effort and have fewer incentives to reduce their effort (Fafchamps 1992b).

The comparison of ex ante and ex post forms of assistance also alerts to the fact that ex ante assistance may not only be preferred because they involve fewer incentives problems. It might also be less costly to individual actors who provide assistance as well as to the collective.

Limited enforcement: From exclusion to endogenous extrinsic enforcement

The autarky payoff as punishment is the cornerstone of formal models of full insurance. The threat of is credible since cost of exclusion is high: "breaching an informal arrangement not only leads to the loss of further exchange within the arrangement, but possibly leads to the loss of other benefits associated with this relationship, such as socialization, participation in religious and social rituals, access to potential mates" (Cox, Fafchamps 2007b, p. 3725).

Cox and Fafchamps describe an environment for enforcement working through a reputational mechanism. Platteau (1991) argues that public denunciation of deviant behaviour is a sometimes perverse, but powerful self-enforcing mechanism, in which the public holds prosecutorial powers. Ostracism and public rebuke as common forms of punishment fulfil the function of 'marking' someone as defector and sharing his record with other players (Ray 1998). In his theoretical extension to repeated and matching games, Kandori analyses the role of community enforcement with "agents [who] only care about their own utility; that is, we do not assume that people follow a social norm for its own sake" (Kandori 1992, p.63). A cooperation norm with community enforcement - i.e. punishment (e.g. exclusion) is not only enacted by the cooperation partner, but the whole community - can be sustained even if the interaction between actors is not frequent as long as information about the actors' past games transferred locally. Put differently, enforcement in a cooperation game in a large group can be shown to be effective as long as information about cooperation and non-cooperation is shared within the community.

An important aspect of this "puzzle of incomplete insurance" is that despite the continued efforts to uncover and model general patterns in institutional design, multiple sub-game perfect equilibria can theoretically emerge (Goldstein, Janvry et al. 2005, p.217). The specific institutional form of the equilibrium is ultimately contingent. This brings us back to the "enigma of the gift", which is enigmatic because of the similarity of its patters across different context on the one hand and the diversity of specific forms it assumes on the other (Godelier 1999).

b. Understanding the specificity: Conceptualizing contingency

Social and cultural anthropology offers a relevant approach to analyse the specific forms gift-giving can assume, namely the concept of contingent rationalisation. This is by no means limited to the

analysis of gift-giving, but rather constitutional to the interpretative and hermeneutic approach of social and cultural anthropology.

Contingent rationalisation of gift-giving

Lichbach aptly describes reason as "conditional and contingent, (…) it varies by culture, which means that the individuals in a group or community have common orientations" (2003, p.78). Social norms are expected to be contingently rational, because "[p]eople must reason through their experiences coherently and clearly in order to agree an account of what they do" (Sykes 2005, p.8). From a culturalist perspective, explanations of reciprocity will and can thus never be either rational or cultural as "rationality is an expression of culture, of its meaningful system of utilities, not the antithesis [of culture]" (Sahlins 2004, p.xiii).

In the context of gift-giving, this means that the rationality of the three obligations that constitute reciprocity according to Mauss (1954[1924]) - namely, the obligations to give, to receive and to reciprocate - must be reconstructed in each case. Any attempt to interpret the underlying mechanisms, reasons or motivations to must follow from an understanding of these rationalisations.

METHODOLOGY AND ETHICAL CONSIDERATIONS

This section will outline the (1) epistemological foundations and (2) methodical design of this research project. Furthermore, the (3) study background is discussed. The section will conclude with a critical discussion of (4) potential sources of bias.

1. A brief note on research paradigms and the (inter-)disciplinary approach

In the conceptual framework, we consciously draw on different literatures and disciplinary traditions. The fundamental differences between disciplines within and beyond the social sciences are epistemological, i.e. concerning questions of how we can know (Appadurai 1989). This research project must therefore explicitly, if briefly, address which foundational assumptions are made, especially since economics and anthropology are situated at the epistemological poles of the "standard distinction in the philosophy of social science between empiricism/positivism [and] hermeneutics/interpretive approaches" (Kanbur, Shaffer 2007, p. 185).

The "account of knowledge" adopted here is at its core positivist (Moser 2002, p. 3). This means that we assume the general capacity to gain an "intersubjectively observable and subject invariant" knowledge of reality (Kanbur, Shaffer 2007, p. 187). I do not assume, however, that the only way we can know about this reality is by approaching it with the methodological tools commonly used in the positivist paradigm. In this research project, questions of meaning and the social construction of reality are extremely relevant. The interpretative approach to obtaining data on these aspects of reality - which cannot be immediately observed - is extremely relevant for the analysis at hand. The positivist approach (which seeks to explain) and interpretative approach (which aims to understand) are seen as complementary in a methodological sense, but not in its fundamental epistemological dimension, i.e. concerning claims about "how we come to know" (Wight 2002, p. 42).

Concerning the behavioural assumptions of this research, the conceptual framework based on game theory indicates a rationalist orientation. In particular, methodological individualism and (expected) utility maximizing behaviour are explicitly assumed.

2. Methods of data collection

This study presents an in-depth institutional analysis of an informal social institution. The research conducted for this study was designed to complement existing studies by focussing, in particular, on the often neglected, immaterial aspects of seed assistance and informal social institutions more generally. Methods are chosen to capture aspects beyond the material practice, which are not immediately observable and quantifiable, such as motivations to give, conditions or sanctions for denial, and ultimately, the social norms underlying the practice.

a. Overview of the research design

The research design can be described as a "congruent mixed methods approach", in which both quantitative and qualitative data is collected simultaneously to provide a "comprehensive analysis of the research problem" (Creswell 2003, pp. 15-16). This design follows from the theoretical framework, outlining a cross-disciplinary analysis of informal seed assistance. Furthermore, it reflects the growing understanding in the social sciences, that a mix of qualitative and quantitative date is critical in any study of human behaviour (Bamberger 2000, Kanbur 2001, Bernard 2006).

Representative household surveys, capturing some of the material aspects of seed assistance, have already been conducted in the eastern part of Oromiya regional state (Mekbib 2006, Winters, Cavatassi et al. 2006, Mekbib 2008a). Moreover, data collection based on a regionally representative household survey as well as an ethnography were beyond the realisable scope of this research project.

Instead, two field sites (*kebeles*) with a majority Muslim Oromo population in the West Hararghe zone were deliberately chosen, approximately 60 kilometres apart, in different agro-ecological settings (approximately 700 metres difference in elevation), one site with and one without an Orthodox-Christian Amhara minority population. To allow for meaningful quantitative analysis, a sample size of over one hundred respondents was planned. Individual interviews with a fully structured part, collecting quantitative information and a semi-structured part to collect qualitative data were complemented by key informant interviews and focus groups for triangulation.

b. Methods

Data was collected in two stages: during six weeks in July to September 2010 and during four weeks in July and August 2013. During that time, I immersed myself as much as possible by learning the local language, Afaan Oromo, and living in the communities with a research assistant during fieldwork rather than commuting to the zonal capital, Asebe Teferi, on a daily basis. Although the research was not ethnographic, I was invested to adopt what Hammersley and Atkinson call the anthropological "mode of being-in-the-world"(1995, p. 249).

Sampling strategy

During a pilot phase of two weeks in 2010, in which the interview instruments were developed and refined, we relied on local contacts to establish contact to 21 interviewees (mainly donors) from all six gandas of Asebot *kebele*. For the remaining four weeks of data collection in 2010, 50 interviewees were randomly sampled from a complete list of households of Tukune *ganda*. A random sampling strategy (even if the area was geographically limited) was crucial for an assessment of the scope and frequency of seed assistance in a rural community and to identify

potential reasons for exclusion from seed assistance from respondents, who do not actively participate in seed assistance.

In 2013, three *gandas* in Schola *kebele* were randomly chosen and 70 respondents were randomly sampled from household lists of the following gandas: Dhumuga (N=20), Qirixe (N=25) and Tagel (N=25).

Additionally, a small number of randomly sampled households (N=5) from Hasan Bory *ganda* in Asebot *kebele* was interviewed to explore whether potential differences between the 2010 and 2013 round of data collection were linked to the location or the time that had passed between the two rounds.

Qualitative interviews & analysis

The 146 individual interviews with small farmers, which constitute the core of the collected data, were based on a fully-structured questionnaire and a semi-structured interview guide.

The semi-structured part of the interview followed different interview guides for donors and recipients (see table 26 in the appendix for the interview guide for donors). Interviews with respondents who were neither recipients nor donors (NDRs) were open and with immediate translation. Interviews were conducted with live translation and recorded with the consent of the interviewee and confidentiality was guaranteed. The interviews were fully transcribed.

The interview guide gives an overview of the questions around reciprocal behaviour that were posed to all respondents that reported seed transactions. Additional questions were added when appropriate to probe the answers. Detailed questions about other forms of assistance beyond seed assistance which were explored in focus groups and with key informants. The fully structured questionnaire, however, recorded details of the relationship and mutual membership in other social networks for each seed transaction reported by the respondent. As discussed in more detail below, questions on assistance in the distant past were much more difficult than questions on assistance in the near past. A small number of respondents refused to answer questions about the past altogether. Therefore, the information reciprocal practices between two households remains partial and questions around the frequency of seed receipts and donations were dropped altogether.

It became apparent that the discussion of more critical topics (like conditions for seed denial) required a confidential and private environment, in which interviews could not be overheard, for respondents to speak freely. Thus, the interviews in 2010 were conducted either in a secluded compound in the village centre or at the Farmer's Training Centre (FTC). In 2013, an appropriate

place was chosen in each interview location. This is also one of the reasons why individual interviews emerged as the more appropriate method compared to focus groups.

The structure of the qualitative data allows the analysis of a comparatively large number of answers to the same question to identify similarities or patterns on an aggregate level (i.e. in cross-section perspective), thus ensuring the reliability and replicability of the findings.

The qualitative data analysis was conducted in Nvivo. The process of data analysis followed Le Compte and Schensul's stages from item (or code) to pattern and finally to structural analysis (1999). The analysis was based on the detailed coding of thematically organized sets of questions using mainly "a priori codes", which emerged mainly during data collection, but evolved during the analysis (Bazeley 2007, p. 76). Patterns and relationships between codes were than analysed and summarized into models for different aspects of seed assistance, including sanctions, motivations, conditions and seed concepts.

Household survey & analysis

The fully structured part of the interview provides information on household characteristics, production indicators as well as basic, quantifiable information on seed transactions.

The fully structured part played an important role in the dynamic of the interviews, i.e. in establishing a positive relationship and mutual trust between research assistant, researcher and interviewee. The descriptive quantitative data, using mainly summary statistics, was conducted in Excel and STATA.

Focus Groups and Expert Interviews

Expert interviews and focus groups were used as complementary qualitative methods. The focus group discussions were conducted during the final weeks of fieldwork in 2010 to validate the findings by extending the group of respondents to other sub-villages, to collect more data on ambiguous findings or questions emerging from the individual interviews. The interviews with researchers and local authorities were conducted in the pilot phase and before fieldwork to deepen the understanding of the research topic and to gather contextual information.

In the final stages of fieldwork in 2010 and throughout fieldwork in 2013, having developed a good grasp of informal seed assistance, seven interviews (non-)governmental actors involved in seed aid in the region were conducted. The aim was to get an overview of the approaches to seed aid, to evaluate the existing understanding of informal seed aid and ultimately, assess to what extent the policies strengthen or potentially pose a challenge to informal seed assistance.

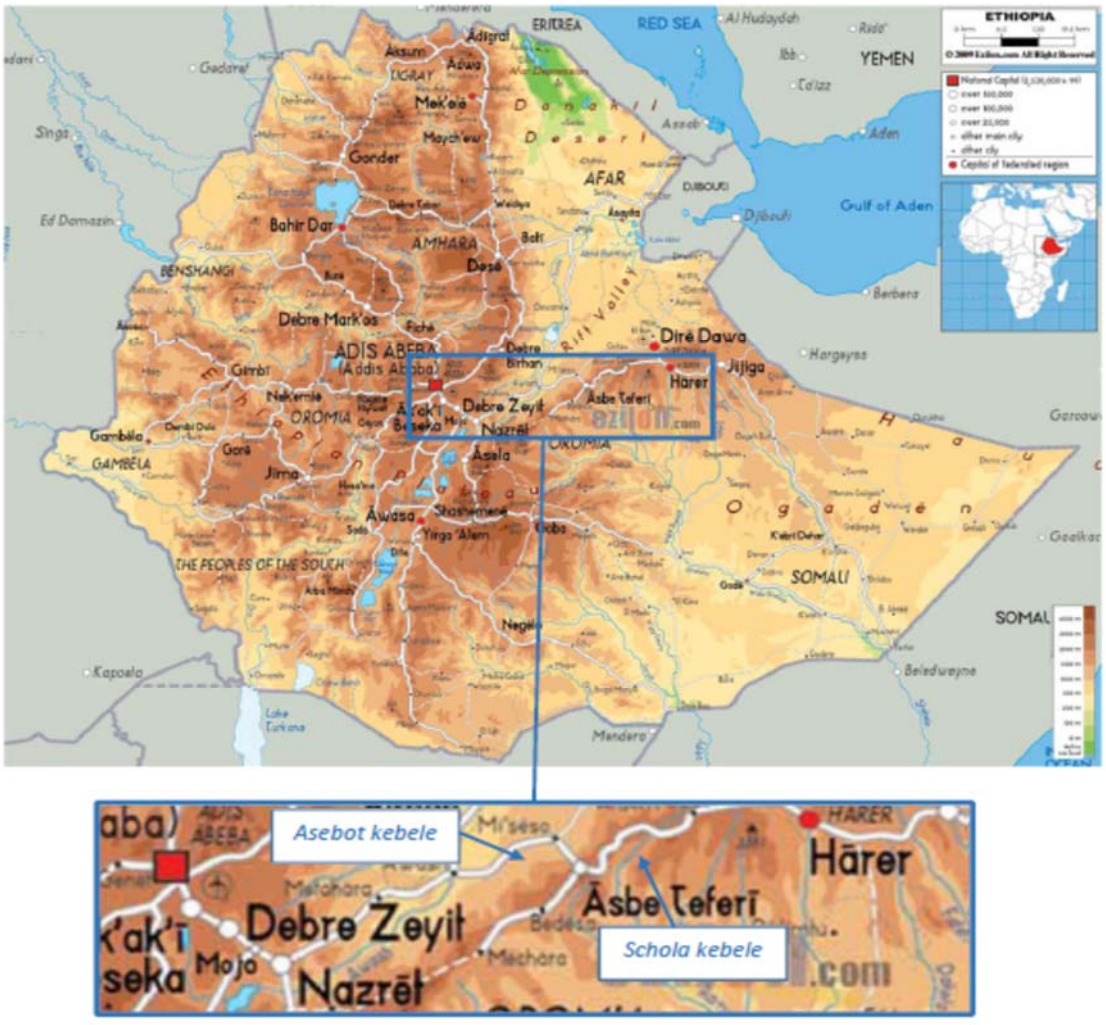
3. Study Background

The two study sites, Asebot *kebele* in Mieso *woreda* (district) and Schola *kebele* in Chiro Zuria *woreda* (district) are located in the West Hararghe zone of Oromiya regional state. Both sites are close to Route 10, one of the major roads in the Eastern part of the country, connecting the capital Addis Abeba to the eastern towns of Harar and Dire Dawa. The closest town is the zonal capital, Asebe Teferi, where a number of non-governmental organizations have their regional office.

a. Physical and environmental characteristics

The two sites, which are approximately 60 kilometres apart, were chosen to represent different agro-ecological and social settings, in which seed assistance is practiced. While Schola is located in the Amhar mountains at approximately 2,000 to 2,200 meters above sea level, Asebot is located in the plains at an elevation of 1450 m.

Figure 3: Locating the field sites in Ethiopia



Source: http://www.ezilon.com/maps/africa/ethiopia-physical-maps.html

With an annual precipitation of 769 mml in Asebot[104] and 817 mml in Schola the moisture regimes in both locations can be characterized as dry, with a bimodal rainfall regime with short (and increasingly unreliable) *belg* rains from March to May and a longer *kiremt* rainy season from July to September (Hurni 1998).

b. Agricultural system & livelihoods

The agricultural system in the region was well described as the "sorghum-plough complex", which is practiced throughout the highlands of Hararghe (Westphal, Stevels 1975). Sorghum as a drought-resilient crop is cultivated by the mast majority of households in the region, which is the centre of genetic crop genetic diversity for sorghum (Brush 2004, Mekbib 2008c).

In the highlands, sorghum is typically cultivated alongside maize, intercropped with common beans or, to a lesser extent, with chickpeas or cow peas. The higher altitude also allows for barley cultivation, often in rotation with fava bean. Chat, a popular mild narcotic in the Horn of Africa, is grown by two thirds of all households in both regions for consumption and as cash crop. In the highlands, only a small share of households grows tuber crops (potato and sweet potato) and vegetables (onions and tomatoes). In the lowlands, maize is less popular, grown by half of the sample households, but sweet potato is widely cultivated.

This summary of the cropping system in both field sites illustrates that crop diversity in the highland location is higher than in the lowland community, where farmers grow significantly more varieties of sorghum (1.7 vs. 1.2 varieties on average). These varieties are typically landraces as breeding efforts are limited for marginal crops such as sorghum and since landrace varieties have a number of more attractive use traits (Mekbib 2008c, Cavatassi, Lipper et al. 2011). This difference in the crop and varietal portfolio could indicate a trade-off between intra- and interspecific diversity for food crops. While average land holdings in both field sites are similar, the average number of tropical livestock units is significantly higher in the lowlands (5.6) than in the highlands (2.9). Similarly, on average a household in the lowlands has one head of cattle more (2.7) than in the highlands. In both areas common grazing areas (as well as woods to gather firewood) are extremely limited due to increasing population density and the expansion of farmland. Livestock is therefore mainly fed with feed, i.e. stalks and leaves of sorghum and maize, which are a very important by-product of agricultural production.

In summary, we can conclude that the livelihood strategy in the highlands is more agriculturally oriented with a more diverse crop portfolio, whereas a dominantly agro-pastoralist livelihood

[104]Average annual levels from 1990 to 2012, from Mieso and Hirna weather stations, Source: The Climate Change Knowledge Portal of the World Bank: http://sdwebx.worldbank.org/climateportal/index.cfm

strategy dominates in the lowlands with a strong emphasis on sorghum as the main food and feed crop.

c. Food security

In 2013, the food security status of all households was also assessed. We found that only 32 percent of households had not experienced a food gap – defined as a period in which the household could not cover consumption needs with its own production. Over thirty percent of households were food insecure for at least two months in the previous year. This period is often called the "lean season". Seventy percent of all households reported to have received food aid in the last year. Expert interviews confirmed that this region is now considered to be chronically food insecure due to changing rainfall patterns and the increasing population. Annual food handouts are administered by the World Food Programme in cooperation with non-governmental organizations and the government since the mid-2000s.

d. Population

Both study sites have a majority Oromo, Muslim population. The Oromo are - with 34 percent of the country's and 88 percent of the region's population - the largest ethnic group (Federal Democratic Republic of Ethiopia 2008). In the study region, however, mainly ethnic Amhara are members of small Orthodox-Christian minority. Since one of the few Christian churches in the rural areas is located in the highland *kebele,* one third of the sample population is ethnic Amhara and Orthodox-Christian. Respondents explained that they had been resettled from the Western zone of Wollega to this area several decades ago and that the Christian minority usually lived close to the church.

