Climate Variability and Livelihood Diversification in Northern Ethiopia – A Case Study of Lasta and Beyeda Districts

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Keywords:	adaptation, Ethiopia, qualitative methods, livelihood diversification, smallholders, climate variability
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**Climate Variability and Livelihood Diversification in Northern Ethiopia –
A Case Study of Lasta and Beyeda Districts**

Abstract

This article examines smallholders’ perceptions of climate variability in two districts in Northern Ethiopia, and the diversification options pursued within and outside agriculture. Meteorological records corroborate smallholders’ belief that temperatures are increasing but do not support assertions that rainfall is decreasing. Farm-level adaptation mainly involves soil and water conservation measures learnt from state-led schemes as well as planting a broader crop mix. Diversification outside agriculture is mainly wage labour: international and national migration, construction work in local towns, participation in public works and piecework on nearby farms. The article concludes by arguing that policymakers could do more to support non-farm diversification strategies by recognising the importance of rural-urban connections in fostering adaptation.

KEYWORDS: Ethiopia, adaptation, qualitative methods, livelihood diversification, smallholders, climate variability.

Introduction

According to the Climate Change Vulnerability Index, Ethiopia is ranked 7th among countries at risk from the impacts of climate change (Maplecroft 2015). This vulnerability largely emanates from its low level of development and dependence on agriculture - the mainstay of Ethiopia's economy, which contributes 40.2% of GDP, employs 80% of its population and accounts for 70 % of export earnings (African Development Bank 2015). Most climate models predict temperatures in Ethiopia will rise over the coming years, increasing by 2.1°C in 2050 and 3.4 °C by 2080 (FDRE 2007). Over the past five decades, rainfall has shown a high degree of variability (ibid.). This is expected to continue, and the frequency and severity of droughts and floods is expected to increase (Deressa et al. 2011). Thus, proactive adaptation strategies are necessary to reduce the impact of climate change on agriculture and to improve resilience. Smallholders' perception of current climate variability and their response through local adaptation measures can serve as useful input for integrated and sustainable adaptation strategies. The strategies smallholders pursue are the result of long-term experience and assessment of risks in their day-to-day production and consumption decisions (Dinar 2008). Policy needs to understand these autonomous adaptation decisions and provide the right incentives for positive and long-term forms of adaptation. In this respect, adaptation to short-term climate variability and extreme events can serve as the basis for reducing vulnerability to longer-term climate change (Baas and Ramasamy 2008; Field 2012). Past experience with agricultural technologies and natural resource management shows smallholders are more likely to adopt new practices when there is a close fit with existing practices and the social/environmental context (Below *et al.* 2010; Kassie *et al.* 2013).

This paper contributes to debates on adaptation by presenting an empirical study from two districts in Northern Ethiopia. Two questions guided the research: To what extent do smallholders' perceptions of climate variability correspond with meteorological data? What forms of diversification are smallholders pursuing? The rest of the paper proceeds as follows. Section 2 provides a literature review on perceptions of climate variability and on local adaptation. Section 3 gives a description of the research sites and research methods. Section 4 presents the results and discussion. This section starts by summarising smallholders' perceptions of climate variability before comparing these to meteorological data. It then describes the effects of climate variability, smallholder diversification within and outside agriculture as well as the sequencing of livelihood activities. The fifth section summarises the conclusions drawn from the research.

Literature review

Successful adaptation to climate change involves two steps: the perception of changes in climate and taking action in response to the perceived change (Maddison 2007). Many studies do not focus on perception but on the determinants of adaptation using models that combine climatic, biophysical and economic variables (McCarthy *et al.* 2001). While such studies are important, understanding people's experiences of climate variability is equally relevant: perception is crucial in shaping responses. For example, Adger *et al.* (2009, 346) argue that perception is one factor that constrains or facilitates decision-making for both individual and collective adaptation. This section therefore reviews two groups of studies: first, those that examine perceptions; and second, those that focus on local adaptation strategies.

Perceptions of climate variability

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It is clear that people experience changes in local weather patterns. These may not necessarily reflect long-term local and global trends in the climate. Nevertheless, drawing from behavioural research, many have argued that the perception of changes in the weather can play an important role in adaptation and in supporting climate policy (Howe *et al.* 2013; Clayton *et al.* 2015). Research from psychology and environmental psychology conducted in the North reveals the importance of perceived changes in temperature for action. Based on studies in the USA and Australia, Joireman *et al.* (2010) and Li *et al.* (2011) found individuals' perception of increased daily temperature correlates with a greater belief in global warming. It also increases the propensity to act. Moreover, based on a survey from 89 countries, Howe *et al.* (2013) found that most people perceive and adapt to local climatic changes and their perception largely correspond with patterns of observed temperature change from meteorological records. Turning to Africa, based on a survey from 10 African countries (including Ethiopia), Maddison (2007) analysed perceptions of and adaptation to climate variability. The results showed most smallholders perceived an increase in temperature and a decrease in rainfall and implemented some adaptation measures within existing institutional and financial constraints (see also Di Falco and Veronesi 2014).

