Cattle farmers' perceptions of risk and risk management strategies

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Cattle farmers' perceptions of risk and risk management strategies: Evidence from northern Ethiopia

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Abstract

This study analyzes cattle farmers' perceptions of risk and risk management strategies in Tigray, Northern Ethiopia. We use survey data from a sample of 356 farmers based on multistage random sampling. Factor analysis is employed to classify scores of risk and management strategies, and multiple regression is then used to investigate the relationship of scores and farmers' characteristics. The results demonstrate that shortage of family labor, high price of fodder and limited farm income were perceived as the most important risks. Use of veterinary services, parasite control and loan utilization were perceived as the most important strategies to manage risks. Livestock disease and labor shortage were perceived as less of a risk by farmers who adopted the practice of zero grazing compared to other farmers, pointing to the potential of this practice for risk reduction. We find strong evidence that farmers engage in multiple risk management practices in order to reduce losses due to cattle morbidity and mortality. The results suggest that government strategies that aim at reducing farmers' risk need to be tailored to specific farm and farmer characteristics. Findings from this study have potentially important policy implications for risk management strategies in developing countries.

Key words: risk perception, risk management, livestock farming, multivariate analysis, Ethiopia

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1. Introduction

Small-scale livestock farmers, many of whom live in severe poverty, represent almost 20% of the world's population and utilize most of the agricultural land in the tropics. Intensification of livestock production is widely advocated to meet the increasing demands for livestock products and to improve rural incomes (McDermott et al. 2010; Udo et al. 2011). Natural and human induced risks, however, impose severe constraints on agriculture (Hardaker et al. 2004). Poor rural people in developing countries are exposed to numerous risks while often lacking the means to manage them adequately, and so are highly vulnerable (Gilligan, Hoddinott, and Taffesse 2009; Anderson 2003; Dercon 2002; Barnett, Barrett and Skees 2008; Tadesse, Shiferaw, and Erenstein 2015). Previous studies reveal that in the arid and semi-arid environment of East Africa the predominant risks are mainly related to drought and infectious disease (Doss, McPeak, and Barrett 2008; Thornton et al. 2006; Yesuf and Bluffstone 2009; Chantarat et al. 2007; Matsaert, Kariuki, and Mude 2011; Hill, Hoddinott, and Kumar 2013).

While livestock farmers' perceptions of risk and management strategies have received some attention in developed economies, little specific attention has been paid to developing economies (Ahsan 2011; Akcaoz, kizilay, and Ozcatalbas 2009). This is despite the fact that risk in livestock farming is reported to be increasing in the arid and semi-arid regions of East Africa (Doss, McPeak, and Barrett 2008; Headey, Taffesse, and You 2014; Matsaert , Kariuki, and Mude 2011; Chantarat et al. 2013). In the absence of empirical studies, little is known about livestock farmers' perception of risk, about their risk management strategies, or the determinants of such risks and strategies (Gebreegziabher and Tadesse 2014). This paper, therefore, extends previous work by examining livestock farmers' risk perceptions in a developing economy context and explores the relevance of a range of farmers' risk management strategies and their determinants. This provides the basis for an analysis of the influence of demographic and farm characteristics on farmers' perceptions of risk and their risk management strategies, revealing significant differences between farmers. This in turn supports a number of recommendations of potential importance to policy markers concerned

with the development of the small-scale livestock sector in developing countries such as Ethiopia.

The remainder of paper is organized as follows: Section 2 provides background and discusses relevant literature; Section 3 deals with methods; Section 4 presents discussion of the results; and Section 5 presents conclusions and implications.

2. Background and literature

Ethiopia's livestock herd, the largest in Africa, is a major source of income to the poorest section of the rural population. However, the sector's contribution is far below its potential due to low productivity, caused in turn by fodder shortages, high incidence of livestock disease and low level of technology adoption (such as improved cattle breeds, use of veterinary service, feed supplementation and marketing) (Degu 2012; Gebremedhin, Pender, and Tesfay 2004; Jibat , Mengistu, and Girmay 2015). It is widely reported that farmers who are fearful of future loss of earnings may be reluctant to adopt technological innovations that offer uncertain returns (Fafchamps 2010). Dercon and Christiaensen (2011) reported that, despite numerous efforts in Ethiopia, farmers' adoption of new technology is relatively low due to the perceived risks. Reluctance to adopt new agricultural technology is often seen as a contributor to the persistence of rural poverty; poor people fear the risk associated with innovation and this keeps them poor (Fafchamps 2010). To reduce the impact of a range of risks, farmers use various risk management strategies such as diversification of their livelihood activities, saving, debt management, membership of marketing cooperatives, control of pests and diseases and participation in public works programs (Ellis 2000; Gebreegziabher and Tadesse 2014; Headey, Taffesse, and You 2014; Akcaoz, kizilay, and Ozcatalbas 2009; Akcaoz and Ozka 2005; Kazianga and Udry 2006; Dercon and Christiaensen 2011; Andersson, Mekonnen, and Stage 2011). Most of these risk management strategies may be ineffective, however, when an entire

community is hit by covariate risks such as drought or disease outbreak (Meze-Hausken, Patt, and Fritz 2009; Ellis 1998; Castellani and Vigano 2015; Hill, Hoddinott, and Kumar 2013).