While all *gandas* in Schola *kebele* are very rural and the market is situated in a neighbouring parish, Asebot, the lowland location, is increasingly transforming into a town as it has a vibrant marketplace. *Gandas* like Bareda and Salale, situated around the village centre and the market are a more ethnically and religiously diverse and with a substantial part of the population pursuing non-farming livelihoods. The other four *gandas*, two of which are included in the sample, are more homogenous farming communities.

4. Limitations to Inference

a. Representativeness

We situate this research geographically in the West Hararghe zone and in Eastern Ethiopia throughout the study and particularly in the discussion of policy implications. It must be noted, however, that the findings presented here can be neither extrapolated to the zone, nor the region, nor to all ethnic Oromo. The research is representative at the level of the *gandas* and arguably at the level of the *kebeles* it was conducted in. Throughout the study, we therefore seek to relate the findings to other thematic research in the region.

b. A very brief summary of potential sources of bias

Questions about age as well as the frequency of donation or receipt seemed to be difficult to answer for respondents, possibly indicating limits to numerical literacy or rather "difficulties that arise if we ask people to give number for things they have little concept of in a numerical sense" (Overton, Dierman 2003, p. 51). In consequence, elaborate recall questions to assess the frequency of seed assistance in a household were dropped in 2013. We also acknowledge that reported seed transactions are biased towards the most recent ones. Moreover, especially when interpreting data concerning amounts of seed given and received, we discuss the difficulties in interpreting the summary statistics. The findings must therefore be carefully interpreted, bearing in mind that the data collected does not provide a fully picture of the reciprocal relationships the two households are engaged in over an extended period of time.

Several reasons potentially leading to a misrepresentation or censoring of information must be considered, particularly concerning wealth indicators, the amount and the frequency of receipt as well as the more critical aspects of seed assistance (such as sanctions and exclusion). Firstly, through an interview with Dr. Firew Mekbib - an experienced researcher in the region - and in my own research, I became aware that there is a sense of shame involved in receiving assistance, which could plausibly have led to an underreporting of seed receipts.[105] Secondly, an important part of my positionality in the field was that the community intuitively assumed that I had the agenda and access to resources to "help". Especially during the first days of fieldwork in 2010 and 2013, a number interviewees denied the practice of seed assistance all together and stressed their need for seed and food aid. I responded by explaining the aim of the research and my role in more detail. Thirdly, a strategy called "research resistance" describes how some respondents clearly tried to "control [research findings] by withholding information" (Scheyvens, Storey 2003, p. 5). Some respondents obviously resisted to report any evidence that seed assistance did not comply with its normative ideal, which is described in the following sections as the 'pure gift'. Especially random sampling allowed me to talk to respondents who were not eager to talk to me or to present a certain version of seed assistance. The result is a very diverse and varied account of seed assistance, which allows to control for this bias to a certain degree.

As discussed above, during the pilot phase a part of the respondents (21 out of 146 interviewees) were not randomly sampled. Especially when analysing aspects such as the scope and frequency of seed assistance, we therefore exclude these interviews from the analysis.

[105]The interview with Dr. Firew Mekbib, Assistant Professor at Haramaya University, was conducted on 04/09/2010 in Addis Ababa.

FINDINGS: The Practice of Seed Assistance

In this section, the practice of seed request and donations is described in detail, before moving to an analysis of the interpretation and rationalisation of seed assistance in the next section. In particular, (1) we analyse the scope, frequency, (2) the mode of seed transactions and (3) characteristics of donors and recipients of seed assistance as well as (4) their relationship. Finally, (5) we reflect on the inclusiveness of seed assistance and (6) reasons for a break-down of the informal practice.

Previous studies in the area show that seed assistance is widely practised in the region (Mekbib 2006, McGuire 2008). While the vast majority of farmers uses saved seed, off-farm sources become particularly relevant in planting seasons after a drought. Both in terms of frequency and amount, seed gifts are found to be the most important off-farm seed source.[106]

1. Frequency & scope of assistance

Local government officials estimate that 80 to 90 percent of sorghum and maize crops failed in Asebot village (*kebele*) during the 2009/10 season.[107] The food security officer of Mieso district (*woreda*) reports that more than 800 food insecure households were receiving emergency food aid monthly from March to October 2010 in a community of approximately 1,100 households.[108]

In this context, after a particularly severe drought and acute food insecurity, in which fifty percent of all interviewed farmers report to have lost their entire harvest, 56.3 percent of 50 randomly sampled farmers in Tukune village (*ganda)* have received seed and 29.7 percent donated seeds. Only 12.8 percent or six households did not participate in informal seed assistance. These farmers were either self-sufficient in seed or bought seed from the local market.

In a less severely stressed environment in 2013, 40 percent of 75 randomly sampled farmers from the highland community (*kebele*) Schola, report to have given seed that year and 17.3 percent to have received seed. This high degree of participation in seed assistance emphasises the importance of this seed source in times of crisis and normality.

[106]In a representative study of 12 kebeles, about 35 per cent of farmers indicate to be seed insecure in a bad season and the majority of these farmers use "'non-cash-based networking' (exchange or gifts) to supply themselves" (Mekbib 2006, p.73). The average amount given as a given was 10 kg, whereas the average amount purchased was 13.6 kg. In his study of 2 woredas in East Shewa, McGuire concludes that seed assistance - with an average amount of 7.5 kg given - is "the most frequent source of off-farm seed, though markets were used for larger individual amounts (>15 kg)" (McGuire 2008, p.221).

[107]Interiews with Ali Mehamed, Development Assistant Supervisor and Dr. Azage Tegene, Extension Officer at Mieso woreda were conducted on 15/08/2010 and 21/09/2010 respectively.

[108]The interview with Abrahim Ali Rane, Food Security Officer of Mieso wordea, was conducted on 15/08/2010.

Notably, in both years and in both study locations, considerably more donations – roughly double the number - than receipts are reported. In a random sample, however, we would expect the difference not to be significant. To understand why there seems to be an underreporting of seed receipts, we cross-checked seed transactions in 2013. A small number of transactions (N=5) are reported by donors, but not by recipients and for which we interviewed both donor and the reported recipient. In most of these cases, the recipient usually acknowledges the transaction and explains that he or she has forgotten about it. This suggests that there is a conscious underreporting of seed receipts. While all respondents explicitly agree that a seed request is not considered as a form of begging, there appears to be a sense of shame attached to having to ask for seed assistance, while donors take pride in their giving seed. This is discussed further in the analysis of a legitimate request in the next section.

Table 16: Amount of seed given or received as declared by donors and recipients

		Recipients (Std. Dev)	*Donors* (Std. Dev)
Asebot (lowland)	Average amount (kg)	12.70 (6.71)	7.43 (5.37)
	N	31	74
	Range (kg)	0.2;34	1;17
Schola (highland)	Average amount (kg)	5.57 (5.20)	5.13 (4.03)
	N	71	111
	Range (kg)	0.5;30	0.5;28

While seedlings and seeds of all sorts of crops are shared in the community (especially sweet potato, for which only a small piece of the plant is needed for multiplication), seed assistance, as discussed in this study, mainly refers to cereal crops. Sorghum as the primary staple crop and as a crop with traditionally high genetic diversity in the region is most frequently given and received (47.8 percent), followed by maize (32.7 percent), which is becoming increasingly popular in the region.[109] Less frequently, farmers give barley (8.1 percent), wheat (3.6 percent) or haricot bean (7.2 percent) as the only legume.

To assess the size of seed donations, both in comparison to previous studies and relative to total household production, we analyse average amounts given and received across different crops. The numbers, however, have to be analysed with some caution as farmers used a range of different measures and units, many of them referring to volume, rather than weight (such as kuna, which describes a commonly used tin of a consistent size). Although we asked for weight estimations in kilograms alongside local units, the information is certainly subject to measurement error. Roughly ten percent of all respondents were unable to recall the amount they gave.

Nevertheless, the average amount reported by recipients and donors in the lowland community is significantly higher than in the highland community. Furthermore, recipients report on average a

[109]The basis of this analysis are all 222 reported transactions with full information on the crop given.

significantly higher amount than donors in the lowland community. The amounts reported by donors in the lowlands are consistent with previous studies, which found that 7.5 kg and 10 kg were given on average ((Mekbib 2006, McGuire 2008). As will be discussed throughout the paper, despite random sampling, a significantly higher number of seed donations than seed receipts is reported as also reflected in this table, which analyses all reported seed transactions. As will be discussed in more detail below, the fact that recipients report seed receipts less frequently is very likely a reflection of the honour involved in giving and the shame involved in receiving seed.[110]

From the qualitative interview one possible explanation for the lower amounts reported in the highlands emerged. It was consistently stressed by farmers in the lowlands that the sorghum varieties available from the local market in the lowlands are not well adjusted to the agroecology in the lowlands. In Schola *kebele*, however only a small number of respondents questioned varieties on the market. Thus, the market appears to be the more viable option for sourcing seed in the highland communities, possibly leading to lower amounts given.

To put these amounts into context, we compare the average amount of sorghum given in 2013 to the average productivity on the average plot size cultivated. At an average productivity of 5.86 quintiles of sorghum per hectare and an average area allocated to sorghum of 0.7 ha (or 2.84 timmad), farmers donate on average 2.6 percent (5.1 kg) of their yearly production per seed transaction. For maize, this average share would be slightly higher.[111] Nevertheless, this comparison shows that the amount given in seed assistance is usually a small share of the total harvest, even if seeds are selected, treated and stored differently than grain, i.e. seed has a higher value and involves more labour than grain. While grain is typically stored in sealed holes in the soil, which deteriorates the germination capacity, seed (for which the best heads of sorghum or other crops of the previous harvest are carefully selected) is kept in small quantities in the house over the fire, where it is preserved from rat or worm infestation.

2. Mode of transaction in informal seed assistance

In the vast majority of seed transactions reported seed is given as a gift. We find no evidence of cash or in-kind compensation or return in services, all of which were explicitly asked about. In 2010, three cases are reported, in which seed was exchanged. Eight cases of exchange were reported in 2013. Usually, seeds of different crops were exchanged.

[110] The fact that recipients report a higher amount (see table 16), however, remains somewhat puzzeling and cannot be fully explained.

[111] Since maize is usually intercropped with beans, this estimation would be very imprecise. The average amount given for maize is slightly lower (4.8 kg), but the average harvest of maize is about half of the mean yield of sorghum.

There are three options of where and how a seed transaction takes place. Firstly, a re-occurring theme is the donation of seed on the day the donor sows his seed. This is observed by potential recipients and allows to assess how much seed is left over after the donor covered his or her own plot. Secondly, in a few cases (N<10) donors or their family members brought a seed gift without prior request to the neighbour's field, knowing that the neighbour is in need. Thirdly, the most common case is a transaction at the donor's home upon request of the recipient. While usually the male head of household requests and donates seed, almost male respondents report to have consulted with their wives before giving away seed.

Farmers consistently argue that the only way seed could be sold among community members is at the market and when it concerns a large amount. In our sample, however, we find no evidence of seed being sold between neighbours. This confirms results from previous studies, which find that the average seed amount purchased is larger than the amount typically given as a seed donation (Mekbib 2006, McGuire 2008).

3. Characterizing donors and recipients

The analysis of all past seed donations and receipts respondents can recall, when asked in 2013 confirms a central claim of seed assistance concerning the fluidity of assistance roles (see table 17). Only a small minority of five households has never participated in seed assistance and two thirds households received and donated seed at least once. Despite the limits of recall data, this clearly indicates that assistance roles are indeed flexible for the majority of households. On average respondents recall 1.41 seed donations and 0.79 seed receipts per household.

To further investigate the stability of assistance role further, we analyse whether there are systematic differences between (net) donors and recipients in table 18. The most important category is thereby land size (and plot diversification) as an important indicator of wealth as well as of the household's capacity to spread production risk. Land size and the number of plots operated is thus also an indicator of a lower vulnerability to total crop failure and acute seed insecurity.

Table 17: Overview involvement seed assistance

(2013 households, recalling all receipts and donations)

Household…	N	%
neither gave, nor received seed	5	6.85
only received seed	7	9.59
only gave seed	13	17.81
received and gave seed	48	65.75
Total	73	100.00

Other possible indicators for the wealth status of a farmer household are livestock holdings in general and oxen in particular (as the most expensive animal and the most extensively used for cultivation) as well as the number of children in the household, which are often used as a proxy for available labour on farm in context with missing labour markets.

Table 18 shows that while means across all categories of wealth and education are higher for donors than for recipients, the variance in the donor group is also greater in all categories. Thus, while donors are wealthier or better educated on average, there is considerable diversity within the net donor group.[112] All differences, except for the heads of oxen, are different on statistically significant level. Despite offering a different interpretation of group differences, these findings generally confirm McGuire's results which show that donors tend to be better-off (McGuire 2008).

Table 18: Mean and variance comparisons for donors and recipients

Indicator	Mean, Recipients (N=59) (Std. Dev)	Mean, Donors (N=70) (Std. Dev)
Land size in timmad	1.46 (0.65)	1.90 (N=74) (0.97)
Nb. of Livestock (cattle, donkey, goat, sheep)	3.46 (2.96)	4.54 (4.42)
Nb. of cattle	1.95 (1.54)	2.24 (1.78)
Nb. of children	4.33 (2.35)	5.33 (3.15)
Years of education	0.96 (2.11)	2.14 (N=72) (2.69)

*Means of Donor and Recipient Responses different at * p<0.1, ** p<0.05 & *** p<0.01*

Some donors, despite have significantly more children to feed, also give seed gifts in times of acute food insecurity as one (admittedly exceptional) example illustrates. A respondent from the lowland community, who has 13 children, sold an ox to buy food grain for his family, additionally received food aid though Care Ethiopia's emergency programme and still donated seed to 4 people (JMA).

In informal conversations farmers explained that the water stress in the region is not only a challenge for farming but also for pastoralism since the animal feed in this densely populated area is not primarily provided through communal grazing areas, but through leaves and stems of sorghum and maize. This illustrates that cattle as asset for saving are subject to highly covariate risk (Dercon 2005b). The fact that farmers avoid investments in these increasingly risky assets might offer an explanation as to why differences in livestock holdings are not (highly) statistically different.

In summary, we find that (net) donors tend to be better educated and better-off in terms of land holdings, which appears to translate into an overall lower probability to be seed insecure and to request seed. Nevertheless, the majority of (net) donors (54.2 percent) also received seed at least

[112]For the 2013 sample, were all seed donations and receipts were recalled by respondents and two thirds of households received and gave seed, we group households into the "donor" and "recipient" category using the net number of donations and receipts.

once, indicating that delayed – although not balanced - reciprocity (i.e. the expectation to receive seed in the future) is an incentive for donors to give.

4. Recipient-donor relationship

We now turn the focus to who donors and recipients are to each other. Beyond family relations, the interest is particularly in farmers' social connections through other informal social institutions. Based on secondary literature and pilot interviews three relevant solidarity networks were identified: *idir*, *afooscha* and *guza* (Lewis 1974, Tesema 1996). In their core functions *idir* and *afooscha* can be described as group-based funeral insurance for men and women respectively, which have up to 40 members (Dercon, De Weerdt et al. 2006). They convene when one of the members dies to support the family in case of bereavement (mainly through *afooscha*) and to organize the funeral (mainly through *idir*). Regular financial and occasionally other material contributions are made.

Guza, which can be translated as "force", is a labour-sharing arrangement, which is organized in groups of around 10 men with slightly varying membership (depending on the task). The *guza* group is called together for labour intensive tasks such as ploughing, weeding, house construction etc. The host of the *guza* group is responsible for providing the group with the narcotic chat and food for the day.

Throughout the first round of data collection, it became clear that oxen sharing arrangements (usually between a small number households) are also relevant social institutions, in which potential relationships for seed assistance can be established. The diversity of these arrangements

Table 19: Types of Relationships - Recipients and Donors

Share…	Reported by Recipients (N=106)	Reported by Donors (N=202)
Same village (*ganda*)	74.00%	79.17%
Family members (including in-laws)	46.00%	42.57%
Immediate family members (i.e. parents, siblings)	14.15%	13.68%
Members in same funeral association: *idir***	74.00%	74.75%
Members in same women's association: *afooscha***	71.72%	73.27%
Members in same collective labour service group: *guza*	83.84%	84.65%
…of donors who have and recipients who received from this person before	19.15%	20.44%
…of donors who received from and recipients who donated to this person before***	16.28%	25.89%

** Kinship bonds often translated as "brother" or "uncle" can include non-relatives in the first and distant relatives in the latter case. The interviewer tried to exclude non-relatives.*
*** This share refers to the percentage of respondents who reported that they themselves or their spouse were in the same afooscha or idir group as the person they gave to/received from or their spouse.*
**** This is the only statistically significant ($p<0.05$) difference.*

(called e.g. *dire*, *ynii* or *fedino*) and the partial overlap with the *guza* group, however, complicated a systematic analysis.

The findings summarized in table 19 clearly indicate the crucial importance of familial bonds, and more importantly, connections formed through informal social networks. The fact that over seventy percent of all seed transactions happened between members of the same labour sharing network and/or funeral society illustrates that seed assistance is embedded in existing mutual-help networks.

Social connectedness goes hand in hand with spatial proximity. Almost 80 percent of donors come from the same *ganda* as the recipient. In cases, where a recipient or donor comes from another *kebele*, they usually do guza together and/or have familial relationships, which - as the relatively small share of immediate family members suggests - are mostly distant relatives and especially in-laws The latter potentially indicates risk spreading behaviour in marital choice.

Out of a total of 308 reported seed transactions, there are merely 10 cases, in which the recipient and donor do not come from the same village and are neither related nor organized in the same labour sharing group.

Finally, the share of repeated transactions or direct reciprocity between the same donor and recipient of roughly one fifth to one quarter of all transaction is relatively low. This suggests that seed assistance is better described as a form of group insurance than a reciprocal relationship between individual households.

5. Inclusiveness of seed assistance

Based on a similar finding – namely that pre-existing social bonds matter significantly for the establishment of an assistance relationship - McGuire hypothesises that the institution of seed assistance is not fully inclusive (2008). Moreover, he interprets the differences between donors and recipients as an indicator for the existence of patron-client relationships and the exclusion of the poorest households in the community.

Generally, we observe a high degree of participation in seed assistance in this study. Furthermore, more than 92 percent of households (N=>113) in this sample are members of an *idir* or *afooscha* as well as a *guza* group (refers only to male respondents). [113] All of the thirteen households who have neither received nor given seed are organised in these social networks, except for one female

[113]Exceptions are female headed households without males participating in guza or male headed households with no female household member who is organised in afooscha. There is, for example, no male headed household, which is not organized in an idir group.

headed household. This provides some evidence that the mutual-help institutions, in which seed assistance appears to be usually embedded, are highly inclusive.

A closer analysis of the respondents (N=10) who neither gave nor received - excluding cases of one very young and one landless farmer - shows that two farmers are usually seed secure, but according to their own assessment, not in a position to give. Three other respondents have comparatively lucrative off-farm activities, which enables them to buy seed from the market, which they prefer given that they have the means to do so.