There are only a small number of studies that focus on perceptions of climate change specifically in Ethiopia. Based on qualitative data from group and in-depth interviews in Northern Ethiopi, Meze-Hausken (2004) found smallholders strongly perceived a change in the climate even when meteorological records showed no reduction in total rainfall. A further study, by Deressa *et al.* (2011), applied the Heckman selection model to a sample of 1,000 households in five regions and found smallholders' perceptions of climate variability are related to age, wealth, social capital, access to information and agro-ecological settings. A more recent study by Kassie *et al.* (2013) examined farmers' perception in the Central Rift

and Kobo Valley areas based on a household survey of 200 farmers, interviews and group discussions. The findings showed smallholders in both areas perceived a change in their local climate and implemented various on-farm adaptation strategies, in particular by changing their crop mix. This brings us to our review of studies in Ethiopia that focussed on local adaptation.

Local adaptation to climate variability

Much of the empirical literature on rural Africa focuses on agricultural technology adoption. Although the importance of such adaptation measures is undeniable, it is debateable whether such technologies are easily accessed by the majority of smallholders in Africa. Moreover, as smallholder agriculture is highly sensitive to climate conditions, it is difficult to predict which technology is useful in a locality since climatic models do not predict scaled-down changes let alone threshold effects and non-linear changes in systems (Cannon 2014; Seo and Mendelsohn 2007).

Numerous studies suggest it is important to consider the autonomous adaptation practices that rural communities are implementing (see Cooper *et al.* 2008; Forsyth and Evans 2013; Campos *et al.* 2014). Strategies in smallholder agriculture often involve switching crop varieties and livestock species (Seo and Mendelsohn 2007), the use of irrigation, greater crop diversification and changing planting dates (Bauer and Scholz 2010; Mertz *et al.* 2009; Gebrehiwot and Venn 2013).

Previous studies on climate change in Ethiopia have focused on measuring the impact of climate change on agriculture (see Deressa 2007; Hailemariam 1999). These studies analysed the monetary impacts of climate change using Ricardian and agronomic models and

suggested water harvesting and irrigation as key adaptation options. However, such studies are limited in terms of offering insights into adaptation strategies at the micro level, because of their aggregate nature (Falco *et al.* 2011). The number of studies that have investigated local adaptation strategies are limited (Gebrehiwot and Venn 2013; Kassie *et al.* 2013; Legesse *et al.* 2013).

Gebrehiwot and Venn (2013) studied farm-level adaptation to climate change in Tigray, northern Ethiopia. Using a multinomial logit model and data from 400 smallholders, they found that the majority of farmers perceived an increase in temperature and a decrease in rainfall in the last two decades which matched climatic data. However, only half of the farmers that reported changes responded by adopting new strategies (including crop diversification, soil conservation, irrigation, planting trees and changing planting dates). Legesse *et al.* (2013) conducted a survey of 160 households from Doba district in Eastern Ethiopia and applied a multinomial logit model to identify factors influencing adaptation strategies. They found crop and livestock diversification, soil and water conservation practices, off-farm activities (such as piecework and harvesting natural resources) and rainwater harvesting as the dominant adaptation strategies. This study aims to complement these studies by offering an explicit focus on non-farm forms of livelihood diversification (see also D'Haen *et al.* 2014, 1). The Kassie *et al.* (2013) study is described above. We now turn to the research sites and research methods for this study.

Research sites and research methods

The study was conducted in Lasta and Beyeda districts of Amhara National Regional State, Northern Ethiopia. These districts were chosen due to their livelihood and vulnerability profiles which we now describe in turn. The two districts are part of different livelihood zones: Lasta comprises mainly the North East Mixed Cereal Livelihood Zone where the key crops are sorghum, teff, barley and wheat alongside legumes. Beyeda mostly consists of the North Highland Wheat, Barley and Sheep Livelihood Zone which is a mixed farming system dominated by wheat, barley, beans and livestock. Turning to vulnerability profiles, both districts are classified as food insecure and are served by the Productive Safety Net Programme (PSNP – see Weldegebriel and Prowse 2013). Beyeda faces food deficits every year. Almost all farmers depend on food purchases and food aid makes an important contribution to consumption for many households. Lastly, both districts have extreme climatic conditions. Lasta frequently suffers from droughts and was at the centre of famine in the mid-1980s. Beyeda is located in the foothills of the highest mountain range in Ethiopia with temperatures ranging from *werich* (very cold) to *weyna dega* (moderate). A full comparison of biophysical and socio-economic characteristics is presented in Table 1.