In light of a lack of agreement on the meaning of the term risk (Legesse and Drake 2005), the literature makes a useful distinction between uncertainty, as in imperfect knowledge, and risk, as in exposure to uncertain economic consequences (Legesse and Drake 2005; Hardaker et al. 2004; Holton 2004). Following Legesse and Drake (2005), risk is defined in this paper as the impact of an undesirable outcome arising from natural events or human action.

Furthermore, we note that risk attitude and risk perception are two different concepts. Whereas risk attitude refers to a decision-maker's interpretation of the content of the risk and how much they like or dislike the risk (typically characterized as risk-seeking versus risk-aversion), risk perception refers to the decision-maker's interpretation of the potential impact of the risk (Pennings et al. 2002). Risk perceptions are thus subjective measures of risk which are based on subjective evaluation by the individual (Hansson 2010; Georgakopoulos and Thomson 2005; McCarthy and Henson 2005). The terms 'subjective risk' and 'perceived risk' are used interchangeably in the literature (Hansson 2010). Risk management strategies adopted by farmers reflect their personal perceptions of risk and other available resources (Beal 1996). Risk prevention and mitigation are parts of the ex-ante risk management strategies, while risk coping is part of the ex-post shock coping strategies (Holzmann and Jogersen 1999).

Taking into account the above-mentioned literature, it is argued that risk aversion combined with inadequate risk management responses is a potentially important contributing factor to poverty traps (Fafchamps 2010). An understanding of farmers' risk perceptions and how farmers respond to risk is therefore important in order to understand the decision-making behavior of farmers under different economic and institutional conditions, especially for agencies interested in agricultural development and poverty alleviation (Flaten et al. 2005; Legesse and Drake 2005). Smallholders' risk perceptions and risk responses have a bearing on the type of intervention measures to be considered, and have therefore been a focus of interest for policy makers and researchers for some time (Legesse and Drake 2005; Sjoberg 2000). Legesse and Drake (2005, p. 383) argue that: "If risk is excluded from the livelihood analysis, then findings

would be misleading and policy recommendations and ultimate decisions on identification of relevant improvements and intervention measures might be inappropriate." Similarly, Anderson (2003) and Barnett , Barrett, and Skees (2008) argue that devising appropriate risk-management strategies and supporting the critically vulnerable are key pillars in an effective and sustainable rural poverty-reduction strategy.

The recurrence of humanitarian disasters in the Horn of Africa has prompted renewed interest in achieving sustainable development, particularly with regard to enhancing the resilience of the region's economy to withstand shocks (Headey, Taffesse, and You 2014; Gilligan, Hoddinott, and Taffesse 2009; Andersson, Mekonnen, and J. Stage 2011; Gebresilassie et al. 2014). Among government departments and development organizations, however, there is very limited information or consensus on how to reduce the region's extreme vulnerability to shocks and stresses (Headey, Taffesse, and You 2014). Doss, McPeak, and Barrett (2008) investigate interpersonal, intertemporal and spatial variations of risk perceptions in East Africa. The authors analyze the relative level of concern about risk among pastoralists, using risk ranking, and its determinants, and identify a need for intervention in the areas of food security and public health in order to mitigate the risks faced by pastoralists. Other recent studies of risk management in livestock farming in East Africa have focused on the role of insurance in poverty reduction (Matsaert , Kariuki, and Mude 2011; Chantarat et al. 2013).

Overall, livestock in Ethiopia is an integral part of agricultural livelihoods for most smallholder farmers (Tegebu et al. 2012; Haftu , Asresie, and Haylom 2014). Ethiopia has a large livestock population but the contribution to the national economy is still low due to constraints associated with risk and inadequate management responses. Therefore, it is important to understand the impact of risk and improve the existing risk management strategies of smallholder farmers.