Only the remaining three respondents (i.e. two percent of the sample) can potentially support the hypothesis of selective access to seed assistance. The two elderly brothers, who are the only ethnic Amhara in the sample from the lowland community and one female head of household, whose husband also used to work off-farm, from the highland community, were quite reluctant to answer the questions and to elaborate further on their social integration in the community. These might be cases of households, which are excluded from seed assistance.

6. Seed assistance in the presence of a local benefactor

While there are no reports of seed denial in the 2010 sample and generally from the lowland communities, recent cases of denial or the explicit fear of being denied seed was expressed by a small number of respondents from the two villages (*gandas*), Dhumuga and Tagel, in the highland community. Two people reported to have been denied seed and six people reported to have recently heard about seed denials, whereas all other respondents reported to know of no cases of seed denial.

During interviews in Dhumuga village, it became apparent that a substantial share of respondents from that community (N=10) had received from the same person. Aliyi, a former member of parliament, moved back to his ancestral village to cultivate six hectares of land he owned in the area. He also (re-) introduced a landrace variety to the area, which he generously shared. According to his own reports, he gave seed gifts to more than one hundred farmers (AMMI 2013).

As will be discussed in more detail in the next section, the presence of this wealthy local benefactor, who acts as a seed donor for the community, appears to have contributed to a break-down of informal seed assistance as these recent and exceptional reports of seed denial indicate.

FINDINGS: Interpretation and Understanding of Seed Assistance

Going beyond the material practice of seed assistance, this section explores farmers' contingent rationalisation and interpretation of their giving and receiving. We thereby identify explicit and implicit norms governing seed donations.

The analysis takes us from (1) the ideal-type normative formulation of seed gifts to (2) an analysis of motivations and (3) conditions for seed assistance to (4) conceptions of reciprocity. The analysis of (5) potential sanctions for non-compliance will lead into a closer examination of (6) the symbolic understanding of seed. In the final section (7), the validity of three normative claims, which are made in the ideal-type formulation of seed assistance are evaluated based on the evidence presented in this and the previous section. The concluding section will complete the empirical basis for and lead into the institutional analysis of seed assistance in the next section.

1. Normative formulations of seed assistance: claims of unconditionality

The dominant normative expression of seed assistance is here called the norm of non-denial. The norm has a generic formulation, which features prominently in the narrative around seed assistance. It was explicitly expressed in the vast majority of interviews as the following quotations illustrate.

> "Seed and bull sperm will never be denied. All Oromo know this by heart" (FAW 2013).
>
> "Among Oromo, it is forbidden to deny bull sperm or seed" (MES 2010).
>
> "Seed will never be denied. It is like a bull" (NUM 2010).

The norm of non-denial is formulated in a concise and consistent manner. It is expressed as a non-violable norm in the Oromo community. The frequently recurring word "never" in the formulation of the norm suggests that it is understood as an absolute normative standard with no exceptions, which can be further broken down into three normative claims of unconditionality.

a. No legitimate denial

Firstly, seed assistance is presented as unconditional because a request for a seed donation cannot be legitimately denied. As one respondent phrases it "There is no reason which would justify not to give seed to each other" (MSA 2010).

b. Universal access

Secondly, unconditionality manifests itself in universal access to seed assistance, i.e. everyone can (hypothetically) receive seed gifts. This is partly assumed in the first normative claim, but goes beyond it in stating universal entitlement to assistance. A respondent expresses this as follows "[f]armers from each corner come to ask for seed: The poor and the ones who have assets; all

those who have no seeds" (MEAV 2010). Another respondent simply states "In our community, we will not deny seed! It does not matter who comes" (SJA 2013).

c. Non-compensation

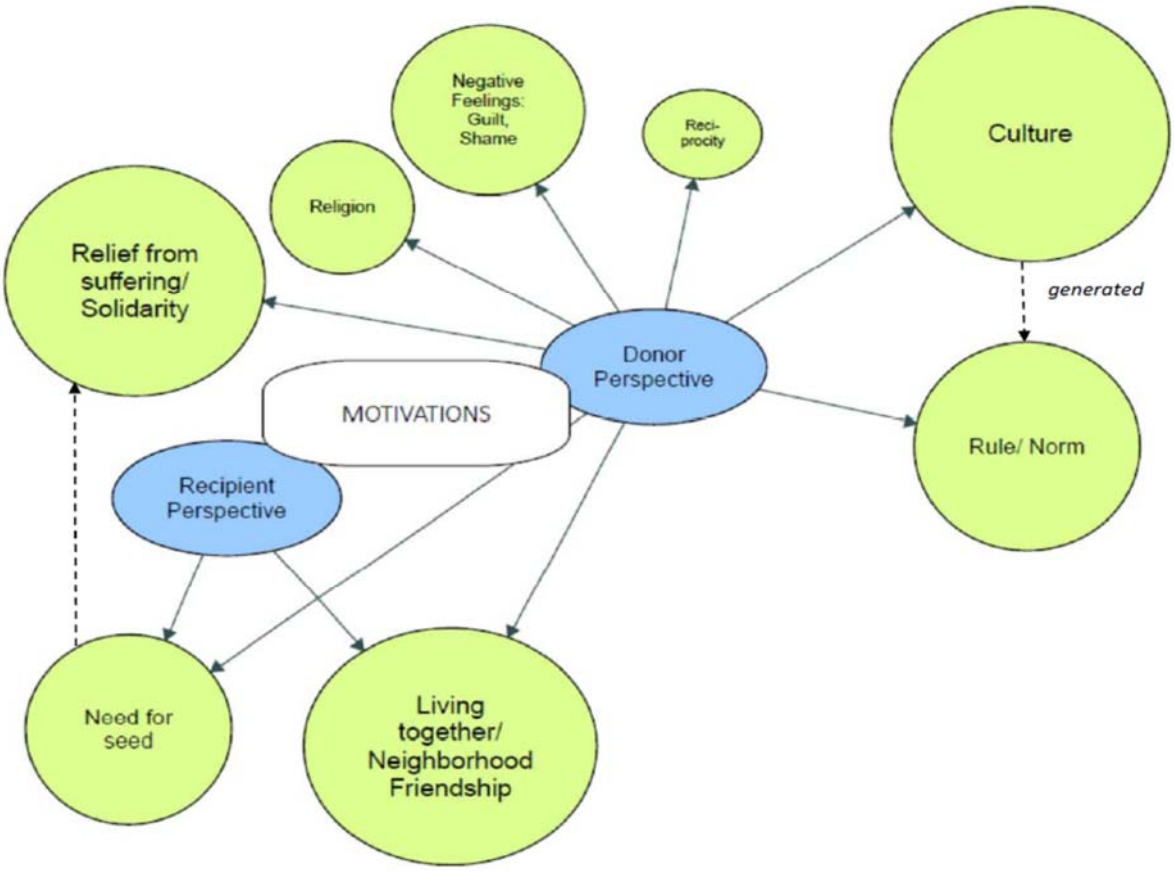
Thirdly, seed assistance is not conditioned on or, more precisely, it does not allow for any form of return. The idea of direct payment – be it cash, in-kind or in the form of assistance - is explicitly rejected. The following comment exemplifies this clearly "I will not ask for any kind of compensation. It is forbidden. It is shame" (ABI 2010).

These three normative claims of unconditionality illustrate that seed assistance is frequently portrayed and understood as the perfect altruistic gift: a normative ideal type.

Part of this exercise in understanding, is to investigate and evaluate to what extent these explicit normative claims are valid and whether other, more implicit norms exist.

2. Motivations

Any motivational account of norm-compliant behaviour will start with "imputation … based on the



actor's direct reports about objectives" (Kratochwil 1989, p. 25).

When asked about motivations to donate, a respondent notes "There is nobody who will think about not giving" (ABI 2010). Like him, many other respondents were puzzled by the question and simply stated that it was “normal” to assist each other. This illustrates aptly the degree of internalization of the norm of non-denial. The answers of those respondents, who reflected on their motivations to assist, are summarized in Figure 4.[114] These categories emerged from the answers and are obviously not entirely distinct, but overlapping and intertwined.

a. Culture and norms

As discussed above, formulations of the norm consistently refer to "culture" or "the Oromo" as the source for the norm and draw a link between bull sperm and plant seed.[115] Hence, it is not surprising that culture is most frequently referred to as a motivation for seed assistance. Culture is, in fact, a central concept in the narrative around seed assistance, a definition of culture derived from the respondents' answers is essential to this study given the elusiveness of the term. The understanding of word “ada”, i.e. culture as used in the context of seed assistance, can be summarized in five key statements, which are each supported with a representative quotation.

(1) Culture is passed on from the ancestors to the current and the future generations of Oromo.

> “It comes from the ancestors. And it is also the way I pass it on to my child: as a culture, we do not deny seed and bull sperm" (AKX 2013).

(2) Culture must be learnt and it is not intrinsic or universal.

> “[A]dvice will be given to the person. This advice will start from very early on, from the childhood. […] We have seen our fathers give” (ABMII 2010).

(3) Culture needs to be actively practiced and upheld, it is not static. Rather, it can deteriorate when current cultural practices are not continued. This is illustrated by a respondent’s opinion about a seed denier.

> “If you do the same thing, our culture will deteriorate. We should respect and maintain the culture. I would see him as someone who is not aware of our culture" (MES 2010).

(4) The culture of the Oromo manifests itself in mutual assistance.

> “In our tradition there is a mutual understanding of assistance” (AHU 2010).
>
> “Because it is our culture to assist” (HUM 2010).

[114]This figure is a simplified graphical representation of the main motivational categories which emerged from the qualitative analysis responses from donors and recipients of seed assistance. The size of the circles indicates the relative frequency of the respective response.

[115]The link between plant seed and bull sperm is discussed in more detail below.

(5) The culture consists of norms (such as non-denial), but also of a shared understanding of the world (such as conceptions of seed) that legitimise and rationalise these norms. To illustrate, a respondent's explanation on the importance of readily assisting with bull sperm is particularly useful: "If a cow needs a bull, you can see it. It shows! If this day passes, the cow will not conceive in her womb. That is why we have such culture" (AAF 2010). This quote shows that there is a clear understanding that culture does not exist for the culture's sake, but that the norms it entails, especially the norm of non-denial, serve a specific purpose.

b. Relief from suffering

Respondents express a strong belief in the goodness and a pride in their culture: "The culture of the Oromo people is beautiful. Your brother or sister they would never starve behind your back. That is why we assist each other: to avoid starvation" (ABA 2010). The intention to protect a community member from being hurt or wanting to see him produce and eat as well (which are both recurring formulations) are expressions of compassion, empathy and solidarity, which are dominant themes in explanations of the personal motivation to donate. In the donor narrative, feelings of guilt and shame are often linked to this interest in the well-being and protection of community members.

c. Community and social ties

Very consistently recipients mention two motivations for donors to assist them: firstly, their need of seed and secondly, their relationship as neighbours and friends as well as their "living together". These two categories could be interpreted as legitimate reason and relationship for a request (further discussed below). These motivations also feature prominently in the answers of seed donors.

The spatial, the social and emotional proximity explains the feeling of responsibility or as it was put by one respondent "Those people and I, we depend on each other, we love each other and we make sure that we develop and grow" (AKX 2013). The close social ties to neighbours are described in a powerful image: "There is a rope is tied between us and if you don't give, you are considered as the person who cuts through it. If you deny seed, you cut off the relationship you have with this person. The rope is a connection made by God" (ADM 2010).

d. Additional Motivating Factors: Religion, Fear of Retribution and Reciprocity

Comparatively few respondents stated religious motivations (e.g. the fear of having to justify denial before God). Only two donors mentioned that they would fear retribution by the children of the denied. Both are examples of a negative motivation, in the sense of fearing sanctions in the case of denial.

About one quarter of all donors states to be motivated by reciprocity, as the following statement illustrates: “Maybe another time, I will go to them when I need seed” (ABAI 2013). The expectation of delayed reciprocity and the appreciation of culture often go hand in hand. A substantial number of respondents, however, strongly rejects the idea of reciprocity as motivation and stresses the selfless nature of assistance, stressing, again, the normative claim of unconditionality and altruism of seed assistance.

3. Conditions for seed request and denial

Asked to name any particular circumstances that would allow denial, 58 percent of respondents reject the idea that there were any legitimate reasons to deny seed. Based on pilot interviews, a set of questions was developed to evaluate potential unspoken conditions for seed denial (see Table 26 in the appendix). Donors and recipients were presented with different scenarios and were asked to state whether they would give or request in the given case.

a. Conditions for denial

A small number of respondents continue to make strong statements of unconditionality in seed assistance when asked about particular circumstances which might justify denial. The majority of respondents, however, stated that they would deny seed in some of the scenarios while stressing that they were unlikely to occur.

Previous denial

The vast majority of respondents would still give to someone who has previously denied seed. Remarkably uniform was the reconciliatory response to a person who broke the bond of mutual solidarity. Many respondents comment that the denier should learn from their positive example or that they would not want to repeat the mistake made. A proverb was repeatedly quoted in this context “If a person has made you drink blood, you will give him milk to drink” (ABMII 2010, ADA 2013, ZAAII 2013, SFH 2013). One respondent elaborates on the rationale of a reconciliatory response to norm violation “If you do the same thing, our culture will deteriorate” (ABMII 2010). It illustrates, as discussed above, that behavioural norms must be actively upheld.

Quarrel

People who have previously been on bad terms or fought with the donors, are met with a similarly reconciliatory response. Over eighty percent of respondents would still give to someone they quarrelled with. A respondent explains “I will give to him because he has come to forget about it” (AMMI 2013). However, many respondents argue that they would not be approached by someone they are not on good terms with, emphasising the role of the relationship between donor and recipient which is further discussed below.

Careless treatment of seed/ Missing effort

In the case of a request from someone who is known not work hard or does not take proper care of the seed, an impulse to teach and cooperate is also often expressed. Roughly half of the respondents would give in this scenario. To ensure that the seed is used well, many are prepared to offer advice, teach the person or even work on their farm.

A number of respondents further qualify their cooperative statement by saying that they would only give once and observe how the seed is used (HAQ 2013, MAA 2013, KEG 2013, ZAAII 2013, GAI 2013, GET 2013). This suggests that missing effort is indeed a legitimate reason for denial. One respondent describes his rationale for giving as follows “If the situation is that the person works but does not grow well, I want to help him. You cannot know, so we do not deny to each other” (TEB 2013). What can be observed, is that a farmer “does not grow well” (this is a reoccurring description). It cannot be easily assessed if the cause is missing effort or a legitimate reason (e.g. sickness, infertile land or weather shocks).

A substantial number of respondents would deny seed in this case. Listing some observable indicators of missing effort, one respondent explains that he would reject the request of "people who sit and chew [chat], […] sleep all day and […] just sit home and do nothing" (AMAI 2010). Furthermore, respondents express concern that the seed would be eaten, rather than sown. Seed assistance is thus intended for emergencies (as opposed to regular seed supply). Moreover, the purpose of seed assistance is to “enable them to plant their plot […], to have their own seed and after that, their own grain” (MUS 2010). Food assistance, however, is regulated by other norms as discussed below.

Stranger

While a substantial share of respondents would give to a stranger - to someone from outside the community - some stress that they would try to gather information about that person before giving JAA 2013, SHS 2013, MAA 2013, TEB 2013).[116] This illustrates that some information is required to check the legitimacy of a request.

Money or assets to buy seed

[116]This scenario is one of the few questions where the answers from farmers in lowland communities interviewed in 2010 differed substantially from answers in highland communities in 2013. While the respondents generally insisted the unconditionality of seed assistance in the lowland communities, the majority of farmers would not give seed to a stranger. In the highland communities, were the cultural narrative around seed assistance was less pronounced, the majority of respondents would give seed to strangers.

If the person asking for seed is known to have enough money to go to the market to buy seed, donors' responses are ambiguous. While many agree that in cases where the requester has access to cash, he should buy the seed, the expectation to sell other assets to buy seed (esp. livestock as the main saving asset) is much lower. Some respondents argue, however, that the farmer might legitimately ask for a specific variety from a neighbour even if he has money (AKX2013, TEB 3013, ABAII 2013).

Donor does not have enough seed

There are two scenarios, in which the vast majority of donors would deny seed. Firstly, if the donor does not have enough seed to fully cover his or her own plot, a request can be denied. Respondents argue "if he has no seed, he has the right to deny" (AMAI 2013) and state that "the rule is broken when there is no seed" (AMAII 2013). These statements indicate that the lack of seed is the only explicit, legitimate reason for denial. Some farmers would still give a give a very small amount as a token (GAT 2013, ZAAII 2013, SAM 2013, AIH 2013, SJA 2013). Consistently farmers also argue that a seed request can only be made after the donor has finished sowing, in order to assess his own need and what is left to give away (HAQ 2013, ADM 2013, TAJ 2016, HIZ 2016).

Requester has seed at home

None of the respondents would give to a person who has seed at home, unless they are asking for a specific variety which they do not have. A number of respondents noted that the scenario was extremely unlikely: "He just would not ask. If you have very similar seed, you will not ask for seed from your neighbour" (ABT 2013). Recurring comments like: "He will not ask, so I will not give" (MUS 2010), imply that there are unspoken norms which ensure who will ask for seed and who will not. This conclusion is confirmed by the persistent differences between the answers of donors and recipients.

b. Conditions for a legitimate request

While donors would not deny seed in many of the scenarios presented to them, recipients clearly indicate that they would not ask for assistance in most of them. Recipients consistently answer that they would neither ask a stranger nor someone they are not on good terms with for seed. Furthermore, recipients would not ask their neighbours or relatives for seed if they had the money to buy it, unless they were looking for a specific variety or a quality which is not available from the local market.

On the one hand, this indicates the existence of additional unspoken norms defining conditions for seed assistance. On the other hand, it suggests that the responsibility to enforce implicit norms of a legitimate request is not primarily borne by the donor, who would deny in case of a violation,

but by the recipient, who makes no request if the conditions for a legitimate request are not fulfilled.

Responses suggest that a legitimate request has three dimensions: (1) a legitimate relationship, (2) (the acknowledgment) of the requester's need and (3) seed availability.

Legitimate relationship: neighbours and relatives

Some respondents indicate that to receive seed "there has to be a kind of relationship, a kind of reciprocity [Amharic: 'woleta'], it means that you help each other in the future" (YWA 2010). Others state that a donor will give to "someone who he has a 'give- and take- relationship' with" (AAF 2010).

Relatives and neighbours appear to fall into this category. As seen already in the analysis of motivations to give seed, neighbourhood is a central concept to define the relationship of seed donors and recipients. Respondents describe their relationship to neighbours as follows:

> "We are always working together and his house is close to mine" (GAI 2013)
> "These people are my neighbours. We know each other. I also help them with other things, not just seed" (ZAAII 2013)
> "If we are living together, we have to assist each other." (MSA 2010)

These statements point to three aspects of the relationship between seed donors and recipients: firstly, spatial proximity, secondly, the joint participation in social networks, thirdly and consequently, detailed information and knowledge about the farmer. Asking someone for seed who lives close by, means that the transaction costs for accessing seed are low as this respondent argues "I choose to go to my neighbour rather than from the market. Because it is closer" (TAJ 2013). Spatial proximity and especially the joint participation in labour sharing groups, called "guza", give the donor detailed information about the production and the effort of someone who requests seed. This is often described as "knowing his plot" (DEA 2010, AMM 2010).