<Table 1 around here>

In terms of research methods, the study followed a broadly inductive approach to data collection. Fieldwork took place between May to August 2013 and included semi-structured interviews with key informants, focus group discussions and direct field observation.¹ Moreover, participatory techniques such as wealth-ranking exercises, historical timelines, seasonal calendars, transect walks and a problem-ranking matrix were conducted with smallholders in Lasta.

Smallholders' perception of climate variability and change were compared with rainfall and temperature records obtained from the nearest meteorological stations of Lalibela (for Lasta) and Debark for Beyeda (both run by the National Meteorological Agency). These data were monthly records of rainfall and maximum and minimum temperature for the period 1989–2011 for Lasta and 2000–2011 for Beyeda. Rainfall variability was calculated using the coefficient of variation (CV) on both a year-to-year basis (inter-annual variability) and for the whole period. Linear regressions and Mann-Kendall (non-parametric) trend tests were used to detect trends on temperature and rainfall data. We now turn to the results and discussion. As described above, this is split into four sections starting with smallholders' perceptions of climate variability and a comparison with meteorological records.

Results and discussion

Respondents in both districts stated they perceived increased temperatures and erratic rainfall patterns in the last two decades. We report results from Lasta before turning to Beyeda. In Lasta, respondents described a warming trend in the past five years with both minimum and maximum temperatures increasing. They also offered local indicators to support this increase in temperature: that smallholders used to wear locally-knitted clothes thick and warm enough to be used as blankets (*koborta* and *gabi*), now they use a very light cloth (*netella*). And that whilst fifteen years ago, *injera* used to stay fresh for 4 to 5 days it now becomes mouldy in 2 days.²

Respondents from Lasta stated that the short March – May rains (*belg*) are becoming more erratic and unreliable for crop production. The famine year of 1984 is frequently mentioned as a turning point for these changes. Smallholders in Lasta have relied heavily on *belg* rains for growing sorghum, millet and maize (referred to locally as *belage*). In addition to the changes in *belg* rains, participants in Lasta highlighted how precipitation is coming late and stopping early during the main rainy season (*kiremet*). Two or three decades ago, *kiremet* rains used to start as early as 12th June and finish in mid-September. *Kiremet* rains now arrive later, are erratic and stop earlier, sometimes in mid-August. Respondents referred to *kiremet* rains as a ‘fickle friend’. When referring to longer-term changes in the climate, smallholders in Lasta referred to land becoming *berha* which can be translated as ‘desert, unsuitable for both farming and livestock rearing’. This is a strong indication that farmers believe unusual weather patterns will lead to non-linear changes in agro-ecological conditions.

In Beyeda, respondents stated that changes in temperature are a recent and abrupt phenomenon. According to group discussions, for much of the dry *bega* season, they experience several days with temperatures oscillating between cold (in the mornings) and very hot (in the afternoons). Such conditions are very different from ten years ago. Respondents also offered local indicators of changes in the climate. For example, beer brewers are finding that during the dry season, their product, *tella* (prepared from barley, hops and spices), is fermenting at too high a temperature which imparts a harsh taste. Similar rainfall trends are reported as in Lasta with greater variability in the pattern of rains in both *belg* and *kiremet* seasons.

Respondents in both areas also highlighted an increase in extreme climatic events. In Lasta participants of both focus group discussions almost unequivocally agreed that since the mid-

1990s droughts now occur every three to five years. In Beyeda, respondents focused on greater intensity of rainfall leading to frequent flash floods which aggravates land degradation. These responses from smallholders were corroborated by interview data from key informants in district offices. We now turn to the analysis of meteorological data.

Meteorological data

Meteorological data for Lasta recorded rainfall and temperature measurements since 1989 with a brief interruption during the change in regime from 1990-1991. For Beyeda, records from Debark station were only available for the period 2000–2011. Temperature and rainfall data for the Debark station prior to the year 2000 are patchy with many missing data points and are unsuitable for trend analysis. The maximum and minimum mean temperatures across years for Lasta are shown in Figure 1. These data show a greater increase in the former than the latter. The mean maximum temperature in Lasta has increased by about 0.035 °C every year during the years 1989-2011 indicating a warming trend over the past two decades. Figure 2 shows the data for Beyeda. Here, maximum average temperature shows an increasing trend (increased by 0.05 °C per year) while the minimum temperature did not show a marked trend. We implemented a linear regression model to test the existence of a trend for temperature and rainfall data and then used the Mann-Kendall trend test on data that have shown a reasonably high R-squared value to check for statistical significance.³ A significant trend was detected for the annual mean maximum temperature data from the two districts (at the 99% level). The trends with their linear regression equations and coefficient of determinations (R²) are summarized in Table 2.

The figures on rainfall are shown in Table 3. Here we find no increases or decreases in total rainfall in either Lasta or Beyeda ($R^2=0.0001$ and 0.0223 , respectively). In addition, recent trends in *belg* and *kiremet* rains in Lasta do not show any marked changes. However, in Beyeda, *kiremet* rains are stable over the period (2000-2011) while, interestingly, *belg* rains show a slightly increasing trend ($R^2=0.27$, $p<0.10$).