3. Methods

3.1 Study area and sampling design

This study is based on a survey of farm households carried out in 2011/2012 in rural Tigray region, Ethiopia. The reason for choosing Tigray is the region's vulnerability to drought, high food insecurity, livestock feed constraints and poor animal health services (Vander der Veen and Gebrehiwot, 2011; Abegaz, van Keulen, and Oosting 2007; Haftu, Asresie, and Haylom 2014; Gebreegziabher and Tadesse 2014; Tegebu et al. 2012; Haileselassie et al. 2011). Tigray is located in the Northern highlands of Ethiopia, stretching from 12° 15' to 14° 57'N and 36° 27' to 39° 59'E, and covers an area of approximately 53,000 square kilometers. The region is bordered in the north by Eritrea, in the west by the Sudan, in the south by Amhara region of Ethiopia and in the east by Afar region. In Tigray 53% of the land is classified as lowland (less than 1,500 meters above sea level), 39% as mid-highland (1,500-2,300 meter above sea level), and 8% as highland (greater than 2,300 meters above sea level). The mean annual rainfall of the region varies from 200 mm in the east to over 950 mm in the south-west, and the average annual temperature ranges from 15 to 25°C (Birhane et al. 2014). According to the report of the 2007 housing and population census, the total size of the Tigray population in that year was 4.3 million (5.8% of the Ethiopian population). Of this population, 49.2% was male and 50.8% female. In terms of settlement, 19.5 % of the population was living in urban areas whereas 80.5% was living in the rural areas (CSA 2008). The region is divided into five administrative zones, which in turn are subdivided into 34 rural *woredas* (districts) and 12 urban *woredas,* further divided into 660 *tabias* (sub-districts).

Fieldwork was conducted in three out of the five zones of Tigray: North Western, Eastern and Southern. Within these zones, a total of six woredas and 12 tabias were selected. Multistage random sampling was used to account for spatial distribution, agro-ecology and accessibility (with regard to infrastructure), in order to generate a representative sample of the regional population. In the first stage, three zones (Southern, Eastern and North Western) were selected based on spatial distribution. In the second stage, six woredas (two from each zone) were selected as representative of their respective zones in terms of agro-ecology. In the third stage, two tabias

were drawn from each woreda, representing varying degrees of accessibility. In the fourth stage, a proportional sample of households was drawn from an official list of all households in each tabia, resulting in a total sample of 356 households. The woredas and tabias of the North Western zone included in the fieldwork were Asgede Tsembela woreda (tabias of Lemlem and Kesad-Gaba) and Tahtay Koraro woreda (tabias of Lemlem and May-Demu); in the Eastern zone, Saesie Tsaeda-Emba woreda (tabias of Hadush Hiwot and Senkata) and Kelete Awlaelo woreda (tabias of Adi-Kesandid and Mesanu) were included; while in Southern zone, Ofla woreda (tabias of Hashenge and Hayalo) and Raya Azebo woreda (tabias of Begae-Delebo and Hawelti) were included. A pilot survey of 24 respondents was carried out in Enderta district (Romanat tabia), 8 km away from Mekelle city, the regional capital, in preparation of the main household survey. The main household survey was then conducted face-to face with farmers with the help of trained and experienced enumerators from Mekelle between October 2011 and January 2012.

3.2 Data description

A cross-sectional design was implemented using a household questionnaire. The data collected included information on household characteristics, village characteristics, cultivated and grazing lands and market conditions. Information on farmers' risk attitude was gathered using Likert scale questions regarding the categories of production, market, finance and investment and technological risks. Farmers' risk attitude was recorded as compared with other farmers in the same locality (see Meuwissen , Huirne, and Hardaker 2001 for similar treatment). The following statement was used in our questionnaire to assess farmers' risk attitude: "I am willing to take more risks than others with respect to: production, marketing, finance and investment, and technological risks." Each respondent was asked to indicate their degree of agreement or disagreement for each of these four sources of risk using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The eigenvalue of the four statements of risk aversion was found to be 3.05 in a single factor model with a Cronbach's alpha of 0.85. It is therefore possible to conclude that the four statements of risk aversion items measured the same construct. Hence, the four statements of respondents' risk aversion items were aggregated to a single variable

index ('risk attitude index'), using factor analysis for further regression analysis (see Flaten et al. 2005; Meuwissen , Huirne, and Hardaker 2001).

We used 37 Likert-scale questions for risk sources such as production risk, market risk, financial risk, human risk, technological risk and institutional risks. Each respondent was also asked to rate the importance of each risk source on a Likert scale from 1 (very low) to 5 (very high). Likewise, a Likert scale was used to capture the importance of risk management strategies, scoring from 1 (very low) to 5 (very high). We used a total of 53 Likert-scale questions for risk management strategies included; financial management, diversification, sale or transfer asset, disease prevention, market information, emergency assistance, feed management and community asset building.