Assessing the recipient's need

A request also requires a legitimate cause, thus an acknowledgement of the recipient's need. The spatial proximity that is constitutive to the relationship between neighbours, plays an important role in demonstrating the recipient's need, as this statement illustrates: "I have seed and they don't. I can see their plot is not covered" (AHY 2010). In stressing repeatedly the importance of "seeing the plot", respondents point to visibility as a crucial factor in establishing the legitimate cause. Some donors even gave seed to neighbours without a prior request, because they 'saw' their need (ABI 2010, ABMI 2010, AMAI 2010, AMW 2010, MAW 2010, MOAII 2013, ZAAII 2013)

Seed availability

A seed donation is subject to availability as this farmer explains: “If the request is for more than what I need for sowing my own land, I will not give it. I give priority to my own land” (JMA 2010). The following extract from a focus group discussion illustrates that a personal relationship is not only crucial for feeling entitled to ask for seed, but also for accessing information about seed availability:

> “Interviewer: And people in your community, do you think they know that you are a good farmer and most of the year, you are in a position to give seed?
>
> Interpreter: What he said is: people who are receiving seed from me they may know but the other people may not know.” (Salale Donors 16/09/2010)

Furthermore, several recipients describe that they consult other community members to ensure that seed is available and that the respective farmer has already sown, before approaching a donor directly (ABJ 2010, GIG 2013, SAM 2013)). This illustrates that the responsibility to obtain information about available seed also lies primarily with the recipient.

4. Reciprocity and compensation for assistance

In the previous section, we have seen that what is described by some as ‘give-and take-relationship’ matters for a legitimate request. A more detailed analysis of return for assistance sheds light on the nature of these personal relationships and the role of compensation.

a. Donors: Direct reciprocity

A small number of donors expresses the expectation of delayed reciprocity in the form of future seed assistance from the recipient (USH 2010, ABAI 2013, AKX 2013, ESK 2013, GAI 2013, INL 2013, SHS 2013, YIG 2013).

Most donors, however, explicitly reject the suggestion that other forms of assistance (such as labour or oxen services) are offered in return for a seed donation. One respondent explains why assistance among donors and recipients is not seen as compensation "For the sake of brotherhood, for the sake of God, but not for the sake of return, he asks me for assistance" (HAH 2010). Similarly, this respondent states that “[w]e do not offer this [labour assistance] for seed. But I will give my hand to him whenever he needs help in guza” (GAT 2013). Elaborations concerning food and labour assistance suggest that these forms of assistance have their own, distinct set of rules.

b. Recipients: Future assistance “Not for the sake of the seed”

This theme also runs through recipients’ answers. Recipients either state to have offered nothing in return for the seed or that they assisted the donor in some way, but not "for the sake of the

seed" (ABMII 2010, ABS 2010, ADJ 2010, AMAII 2010, MEAV 2010, MUM 2010, ABAI 2013, AMAI 2013). This recurring expression illustrates how clearly the idea of payment is rejected in the case of seed assistance. A respondent puts it as follows: "He can ask me for guza, but not as a return for the seed, but just because of the relationship we have. Otherwise it will appear like a sort of repayment" (AMM 2010). The following answer gives some insight about what motivates this rejection: "So, if we reveal that there was a payment, it would deteriorate our culture" (AMEI 2010). A contemporaneous payment would end what is seen as an intertemporal cycle of seed assistance and thus end the donor's entitlement to future assistance. This interpretation is supported by this elaboration: "If I ask for money and in the future I will ask for seed, they may not give me" (ABI 2010).

c. Perceptions of exposure to & capacity to cope with risk

Securing their entitlement to future assistance by not asking for return is motivated by the understanding that they "might be in a similar situation one day" (INL 2013), i.e. that they are also vulnerable to being seed insecure. Moreover, the importance of seed to the agricultural livelihood is emphasised by seed donors and recipients alike and aptly illustrated by this statement "In the case of the seed, if you do not have it his year, you will not live next year" (ABAII 2013).

More ambiguous are statements concerning farmers' capacity to cope with seed insecurity. A number of farmers expresses egalitarian perceptions: "Nowadays, people are all equal" (DEA 2010) or "He is like me. I am like him" (INL 2013). Other respondents make it clear that some farmers are better off, often called "stronger", and thus in a better position to give seed and less like to need seed, as this quote illustrates:

> "A person who gives seed, is a better person. A person who does a better job in farming. He can save seed and give it to the other people." (AMW 2010)

A shared premise seems to be, however, that assistance roles are fluid. This is also expressed in the partly vehement rejection of the idea that there are consistent seed donors in the community: "No, we don't like such things. He just gave me what he has. It is not a particularly well known guy, not someone who gives to many people" (UJW 2010).

The rationale of seed assistance is, thus, based on a shared understanding of the consequences of, the exposure to and - to a lesser degree - the capacity to cope with seed insecurity.

d. Asymmetric relationships & the break-down of seed assistance

That these shared perceptions matter fundamentally for seed assistance, is illustrated by the case of the two communities with a wealthy local benefactor, Aliyi. As discussed above, the only

reported cases of seed denial come from the two neighbouring village communities of Dhumuga and Tagel. Farmers in other communities argue that because everyone is in the same situation, there is a need to assist each other. Farmers in Dhumuga and Tagel argue differently, as the following statements illustrate:

> "The people are different. Some may be thinking for you and others may not. They might not be on good terms with you and might, thus, not give to you. The second reason is that they do not have enough seed, not as much as Aliyi" (AMMI 2013).

> "Most of us are not well enough to give each other [seed], even as a loan. Only people who have more land or grow more give loans to each other" (AMA II 2013).

> "The community is not in the position to give seed as a gift. Only Aliyi is strong enough. He is in a good position. We can ask him. […] The community has nothing. Only Aliyi has more. We do not even have to ability to cover our own plot, so how will you give? It is difficult. This is why you can go to Aliyi or to the market." (TAJ 2013).

Factually, farmers in these two villages are not poorer than the average farmer in the sample. However, they consistently argue that they are not well enough to give. This is also explicitly linked to the comparison with Aliyi, who is significantly wealthier. Moreover, farmers argue that changes in the way seed is shared among neighbours are recent, e.g. the fact that the rule not to deny seed or bull sperm is no longer applied. While the vast majority of farmers in the sample agrees that seed is not sold among neighbours, this respondent argues differently "In the past, we did not sell each other, but we started to do this" (MUS 2013). When asked why Aliyi does not sell or exchange the seed he shares, she replies "He is a rich man. He helps the community. […] I don't know why the other people are like stone. The people who are in a little bit better situation, do not help out those who are worse off, who are in need of seed anymore." (MUS 2013).

These statements indicate that seed assistance among neighbours and relatives is no longer actively practiced. The rationale of mutual assistance appears to be challenged by the presence of a significantly wealthier farmer who acts as a seed donor for the community.

5. Sanctions

a. Sanctions as hypothetical construct

Similar to the conditions for denial, sanctions are of a more hypothetical nature. One reason is that cases of denial are exceptional and the norm is highly internalized, which means that sanctions cannot be easily observed. One respondent explains "[E]veryone is governed by that rule. Everybody who has seed will give it. There is no need to pressure" (MUS 2010).

Furthermore, about one third of all respondents would argue that there are no consequences for someone who denied seed. However, even if no explicit consequences were mentioned by many respondents, they would describe strong feelings of shame and guilt as a reaction to denial or negative feelings, such as hate, towards the denier. One respondent describes how he felt if he denied: "I am feeling very guilty, if I have seed and don't give it "(JAU 2010).

b. Elders as mediating and sanctioning entity

Specifically in the lowland communities, farmers expected the elders to get involved in the case of seed denial. The elders are presented as the key mediating and sanctioning entity for conflicts related to norm violation, which are not subject to any legal punishment. More important than the actual punishment, is the consultation or the trial before the elders where all parties get the opportunity to explain themselves.

c. Marriage denial as sanction

Another form of sanction, which has been raised surprisingly coherently by many respondents in highland and lowland communities - and which is also mediated and enforced by the elders- is the sanction of 'marriage denial'. After seed (or bull sperm) was denied, the person who denied seed cannot marry into the family of the person he denied seed to.[117] The following quote gives insights into the rationale of this sanction:

> "In the case of the seed and bull sperm, he is considered as someone who does not want a child to grow and to develop. Without the bull sperm, a child cannot grow, the cow will give no milk. This is also the case in the marriage: you get married and then you have a child. Concerning the marriage, the person who has denied will talk to the elders, be punished and only then can he get married to the daughter of the one he denied to." (AIH 2013)

Despite the consistent description of the marriage sanction, there are no accounts of it being executed. Several of the elders confirmed that they had never heard such a case. This suggests that marriage denial as response to seed denial is part of the narrative, rather than a de facto sanction, which is passed on in the community. The link between marriage and crop seed is a recurring topic in the analysis of the seed assistance (see below).

d. Hate as sanction

A dominant theme in farmers' answers concerning the consequences of denial are negative emotions towards the denier by the community. Consistently, respondents said that someone who

[117]This sanction was mentioned by 14 respondents: ABMII 2010, AHU 2010, IBA 2010, MES 2010, MEAIV 2010, MUS 2010, YAM 2010, ADA 2013, AIH 2013, JIY 2013, MAK 2013, SJA 2013, TEB 2013, ZAAII 2013.

denied seed or bull sperm would be "hated by the community" (MEAII 2010, MES 2010, MUS 2010, YAM 2010, ADA 2013, AMMII 2013, HUA 2013, MAA 2013, SHB 2013, ZAAI 2013). Other respondents describe a person who denied as "cruel" or "bad". Moreover, respondents explain that a denier is "not considered a human being" (JAU 2010, USH 2010, AKX 2013, JAA 2013, SHB 2013).

These statements suggest that seed denial may lead to ostracism in the community, which constitutes a serious mechanism to sanction rule violation in communities with strong social networks. However, negative feelings do not lead to social exclusion. Two thirds of all respondents argue that he will still be able to receive assistance despite the community's negative attitude towards him. Explanations for continued assistance refer to the fact that other forms of informal assistance (especially labour and oxen) are regulated in their own way. Moreover, only the person who was denied has the right to directly retaliate, as this statements illustrates: "He did not deny the community, but he denied one person. So, they will continue to assist him" (JAA 2013). Ostracism and continued cooperation thus appear to coexist. Both can be understood as ways to uphold the norm and ultimately the local culture.

6. Symbolic understandings of seed and reproduction

In order to understand why such strong feelings of hate and shame are provoked by denial and how marriage is linked to seed, we examine the symbolic dimension of seed more closely.

a. Linking livestock, crop & human reproduction

The norm of non-denial refers equally to bull sperm (*korma*) as to crop seed (*shainyi*). This respondent explains how these seed and sperm are linked "In the case of the bull sperm. If it is denied, the multiplication is stopped. The same with the seed, the seed is multiplied. This is why we do not deny these things. It is about growth" (ZAAII 2013). This quote shows that importance of animal and plant genetic resources for reproduction and for the agro-pastoral livelihood is well understood. Livestock and crop production are the means of human survival as this respondent elaborates: "Without these two things, it is impossible to think about the next generation, to produce the next generation" (JAM 2010).

Not only the multiplication of livestock and crops are closely linked, but the concept of seed also extends to human reproduction. Repeatedly respondents point out that "[t]here is no way to deny seed, only 'human seed' can be denied" (JMA 2010). This means that a married husband or wife must never be 'given' upon request. Human reproduction is regulated in the institution of marriage. The elaborate narrative around the marriage sanction suggests clearly that the concept of seed links human, animal and plant reproduction in the understanding of the Oromo. One

respondent explains this as follows “A person will not give birth unless he is married. The same is true for the seed. A person can only grow with seed” (UMB 2010). Thus, seed is understood as the basis for growth, reproduction and the continuation of life. Denying seed is therefore often described as “cutting off life” (ADM 2010, AMM2010, AIH 2013, SHS2013). This explains why access to seed is regulated by an elaborate set of norms.

b. Denial as murder

In the understanding of the Oromo, denying seed means denying reproduction and life more generally. Many respondents literally equate seed denial with murder as this statement illustrates “When I know you have seed home and you don't give it to me, it will be considered as killing me” (JMA 2010). The severity of the offence that follows from this understanding should not be underestimated. It also helps to understand the degree of hostility and the strong negative emotions which seed denial invokes.

7. Summary: Evaluating the validity of the three claims of unconditionality

After this comprehensive analysis of seed assistance, we come back to the question of universality. While non-denial is expressed as a norm that is unconditional, we explore whether the three normative claims of unconditionality hold in the light of the findings presented here.

a. Non-denial

The normative claim of non-denial generally holds with the exceptions of very few reported cases of seed denial from two communities, where seed assistance is challenged by the presence of a wealthy local benefactor.

The analysis shows, however, that there is room for denial even in communities where the practice of seed assistance is intact. Particularly when the donor does not have sufficient seed, denial is legitimate. Moreover, when the recipients have sufficient seed of a similar variety or enough money to buy seed or if a recipient knowingly lacks effort in handling the seed, a large share of donors would deny a request for seed. The reason that these conditions are not practically applied, lies in the fact that the responsibility to enforce the implicit unspoken norms about what constitutes a legitimate request - which include all conditions for a legitimate denial - is borne by the recipient.

b. Universal Access

Findings suggest that seed is usually given among neighbours, relatives, members of the same mutual assistance networks and village. Cases of seed assistance to farmers outside these social spheres are exceptional. Moreover, a substantial share of farmers is not willing to assist someone with seed who they do not know.

We find that access is not only a question of donors denying seed under certain conditions, but of a sense of entitlement to assistance by recipients, which is linked to the relationship with a potential donor. The fact that seed assistance is usually given in what is described as “give-and-take relationships”, challenges the idea that entitlement to seed assistance is indeed universal.

c. Non-Compensation

In the sense of monetary or direct in-kind return, we cannot observe compensation for a seed donation. Nevertheless, there are a number of reports of recipients assisting donors through labour or oxen services. These forms of assistance are, however usually given in the context of other mutual-help arrangements. Therefore, as recipients and donors equally emphasise, this assistance is not given “for the sake of the seed”.

In conclusion, all three normative claims of non-denial must be qualified. While non-compliant behaviour can only rarely be observed, the normative claim of unconditionality of seed assistance is not necessarily valid, as the norm of non-denial suggests. Rather, it indicates the existence of unspoken norms or tacit understandings, which alongside the explicit, ideal-type norm of non-denial, constitute seed assistance as social institution, which will be analysed in more detailed in the next section.

DISCUSSION: The Institutional Design of Informal Seed Assistance

This section aims to integrate the three previous sections by analysing seed assistance as a social institution or more explicitly as a contingent institutional equilibrium solution of a repeated game, which is stable and self-perpetuating.

It will answer the central research question by explaining the sustainability of mutual assistance through seed gifts in reference to the broad body of literature on mutual insurance and risk-sharing.

The section begins by (1) critically discussing insurance as the core principle of the institution and (2) analysing central norms and institutional roles. It then moves on to a detailed analysis of particular institutional characteristics, such as (3) the social network underlying the institution, (4) the gift as mode of transaction and (5) the role of seed as object of mutual assistance. Finally, (6) incentive problems and (7) the enforcement mechanism will be discussed in detail.

1. Insurance as core principle

Underlying the practice of seed assistance through gifts is the principle of collective insurance against risk which - as has been argued extensively - is a fundamental mechanism in the subsistence-oriented, pre-capitalist, rural economy (Posner 1980, Platteau 1991, Alderman, Paxston 1992, Fafchamps 1992b). By giving a seed gift, a farmer secures or reproduces her future entitlement to receive seed - as an important productive asset - from the community. Compared to more comprehensively discussed mutual aid arrangements for consumption smoothing or asset sharing, informal insurance through seed assistance has a number of noteworthy features.

a. Group insurance vs. insurance in social networks

Seed assistance is a collective form of assistance, but cannot be described as a group insurance with (relatively) clearly defined membership, in which an insurance premium is paid by every member and resources are pooled, as practiced in the funeral associations, *idir,* or savings groups, in Ethiopia often called *iqub* or *equb* (Platteau 1991, Aspen 1993, Dercon, De Weerdt et al. 2006). On the other hand, seed assistance - although given between individual households - is a collective form of insurance, as seed is usually not only given and received over time in these dyadic relationships, but in a network of linked households (Bloch, Genicot et al. 2007). The networks links underlying seed assistance will be analysed in more detail below.

b. Ex ante production insurance & securing access to genetic resources

Seed insurance represents an ex ante form of collective production insurance, rather than an ex post redistributive mechanism to smooth consumption (Platteau 1991, Fafchamps 1992b). It is

thereby closely linked to individual risk spreading behaviour. Portfolio diversification - i.e. strategically diversifying sources of household income, crops and crop varieties as well as plot locations - is a potentially important strategy to manage risk or smooth income at the household level (Morduch 1995, Fafchamps 2003). Sustainable access to diverse crop genetic resource is requirement for diversifying the household's crop and varietal portfolio.

One of the particularities of seed assistance is its dual purpose as a form of hunger insurance with fewer incentives for moral hazard than ex post assistance as well as an institution to maintain genetic resources and supply seeds in the absence of functional seed markets. One contribution of this study is to recognise the role of this dual purpose of seed assistance for its institutional design as the two functions of informal seed assistance have been discussed in different bodies of literature.

c. Reciprocity in seed assistance

Reciprocity or the obligation to reciprocate has been identified as the fundamental principle in the evolution of human cooperation - formalised in the tit for tat strategy - as well as in explaining gift-giving across cultural contexts (Marcel 1954[1924], Gouldner 1960, Axelrod 1984, Nowak 2006). Based on empirical evidence, Platteau (1997) argues that balanced reciprocity captures more accurately the principle what is often described as informal insurance arrangements. Platteau argues that actors expect a tangible quid-pro-quo for their contribution and that the return for cooperation while delayed, cannot be uncertain.

If seed assistance were studied in isolation, with no reference to other mutual aid institutions in which donors and recipients cooperate, it is not self-evidently governed by a principle of balanced reciprocity. There is no indication that farmers who are giving seed much more frequently or even exclusively will eventually try to opt out of seed assistance. Moreover, in contrast to many other empirically studied institutions, the mode of transaction is a gift rather than a loan or what is often called a quasi-credit, which explicitly involve a return (Platteau 1985, Udry 1994).

Finally, the nature of the risk that is being insured in seed assistance is not favourable for the emergence of highly reciprocal arrangements. The realisations of the risky event - seed insecurity - are less frequent than in comparable arrangements

Evidence suggests that many donors seem to know and accept that they are more likely to contribute to than to benefit from seed assistance. Nevertheless, seed assistance is clearly a form of delayed reciprocity and the evidence presented here only gives insights into seed transactions over a limited period of time. We can therefore not conclusively argue that seed assistance is not balanced over a long period of time.

Furthermore, it must be stressed that seed assistance is embedded in other mutual aid arrangements, which more clearly follow a rationale of balanced reciprocity. In this sense, the multiple informal institutions seed assistance is embedded in could be more described as what Platteau described as one example of informal insurance that follows the principle of balanced reciprocity: "multi-purpose risk-sharing arrangements" (1997, 781-782). This becomes particularly clear as we recall the way in which respondents describe the relationships, in which seed is given and received as "give-and take relationships".

Furthermore, the premium paid in seed assistance, i.e. the cost of cooperation, is lower than in many other risk-sharing arrangements. As an ex ante production insurance, the relationship between seed and food assistance must be further explored.