<Table 2 around here>

<Table 3 around here>

Moreover, rainfall data also show interesting changes in variation around the mean. We use the coefficient of variation because we require a relative and not absolute measure of dispersion. The data for Lasta (1989-2011) showed moderate inter-annual variation based on a range of 338-1002 mm (CV=26.3%). Rainfall in the *belg* season shows greater variability within a range of 23-310.9 mm (CV=61%). The *kiremet* rains showed moderate variation with a range of 153.4-893.6mm (CV=34.5%). Overall, these data suggest a small degree of compensation between seasons: in other words, rainfall shortages in the *belg* tend to be slightly compensated for through greater amounts of *kiremet* rain.

In Beyeda, inter-annual rainfall variation is less than Lasta and has a tighter range of 810–1357 mm (CV=14.4 %). *Belg* rainfall also displays less variation than Lasta within a smaller range of 41.2-219.6 mm (CV=54%) as does the *kiremet* rainfall (which ranged between 740-

1198mm - CV=13.8%). In Beyeda capricious *belg* rains appear to be compensated by more stable *kiremet* seasons.

Rainfall anomalies (defined as deviations from the ten and twenty-one year mean rainfall figures for Lasta and Beyeda, respectively) compared to moving averages are given in Figures 3 and 4. In neither district does total annual rainfall show an increasing in the anomalies over time; rather, their distributions remain relatively stable with the number of deficit years more or less equalling those with above-average rainfall.

To summarise, then, the analysis of rainfall and temperature records shows maximum temperatures to be increasing, while there is no apparent decline in rainfall amount. The data also show greater rainfall variation in Lasta than Beyeda. Moreover, they show greater variation in the *belg* than in the main *kiremet* season in both districts. This last result chimes with climatological studies that have analysed long periods of rainfall and temperature trends in Ethiopia (Conway et al. 2004; Seleshi and Zanke 2004).

Comparison of meteorological data with smallholders' perceptions

Whilst maximum temperature records are consistent with smallholders' perceptions of higher temperatures in both districts, rainfall data show no significant decline which, overall, conflicts with smallholders' assertions. This tension is most severe when we compare those years highlighted by smallholders as drought years. In Lasta, both 2002 and 2005 were highlighted as a drought year, but the rainfall records show that both *belg* and *kiremet* seasons had average rainfall in 2002 and higher-than-average in 2005. In contrast, the more recent rainfall deficit, in 2010, was not flagged by smallholders as an extreme year.

There are different ways of interpreting these discrepancies. One is that the spatial distribution of rainfall was such that the experience of participants did not correlate well with that of the meteorological stations. This highlights the deficiencies of such a small-n qualitative study and the lack of observations within the meteorological data. A further interpretation is that farmers responded to the low rainfall in 2001 and 2004 to categorize 2002 and 2005 as drought years. One final interpretation is that the discrepancy highlights an important but subtle difference between farmers' perceptions and climate records; namely, that farmers' perceptions are heavily influenced by irregularities in the patterns of rain – the onset, duration and cessation – rather than by the amount of rain. Such information is lacking in aggregate rainfall records.

Effects of climate variability

The effects of climate variability are discussed here in terms of agriculture, livestock, disease and social reproduction, beginning with agriculture. Respondents in Lasta highlighted how the frequent dry spells in the rainy season are affecting teff yields, which have declined in recent years. The late onset of *belg* rains was also highlighted as a key factor in the reduced production of millet and sorghum. Focus group discussion participants from Beyeda indicated a different set of challenges: hail storms and frost, coupled with more erratic rains, are damaging barley and wheat crops. In both districts, all key informants highlighted that the increase in temperature along with variability in rainfall poses a risk to their livelihoods.

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2 In Lasta, all respondents in focus groups mentioned an increase in livestock diseases
3 associated with increasing temperatures and a lack of water. Some respondents explained
4 how higher temperature can create more favourable conditions for the spread of skin diseases
5 amongst cattle. Key informants suggested a slightly different mechanism for the greater
6 incidence of disease: namely that changes in climatic conditions reduce the availability of
7 fodder and water, leading to greater contamination of different herds. Examples include
8 infestations of tick-borne diseases that cause lumpy skin disease (*gureb-reb*), foot-and-mouth
9 disease and anthrax (*aba-senga*). Respondents in Lasta also highlighted less human morbidity
10 from the new climatic variability: that malaria incidence in low-lying (*kola*) villages had
11 showed a marked reduction in recent years. Respondents related this to the frequent dry spells
12 and shortages of rainfall. Lastly, women highlighted how higher temperature means that food
13 (*injera* and stew) has to be consumed immediately now, placing a greater burden on women
14 and girls who expend more energy on cooking more frequently. Moreover, the greater
15 distance to collect water has further increased the social reproductive burden they carry. The
16 main impacts of climate variability on livelihoods are summarized in Table 4. We now turn to
17 diversification within agriculture before turning to diversification outside agriculture.
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45 **Diversification as an adaptation strategy**