Where one or more questions about risk sources or management strategies were not answered by farmers (because they did not consider them relevant to their situation), these questions were treated as missing values. If remedies for missing data are not applied, any observations with missing values on any of the items would have to be omitted, resulting in a loss of precision as the sample size is reduced (Hair et al. 2010). Our approach for dealing with missing data in these factor analyses was, therefore, to first delete variables where more than 45% of the values were missing (Hair et al. 2010). We then replaced the missing data points with the mean value of that variable based on all valid responses (see Flaten et al. 2005; Lien et al. 2006; Ahsan 2011). As a result, from 37 risk source variables, 13 (35%) were removed entirely from the factor analysis and for the remaining 24 variables any missing values were replaced by the mean value of that variable. Out of those 24 variables, a further 12 were removed due to low communality as indicated by a Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) value less than 50%. As a result, for risk sources, 12 variables out of 37 were considered for factor analysis. Out of 53 risk management strategies, 18 (40%) of the variables were removed from the factor analysis for having missing value of more than 45%. For the remaining 35 variables, any missing values were replaced by the mean value of

that variable. However, a further 23 variables (43.4%) were removed due to low KMO values (KMO values less than 50%). Thus, from the total of 53 risk management variables, 12 variables (22.6% of the originals) were included in the factor analysis.

3.3   Analysis

Method of estimation

Descriptive statistics were used to identify the various risk categories and risk management strategies of importance to livestock farmers. Factor analysis was employed to reduce the large number of risk categories and risk management variables and to derive indices, while principal component factoring extraction was employed to analyze common factor variability.

Factors were considered with eigenvalues greater than 1. For the factor analysis we assumed that standard parametric statistical procedures were appropriate for ordinal variables in the form of Likert-type scales (Ahsan 2011; Flaten et al. 2005; Meuwissen, Huirne, and Hardaker 2001). Orthogonal (varimax) rotation was used to ensure, inter alia, that the factors were as independent as possible for subsequent use in multiple regressions (Flaten et al. 2005). Standardized factor scores were used (as dependent variables) for multiple regression analyses (Ahsan 2011; Flaten et al. 2005; Meuwissen, Huirne, and Hardaker 2001). Total variance accounted was found to be 69% and 76% for risk sources and risk management strategies respectively. Factor loadings with absolute values of greater than 0.50 were analyzed for interpretation of the structures (Hair et al. 2010). Ordinary least squares (OLS) multiple regression was used to explore the relationship between socio-economic variables and perceived risk and management strategies. A high *risk attitude* index variable was associated with low risk aversion (risk taking).

Diagnostic tests

The Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) was used to check the factorability of the correlation matrices, yielding KMO values of 81% for risk sources and 85% for risk management strategies, which indicates that patterns of correlation were relatively compact and factor analysis was appropriate (Ahsan 2011). This KMO value indicates that overall the risk sources have 81% in common and risk management strategies have 85% in common, thereby warranting a factor analysis. Individual KMO values less than 50% were excluded from the analysis of the risk sources and risk management strategies (see Hair et al. 2010).

In interpreting the retained factors, we only used variables with factor loading greater than 0.50, which are generally considered to be above the minimal level for interpretation of the structure (Hair et al. 2010). To check the internal reliability we used Cronbach's alpha. The Cronbach's alpha value for risk sources was found to be 0.82, while the Cronbach's alpha value for risk management strategies was found to be 0.87, which is deemed high (Greiner, Patterson, and Miller 2009; Meuwissen , Huirne, and Hardaker 2001). Variance inflation factors for all variables used in the regressions were found to be less than 1.7, indicating no multicollinearity problems (Gujarati 2004). Heteroskedasticity problems were detected using the Breusch-Pagan test of post-regression models (Breusch and Pagan 1979; Baum 2006), which suggested that heteroskedasticity was an issue for variables such as risk attitude index and risk management strategies (disease control, diversification, safety net, loan utilization) which were significant at p-values <0.05. Where the usual assumptions of homoscedastic disturbance are not met, the loss in efficiency in using ordinary least squares (OLS) may be substantial and, more importantly, the biases in estimated standard errors may lead to invalid inferences (White1980; Breusch and Pagan1979). A heteroskedasticity-robust standard error was estimated to avoid biased estimated standard errors and inferences (Cameron and Trivedi 2005).

Although all models presented are statistically significant at P-values <0.001, the goodness-of-fit measures (Adjusted R^2) for some of the risk source regression models were found to be relatively low. The appropriateness of these models, in terms of the inclusion of

all relevant variables, and specification error was tested with the use of ovtest and linktest (Musman et al. 2011). Both tests failed to reject the null hypothesis at P-values <0.05, which implies no evidence of omitted variables or specification error.