2. Norms and roles

After having discussed insurance as a core principle of the informal institution, we know move to an analysis of norms and institutional roles.

a. The moral norm of non-denial

The only explicitly and overwhelmingly consistently formulated norm in seed assistance is the norm non-denial of both plant and animal genetic resources. It is formulated as a simple and unambiguous "moral norm", a standard of behaviour for donors, prompting *unconditional* cooperation (Elster 2007, p.104).

The central norm of seed assistance is, notably, not a norm of reciprocity. While Scott defines reciprocal norms as moral norms, Elster classifies it as a "quasi-moral norm" as reciprocity strictly implies conditionality as opposed to the norm of non-denial (Scott 1976, Elster 2007).

b. Institutional roles for donors and recipients

The empirical analysis has shown very clearly that – although the norm of non-denial is adhered to in the vast majority of cases – the practice of seed assistance is not as unconditional as the norm of non-denial suggests.

The different institutional roles for donors and recipients can explain how conditions are established despite the pervasiveness of the moral norm. Institutional roles involve different decision scenarios and different norms guiding decision-making in seed assistance.[118] The

[118] Using the concept of roles in the context of institutional analysis, requires a brief note on the understanding of the term. In constructivist institutionalism, which juxtaposes the logic of appropriateness with the logical of consequentialism, the term "role" is often used in closely linked to the term identity as "providing rules of appropriate behaviour" (March, Olsen 2011, p.479). Although many of the conceptual tools developed in this literature, including the concept of institutional roles, are useful and have guided this

conceptualisation of informal insurance as an iterated cooperation game draws attention to the donors' decision scenario. While recipients assume the role of donors in the future, their contemporaneous decision scenario is not concerned with cooperation, but with the decision to request. The empirical analysis suggests that a set of implicit social norms define a legitimate cause and a legitimate relationship for a seed request. While many donors state that they would give seed in wide range of scenarios (and deny in some), a large share of recipients states that they would not ask for seed in any of the respective scenarios.

Especially the rules concerning the relationship, in which seed can be legitimately requested, suggest that the recipients' social norms institutionalise reciprocity, while the donors' moral norm dismisses it. This takes us to a closer analysis of the social network in which seed assistance is provided.

3. Social network and inclusiveness

From the empirical analysis, we know that seed transactions between households from different sub-villages (*gandas*) - with a typical population size of one to three hundred households - which are neither connected through family nor through participation in a labour sharing group, are exceptional and rare. Nonetheless, seed transactions beyond the reach of the local community occasionally occur and are encouraged by the norm of non-denial, which refers to all Oromo. This can be interpreted as a provision for an extreme realisation of aggregate risk. If the community is severely hit by a shock, individual households can seek seed sourcing opportunities or specific genetic resources in other, less affected villages. In our sample, two cases of donations to (neighbours) of distant relatives, which were looking for a specific variety of sorghum which performs well in the local environment, were reported.

a. Networks links: relationships of generalized reciprocity

The considerable overlap of membership or participation in mutual-aid institutions and seed assistance indicates, however, that seed assistance is generally embedded in arrangements, which are clearly driven by the rationale of reciprocity. Interestingly, two highly relevant informal social institutions are also input-sharing arrangements, namely for labour and for oxen. As discussed in more detail above, *guza* is a labour sharing group arrangement, oxen sharing usually happens in stable dyadic relationships (i.e. involving two households).

The literature offers a number of useful concepts to capture this overlap of different informal forms of risk-sharing. To describe patterns of multiple forms of risk-sharing being combined, Platteau has

analysis, the premise that a logic of appropriateness is incompatible or a substitute for utility maximizing behaviour is not shared.

introduced the term "multi-purpose insurance networks" (1997. pp.781-782). If a household calculates its net benefit from seed assistance simultaneously with other forms of risk pooling, the overall benefit from participation can be positive, even if the household's contributions in seed assistance are not balanced.

Sahlins describes the assistance exchanged in a network or group of spatially and socially close households as "generalised reciprocity" (2004 [1974]). Gift-giving is frequently observed in relationships characterised by generalised reciprocity, but it is not free from the obligation to reciprocate. Rather, the expectation is indefinite to an extent that even a "one-way flow" can be sustained over long periods of time (Sahlins 2004 [1974], p.179). Sahlins emphasises the close social sphere, in which this form of reciprocity is practiced. In farmers' accounts of their motivation to give seed, they often stressed the close relationships they had to their neighbours, also frequently called "friends" or "brothers".[119]

Network analysis applied to risk-sharing arrangements has not only revealed that insurance is rarely given in pairs or groups with a well-defined, fixed membership, but also that the structure of networks is complex (De Weerdt 2004, Bloch, Genicot et al. 2007, Fafchamps, Gubert 2007a, De Weerdt, Fafchamps 2011). While we do not attempt to conduct a network analysis in this study, it strengthens the intuition that assistance is given in dyadic, partially highly personalized relationships of individual households in a "thickly connected" network, in which high degree of information is available and communicated (Bloch, Genicot et al. 2007).

b. Inclusiveness

If seed insurance is not given within a well-defined group, but in a network of linked households, evokes the question of exclusion. McGuire (2008) suggests that the institution of seed assistance is much less inclusive than this case study finds it to be. He argues that it excludes the marginalized members of the community.

Analysing the few cases (N=10), in which a respondent neither received not gave seed (hereafter called NDRs) provides only very limit evidence on possible patterns of exclusion. Two of the NDRs are Amhara, thus from an ethnic minority in the lowland community and three other NDRs are engaged in off-farm activities. In the highland site, where one third of the sample are ethnic Amhara and Orthodox-Christian, we do not find evidence of exclusion based on ethnic or religious

[119]Hirsch elaborated how friendship creates conditions of generalized reciprocity similar to those in the close kinship relationships: "Friendship contains an element of direct mutual exchange and to this extend is akin to a private good. But it is often much more than that. Over time, the friendship 'transaction' can be presumed, by its permanence, to be a net benefit to both sides. At any moment of time, though, the exchange is very unlikely to be reciprocally balanced" (Hirsch 1976, p.78).

identity, but active participation in seed assistance. Based on recipients' names, which indicate their ethnic and religious identity, we estimate that donors who are Amhara in the highlands have given eighty percent of seed donations to other Amhara and twenty percent to Oromo. Furthermore, Amhara farmers report significantly more seed donations per household than Oromo. This resonates with the broader literature on the (identity) characteristics, based on which network links are established (Fafchamps, Gubert 2007a).

Ethnic identity and off-farm employment are two of the categories that McGuire identifies as common exclusion criteria (McGuire 2008). Fafchamps offers an interesting insight on potential incentive problems arising from cooperation with actors engaged off-farm activities, when he argues that "those who do not grow food crops would be threatened with exclusion because they have signalled their intention to free-ride the system" (1992b, p.153).

c. Self-exclusion

Despite these insights, which could possibly identify patterns of exclusion, most respondents who were neither donors nor recipients of seed consistently argue that they had full access to seed assistance if needed. According to their account they were neither in need of assistance nor ever in the position to give. This gives us some indication that exclusion should not be conceptualized and analysed as a question of denial of a request, but rather as a question of access, i.e. the subjective assessment of being entitled to request. Thus, exclusion could very plausibly take the form of self-exclusion, if the legitimacy of the request, i.e. the legitimate relationship or cause, cannot be established according to the social norms regulating seed requests.

Given that self-exclusion is very plausibly based on a subjective assessment of entitlement to assistance based particularly on a legitimate relationship in which seed can be requested, clear evidence on self-exclusion is very difficult to obtain. As discussed above, there are three cases which might indicate (self-)exclusion from seed assistance: two elderly brothers from the Amhara minority in the lowland community and a woman with a husband who works as a wage labourer in the highland community. None of these respondents report explicitly to have been denied seed or to feel excluded from seed assistance. They are, however, reluctant to answer questions about their social ties in the community, which might be an indicator of missing relationships in which seed assistance can be requested.

4. Mode of transaction: gift

Gift-giving features prominently in the anthropological accounts of social organisation in subsistence-oriented agrarian societies (Marcel 1954[1924], Scott 1976, Sahlins 2004 [1974]). In

the specific case studies of development economists interested in the same phenomena, however, the gift as the mode of transaction in risk-sharing institutions is remarkably absent.

The fact that seeds are given as gift (which is portrayed also portrayed as a 'pure gift') is therefore one of the most intriguing institutional features of informal seed insurance.[120] While there a small number of direct exchanges of seed, we generally observe no form of compensation for a seed donation.

In the following, we consider two plausible explanations for the emergence and sustainability of assistance through gifts. Both arguments are, to some degree, related to affordability or the comparatively low cost of seed assistance, i.e. the relatively low share of total output given in a transaction (estimated at 2-3 percent on average).

a. Indirect reciprocity and the reputation mechanism

One of most fitting description of the form of cooperation observed in seed assistance was described by Nowak (2006) in the concept of "indirect reciprocity", which is motivated by a reputational mechanism. In a game-theoretic framework, it is shown how repeated donations can be sustained even in relationships between donors and recipients who do not maintain a reciprocal relationship. The donor's reward is to establish a good reputation as a helper, which is observed by a sub-set of the population.

As has been argued, seed donors proudly share reports of their seed donations, while receipts tend to be underreported. This provides some intuition for the role of reputation in seed assistance. The setting, in which such forms of cooperation typically emerge is characterised, firstly, by a network in which someone's reputation can be known. Secondly, the cost-to-benefit ratio of the altruistic act is low. A small seed gift can arguably be a comparatively affordable way to improve the household's reputation.

b. Ex ante solidarity: seed vs. food assistance

The empirical evidence clearly suggests that seed assistance is seen as a form of insurance against hunger as this statement illustrates: "If a person cannot sow the next year, he cannot eat. He

[120]In the normative ideal of seed assistance, in its unconditionality (particularly the vehement rejection of compensation) seed is presented as a 'pure gift'. The idea of the 'pure gift' is as intriguing as it is misleading, implying to be free from the obligation to reciprocate and thus entirely altruistically motivated. Malinowski, from whom the expression 'the pure gift' originates, was fascinated by it in his early scholarly years. However, he rejected the idea of a disinterested, voluntary entirely in his later writings. "He eventually settled for a notion of reciprocity, in the sense of 'give and take', which he believed to underlie all human life" (Hann 2006, p.211).

suffers hunger. (…) I do not want to see them starve." (SAM 2013). This, as many other statements, has striking resemblance to Scott's formulation of the right to subsistence (1976).

Fafchamps (1999) formalises this right to subsistence in the value function of actors by introducing a lower bound to zero income of each member of the insurance group. He argues that if any community member goes below this subsistence line it generates disutility for all community members (in the form of feelings of guilt and shame).

In the 2013 round, data was collected to compare food and seed assistance as ex ante and ex post forms of a hunger insurance. While seed assistance is given as gifts, food assistance is given as a loan without interest. Asked why seed and food are shared in different ways, respondents answered uniformly that it was a question of quantity and affordability. Due to the small amount of seed given in a donation, households can afford to give it as a gift, whereas the household cannot afford to freely give food assistance even with a possibility of reciprocation as a gift in the future. Food donations often comprise of one or two quintiles of grain. A loan given without interest is also a much more commonly observed mode of transaction in informal risk sharing.

Furthermore, a contribution to hunger insurance in the form of seed, is a form of investment in the self-sufficiency of the recipient, reducing the probability that the recipient will claim food assistance later on. This respondent explains the rationale of ex ante solidarity: "You multiply the seed today rather than asking for food tomorrow" (HUA 2010). Finally, as Fafchamps (1992b) argues, an ex-ante insurance involves fewer incentives for moral hazard as the actors can capture the marginal product of their effort.

Based on these arguments, we conclude that donors, though committed to providing hunger insurance, prefer to give seed assistance over food assistance as it incurs lower costs and fewer incentive problems. Therefore, the gift as a mode of transaction in seed assistance can be interpreted as a way to incentivize claiming ex ante rather than ex post insurance at the cost of not receiving a return for the seed given.

5. Object of assistance: seed

While informal insurance has been extensively studied in its diversity of institutional forms, institutions evolving around seed as an object of informal risk-sharing have rarely been explicitly studied (Coomes, Mcguire et al. 2015, Ricciardi 2015). We will therefore analyse what role seed as the object of insurance plays in explaining specific features of the institutional design of seed assistance.

a. Conceptions of seed as linked spheres of reproduction & non-denial

In order to understand why the norm of non-denial seems to be an incontestable obligation for most donors, we analyse the rationalisation of the norm more closely. Finnemore and Sikkink argue that "norms prompt justifications for action and leave an extensive trail of communication" (1998, p.908). Reconstructing the rationalisation of a norm, means tracing back the trail of communication, as it was done in some detail in the previous section.

The norm of non-denial is firmly rooted in the symbolical understanding of seed, through which spheres of human, animal and plant reproduction are intimately linked, so intimately linked that seed denial is equated murder. This gives a clearer understanding why seed denial is seen as such a severe offence and non-compliance trigger such strong emotions of guilt and shame.

Though there is only very limited historiographical evidence on the Oromo, it is a well-established fact that the Oromo were exclusively pastoralists until roughly one and a half centuries ago, when they moved into the lowlands to start cultivating sorghum (Hassen 1990). This historical development of the livelihood activities of the Oromo could be one of the reasons why "korma" and "shainyi", bull sperm and plant seed, are so intimately linked, building the basis for a conception of seeds that spans across human, animal and plant reproduction. Respondents often use the phrase "seed is a bull". The pastoralist livelihoods in the past can also explain why the norm of non-denial refers to bull sperm instead of all animal genetic resources. Due to the limited evidence this must, however, remain only a hypothesis at this point, rather than a well substantiated argument.

b. Genetic resources as public good

Plant and animal genetic resources are in fact the basis of reproduction and adaptation to changing conditions and they are an (impure) public good (Smale 2006b). On the international level, the conservation of many crop genetic resources is therefore organised in the public domain (Evenson, Gollin et al. 1998).

Donors and recipients alike indicate an understanding of genetic resources as a public good and the right to free access to these resources as illustrated by the following statements:

> "For example, if you look at the seed, one day the crop fails, you will lose that seed. That is why you give, you transfer the seed to someone else, so he will have it as well and he can continue to grow it. And you can ask him when you face a similar situation, when your crop fails." (ESK 2013)

> Seed is shared to "To progress, to multiply the seed. To make sure that seed will not disappear." (TEB 2013)

Seed donations made as gifts are smaller than the amounts bought on the market. Some respondents also argue that seed sales among neighbours are hypothetically possible if the amount is large. Only a small amount is seed is required to pass on a variety. The multiplication of the seed can take place on the recipient's farm, stressing the emphasis on passing on the variety rather than the correct amount. Seed assistance can thus be understood as a way of collectively conserving (in-situ) plant genetic resources (by spreading them widely to many households) and of guaranteeing public access to their use.

c. Community provision as response to market failure

The community is known to be a more frequently used (and preferred) off-farm seed source in the region compared to the market or the government extension service (McGuire 2000, Mekbib 2006, McGuire 2008). Informal seed insurance as a seed sourcing strategy must be understood also a response to failure in the formal seed market. Given the nature of the good, information asymmetries are prevalent. The seed buyer has very limited means to verify the quality of seed, i.e. to obtain correct information concerning the specific variety offered and the germination rate. Especially in the case of sorghum in the lowland community, the adaptation of the variety to local agro-ecology is a central determinant of output. While the merchant usually knows where the seeds he sells come from, the in the lowland buyer cannot distinguish by appearance whether he is buying a lowland or an unsuitable highland variety. Thus, unless there the buyer can trust the merchant, he will most likely to avoid the risks connected to buying on the market.

Equally, if seed comes from a community member, the recipient has no way of verifying the quality of the donation. The recipient has to trust the donor not to hand out food grain, which is stored differently and has a lower germination rate. However, donor and recipient maintain a mutually beneficial relationship that goes far beyond seed exchange and will be harmed by such behaviour.

6. Incentive problems

An institutional analysis must include a discussion of incentive problems, which threaten any kind of collective action (Olson 1965). Problems arising from limited information and limited commitment challenge the functioning of formal as well as informal insurance. In a context, in which insurance is provided without a binding contract and in the absence of an enforcing authority, moral hazard, especially through free riding, and endogenous coalition formation threaten the insurance arrangement.

a. Moral hazard problems

Since non-cooperation of donors is very unlikely and seed is given without return, seed assistance appears to be particularly prone to free riding behaviour, i.e. for farmers to rely on access to seed from neighbours through informal seed assistance and to reduce effort in selecting and storing seed themselves. The repeatedly expressed concern that seeds are eaten rather than sown by a recipient of seed assistance, illustrates that incentive problems are at play.

It has been argued exhaustively that the high degree of social control exerted in the close social networks of the rural village economy and the comparatively limited degree of privacy co-evolved with forms of collective risk-sharing, constituting a necessary condition for them to function efficiently (Posner 1980, Platteau 1991, Ligon, Thomas et al. 2002, Bloch, Genicot et al. 2007). The empirical findings of this study strongly support this hypothesis, firstly, through actors' recurring statements stressing the importance of visibility of output in neighbouring and connected households (e.g. "seeing a field without seed"). A household with a good harvest in the previous season will be expected to have saved seeds and will, thus, be unable to legitimately claim insurance. Secondly, since labour sharing network play such a prominent role in the establishment of assistance relationships, not only output, but also effort can be monitored more closely.

Nevertheless, gift-giving in a network of personalized relationships between linked actors with a high degree of social control might not solve all moral hazard problems as this respondent indicates: "There are some of those people, who do not work hard on their fields. But they will still get seed" (NUM 2010). Empirical results indicate that missing effort is widely considered as a legitimate reason for denial, but that it is difficult to verify. One response to control this moral hazard problem is that under the suspicion of missing effort, seed is given once and its use is then monitored.

b. Limited commitment

Studies of quasi-credit indicate that there is a link between the mode of exchange and the degree of self-enforcement (Udry 1994, Fafchamps 1999a, Fafchamps, Lund 2003). In Udry's (1994) study of risk-sharing through credit in Northern Nigeria, ten percent of all credits were defaulted, even though the terms of repayment were flexible and adaptable to the situation of both players. This result is interpreted a consequence of limited commitment.

The degree of commitment in the case studied here with gifts as the mode of transaction despite incentive problems, reflects a powerful enforcement mechanism, which will be analysed in the next section.

c. Endogenous coalition formation

Evidence suggests that a majority of farmers claim insurance at some point. However, as has been argued repeatedly, it does not imply that idiosyncratic risk probabilities are equally distributed, despite a strongly egalitarian narrative around mutual assistance. Heterogeneity in risk probabilities and risk aversion has been shown to encourage the formation of endogenous coalitions of households based on similar risk properties (Jaramillo, Kempf et al. 2015). Fafchamps calls this form of break-down of collective insurance a "coalition of the poor against the poorest" (1992b, p.167).

Based on the data presented here, we cannot analyse patterns in risk properties in the formation of assistance relationships underlying seed assistance. Nevertheless, some intuition against the existence of these coalitions is based from a closer look at the rationale behind the formation of and participation in other input sharing networks. Aspen (1993) describes that farmers participating in *guza* seek to secure labour in peak times for weeding or harvest as well as to find a partner for an oxen-sharing arrangement. Lending of oxen to members of the labour-sharing group, for example, is often compensated with labour on the lender's land during peak season. Relationships emerging from these interactions, in which seed is often given (as described above), are likely to connect households with different levels of idiosyncratic risk.