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49 Climate variability forces farming communities to adapt to dynamic environmental
50 conditions. The maintenance of a diversified resource or income base helps reduce
51 vulnerability by spreading risk (Kelly and Adger 2000; Macchi *et al.* 2008,18). In view of
52 this, we examine livelihood diversification strategies in both districts. As in the case for most
53 rural parts of Ethiopia, smallholders in the districts rely largely on mixed agriculture i.e. crop
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and animal husbandry. Here, however, we discuss two broad categories of diversification; within and outside agriculture.

Diversification within agriculture

The role of farm diversification on the viability and vitality of agriculture is well documented (Barnes *et al.* 2015; Hansoon *et al.* 2013). In the context of climate adaptation, the use of crop varieties and livestock species well-suited to drier conditions, irrigation, crop diversification, and changing planting dates are identified as the most common adaptation methods (Bradshaw *et al.* 2004; Hassan and Nhemachena 2008; Kurukulasuriya and Mendelsohn 2006).

In Lasta, on-farm diversification takes two forms. First, participants in the Productive Safety Net Programme (PSNP), which conducts water and soil conservation measures (such as creating terraces, check-dams and afforestation measures) on public land (common pool resources), also apply such measures on their own land. This leads to a more diversified cropping system. A good example is shown in Box 1. For example, in recent years smallholders have started to harvest rainwater to irrigate land and to grow perennial crops and trees instead of cereals. Second, bee-keeping has been encouraged by local government through training sessions and credit.⁴ This has had some success with smallholders supplying honey to Lalibela town. In Beyeda, respondents have started planting early-maturing varieties of barley (used as malt for brewing beer). But according to one key informant, such on-farm diversification is only undertaken by a handful of model farmers. A further form of crop diversification is growing eucalyptus trees for sale. Discussions with key informants revealed that because of attractive prices for eucalyptus trees and *gesho* (hops) at the local market,

many farming households have recently begun to harvest rainwater to irrigate their land (see Box 1). Some have shifted from cereals to growing perennial crops and trees. Similar rainwater harvesting techniques are found to be the most popular adaptive strategies among smallholder farmers in South Africa (see Gandure *et al.* 2013). This finding also chimes with Di Falco and Chavas' (2009) investigation of how the genetic diversity of crops contributes to farm productivity and reduces the cost of weather risks.

Box 1 - A case of successful smallholder adaptation

Amanuel Bereket, a priest in a local Degosach parish, Lasta, is a father of 6 children. He was born in the same village and recalls two devastating droughts and the resulting famines. He remembers losing two of his close relatives in the 1984 famine. He owns one hectare which he uses to grow teff. He claims his experience of the frequent droughts and crop failures has thought him a good lesson on the need to harvest and conserve water. He first volunteered part of his farmland for a model water-harvesting schemes, and then learnt the skills to use and maintain the well. Later on, he dug up another two water-wells in his yard and began to grow fruits and vegetables on a small patch of land. After five years of hard work, he was able to save money that he used to borrow land from other farmers and started breeding sheep, bee-keeping and growing gesho (hops) as a cash crop. Now, he owns a local shop/kiosk and hopes to expand his business.

Diversification outside agriculture

Diversification away from farming one's own land is driven by multiple processes including changing landholding patterns and demand for non-farm goods and services. It creates opportunities for accumulation as well as cushioning smallholders from losses due to climatic variability (Debela *et al.* 2014). Although the role of non-farm diversification within the rural development is very well-documented, there is less discussion within the adaptation

literature (see Cannon 2014). Thus, there are only a few studies that demonstrate the positive role of diversification away from farming as an adaptive strategy. For instance, Bryan *et al.* (2009) demonstrate how non-farm activities have the most positive effect in encouraging adaptation options in agricultural livelihoods in Ethiopia and South Africa (see Bryan *et al.* 2009). Diversification outside agriculture may also occur either as a deliberate household strategy (by design) or as an involuntary response to a crisis (by default) (Ellis 1998). The former usually involve non-farm activities in manufacturing or service sectors, whilst the latter are often termed off-farm activities and include piecework on other farmers' land or harvesting natural resources.

Overall, in both districts, diversification away from seasonal agriculture can be broadly categorized in line with Warren's (2002) classification: a wage labour path and a self-employment route. We discuss the findings from Lasta before turning to Beyeda. We conclude the section by discussing the sequencing of diversification strategies.