4. Discussion of results

4.1 Demographic and farm characteristics

The average household size for the sample was found to be 6.1 (6.5 Eastern, 6.3 North western and 5.4 Southern zones of Tigray), that is, well above the average household size of 4.7 at national level (CSA 2008). The mean age of the sample household heads was 45 year, in a range from 22 to 84 years. Household size ranged from 1 to 13 members, and averaged 6. The ratio of dependents to adults of working age was 96.6%, out of which 92.1% were less than 15 years and 4.5% were greater than 64 years. The total dependency ratio in the study area was found to be slightly lower than the national level of 92.3% (CSA 2008). In terms of literacy, 48.9% of household heads were illiterate (cannot read or write); the remaining 51.1% were found to be literate. The average level of education for head of households, in terms of school grades completed, was 2.3 (2.3 for Eastern, 1.9 for Northwestern and 1.8 for Southern zones). Education is important in that it may enhance farm productivity directly by improving the quality of labor. The study also found that 20% of household heads were female and 80% were male. The average land holding per household in the survey area was 1.0 hectare (0.58 hectare for Eastern, 1.25 hectare for Northwestern and 1.05 hectare for Southern zones). The average land holding of farmers in eastern zone is much lower than the overall average, reflecting to the high population density compared to other zones.

The mean number of cattle per household was found to be 6.6, ranging from 1 to 49. With regard to geography, 20% and 50% of the sample households resided in highlands and midlands, respectively. The remaining 30% of the sample household lives in the lowlands (Table 1).

[Insert Table 1 here]

4.2   Perceptions of risk

The descriptive statistics on the risk sources include mean values and standard deviations for the Likert scale entries (Table 2). Shortage of family labor was found to be the most highly rated risk, followed by high price of forage and small farm income. Our findings can be compared with similar cattle studies, suggesting that labor scarcity and forage prices (absolute levels and variability) are of primary universal concern, irrespective of the country of study. The study by Doss, McPeak, and Barrett (2008) pointed out that human illness, shortage of forage and animal sickness were the major concerns of residents of the arid and semi-arid lands of East Africa (Northern Kenya and Southern Ethiopia). Low milk yield due to feed shortage was identified as the top rated source of risk in urban and peri-urban areas of northern Ethiopia (Gebreegziabher and Tadesse 2014). Studies on beef cattle producers in Texas and Nebraska in the USA similarly found that severe drought, forage price variability, cattle diseases and labor availability were perceived as major sources of risks (Hall et al. 2003).

[Insert Table 2 here]

A factor analysis of 12 risk sources was conducted; four factors and their respective factor loadings are presented in Table 2. Factor loadings are the weights and correlations between each source of risk and the various factors. Higher loadings are more relevant in defining a factor's dimensionality. Based on the loadings, four factors were identified and labeled as *disease, financial, market* and *labor* risks.

Factor 1, *disease risk,* loads significantly on morbidity and mortality of livestock. More specifically, disease risk had high loadings on *epidemic* and *non-epidemic livestock diseases, death* and *cattle accident.* In other studies from developed economies (Norway, Netherlands and Northern Belgium), livestock farmers also perceived livestock diseases to be important (Flaten et al. 2005; Meuwissen , Huirne, and Hardaker 2001; Van Winsen et al. 2016). Factor 2, *financial risks*, had high loadings on *small farm income, cash shortage and lack of saving.*

Factor 3, *market risks*, had high-loading variables on *high price of forage, forage shortage and livestock price variability.* These sources of market risk were also found to be the most important in previous studies of dairy farmers in Turkey and Ethiopia (Akcaoz, kizilay, and Ozcatalbas 2009; Gebreegziabher and Tadesse 2014). Factor 5, *labor risk,* had high loadings on *shortage of family labor* and *shortage of herders.*

4.3   Perceptions of risk management strategies

The descriptive statistics revealed that the use of veterinary service was rated by farmers as the most important strategy for managing risk (Table 3). A study in Ada'a district of Oromia region of Ethiopia reported that the public veterinary service was consider as the preferred choice for livestock owners for its effectiveness and affordability compared to private veterinary services in their areas (Jibar, Mengistu, and Girmay 2015). Veterinary service provision in Ethiopia has been dominated by the public sector. However, the available clinics are not well equipped with facilities to provide adequate veterinary services (Desta 2015; Haftu, Asresie, and Haylom 2014). Parasite control was found to be the second most important risk management strategy, followed by loan utilization. The standard deviation for risk management strategies such as use of veterinary services, parasite control and loan utilization were found to be less than 1, indicating consensus among respondents.

[Insert Table 3 here]

The number of risk management items was reduced by applying factor analysis, using principal component extraction. The factor analysis identified four factors with eigenvalues greater than one, which accounted for 76% of the total variance. Table 3 shows the four factors and their respective loading items (loading items of absolute values of greater than 0.50). According to the loadings, factors 1-4 are interpreted as *disease control, diversification, safety net and loan utilization.* Farmers reported similar risk management strategies in Ethiopian urban dairy farming (Gebreegziabher and Tadesse 2014).