7. Enforcement mechanism

The fact that insurance payments are made in the form of seed gifts and only very rarely observed cases of denial prompt questions about the way norm compliance is enforced in seed assistance. It was argued that self-enforcement through a quid-pro-quo rationale is linked to the embeddedness of seed assistance other arrangements of reciprocal exchange.

In the absence of extrinsic enforcement and exclusion as non-credible threat in this case, we argue that intrinsic enforcement as well as endogenous extrinsic enforcement can sufficiently explain the high degree of commitment observed.

a. Exclusion as non-credible threat & cooperative strategy

The empirical analysis has shown clearly and consistently that exclusion from mutual assistance or community enforcement, as Kandori (1992) calls it, as a response for seed denial (i.e. non-cooperation) does not constitute a credible threat. In fact, donors consistently signal a highly cooperative attitude towards a potential defector, which does not indicate a clear tit-for-tat

strategy, but a reconciliatory strategy that prescribes cooperation even as a response to non-cooperation.[121]

b. Extrinsic endogenous enforcement

Findings do, however suggest that endogenous extrinsic enforcement through public ostracism (e.g. "being hated by the community") is effective in preventing defection (Barr, Dekker et al. 2012). Fafchamps argues that a penalty for non-compliance does not have to be material: "Failure to comply is met with anger and resentment. Such forced transfers can be viewed as fines that sanction an attempt to circumvent mutual insurance obligations" (1992: 164). Platteau's (1985) concept of a triadic relationship in reciprocal credit is applicable in this context. The community plays a role of a third party next to creditor and debtor - or in this case seed donor and recipient - by ensuring adherence to the rules of the game though the threat of ostracism in the case of defection and social control in verifying the insurance claim. As Platteau also points out, the threat of social exclusion and ostracism is only truly credible when the parties have only limited mobility, i.e. if there are no alternative employment opportunities that allow for a livelihood beyond the reach of the community.

As described above, the general attitude towards a defector is cooperative and there is no clear common understanding of what constitutes a legitimate punishment for seed denial. Therefore, we find no clear evidence of the existence of meta-norms according to which a farmer is punished by the community when he refuses to share seed or according to which community members who fail to punish deviant farmers are punished (Horne 2001).

c. Intrinsic enforcement

Feelings of shame and guilt as well as pity and compassion are overwhelmingly prominent in the narrative of seed assistance. As Barr, Dekker et al. (2012) point out, negative feelings are the essential mechanism through which intrinsic enforcement works.

This relationship is not only intuitive, but also well established in the literature. Emotions play a vital role in sustaining norms (Elster 1996, Elster 2007). Elster argues that the violation of a moral norm triggers both (1) feelings of guilt by the violator and (2) anger by the person affected by violation; both emotional reactions clearly resonate with the answers given. We have explored above that due to understanding of seed as the source of life, violating the norm of non-denial can trigger emotions of an intensity that makes intrinsic enforcement so powerful.

[121]It must be noted that the tit-for-tat strategy is used to explain the evolution of cooperative equilibria (Axelrod 1984). The cooperative strategy described here is explicitly aimed at maintaining the cooperative equilibrium.

Intrinsic enforcement can also be described in terms of psychological effects as the farmer who received help feels indebted and wants to reciprocate.

8. Summary

In this section we have comprehensively explained different features of informal seed assistance as a social institution. To conclude this section, we summarise the conditions that allow for the equilibrium to be stable.

Firstly, perceptions of relatively equal exposure to and capacity to cope with the risk of seed insecurity are foundational to the stability of the institution. In the case of the presence of a wealthier local benefactor that equilibrium is affected, and seed assistance is no longer practiced. In the presence of substantial difference in wealth, farmers argue that they are too poor to share side with their neighbours.

Secondly, in the absence of a functional seed market (partly due to lack of trust and the prevalence of information asymmetries) and in the absence of local reserves for crop genetic resources, the community is the preferred off-farm seed source. In this context, even farmers which are better-off, have a lower probability of being seed insecure and are very likely net donors of seed, have only limited, alternative options for sourcing genetically diverse, high-quality seed.

Thirdly, the actors involved in this repeated game are in mutually dependent relationships over a long period of time which go beyond instances of seed assistance.

CONCLUSIONS

We conclude this study by (1) summarising the institutional design of informal seed assistance and by (2) identifying areas for further research.

1. Summary

This study has analysed the practice of informal seed assistance in two rural communities in the West Hararghe zone of Eastern Ethiopia as a social institution or an equilibrium solution of a repeated game, which is stable and self-perpetuating. As informal insurance institution, seed assistance is characterised is by a number of institutional features, which are remarkable in comparison to other risk sharing arrangements among the Oromo and beyond.

At the core of the institution is the explicitly and universally formulated moral norm of non-denial. Findings suggest almost complete compliance to this moral norm, which is primarily intrinsically enforced. The powerful intrinsic enforcement mechanism can only be understood in the context of a contingent understanding of seed as continuation of life, encompassing human, animal and plant reproduction. Intrinsic enforcement is accompanied by endogenous extrinsic enforcement through ostracism, but not by exclusion from mutual aid arrangements.

The institution provides two sets of rules for the roles an actor can assume in seed assistance. While non-denial defines a standard appropriate behaviour for the donor, the recipient follows a set of unspoken norms, which define a legitimate request in two dimensions: as legitimate relationship (to a potential donor) and a legitimate cause. Given the non-violability of the donor's norm, the recipient is responsible for implementing rules regulating access to seed assistance. Relationships between donors and recipients are characterised by kindship relationships and, more importantly, by joint membership in risk-sharing institutions of balanced reciprocity, in network links for seed assistance are formed. The spatial and social proximity, which usually characterises the relationship donors and recipients, allows for a very high degree of social control (monitoring of effort and output) and thus prevents moral hazard problems. Exclusion from seed assistance is, therefore, not primarily a question of the denial of assistance, but of self-exclusion of community members with insufficient social ties or network links to feel entitled to ask for assistance.

Furthermore, the dominant mode of transaction in seed assistance is the gift (alongside some cases of direct exchange), which is presented as pure and disinterested. No forms of direct in-kind, cash or in-service compensations are observed. Three complimentary arguments offer explanations as to why gifts, as opposed to more commonly observed loans, have emerged as the mode of transaction in this form of cooperation.

Firstly, seed gifts set incentives for potentially food insecure households to claim seed insurance rather than food assistance (given as loan) as an ex ante form of hunger insurance. Secondly, plant and animal genetic resources (as the practice extends to the sharing of bull sperm) are understood as a form of public good, which is conserved collectively by spreading the genetic material. Seed gifts, which are typically small, represent a form of public access to the genetic resources of the community. Thirdly, in the thick social networks which characterise these rural communities and in which information is widely shared, seed gifts – which incur less costs than many other forms of assistance – are a cost-effective way to invest in the good reputation of the household.

In summary, informal seed assistance has emerged as a stable and self-perpetuating equilibrium of a repeated cooperation game because farmers interact as forward-looking agents in mutually dependent relationships which go beyond seed assistance and are characterised by a high degree of social control. Farmers have strong incentives to participate in seed assistance even in the absence of a credible threat of exclusion as alternative options to access high quality off-farm seed are limited and as it offers an option to provide an ex-ante hunger insurance which is considerably less costly than food assistance.

2. Avenues for further research

a. Adaptation and resilience: The impact of stress factors on insurance in comparative and dynamic perspective

Sperling, Cooper et al. (2008) offer some relevant insights about the potential evolution of informal seed assistance under extreme environmental stress, a topic of urgent relevance in Eastern Ethiopia. Particularly, the case of complete break-down of seed insurance after prolonged drought in Mali illustrates the potential of a comparative analysis of insurance institutions under environmental pressure. Such a comparative analysis is valuable in deepening our understanding of institutional design of informal insurance. It will also allow for some predictions about the sustainability of informal seed assistance in Eastern Ethiopia under increasing environmental pressure. A dynamic perspective would allow to analyse whether and how informal seed insurance is re-established after extreme shocks, with or without intervention. Moreover, it would allow a more rigorous analysis of patterns of exclusion. This empirical analysis would be useful to re-examine theoretical hypotheses which conceptualize exclusion and the breakdown of insurance during famine as a "coalition of the poor against the poorest" (Fafchamps 1992b, p.167).

b. Importance of culture for seed assistance and other informal insurance institutions in comparative perspective

The empirical analysis strongly points to the role of culture in respondents' understanding of and motivation to participate in seed assistance. We stressed the symbolical understanding of seed, in which spheres of reproduction are connected and which seems to be related to the pastoralist

past of the Oromo. The high degree of norm compliance and the non-violability of the norm is, as we argue, related to this symbolical understanding of seed. This illustrates - for one aspect of institutional design - how informal seed assistance could be a fruitful case study for discussing the role of culture in the conceptual framework of informal risk-sharing. To give another example, the explicit understanding that culture can deteriorate and that is must be actively upheld (e.g. expressed in the continued cooperation with someone who denied seed), invites a discussion of theoretical propositions concerning agency and culture.

There is a growing acknowledgment of the role of culture in economic decision making and institutional design (North 1990, Platteau 2000, Appadurai 2004, Rao, Walton 2004, Sen 2004, Bardhan, Ray 2008, Platteau 2011, Yousfi 2011). Going beyond that, the need to ask more systematically "how culture matters" is increasingly recognised (Sen 2004). This fundamentally requires that major analytical, meta-theoretical problems involved in modelling culture in rationalist frameworks are more explicitly addressed.

A comparative, mixed-method approach would be particularly useful for analysing the role of culture in the institutional design of informal seed assistance. Ideally such a comparative analysis would follow a "most similar systems design" ((King, Keohane et al. 1994). A rigorous analysis of this kind would be relevant both from a theoretical point of view - i.e. to conceptualize cultural variables in a rationalist framework - as well as for discussing anew the role of culture in development interventions.

c. The role of informal seed assistance for seed interventions

Further research is also required to describe more clearly the role informal seed assistance can play for improving the effectiveness of seed security and seed aid interventions, including better access to new varieties as well as the agency of local communities. Building on the success of participatory breeding, more participatory forms of seed dissemination (e.g. in the form of local seed businesses or revolving seed banks) have been identified as one of the central challenges in improving access to seed (Almekinders, Louwaars et al. 1994, Almekinders, Louwaars 1999, Mulatu, Belete 2001, McGuire, Sperling 2008).

An emerging literature - which links social learning with technological innovation - builds on the realization that successful extension policies require more "adaptive, flexible, learning organization" (Leeuwis & Van den Ban 2004: 16). The analytical tools and insights from this literature could be fruitfully applied in the Ethiopian context, in which highly developed informal institutions are faced with increasing environmental and demographic stress and where food and in which food and seed security have become an urgent policy concern.

Conclusions

In the conclusion to this thesis we present a summary of overall conclusions and reflect on the implications of the three research papers for designing interventions in seed security and agrobiodiversity conservation.

OVERALL CONCLUSIONS

1. Resilience & crop genetic diversity- Opportunities and challenges

Climate change poses new challenges for agricultural production and consequently for food security, especially in tropical and sub-tropical regions (Hayes, Wilhite et al. 2011, Thornton, Herrero et al. 2011, Parry 2014, Zeigler 2014). Improving small farmers capacity to cope with climate change or more generally strengthening the resilience of rural households is now a focus of academic research and policy interventions alike.

This thesis has highlighted how the shift from increasing productivity to resilience as simultaneous objectives of rural development interventions has created new opportunities for on-farm conservation of crop genetic diversity.

Firstly, the data for papers 1 and 2 was collected by Bioversity International as part of a World Bank funded project identifying and introducing suitable wheat and barley landraces from the Ethiopian gene bank to improve farmer's capacity to cope with climate change through access to diverse genetic resources. This illustrates that both funding opportunities and policy approaches to conservation are now strongly framed by resilience.

Secondly, an emerging literature on pest dynamics under climate change highlights the role of agrobiodiversity for building robust cropping systems (Gurr, Wratten et al. 2003, Cavatassi, Hopkins et al. 2006, Jarvis, Brown et al. 2007, Berry 2009, Lin 2011). In paper 2, we find no conclusive evidence that the cultivation of wheat landraces was an effective strategy for farmers to manage wheat rust. In other parts of the Ethiopian wheat belt, however, wheat landraces are specifically grown and multiplied for their rust resistant properties. This illustrates the opportunities for examining or extending collections in community gene banks in the study area.

While the resilience approach to in-situ conservation of genetic resources creates new opportunities, it also involves new challenges for targeting conservation efforts.

The academic interest in resilience has inspired a body of literature investigating the risk-spreading properties of food crop and crop genetic diversity, drawing attention to the use crop genetic diversity as a means to manage production risk (Smale, Hartell et al. 1998, Widawsky, Rozelle 1998, Di Falco, Chavas 2006, Di Falco, Chavas et al. 2007, Di Falco, Chavas 2008, Di Falco, Chavas 2009, Di Falco, Bezabih et al. 2010, Bangwayo-Skeete, Bezabih et al. 2012). One of the central conclusions of this thesis for the planning of conservation interventions is that planners should carefully distinguish between the potential for risk spreading and farmers actual incentives for cultivating a diverse portfolio. Understanding farmers incentives to maintain a diverse portfolio of crops and crops varieties (and the trade-offs between these aspects of diversity) in the specific context is essential for targeting conservation efforts. The evidence presented here suggests that not farmers who are most exposed to production risks, but farmers who are far from markets or well-endowed in terms of land, livestock and other resources cultivate the most diverse portfolios. In the study region, these are also farmers with high social capital and membership in important semi-formal seed institutions, i.e. farmers who are most likely to be multipliers for access to new genetic resources.

The tensions between increasing resilience among the most vulnerable households and conserving as well as spreading genetic resources at the community level become as these interventions are thus typically addressing different target groups within communities. This must be made more explicit and carefully considered in in-situ conservation efforts motivated by resilience objectives.

Going far beyond the design of local level interventions but in clear resonance with this conclusion, *sustainable intensification* is a popular concept aiming to reconcile multiple policy goals with considerable trade-offs in the pursuit of a more sustainable global food system ((Collette 2011, Pretty, Toulmin et al. 2011, Garnett, Appleby et al. 2013). In the short and medium term, and very possibly also in a long-term perspective, many interventions aimed at increasing resilience in smallholder agriculture and at increasing agricultural productivity are not as compatible as they are widely portrayed (Koohafkan, Altieri et al. 2012).

2. Rural development & agrobiodiversity conservation

The comparison between the two study regions within one region of Ethiopia illustrates the trade-offs between agricultural development and agrobiodiversity conservation most vividly. On the one hand, we find a region with agricultural productivity above the national average and a high degree of market participation of small farmers, but a low level of wheat diversity in a secondary centre of diversity for this crop. Furthermore, the fact that landraces are cultivated in this region is only due to existing conservation efforts through which traditional varieties were reintroduced.

On the other hand, we find a region about 300 km further East and culturally very similar with productivity levels below the national average, dominated by subsistence agriculture and marked by chronic food insecurity. This is also the region in which the traditional seed system is still intact and the level of varietal diversity in sorghum is still high, for which this region is the primary centre of diversity.

The in-depth analysis of the informal seed exchange network suggests strongly that interventions promoting agricultural development in this region will very likely weaken this informal social institution. Many agricultural interventions (like the model farmer approach) seek to specifically champion less risk-averse, innovative farmers to adopt new technologies to increase productivity and thus to accumulate wealth. An increasing social differentiation in rural communities will, however, question the fundamental egalitarian and redistributive norms which underlie many informal institutions, including the informal seed network studied here. More productive and increasingly wealthier farmers will have increasingly fewer incentives to participate in these institutions as social change progresses. This does not mean, however, that interventions which are mainly aimed at improving the availability of seed in times of emergency and normality cannot be designed in a way that intently strengthen rather than weaken the institution. This is discussed in some more detail below.

One of the major development challenges in Ethiopia with implications far beyond agriculture, is population growth which has already dramatically changed agricultural practices over the past decades and centuries. Another central finding of this thesis is that more land abundant farmers are more likely to grow a diverse portfolio, which is very likely related to the fixed cost of managing an additional crop or variety. As discussed above, this the positive relationship between land size and crop biodiversity is robust across different contexts and studies. In a land constrained environment with increasing population like the Ethiopian highlands, this finding has important implications for the future of agrobiodiversity. With decreasing farm sizes, incentives for maintaining a diverse crop and variety portfolio are dwindling too.

The case of purple seeded durum wheat varieties points to a potential synergy between landrace conservation on-farm and agricultural development. Especially for crops and crop varieties which are rooted in local culinary practices, niche market opportunities could be identified and developed further in interventions to achieve premium prices and generate income with secondary crops or landrace varieties.

3. Decentralising seed supply to improve local access to seed

While set in very different contexts, the three papers in this thesis highlight the importance of local institutions for seed security in the absence of a fully functional formal seed system.

In East Shewa - as the region which is more agriculturally developed - the informal seed system has broken down, very likely as a result of decades of agricultural interventions. But the semi-formal institutions such as a seed multiplying cooperative as well as the community gene banks are important pathways to accessing and spreading disease resistant or traditional wheat varieties at the local level. As will be discussed in more detail below, farmer based seed business are already promoted throughout Ethiopia to improve decentralise and improve access to seed locally. Since both institutions have exclusive membership, it also raises questions of equitable access to an important agricultural resource such as seed. Especially the second paper has shown that disease management must be deliberately approached from a pro-poor perspective to avoid the deepening of social stratification in rural communities due to inequitable access to agricultural resources.

In West Hararghe – as the region which is less agriculturally developed – informal channels are still most relevant for guaranteeing access to off-farm seed. Formal breeding and seed production of sorghum as the main crop in the area is currently much less developed compared to more commercially viable crops. Given the lower agricultural potential of the region, the extension service is also much less important as a formal seed source than in Est Shewa. In this particular context, agricultural interventions should be designed in a way that is at least cognisant and at best consciously the strengthening informal seed system to maintain local access to seed and genetic diversity.

4. Smallholder agriculture and rural transformation

This thesis discusses almost exclusively issues of agriculture within the realm of rural development. Not least during fieldwork it became very clear that agricultural development cannot be the only avenue of change to improve food security and improve livelihoods more generally in rural Ethiopia and Sub-Saharan Africa. Some of the increasing pressures and environmental challenges in agriculture are a result of the demographic development (and climate change).

As discussed in the introduction to this thesis, agricultural labour productivity in Ethiopia is among the lowest in all of Sub-Saharan Africa (IFPRI 2016). It is widely accepted that increases in labour productivity, as one of the signs of rural transformation, cannot simply be achieved by more intensive smallholder agriculture as well as market and value chain development for agricultural

products. Rather, there must also be other avenues, such as ways out of (smallholder) agriculture (World Bank 2007, Collier, Dercon 2013).

Recent research in Ethiopia has clearly shown that pressures for intensification, which can lead to unsustainable agricultural practices, arise from increasingly binding land constraints in the highlands (Headey, Dereje et al. 2014).

OPPORTUNITIES & CHALLENGES FOR SEED SECTOR DEVELOPMENT

The role of access to seed is an overriding topic that connects all three research papers in this thesis. At the end of this thesis, we therefore discuss implications for policies aimed at improving seed security - defined as the availability, access and utilization of seed (Remington, Maroko et al. 2002).