Respondents in Lasta highlighted the limited opportunities for diversifying livelihoods into non-farm activities in their villages. Existing diversification strategies are to a large extent seasonal and depend on demographic characteristics (mainly age and gender) and wealth group. Key informants explained that as *belg* rains are becoming unreliable and *belg* agricultural production is now uncertain, young adults tend to engage in seasonal migratory wage labour to neighbouring regions: to Raya for agricultural wage labour and sometimes as far as Humera for commercial sesame production. Young adults who have family obligations, such as elderly parents or young children, prefer to engage in daily wage labour (*shekel*) in nearby Lalibela town mostly in the burgeoning construction sector that pays a daily rate of 35-40 Birr.

The poorest households also engage in wage labour, especially in the government's public works activities (the PSNP) and/or in local piecework (weeding, harvesting, threshing) within their village (a form of off-farm activity). Some better-off households engage more in self-employment, especially in more profitable non-farm activities such as trading oxen, sheep and goats.

Respondents also revealed that household participation in other forms of self-employment such as carpentry, masonry or by working as a blacksmith can, as this is manual work, carry a certain social stigma. This can also be the case for petty trading through preparing and selling local food and alcoholic beverages, activities which are mostly pursued by women-headed households (who often lack land, oxen and enough household labour for farming).

Most non-farm activity occurs in the months outside the growing seasons (mainly October–December). This not only indicates the timing of greatest annual demand for non-farm goods and services, but highlights the competition for household labour between farm-based and non-farm based livelihood strategies. Households thus have to make decisions about how to allocate labour resources efficiently: how to engage in non-farm and off-farm activity without jeopardising farm production. A good example of this concerns the public works component of the PSNP. Here, participants are expected to contribute labour for six months within their village. As a result, many poor farmers prefer to engage in locally available off-farm activities rather than engaging in non-farm activities elsewhere. A good illustration of the range of wage employment available in Lasta can be gleaned from Box 2.

Box 2 - One farmer's view on wage employment as a form of diversification

Kassalem Mulugeta, 35, is from Medage village, Lasta district, he is married and has two children. He completed the 6th grade of education.

“I have less than half a hectare of land that I mostly use to cultivate wheat. In the last meher season, I only managed to harvest 150kgs, not enough to feed my family for four months. Therefore, I consider myself poor, though slightly better than those who do not have either farmland or able-bodied family members. Since my income from agriculture is barely enough, I always try to earn extra income by engaging in non-farm activities a few months outside the agriculture season. I am participating in the public works programme and contribute labour to terracing and check-dam construction. Most of the activities involve hard physical labour and one has to work for 15 days per month to earn 19.5 Birr per day. This payment is given in cash for two months and in-kind for four months. I consider the public work payment very low, but I am not complaining, because I consider it to be a way out of misery for farmers like myself who are able-bodied and healthy. I always dream of going to the big cities like Desse and Addis Ababa to work hard, earn more and live a decent life but I cannot afford that because my kids are too young and I have to support my ailing mother. The public works last until the end of June. After the rainy season, I take on locally available labour usually in harvesting and threshing [off-farm], earning some cash which I use to cover some expenses. The wage rate for such activities varies and depends on the employer’s discretion ranging from 20-30 Birr per day. Occasionally, I travel to Lalibela and look for wage labour mostly in the construction of houses and buildings earning 35 to 40 Birr per day”.

Compared to Lasta, livelihood diversification in Beyeda is more limited with few opportunities for smallholders to engage in different activities. In terms of wage employment, seasonal migration for sesame production (to Humera) is common. Participants highlighted how the lack of credit and infrastructure (including an all-weather road and market place) were key obstacles in pursuing non-farm activities, especially trading. Cultural barriers were also mentioned as limiting farmers’ participation in manual self-employment. These cultural impediments also extend to renting mules to tourists and their scouts. Mule ownership has

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2 long been a status symbol in some of the remotest villages but renting-out mules to tourists
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4 can be frowned upon by villagers as an undignified way of earning income. It is important to
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6 note that in both districts respondents did not volunteer information about one off-farm
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8 activity that was widespread – charcoal production – as this is illegal.
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11 12 13 *Sequences of livelihood strategies* 14 15