The first factor, *disease control*, had high loadings on *use of veterinary services, parasite control, disease prevention, clean cattle shelter, and separate cattle pen.* Use of veterinary service and disease control measures such as sanitation, preventive measures (such as use of cattle shed during hot weather, avoiding mixing personal cattle with others) are important to minimize risks associated with livestock mortality and morbidity.

High loadings on *off-farm/non-farm activities, spatial and enterprise diversifications* were found in factor two *(diversification).* In Ethiopia, farming is particularly weather sensitive and farmers face both market and production risks. Farmers can benefit through diversification by cropping in different plots (spatial diversification) and combining farming with off-farm or non-farm activities. A study in Ethiopia by Legesse and Drake (2005) found that diversification of asset and income were important risk management strategies amongst smallholders, and these authors suggested that it is essential to support farmers' management of risk through diversification of assets, incomes and activities.

The factor *safety net* (factor three) had high loadings on *Productive Safety Net Program (PSNP)* and *food or cash for work.* The PSNP provides food and cash to poor and food insecure farmers through participation in public works, such as soil and water conservation, roads construction and school construction. In addition, direct support in the form of food or cash is provided to households with no able-bodied members (e.g. where members are elderly or in poor health). In case of natural disasters, farmers can supplement their consumption through food or cash for work, which helps them avoid selling productive assets.

The fourth factor*, loan utilization* included high loadings on *loan allocation* and *borrow from formal institution.* Loans are important to farmers for buying agricultural inputs, on-farm investment and wider non-farm investments. Farmers in the study area borrow mainly from the formal micro-finance institution known as DECSI (Dedebit Credit and Saving Institution). Lending is based on groups of farmers, whereby all members of a group are responsible for loan default by any one of the members. In this regard, proper loan utilization is an important tool for managing risk.

4.4 Perceptions of risk in relation to farm and farmer characteristics

OLS multiple regression analysis was used to assess the relationship between risk attitude and perception of risks, and a range of farm and farmer characteristics. The summary description of the variables used in the regression analysis is presented in Table 1, while the regression coefficients, robust standard errors and the goodness-of-fit measures of the models are reported in Table 4. All models were highly significant at p-values < 0.001. Variables that are significant at p-values <0.05 are discussed (Table 4).

[Insert Table 4 here]

The results suggest that the household head's level of *education* was positively and significantly related to the *risk attitude index* (p<0.05) (Table 4): farmers with a higher level of education were found to be less risk averse (risk taker). This result is consistent with a similar study conducted in the Netherlands (Meuwissen, Huirne, and Hardaker 2001). An increase in log *number of cattle* owned was associated with risk attitude index, suggesting that farmers owning larger herds could be characterized as less risk-averse: this relationship is consistent with another study on dairy farmers of Norway (Flaten et al. 2005). *Zero grazing* (whereby cattle are confined and fed with fodder gathered by the farmer) was also positively and significantly associated with the *risk attitude index*, indicating that farmers that used zero grazing were risk takers relative to those who did not practice this strategy.

Income *(log income)* was positively and significantly related to the *risk attitude index:* higher income households were found to be less risk averse compared to lower income households. A previous study measuring risk aversion using experimental data from Ethiopia and Zambia found that farm households that were wealthier were more willing to take risk in exchange for higher returns compared to poorer households (Yesuf and Bluffstone 2009; Wik et al. 2004). Evidence from the Netherlands also suggests that higher income farmers were less risk averse than lower income farmers (Meuwissen, Huirne, and Hardaker 2001). Participation in the *livestock package* program (a public support scheme for livestock farmers) were positively and significantly related to *risk attitude index*. This implies that households who participated in the

livestock package program were less risk averse than non-participants. This could be because the livestock package program is integrated with the agricultural extension program. Thus the extension program adds knowledge and skills to farmers on technology adoption, and farmers are becoming less risk averse as a result.

Highland geography was negatively and significantly related to *disease* risks, suggesting that farmers in *highland* locations perceive disease risks as less important compared to households in lowland areas. In Ethiopia, the lowland areas are relatively poorly served in terms of infrastructure and public services such as roads and veterinary services, which may exacerbate cattle morbidity and mortality. In addition, livestock diseases are more prevalent in the moisture-stressed areas of the lowland compared to highland and midland areas. *Adoption of zero grazing* was negatively and significantly associated with *disease* risks; disease risk was perceived less for households adopting *zero grazing* compared to their counterparts. This may be because the practice of zero grazing minimizes cattle contact with neighbors' animals and thereby lower the likelihood of cattle diseases and accidental injury.