Seed security is essential for improving food security both in times of normality and crisis (Scowcroft, Polak Scowcroft 1999). For sustainable seed provision under increasing environmental and population pressure, strategies for emergency seed aid must be complemented by the development and introduction of new crop varieties and crops (McGuire 2000, Mekbib 2008c, Lipper, Anderson et al. 2010).

Seed systems are comprehensively defined as formal and informal (also called farmer, local or traditional) systems, in which seed is bred, produced and distributed (Almekinders, Louwaars et al. 1994). The focus of this discussion is, however, on seed distribution in the informal seed sector as well as on semi-formal institutions, such as revolving seed banks.

1. Overview: the formal seed system in Ethiopia

Nevertheless, we will briefly describe the core features of the formal seed sector in Ethiopia. The seed market in Ethiopia is not fully liberalised, even if a few commercial seed companies are now active in Ethiopia, although especially and almost exclusively for maize (Husmann 2016).

Plant breeding and (pre-)basic seed production remains in the hands of national agricultural research organisations, while state-owned national & regional seed enterprises dominate the production of certified seed for all 18 major crops (Alemu 2012, Husmann 2016). The distribution of seed is then overseen by the National Seed Production and Distribution Committee (Alemu 2012). Certified, improved seed is mainly distributed through the highly developed extension service (Spielman, Kelemwork et al. 2011). Consequently, rural seed markets are particularly thin in Ethiopia (Lipper, Anderson et al. 2010).

Seed sector development has been a strategic area of intervention by the Ethiopian government, expressed in the seed system development strategy (MoA 2016). International actors also contribute to this process, most notably through the scaling-up of farmer seed businesses (Alemu 2011). Nevertheless, at this point the Ethiopian seed sector is characterised by a high unmet demand for improved seed for all crops (in particular sorghum) and a missing capacity to effectively respond to this demand (Husmann 2016).

2. Comparison of seed distribution in West Hararghe & East Shewa

A brief comparison of seed distribution in the two study regions, West Hararghe and East Shewa, illustrates how diverse seed systems can be within one country, stressing the need for careful pre-intervention assessment.

In line with other studies, we find that the informal seed system plays only a marginal role in East Shewa, which can very plausibly be linked to the high intensity of agricultural interventions in the area (Teklu, Hammer 2006, Tsegaye, Berg 2007a). Data presented in the first paper shows that less than three percent of households have exchanged seed, much less given or received seed gifts. In qualitative interviews, older farmers explain, however, that these practices used to be common in the area. Seed supply is dominated by the government extension service as the most important off-farm seed source, followed by community gene banks as a semi-formal institution for seed provision, which will be further discussed below. In line with the above description of the formal seed system, seed markets play a secondary role.

Given its relative remoteness and its limited agricultural potential, the extension service (as well as the local market) plays a significantly smaller role for agricultural inputs, including seeds in West Hararghe. Informal channels, especially seed gifts, as described in the third paper of this thesis, are the most relevant for seed distribution in the region. The community as the most important off-farm seed source and the critical role of informal distribution channels has been confirmed in other studies in the region (McGuire 2000, Mekbib 2006, McGuire 2008). The second most important off-farm seed source is the market, making the extension service the least important and preferred seed source.

This comparison of two areas dominated by agro-pastoral livelihoods in the same Ethiopian region illustrates, firstly, how relevant the informal seed system can be for seed supply in smallholder agriculture. Secondly, we see that interventions in smallholder agriculture have can result in a break-down of established rural institutions regulating access to agricultural inputs. Particularly the second paper in this thesis shows that without the circulation of genetic resources through informal channels, farmers can be severely constrained when responding to crop disease. Inequitable access and an inefficient distribution of these resources appear to be the result.

3. Seed interventions and the informal seed system

By comparing seed supply in the two study regions, we have already provided a strong rationale for strategic interventions to strengthen the informal seed system or at least to protect it from break-down in interventions.

In his comparative study of seed development projects, Tripp (2001b) comes to the unambiguous conclusion that the availability as well as the flow of information is the key to effective policies for seed provision. Moreover, informal rules and networks as essential means to transmit information.

Beyond reducing the cost of information, informal seed systems are also a highly valuable institutional resource. The effectiveness in providing access to seed locally and the pride many farmers take in their cultural practice of sharing seed and thus showing solidarity, are relevant arguments. Interventions aiming to strengthen this social institution, rather than building new institutional structures, will not only have a positive effect on the acceptability of the intervention, but more importantly, it will "strengthen the capacity to aspire" (Appadurai 2004, p.159).

Given the importance of cultural agency in informal seed assistance, it would seem that interventions consciously working to strengthen the institution could have an impact on the self-efficacy of community members (Bandura 1995). Therein lays a contribution to development that goes far beyond finding policy responses to chronic food insecurity.

Expert interviews conducted alongside the primary data collection, clearly indicate that agencies, especially those active in seed aid, seed provision and to a lesser extend those active in integrated seed sector development, have a very limited understanding of the informal seed system and no awareness of potential damage of interventions to local practices.

In the following, we will discuss in more detail how informal institutions can be strategically strengthened or how harm can be avoided in interventions, based on the example of informal seed assistance in West Hararghe.

4. Targeting and timely provision of seed aid

The primary data collected for this thesis resonates strongly with the assessment that environmental and demographic pressures have increased in Ethiopia. Respondents consistently argue that, firstly, average yields are decreasing, and their livelihoods have become more vulnerable. Consequently, interventions, primarily in the form of food aid, but increasingly also in the form of seed aid are now regularly implemented. Secondly, farmers argue that the scope of mutual assistance, particularly the amount of seed given, has decreased substantially. This raises the question of how seed aid can be provided most efficiently in the context of a highly developed informal seed system.

a. Patterns of self-exclusion

Sperling et al. (2008) see better targeting as one of the major approaches to more effective seed aid, this means in particular being able to identify the chronically seed insecure in a community, affected by chronic seed insecurity (Sperling, Longley 2002). The interviews with a small number

of community members, who have not participated in informal seed assistance at all, emphasise the difficulty of relying on targeting based on self-revelation. Those individuals, who seem to have no access to seed insurance, would not necessarily identify themselves.

Identifying patterns of self-exclusion - or put differently, factors leading to low social capital of a small farmer must thus be a subject of further empirical investigation. McGuire's (2008) findings suggest more clearly than this study, the relevance of identity-based factors for exclusion.

The fact that off-farm income generating activities constitute a potential reason for exclusion is particularly challenging if one agrees that an important pathway out of rural poverty, particularly in regions without high agricultural potential (due to moisture stress), is to facilitate "participation in the rural nonfarm sector" (World Bank 2007, p.22).

b. Decentralising emergency seed interventions

Better targeting of chronically seed insecure households within the community is an important contribution to improve seed interventions. The timely provision of emergency seed aid in conditions of acute stress at the community level is another.

Respondents in this and other studies quite consistently rated the community as the best and the government as the worst source for off-farm seed supply. One of the reasons for this evaluation that emerged from interviews with farmers as well as with representatives of non-governmental agencies was the late supply of seeds.

The emergency seed aid provided by the government is seen by farmers as the last resort, which in many cases has negative effects on seed and food security of those, who have no other option than to rely on it. Late sowing has detrimental effects on the productivity of the crop and thus food security.

The fact that the community studied here has very good access to road infrastructure, illustrates the severe capacity problems the government, or more precisely the local extension services (as well as many non-governmental agencies), are facing in ensuring timely access to emergency seed aid. On the one hand, this means that in Western Hargate as opposed to other parts of Ethiopia seed aid is fortunately not (yet) seen "as one of the basic channels on which they [small farmers] count on to procure seed – season after season", which disincentivises the upholding of local seed provision (Sperling, Longley 2002, p.598). For seed aid, it seems particularly true that "providing this assistance without creating dependency remains a challenge" (World Bank 2007, p.14).

A comparative study of emergency seed interventions challenges direct seed distribution as a viable policy response to acute seed insecurity, because of systematically re-occurring problems

such as “small quantities given, unfair targeting and late delivery” (Sperling, Longley 2002, p.285). De-centralising or localising seed provision and strategically investing in improved long-term seed security (to prevent situations of acute insecurity) are also two critical policy concerns concerning the improved distribution of quick maturing and disease resistance seed varieties.

5. Improving access to quick maturing seeds

Leeuwis and Van den Ban therefore emphasise the need in extension policies to “define an innovation more pragmatically (…) in terms of its successful application” (Leeuwis, Van den Ban 2004, p.12). We will therefore briefly discuss the adoption of improved varieties in Ethiopia as a case of such an innovation.

a. Improved seeds and the farmer seed system

Until recently the share of farmers using improved seed varieties in Ethiopia was very low and it remains to be low in some regions, especially for sorghum (Kebede, Gunjal et al. 1990, McGuire 2000, Winters, Cavatassi et al. 2006, Wubeneh, Sanders 2006, Lipper, Anderson et al. 2010). Farmer and expert interviews as well as recent studies suggest that a number of locally adjusted improved seed varieties are available, which are evidently attractive for farmers to include into their varietal mix (Mulatu, Belete 2001, Wubeneh, Sanders 2006). Both empirical studies identify effective diffusion as the major challenge for wider adoption of new sorghum varieties. This confirms Leeuwis & Van den Ban’s argument that “we can only speak of a complete innovation if there exists an appropriate mix and a balance between new technical devices and novel social-organisational arrangements” (2004, p.13). The institution of informal seed assistance is highly relevant as a potential “social-organizational arrangement” for diffusion and thus successful innovation (Leeuwis, Van den Ban 2004). In interviews with Dr Kalema Belete and dir. Fires Mekbib, two leading plant scientists at Haramaya University specialized in sorghum breeding, both experts argued that progress made in developing more adapted and attractive sorghum varieties over the last decade was an outcome of the participatory breeding and varietal selection methods used.[122] The momentum for expanding participatory approaches further to seed multiplication and distribution is thus remarkable. Mulatu & Belete envision farmers as “seed-growers” and argue that the “[p]resence of well-developed farmer-to-farmer seed exchange…will aid diffusion of farmers' preferred improved varieties (if any) within a short period” (Mulatu, Belete 2001, p.217). This is also the rationale of the seed business approach promoted by the Integrated Seed Sector Development Programme (Louwaars, De Beef et al. 2013).

[122]The Interview with Dr. Belete was conducted on 11/08/2010 at Haramaya University. The interview with Dr. Firew Mekbib took place on 04/09/2010 in Addis Abeba.

b. Seed interventions in the context of egalitarian institutions

A comprehensive discussion of the potential of informal seed assistance, as practiced in the communities studied here, for participatory seed production and distribution goes beyond the scope of this thesis. Nevertheless, a brief remark on the compatibility of membership-based seed cooperatives or champion-farmer approaches with informal seed insurance based on redistributive norms seems necessary.

In recent years, the government has tried to work with farmers, who were identified as particularly innovative (i.e. willing and capable to use new production methods on their land) and productive in their respective communities. So-called model farmers receive packages from local extension services, including improved seeds, fertilizer and sometimes tools (Lefort 2012). In line with this approach, there is considerable interest in being able to identify 'seed donors' for the community and to work with them strategically to improve diffusion of improved seeds.

On the one hand the analysis of informal seed assistance has shown that roles of donors and recipients are much less stable than expected by many researchers and practitioners. On the other hand, the importance of personalized relationships for assistance would suggest that farmers with many links to other community members, i.e. a high bonding social capital are potentially interesting cooperation partners for development agencies (Winters, Cavatassi et al. 2006).

However, we also found that the community strongly rejects the (normative) idea of a seed donor and that the presence of a seed donor can lead to a break-down of seed assistance. Informal seed assistance as other solidarity institutions among the Oromo are based on a perception of equal risk probability, but less pronounced also in terms of wealth distribution. Among others, Fafchamps (1992b) argues that the redistributive effect of egalitarian norms is constitutive to solidarity networks and that wealth accumulation of agents within these institutions can lead to the formation of patron-client relationships. Hence, a strategic cooperation with community members as innovators can potentially question the very foundation of informal assistance. These dimensions of social change promoted by development interventions must be considered carefully and consciously.

The advantages and disadvantages of alternative forms for local seed provision, e.g. communal production and distribution or non-targeted, but rotational distribution of improved seeds should be further discussed with respect to their potential effect on the social coherence and institutions.

OPPORTUNITIES & CHALLENGES FOR CONSERVING BIODIVERSITY

Over the last decade in situ conservation of agrobiodiversity has emerged as a field of intervention in sustainable agriculture. As argued above, the farmer seed system is understood to constitute "a dynamic in situ conservation system in which evolution continues to exist" (Almekinders, Louwaars 2002, p.17). This policy area is of particular interest and relevance in the central and eastern highlands of Ethiopia, as the centre of origin for sorghum and a secondary centre of diversity for a number of cereal crops.

As the study from West Hararghe illustrates, farmer seed systems can play a central role in maintaining varietal diversity on a community level and through seed assistance and exchange, in conserving and granting access to these genetic resources (McGuire 2000, Mekbib 2006, Winters, Cavatassi et al. 2006, Mekbib 2008c). Where the informal seed system is only marginal, as in the case of East Shewa, semi-formal institutions, such as revolving seed banks, have high potential for providing access to diverse plant genetic resource and improve their utilization.

1. Community gene banks – a success story

The study of agrobiodiversity in East Shewa suggests that access to plant genetic resources, e.g. through community gene banks, is an important factor in explaining variations in wheat diversity. The analysis of seed sources confirms that neither the seed market nor the informal seed system is well developed. This explains the pivotal role of formal, non-market institutions for access to seed in this context.

Community gene banks (CGB) are a success story in this respect. They were established as part of one of the first large-scale projects to promoted in situ conservation after the Earth Summit in 1992, funded through the Global Environmental Facility and implemented mainly by the Ethiopian Biodiversity Institute. Two out of initially 14 CGB are located in the East Shewa study sites. They are now supported by the non-governmental Ethio-Organic Seed Action (EOSA) and have several hundred members.

Farmers can buy a share in the CGB for a small financial contribution, which entitles them to take out one seed loan of 25 kg per year, which is to be repaid in kind with twenty percent interest. While the CGB has a wide collection of crops (including improved varieties of some crops in the Ejere CGB), the core of the collection are roughly sixty wheat varieties, the majority of which are landraces. A committee and village sub-committees oversee the storage of the seed, enforce rules, implement a rigorous quality control, test and introduce new varieties. Despite some continued support by non-governmental organisations, the CGB are entirely farmer-run and there is a high demand for membership, which cannot be met.

CGB are an example of successful and sustainable rural institution-building as well as of the potential for local seed provision through institutions, which are formal in the sense that they have a set of explicit rules which govern them. CGBs as membership-based institutions differ substantially from informal practices of seed sharing described in the third paper.

CGB are not formal in the sense that the seed is not officially certified. Moreover, it is multiplied and distributed by farmers, rather than through typical formal channels such as markets or the extension service.

Despite the strong indication of the CGB's contribution to in situ conservations, some concerns about the equity of access must be raised. Using a range of different indicators for household wealth, CGB members tend to be significantly better off. These differences could be an expression of the fact that landrace cultivation is more attractive to better-off farmers for reasons discussed in the first paper of this thesis. They can also indicate that the access to CGB is not affordable for relatively poorer farmers. While we cannot substantiate either hypothesis sufficiently here, the equity dimension should be further subject of inquiry as well as project design.

2. Targeting in *in situ* conservation

Interventions for in situ conservation of traditional varieties and marginal crops in the centres of genetic diversity and beyond rely on a thorough understanding of the drivers of on-farm biodiversity. Insights form this and other studies are particularly relevant for the targeting of beneficiaries of such projects. In line with other research, our analysis suggests that land constrained, less wealthy farmers are less likely to grow a large portfolio of crops and crop varieties, thus questioning the practice of targeting the most vulnerable farmers in such interventions (with the aim of increasing resilience). The rationale behind targeting more vulnerable, thus poorer farmers is derived from the understanding that agrobiodiversity is primarily used to manage production risk.

Based on the findings in this specific region of Ethiopia, land abundant farmers, who are well connected (i.e. who have a high linking social capital) appear to be more promising potential adopters and multipliers.

Also for this purpose, the study of agro-biodiversity should return to a more holistic view of risk management and focus efforts on understanding when and where crop or varietal diversification is the best strategy for a small-farming household to reduce risk.

3. Seizing niche market opportunities

A number of recent studies of minor crops highlight potentials in market and value chain development to provide relevant niche market opportunities for marginal crops and landraces (Lipper, Cavatassi et al. 2012, Takeshima, Nagarajan 2012). The example of a slowly developing local market for purple-coloured wheat landraces, discussed in the first paper, is also suggestive of these opportunities.

Furthermore, barley, is another crop of particular interest in this respect. Barley is a minor crop with high genetic diversity which is firmly established in the culinary traditions in the region and has high potential for commercial use, e.g. for beer brewing (Newton, Flavell et al. 2011).

Interventions aiming at value chain development for (traditional barley) varieties and at the improved availability of genetically diverse landraces with attractive use value, have a high potential for creating niche market opportunities, thus setting incentives for de facto conservation. For the identification of traditional barley varieties with high potential (i.e. with superior use qualities and good performance), the cultivation of suitable varieties from ex situ collections on test fields and participatory varietal selection have proven successful methods (Van de Gevel, Gellaw et al. 2013).