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17 Although surpluses generated from non-farm activities can provide farmers with income for
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19 on-farm investment, interviews with key informants revealed that little income generated
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21 from non-farm activities is reinvested into farming. It seems that households are only able to
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23 reinvest in agriculture when non-farm work is short-term and the farm work is not
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25 constrained by a shortage of land, oxen or any other input. Otherwise, smallholders tend to
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27 engage in non-farm activities to earn cash to ensure the household's access to food and so
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29 smooth consumption until the next harvest season. Key informants also disclosed that
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31 earnings from non-farm activities are often used to repay debt or finance social and cultural
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33 events such as marriage and *tezkar* - a memorial feast for a deceased family member.
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40 In sum, diversification away from agriculture is highly seasonal and largely follows a wage
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42 path rather than a self-employment path. Wage labour is the dominant diversification activity
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44 in both districts with smallholders constrained in their ability to enter self-employment due to
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46 a lack of regular demand, skills, finance as well as cultural attitudes.
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51 Within the wage path, we see two tracks. On the one hand, asset-poor households (lacking
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53 land and oxen, and often with a large family size) engage in sharecropping arrangements
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55 (where labour is exchanged for a portion of the harvest) and piecework (on neighbours' land)
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57 rather than sending able-bodied members in search of better opportunities further afield (a
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form of risk aversion which maintains security in the short term but reduces the likelihood of accumulation in the long term). On the other hand, wealthier households send household members further but with clear intra-generational issues. Young adults in such households are keen to engage in the non-farm sector outside their village and demand resources from their household to cover the costs of migration. However, household heads are often reluctant to invest in migration (to places as far as Saudi Arabia) not only because it is costly but also they are unsure if they will receive regular contributions to the household in the form of remittances. Some studies suggest that weather anomalies are likely to increase rural–urban and international migration in sub-Saharan Africa. For example, Marchiori *et al.* (2012) predict that the net environmental migration in response to climatic anomalies in Ethiopia ranging between 5.21 to 7.38 (per thousand of population) from 2000 to 2099, which is the highest in the region.

Moreover, the findings from the two districts clearly reflect the role of location. Despite both districts being major tourist destinations, the proximity to Lalibela town and access to roads and markets to bigger cities such as Dessie and Bahir Dar seem to be the decisive factors in opening-up opportunities for pursuing diversified livelihoods in Lasta district. Improving access to infrastructure appears to be a good avenue for promoting the non-farm rural economy in both districts.

Conclusion

This article has examined perceptions of and adaptation to climate variability and change in two districts in Northern Ethiopia. It has examined the extent to which smallholders diversify

1 within and outside agriculture. We have found that whilst meteorological records support
2 smallholders' perceptions regarding an increase in temperatures, claims of a reduction in
3 rainfall is not reflected in meteorological records: highly variable *belg* rains are compensated
4 for by more stable *kiremet* rains. Most of the adaptation within agriculture comes through
5 demonstration effects from state-led schemes whilst diversification away from farming is
6 mainly wage labour differentiated by wealth group.
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18 There are subtle but important differences between the two districts that highlight the role of
19 both climatic and non-climatic factors in adaptive capacity. Livelihood diversification in
20 Beyeda is more limited than in Lasta where non-farm diversification appears to be growing
21 due to the proximity to urban opportunities and a construction boom (triggered by public
22 investments). But within Lasta a wide range of factors such as asset holdings and socio-
23 demographic considerations such as household size, education, skills and cultural attitudes
24 influence the choice of diversification strategy at the household level. Many broad socio-
25 economic factors are framing adaptation pathways at the local level.
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38 On a wider note, our findings highlight how the source of demand for non-farm
39 diversification may well be found outside agriculture. Higher temperatures and more variable
40 rainfall patterns associated with climate change mean it is likely there will be less fertile
41 agricultural land available. In this context, the ability to increase land productivity to
42 stimulate consistent and stable agricultural growth will become increasingly difficult, limiting
43 incomes and demand for non-farm items (e.g. from vending, petty trading, provision of
44 everyday services).
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55 Our limited data from Northern Ethiopia suggests that non-farm diversification is occurring
56 mainly through wage labour: international, national and regional for wealthier households,
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local and on public works schemes for poorer households. In this context, policymakers could do worse than look more at how urban-rural connections can support smallholders' adaptation efforts.

For Peer Review

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Figure 1 - Maximum and Minimum Temperature in Lasta, 1989–2011.

Source: NMA data from 1989-2011

Figure 2 - Maximum and Minimum Temperature in Beyeda, 2000–2011

Source: NMA data from 2000-2011

Figure 3 - Anomalies in annual rainfall in Lasta, 1989–2011

Source: NMA data from 1989-2011

Notes:

The dotted line shows anomalies of annual rainfall compared to the 21-year mean rainfall (1989–2011) period.
The solid line shows a five-year moving average.

Figure 4 - Anomalies in annual rainfall in Beyeda, 2000–2011

Source: NMA data from 2000-2011

Notes:

The dotted line shows anomalies of annual rainfall compared to the 10-year mean rainfall (2000–2011) period.
The solid line shows a two-year moving average.