Farmers who were members of the livestock *package program* perceived *disease* risks to be higher than non-members. This may be due to the fact that members of the livestock package program adopt cattle breeds (exotic or cross breeds, as encouraged by the program) that are more susceptible to disease, death and accidental damage compared to local zebu cattle. A study in Ethiopia and Kenya, Gari et al. (2011), indicated that sickness, mortality rate and output loss of Holstein Friesian and crossbred cattle was significantly higher than in local zebu cattle. It may also be a reflection of the selection effect that arises as only certain farmers (with certain risk preferences) participate in this livestock package program. The r*isk attitude index* was found to be negatively and significantly associated with *disease* risks, suggesting that less risk averse farmers perceive *disease* risks as less important compared to risk averse farmers.

Log number of cattle was found to be negatively and significantly associated with *financial* risk. This suggests that farmers with larger number of cattle can minimize *financial* risk (such as small farm income, cash shortage and lack of savings) compared to farmers owning smaller

numbers of cattle. The likely reason for this is that farmers owning larger numbers of cattle have the means to hedge their risks, as they can sell relatively more milk, butter and live animals in order to minimize financial constraints compared to their counterparts.

Farmers adopting *zero grazing* perceived financial risks to be greater compared to their counterparts. This may be because farmers who adopt zero grazing invest more in better breeds of cattle, feeding and animal health, all of which increase their financial vulnerability. Further, our results suggest that log *walking time to the main road* is positively related to *financial risks*. The reason could be that a longer walking time to the main road increases transaction costs - and thus diminishes market access - for farm inputs and outputs, resulting in greater financial constraints compared to those with a shorter distance to the main road.

Contrary to our expectation, higher income farmers perceived financial risks to be greater compared to lower income farmers. As Laffont and Matoussi (1995) have observed, risk aversion is typically assumed to be inversely related to wealth. In this case, it appears that higher income farmers may participate in a greater range of farm and off-farm activities and are thus vulnerable to financial constraints.

Unexpectedly, farmers with higher number of cattle perceived market risks to be greater compared to farmers with lower number of cattle; possibly, farmers with more livestock are more market-oriented, and therefore more vulnerable to market risk. The perception of *market* risks included *high price of forage*, *livestock price variability* and *forage shortage*.

Households in *highland* areas perceived *market* risk as less compared to those in *lowland* areas. The reason could be that highland locations tend to have better infrastructure in terms of roads and transport facilities that ease market constraints compared to lowland locations. *Market* risk was perceived greater for households adopting *zero grazing* as compared to other groups. This could be because households who adopt *zero grazing* worried more about *high price of forage* and *forage shortage* compared to their counterparts.

Perception of *market* risk was found to be greater for higher *income* farmers compared to lower *income* farmers. It appears likely that higher income farmers are more frequently

engaged in market transactions that expose them market constraints compared to the lower income farmers.

Respondents with larger *household size* perceived *labor* risks to be less important compared to those with smaller families. This is due to the fact that larger *household size* typically have more labor that can be engaged in livestock activities such as herding, feeding and cleaning shelters. Our results also suggest that farmers who practice *zero grazing* tend to perceive a lower *labor* risk, probably due to the fact that *zero grazing* demands lower involvement of labor to handle the farm activities. Higher income farmers perceived human risks to be greater compared to lower income farmers, possibly because higher income farmers demanded more farm labor to run extensive crop and livestock farming in the context of Northern Ethiopia. Male farmers perceived labor risk to be lower compared to female farmers. Female farmers are strongly associated with poorer and smaller households (especially in terms of adult labor). Female farmers typically lack a male spouse, whereas male-headed households nearly always have both a male and female adult member at a minimum.

4.5 Perception of risk management strategies in relation to farm and farmer characteristics

OLS multiple regression was used to assess the relationship between risk management and farm and farmers' characteristics (Table 5). Therefore, four risk management indices were extracted from the corresponding factor analysis and used as dependent variables (Table 5). The results suggest that farmers with larger *number of cattle* perceived safety net programs as relatively unimportant (p<0.05), indicating that poorer rural households (those with less cattle) depend significantly on safety net programs as a risk management strategy. In Ethiopia, the safety net program provides opportunities to the poorest farmers to be employed in public work in exchange for food or cash.

Farmers in the highlands perceive *diversification* as important but found *safety net* less important compared to farmers in lowland geography. Farmers in the midland location perceived diversification as more important and loan utilization as less important compared to

farmers in other locations. Increase in walking time to the main road discourages farmers'
participation in diversification activities since it results in higher communication, transport and
other transaction costs.