APPENDIX

Table 20:Extended descriptive Statistics DV for the panel dataset

Variable Name	Description	N		Mean		Std Dev		Min		Max	
		'11	'13	'11	'13	'11	'13	'11	'13	'11	'13
Crop Count	Number of crops	301	300	5.123	4.463	1.564	1.495	1	0	9	10
ShannonC	Shannon Index, crop div	n/a	296	n/a	1.406	n/a	0.384	n/a	0	n/a	2.364
HerfinC	Herfindahl Index, crop div	n/a	296	n/a	0.303	m/a	0.142	n/a	0.107	n/a	1
Wheat Count	Number of wheat varieties	301	301	1.346	1.322	0.808	0.774	0	0	6	4
ShannonV	Shannon Index, wheat div	300	300	0.183	0.202	0.351	0.365	0	0	1.386	1.386
HerfinV	Herfindahl Index, wheat div	300	300	0.861	0.847	0.253	0.261	0	0	1	1

Figure 5: Distribution of the number of crops grown in 2013

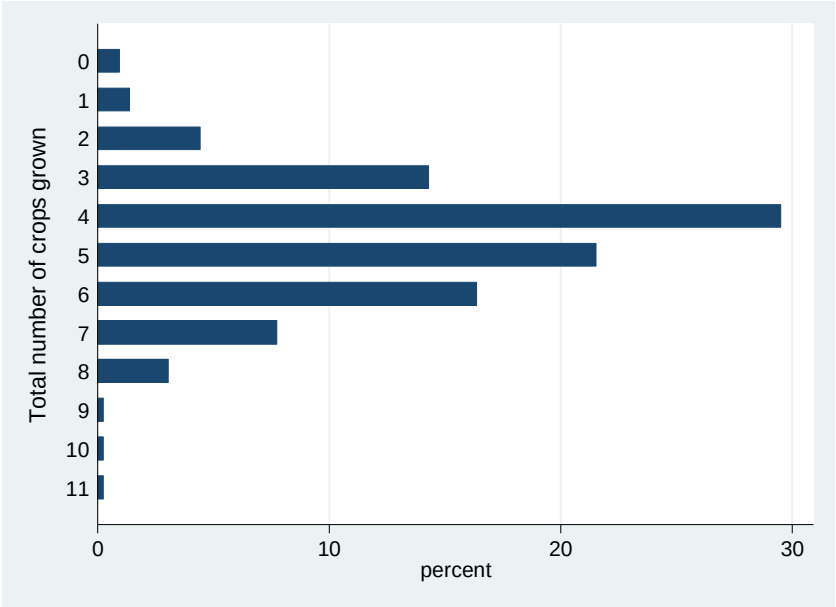


Figure 6: Distribution of the number of wheat varieties grown in 2013

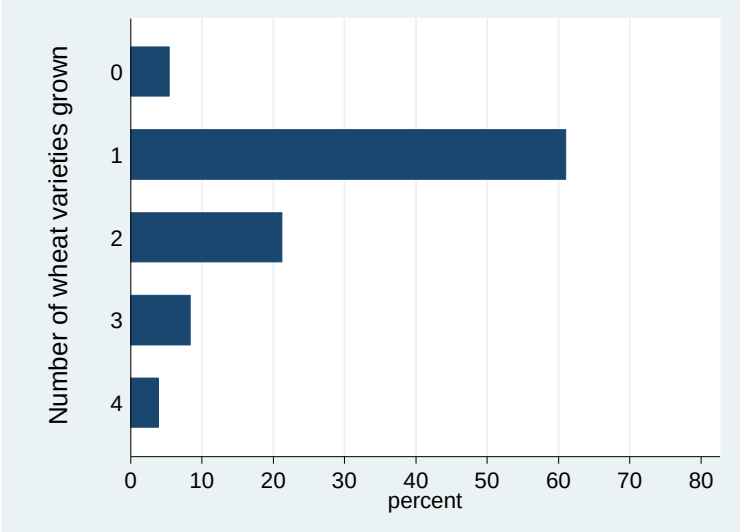


Table 22: Panel Analysis Crop Diversity (Crop Count): Fixed and Random Effects Estimation

VARIABLES	(1) Poisson FE	(2) Poisson RE [a]
Land holdings, ha	0.011	0.037***
	(0.015)	(0.011)
Log value of livestock	0.123*	0.122**
	(0.064)	(0.054)
Off-farm income(dummy)	0.074*	0.038
	(0.042)	(0.027)
Nb of household members	0.012	0.020***
	(0.009)	(0.005)
Walking distance to next market, hours	0.924	0.740
	(0.639)	(0.499)
Walking distance, squared	-0.100**	-0.079***
	(0.043)	(0.027)
Interaction: log livestock*distance	-0.058	-0.047
	(0.060)	(0.047)
Member community gene bank	0.037	0.077***
	(0.051)	(0.029)
Social capital	0.045**	0.039**
	(0.020)	(0.016)
Dummy: Round I 2011: 0, Round II 2013: 1		-0.072***
		(0.023)
Constant		0.047
		(0.551)
Constant lnalpha		-18.114***
		(0.086)
Observations	600	601
Number of HHID	300	

Robust standard errors in parentheses
[a] Coefficients for village dummies not displayed
*** p<0.01, ** p<0.05, * p<0.1

Table 18: Results Hausman Specification Test for Crop Diversity (see models above)

	——— Coefficients ———			
	(b) fixedc	(B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
LANDHEC	.010885	.0370718	-.0261868	.0211147
LOGLIVESTOCK	.1230726	.1221467	.000926	.0436526
OFFFARMINC	.0739838	.0381903	.0357935	.0492085
HHSIZE	.0121392	.0197327	-.0075935	.0123475
DISTMARKETH	.9241711	.7401499	.1840212	.6310414
DISTSQ	-.0997928	-.0793812	-.0204116	.0362978
WEALTHxDIST	-.0578726	-.0468102	-.0110624	.0598476
MEMCGB	.036687	.0770337	-.0403467	.0637756
SOCIALCAP	.044629	.0386012	.0060278	.023298

b = consistent under Ho and Ha; obtained from xtpoisson
B = inconsistent under Ha, efficient under Ho; obtained from xtpoisson

Test: Ho: difference in coefficients not systematic

chi2(9) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 3.46
Prob>chi2 = 0.9434

Table 20: Results Hausman Specification Test for Shannon Index as DV

	Coefficients (b) fixedv	(B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
LANDHEC	.0262355	.0213934	.0048421	.0101508
LOGLIVESTOCK	.0280831	.0321062	-.0040232	.0256897
OFFFARMINC	.0146806	.0291163	-.0144357	.0229758
HHSIZE	.0081157	.0002781	.0078376	.0058878
DISTMARKETH	-.8238668	-.0596338	-.764233	.4573733
DISTSQ	-.0079324	-.0209408	.0130084	.0166101
WEALTHxDIST	.0756978	.0104131	.0652847	.0434
MEMCGB	.0122865	.12537	-.1130835	.0324484
SOCIALCAP	-.0345703	.0033486	-.0379189	.0100896

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(9) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 34.16
Prob>chi2 = 0.0001

Table 24: Pairwise correlation coefficients (& significance) of selected independent variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	*Log value ls &prop*	1.000								
(2)	*Land holdings*	0.521	1.000							
		(0.000)								
(3)	*Number of children*	0.247	0.385	1.000						
		(0.000)	(0.000)							
(4)	*Walking distance*	0.024	-0.033	-0.047	1.000					
		(0.624)	(0.504)	(0.329)						
(5)	*Share of crops sold*	0.117	0.031	-0.052	0.003	1.000				
		(0.015)	(0.525)	(0.282)	(0.949)					
(6)	*Oromo*	0.003	0.075	0.060	-0.033	0.013	1.000			
		(0.956)	(0.126)	(0.218)	(0.501)	(0.781)				
(7)	*Member Gene Bank*	0.127	0.113	0.004	-0.050	-0.002	0.083	1.000		
		(0.009)	(0.020)	(0.928)	(0.300)	(0.965)	(0.086)			
(8)	*Bonding social cap*	0.109	0.146	0.130	-0.011	0.053	0.120	0.009	1.000	
		(0.024)	(0.003)	(0.007)	(0.821)	(0.271)	(0.013)	(0.845)		
(9)	*Linking social cap*	0.254	0.236	0.032	-0.147	0.063	0.030	0.275	0.133	1.000
		(0.000)	(0.000)	(0.511)	(0.002)	(0.193)	(0.534)	(0.000)	(0.006)	

Table 25: Poisson model of wheat variety adoption

VARIABLES	(1) DV: Number of varieties adopted Poisson[a]
Δ Land holdings, ha	0.078
	(0.077)
Δ Log value of livestock	0.121**
	(0.057)
Δ No. of household members	0.075*
	(0.043)
Δ Model Farmer (dummy)	0.383**
	(0.192)
Δ Member seed multiplying enterprise	-0.109
	(0.171)
Δ Member community gene bank	0.042
	(0.185)
Δ Rust problem (dummy)	0.303
	(0.233)
Constant	-1.055***
	(0.228)
Observations	279
Pseudo R^2	0.251

Table 26: Interview guide for donors

	QUESTION
D1	Who are the farmers who usually come to you to request for seed?
D2	Why were you in a position to give seed while many community members did not have enough seed to sow their plots?
D3	Why did NAME come to you to ask for seed and not to someone else in the community?
D4	Why did you decide to give seed to those people/ this person?
D5	Can you think of any circumstances that would allow you to deny any family or community member seed assistance?
D6	Would you deny to a person who does not work hard?
D7	Would you deny to a person who does not or did not treat your seed well?

D8	Would you deny to a person who has seed at home?
D9	Would you deny seed to a person, who has money or assets which he or she could sell to buy seed on the market?
D10	Would you deny to a person who you are not on good terms with?
D11	Would you deny seed to a person you don't know, i.e. someone who is neither a family member, nor in idir/ afoscha/ guza with you and comes from a different PA?
D12	Would you deny to a person from another clan?
D13	Would you deny seed to a person who has previously denied seed to someone?
D14	What would happen to you if you did not assist a family or community member with seed?
D15	If you are not assisting some in need with seed, will there be any punishment from the elders? If yes, what kind of punishment?
D16	Would the elders deny marriage to a person who denies seed?
D17	Would the person who denied seed be hated by the society?
D18	Would the person who denied seed still be able to receive assistance by the community if he or she is in need, i.e. in guza or idir?
D19	Do people you assisted offer you anything in return?
D20	Can you expect someone/ can you hope for someone who you supplied with seed to help you with labour, crop or anything else later on?
D21	Why does the Oromo culture of not denying assistance only apply to seed and bull sperm?
D22	Why does the Oromo saying not refer to other things like food or assistance in case of health problems for example?

PRIMARY SOURCES

1. List of interviews, West Hararghe, 2010 & 2013

2010				2013		
HHID	Respondent Reference	Date	*Ganda* (sub-village)	HHID	Respondent Reference	Date
1	UXX	18 August	Tukune	100	DAMV	25 July
2	MSA	19 August	Qexa	101	YOJV	26 July
3	ABI	19 August	Tukune	102	AMB	26 July
4	SUA	19 August	Haro	103	ZAAI	26 July
5	IBA	19 August	Haro	104	JIY	27 July
6	AHU	19 August	Haro	105	MUA	27 July
7	ABMI	20 August	Tukune	106	INL	27 July
8	AHH	20 August	Tukune	107	JAA	27 July
9	HUM	20 August	Bareda	108	GAT	27 July
10	USH	23 August	Haro	109	ABT	28 July
11	ABA	23 August	Haro	110	JAIV	28 July
12	MEAI	25 August	Tukune	111	DAB	28 July
13	AHU	25 August	Tukune	112	MUAV	28 July
14	JAU	25 August	Tukune	113	ABMV	28 July
15	ADM	25 August	Tukune	114	SHS	28 July
16	AMM	25 August	Qexa	115	UMAV	28 July
17	JMA	25 August	Bareda	116	ABI	29 July
18	ASN	25 August	Bareda	117	SAJV	29 July
19	MES	26 August	Qexa	118	ABAV	29 July
20	AAB	26 August	Daletscha	119	HUA	29 July
21	AHY	26 August	Daletscha	120	DIH	29 July
22	SMM	27 August	Salale	121	YEAV	29 July
23	YWA	27 August	Salale	122	AMMI	30 July
24	DEA	27 August	Salale	123	ABAI	30 July
25	ABS	28 August	Bareda	124	MOAV	30 July
26	AHA	28 August	Haro	125	MAA	30 July
27	HAH	30 August	Tukune	126	HAQ	30 July
28	ABH	30 August	Tukune	127	TEB	30 July
29	MEAII	31 August	Tukune	128	MOAII	31 July
30	AMEI	31 August	Tukune	129	ADA	31 July
31	XAA	31 August	Tukune	130	QAAV	31 July
32	AYL	01 September	Tukune	131	KAAV	31 July
33	HAM	01 September	Tukune	132	ESK	31 July
34	ADU	01 September	Tukune	133	SHB	31 July
35	ABJ	01 September	Tukune	134	AKX	31 July

36	MUI	02 September	Tukune	135	GIG	01 August
37	MEAIII	02 September	Tukune	136	YIG	01 August
38	ZAA	02 September	Tukune	137	SITV	01 August
39	SMA	02 September	Tukune	138	AMAI	01 August
40	AAI	02 September	Tukune	139	MOAII	01 August
41	KAU	02 September	Tukune	140	HUSV	01 August
42	AAF	02 September	Tukune	141	ZAAII	02 August
43	UJW	08 September	Tukune	142	KEG	02 August
44	AMW	08 September	Tukune	143	AMMII	02 August
45	MEAIV	09 September	Tukune	144	SHSV	02 August
46	AMAI	09 September	Tukune	145	FAHV	02 August
47	BAS	09 September	Tukune	146	ALAV	02 August
48	USU	09 September	Tukune	147	ENBV	02 August
49	MAA	09 September	Tukune	148	MOYV	02 August
50	NUM	09 September	Tukune	149	HMS	02 August
51	MUM	09 September	Tukune	150	MUM	02 August
52	YAM	13 September	Tukune	151	ADM	03 August
53	AMM	13 September	Tukune	152	ALM	03 August
54	MEY	14 September	Tukune	153	ALFV	03 August
55	UMB	14 September	Tukune	154	AMAII	03 August
56	AMAII	14 September	Tukune	155	ABAV	03 August
57	AMEII	15 September	Tukune	156	TAJ	03 August
58	MEAV	15 September	Tukune	157	MUS	03 August
59	AYI	15 September	Tukune	158	ALA	03 August
60	ABMII	15 September	Tukune	159	TAD	04 August
61	MAW	16 September	Qexa	160	ADLV	04 August
62	ADJ	16 September	Qexa	161	GAI	04 August
63	MUS	16 September	Qexa	162	SAM	04 August
64	MAB	16 September	Tukune	163	JAM	04 August
65	ABS	16 September	Haro	164	ABAII	04 August
66	AMW	16 September	Haro	165	HIZ	05 August
67	ASM	17 September	Tukune	166	GET	05 August
68	AAD	17 September	Tukune	167	MAK	05 August
69	HSM	17 September	Tukune	168	SHF	05 August
70	ALA	17 September	Tukune	169	MAAV	06 August
71	AUW	17 September	Salale	170	HAMV	06 August
72	AIA	18 September	Tukune	171	AMUV	06 August
73	HMA	18 September	Tukune	172	SJA	06 August
74	SAM	18 September	Tukune	173	FAW	06 August
				174	AIH	06 August

2. List of focus groups

Nb.	Group Reference	Date	Selection Criteria			Nb. of Partici
			Ganda	Gender	Assistance Role	
1	Mixed Male, 24/08	24/08/10	Mixed Haro: 2, Tukune:1, Qexa:1, Bareda: 2	Male	Mixed	6
2	Mixed Female, 24/08	24/08/10	Mixed Haro: 4, Bareda: 2	Female	Mixed	6
3	Mixed Male, 31/08	31/08/10	Mixed	Male	Mixed	5
4	Mixed Female, 31/08	31/08/10	Mixed	Female	Mixed	4
5	Haro Donors 08/09	08/09/10	Haro	Mixed	Donor	5
6	Haro Recipients 14/09	14/09/10	Haro	Mixed	Recipient	5
7	Bareda Recipients 15/09	15/09/10	Bareda	Mixed	Recipient	6
8	Salale Donors 16/09	16/09/10	Salale	Mixed	Donor	6
9	Bareda Donors, 22/09	22/09/10	Bareda	Mixed	Donor	7
10	Salale Mixed 23/09	23/09/10	Salale	Mixed	Mixed	8
11	Daletscha Mixed 24/09	24/09/10	Daletscha	Male	Mixed	10

3. List of expert interviews 2010 & 2013

2010				
Nb	Name	Function	Date	Location
1	Dr. Fekadu Beyene	*Director of the Institute of Pastoral and Agro-pastoral Studies at Haramaya University*	11/08/10	Haramaya University, Dire Dawa
2	Ketema Belete	*Researcher at the Department of Plant Sciences, Haramaya University*	11/08/10	Haramaya University, Dire Dawa
3	Abrahim Ali Rane	*Food Security Officer Mieso woreda*	15/08/10	Mieso
4	Ali Mehamed	*Development Assistant (DA) supervisor, Tukuma kebele*	15/08/10	Asebot
5	Aynalem Yuya	*Development Assistant (DA) Asebot*	15/08-24/08/10	Asebot
6	Dr. Firew Mekbib	*Assistant Professor at the Department of Plant Sciences, Haramaya University*	04/09/10	Addis Ababa
7	Ahmed Yatin	*Seed and Grain Merchant in Asebot*	16/09/10	Asebot
8	Gebeyehu	*Hararghe Catholic Secretariat*	21/09/10	Asbe Teferi

9	*Anonymous*	*Field Staff at Mieso Research Station of the Melkassa Agricultural Research Centre*	21/09/10	Mieso
10	Dr. Azage Tegegne	*Extension Officer Mieso woreda*	21/09/10	Mieso
11	Lulu Taye	*Coordinator of the PSNP Plus Programme of Care Ethiopia West Haraghe*	22/09/10	Asbe Teferi
12	Zewdu Worku	*Community Development Officer at FARM Africa*	22/09/10	Asbe Teferi
2013				
1	Mike Bartels	*Agricultural Dialogue & Capacity Development Seed Projects Project Manager , Gesellschaft für Internationale Zusammenarbeit (GIZ)*	07/04/13	German House, Addis Ababa
2	Wondimagegne Shiferaw & Dr. Bateno Kabeto	*Officers, Food and Agriculture Organisation Ethiopia*	23/04/13 16/07/13	FAO Ethiopia, Addis Ababa
3	Kassahun Habtemariam & Azemeraw Bekele	*Officer, Ethiopian Red Cross Society*	24/04/13 11/07/13	ERCS, Addis Abeba
4	Dr. Dawit Alemu	*Agricultural Economics, Extension and Gender Research Directorate Director, Ethiopian Institute for Agricultural Research*	26/04/13	EIAR, Addis Abeba
5	*Dr. Alganesh Gellaw & Tesfaye Woldetsadik*	*Team Leader & Officer Plant Genetic Resource, Ethiopian Institute for Biodiversity Conservation*	29/04/13	EBI, Addis Abeba
6	*Gemedo Dalle*	*Director General, Ethiopian Institute for Biodiversity Conservation*	29/04/13	EBI, Addis Abeba
7	Dr. Amsalu Ayana Aga	*Integrated Seed Sector Development, Programme Director*	02/05/13	ISSD, Addis Ababa
8	Gadisa Afrasa	*Chairperson Community Gene Bank, Chefe Donsa*	08/06/13	CGB, Chefe
9	Tadesse Fetene	*Chairperson Community Gene Bank Ejere & Seed Cooperative Biftu*	15/06/13	CGB, Ejere
10	Kenij Nakamura	*Officer for the Quality Seed Promotion Programme (QSSP), Japan International Cooperation Agency*	02/07/13	MoA, Addis Ababa
11	Ato Yebegashet	*Officer for Seed Marketing, MoA Ethiopia*	02/07/13	MoA, Addis Ababa
12	Dr. Wubshet Berhanu	*Director, Self-Help-Africa*	03/07/13	SHA, Addis Ababa
13	Robel Getachew & Ravi Shankar	*Officers at the Seed Programme, Agricultural Transformation Agency*	04/07/13	ATA, Addis Ababa

14	Dr. Regassa Feyissa	*Director, Ethio-Organic Seed Action*	10/07/13 17/07/13	EOSA, Addis Abeba
15	Meseret Mengistu	*Livelihoods programme Advisor, GOAL Africa*	15/07/13	GOAL, Addis Abeba
16	Dr. Moges Tefera	*Coordinator, Program Quality and Learning Unit, CARE Ethiopia*	15/07/13	CARE Ethiopia, Addis Abeba
17	Dr. Getachew Desta	*Director of Seed Purchase and Distribution, Ethiopian Seed Enterprise*	16/07/13	ESE, Addis Ababa
18	Dr. Furo Abera	*Director Seed Sector Development, Oromia Bureau of Agriculture*	19/07/13	OBoA, Addis Abeba
19	Moges Tewodros & Samrawit Dangachew	*Team Leader & Team Member Seed Distribution, CARE Ethiopia*	23/07/13	CARE Ethiopia, Asebe Teferi
20	Biruk Roba	*Agricultural Officer, West Hararghe Zone*	24/07/13	Asebe Teferi

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