Table 1 - Biophysical and socio-economic characteristics of study areas

<i>Characteristics</i>	<i>Lasta</i>	<i>Beyeda</i>
Biophysical characteristics		
Altitude	1400-4200	1900-4437
Annual mean temperature (°C)	16-21	8-20
Annual mean rainfall (mm)	600–900	1172–1700
Dominant soil type	Leptosol and Vertisols	Vertisols
Topography	50 % mountainous	70 % mountainous
Socioeconomic characteristics		
Total population (2012)	129,464	105,482
Area in km ² (2012)	1119.35km ²	973.05 km ²
Population density (per km ²)	115.7	108.4
Arable land	70,163 ha	43,562 ha
Distance from regional capital	260 km	410 km
Production activities		
Farming system	Northeast Mixed Cereal	North Highland, Barley and Sheep
Major food crops	Sorghum, teff and barley	Barley, wheat and beans
Livestock	Cattle, goat and sheep	Sheep, cattle & horse
Food insecure population (2009)	42,356 (40 %)	40,610 (36%)

Source: District Agriculture and Rural Development Offices, 2013

Table 2 - Statistics on temperature data for both districts

Station	Record period	MT (°C)	OLS cof.	R ²	MK	S
Lalibela (Lasta)	1989–2011	Maximum	0.0349** (0.0117)	0.31	0.333**	70
		Minimum	0.0153 (0.0121)	0.07	0.28	54
Debark (Beyeda)	2000–2011	Maximum	0.0524* (0.0160)	0.57	0.60**	27
		Minimum	-0.0044 (0.0210)	0.00	0.00	0.00

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: computed from NMA data.

Notes:

MT= Mean Temperature

OLS cof.= Ordinary Least Square coefficients that measure the effect of time on temperature.

MK= Kendall's tau

S= M-K test statistic or the Kendall score

Table 3 – Statistics on rainfall data in both districts

Station	Record period	Season	MR (mm)	St.Dev	CV (%)	Trend
Lalibela (Lasta)	1989–2011	Belg	122.0	74.6	61.0	0.12
		Kiremet	547.7	188.9	34.5	0.04
		Annual	713.5	187.5	26.3	0.00
Debark (Beyeda)	2000–2011	Belg	116.3	62.6	53.9	0.27*
		Kiremet	933.7	129.5	13.8	0.01
		Annual	1098.1	158.1	14.4	0.02

Source: computed from meteorological data

Notes:

*Trend statistically significant using Kendall's tau at $p < 0.10$.

MR = Mean Rainfall

St. Dev= Standard deviation

CV= Coefficient of variation (St. Dev divided by the mean)

Trend is indicated by coefficient of determination (R^2)

Table 4 - Effects of Climate Variability and Change on Agricultural Activities in Lasta and Beyeda

Climatic factors	Perceived impacts	Cases
Increased temperature	Increased hot and dry-spells affecting crop and livestock production Increased pest and disease incidences	Crop failure for teff, <i>ageda-korkur</i> (maize stalk borer) affecting maize and sorghum and <i>plusia warm</i> affecting barley and sorghum in Lasta <i>Yegebs kish-kish</i> (barley aphid; Russian wheat Aphid) affecting both crops in Beyeda
Delay of onset of rains and early set-off	Reducing length of growing period	Frequent crop failures in Lasta are associated with the delay in rainfall in the <i>belg</i> and <i>kirmet</i>
Unseasonal rains	Damage to standing crops	A few cases are reported during the dry season in Beyeda
Increased frequency and magnitude of drought and floods	Drought results in lack of water and fodder for livestock and crops. Flash floods cause livestock deaths can destroy homes and farmland	Droughts are more frequent in Lasta. Crop pests, animal diseases, and loss of income from damages to crops and livestock is reported in both Lasta and Beyeda.

Source: Key informant interviews and group discussions, 2013

¹ Key informants were purposively selected. They included: four smallholder farmers from Medage and Nakuteleeab kebeles, Lasta, and Watti and Ayiga kebeles of Beyeda. one expert from Amhara Region Food Security Coordination Office, one officer from Amhara Region Agriculture and Rural Development Office; and two PSNP coordinators from each district. Three FGDs were held, one in Beyeda and two in Lasta, involving 26 farmers. Prior to focus group discussions and key informant interviews, kebele chairpersons in each kebele suggested possible respondents.

² Injera is a staple food in many parts of Ethiopia. It is a sourdough-risen flatbread usually made out of teff, millet and/or sorghum.

³ The linear regression analysis is used with time as the independent variable and temperature or rainfall as the dependent variable. This method is extensively used in climate change studies (Cheung *et al.* 2008; Río *et al.* 2011). After checking the model for the critical assumptions, the t-test (parametric test) was used to assess if the slope's coefficient of the fitted linear regression is significantly different from zero, indicating the presence of a linear trend. We used the Portmanteau test for white noise in Stata to check for autocorrelation. Maximum temperature data from both districts have passed this test showing no serial correlation. These data also passed the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. Following Yue and Hashino (2003), the non-parametric (distribution free) Mann-Kandall (M-K) test has also been applied to assess the significance of monotonic trend. The test also confirmed the existence of significant upward trends in annual mean maximum temperature in the two districts.

⁴ According to figures obtained from the district Agriculture and Rural Development Office, there were about 1237 participants in training activities in 2013.

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