[Insert Table 5 here]

Disease control, diversification and loan utilization are found to be important risk
management tools for higher income farmers, compared to lower-income counterparts. Such
farmers are likely to be in a position to better control the health and sanitation of their livestock
and to afford for use of veterinary services compared to lower income farmers. Higher income
farmers are also more likely to own oxen and have access to loans, which may encourage
them to engage in diversification such as cultivating different crops: a study in Ethiopia by
Bezabih and Sarr (2012) showed that household wealth in terms of ownership of oxen is
positively and significantly associated with farm diversification. *Male* farmers perceive loan
utilization as a less important management strategy compared to their female counterparts.
Possibly, female farmers are more careful when it comes to cash management, and less
extravagant than males, and thereby utilize their loans better. *Disease control, diversification
and loan utilization* were perceived as important risk management strategies by less risk
averse farmers. A comparable study from Norway showed that disease prevention was
perceived as an important management strategy by risk-taking farmers (Flaten et al. 2005).

The regression model also indicates that the perception of risk was significantly
associated with risk management decisions. Livestock farmers who perceived disease risks
as important were associated with multiple risk management responses: disease control,
diversification, safety net and loan utilization. This implies that farmers are engaged in multiple
management activities and coping strategies, such as disease prevention, participation in off-
farm activities, participation in safety net programs and loan utilization when faced with the
risk of cattle morbidity and mortality. Concern about financial risk was found to be associated
with disease control as a risk management strategy. This indicates that such farmers focus on
livestock disease control in order to curb their financial risks. Farmers who perceived labor

risk as important emphasized disease control, diversification and participation in safety net programs as important risk management strategies.

5. Conclusions and implications

This study provides a survey analysis of households from Northern Ethiopia, exploring perceptions of risk and the role of management strategies in smallholder livestock farming, through factor and multiple regression analysis. It adds therefore to the small but growing literature investigating livestock farmers' perceptions of risk and management strategies in developing economies. Our results suggest that shortage of family labor, high price of fodder and limited farm income are perceived as the most important risks that impact on farmers' livelihood. Use of veterinary services, parasite control and loan utilization were perceived as the most important strategies to manage risks.

Our results further suggest that farmers' education and participation in livestock support programs have a positive influence on farmers' risk attitude by lowering their risk aversion and increasing their willingness to adopt new technologies. This suggests that the expansion of primary schools, adult education and agricultural extension programs in rural areas may contribute to greater technology adoption, thereby improving farmers' risk-taking behavior and potentially lowering poverty levels.

Our findings also provides new evidence on the relationship between risk sources (namely, disease and labor risk) and zero grazing practices, thereby extending previous works (Gebreegziabher and Tadesse, 2014; Flaten et al. 2005), who highlighted the role of disease prevention as a risk management strategy. Interestingly, the importance of disease and labor risks were perceived lower by farmers who adopted zero grazing. This may be because zero grazing practices reduce cattle contact, thereby minimizing livestock diseases and accidental

injury. It also appears that adopting zero grazing practices reduces the need for labor involved in livestock farming activities, thereby reducing the most important risk identified in the study, namely labor risk. Results from factor analysis suggest that livestock diseases are generally more prevalent in the moisture-stressed areas of the lowlands compared to the highlands. Lowland areas are also relatively poorly served in terms of infrastructure and public services such as roads and veterinary services, which may exacerbate cattle morbidity and mortality.

In a second step, our results from the factor analysis were employed as an input for multiple regression analyses. The latter shows that three out of four risk management strategies are perceived as important by higher income farmers, namely *disease control*, *diversification and loan utilization.* This suggests that higher income farmers are in a position to better afford veterinary services to control livestock health and sanitation, and are more likely to diversify their livelihood activities using loans from formal financial institutions. Farmers who perceive disease risk as important are associated with multiple risk management responses: disease control, diversification, safety net and loan utilization. This result highlights the anticipated central role that disease risk plays for livestock farmers. Farmers who were concerned about financial risk were found to be associated with disease control as an important risk management tool: that is, farmers are focusing on livestock disease control in order to curb their financial risks. Overall, this evidence suggests that farmers engage in multiple and concerted risk management and coping strategies in order to secure their livelihood, and that these depend on both objective (e.g. environmental) and subjective (e.g. attitudinal) factors.

A strong policy implication of these findings is the importance of considering farmers' perception of risk and management strategies in policy design for the alleviation of poverty amongst livestock farmers in developing countries. The findings highlight that cattle farmers' perception of risk and management strategies are heterogeneous, and shaped by both socio-economic and agro-ecological factors. Strategies that aim at reducing risk should be tailored to specific characteristics of farmers – including their individual risk attitude - and their farming conditions. Finally, we found important new evidence that the practice of zero grazing has potential to mitigate the risks associated with cattle disease and labor shortages. It should be

considered that changes in risk management for one group has consequences for risk management or perception of risk for other members of the community. Future research need to a) clarify the causal effect of disaggregated socio-economic indicators (for example: single, widow women, widow men, married) on farmers' labor risk, b) examine the role of zero grazing within a broad spectrum of livestock production, risk management and the environment.

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