

Dynamics of rural livelihoods and rainfall variability in Northern Ethiopian Highlands



Muluken E. Adamseged^{a,*}, Aymen Frija^b, Andreas Thiel^c

^a Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany

^b International Center for Agriculture Research in the Dry Areas (ICARDA), Tunisia

^c University of Kassel, Germany

1. Introduction

The livelihood security and well-being of rural households continue to be of prime concern for policy and development agendas in Africa (Ziervogel and Calder, 2003; Agrawal, 2008; Ulrich et al., 2012). Rural households face numerous livelihood security challenges resulting from climate variability, land use change, population growth and political challenges. The expected and increasing frequency of climate variability (Boko et al., 2007) is among the major threats rural households are facing, with rainfall variability in particular being regarded as the most significant climate variable affecting farm household's livelihoods (Brooks, 2003; Hulme, 2001; Teka et al., 2012; Egeru, 2016).

Rural households in Ethiopia are still largely agrarian, and agriculture is a main source of income and employment. Over 90% of producers there are considered to operate small-scale mixed, subsistence farms, relying on rainfall for water. Yet the livelihoods of rural households are not merely dependent on farming but also increasingly on non-farm activities that serve as additional sources of income. In fact, the literature suggests that rural households are becoming less dependent on agriculture and its related activities (Ellis, 2000b; Teka et al., 2012), and there is ample evidence of the growing importance of non-farm livelihood activities over the last two decades (Bryceson, 1999; Ellis, 2000a; Carswell, 1997, 2000; Barrett et al., 2001a; Lemi, 2006). In addition, systematic efforts have also been made to investigate the relevance of non-farm livelihoods and their links with policies aimed towards rural poverty reduction strategies (Ellis, 1999; Scoones, 1998; Carswell, 1997; Woldenhanna and Oskam, 2001; Tesfaye et al., 2011). The works of Baird and Gray (2014) characterize the nature of inter-household exchange of material goods and livelihood diversification using case study in northern Tanzania.

The benefits of livelihood diversification mainly favor the better-off households in SSA but it still provides a safety net for the rural poor and sometimes offers a means for upward mobility (Loison, 2015; Barrett et al., 2001a). The contribution of non-farm economic sector is significant through creating job opportunities for millions to support their livelihoods despite the less policy and institutional support it receives from the formal sector (Hilson, 2016). While the works of Ellis et al. (2003) has put diversifying livelihoods toward non-farm enterprises as one of the four components which can be used by poor rural Malawians to confront severe constraints in their livelihood. But the works of Bryceson (2002) stated the livelihood diversification has not generated adequate over-all levels of gainful employment and welfare employment and thus recommend for further probing in the complex interplay of dynamics in rural Africa.

Resilience refers to the capacity of individuals, or social groups to adapt to stress and turbulences, to self-organize and to learn in order to sustain basic structures and functions or in order to improve them (Berkes and Folke, 1998; Carpenter et al., 2001; Walker et al., 2002; Berkes et al., 2003). Thus, it helps to understand the factors that enable actors to shield their livelihoods from adverse outcomes of change (Speranza and Rist, 2014). Access to capital enables households to be resilient while others could remain vulnerable because they constrained in accessing resources and engage in non-diversified livelihoods (Thulstrup, 2015).

* Corresponding author at: Max-Eyth-Allee 100, 14469 Potsdam, Germany.

E-mail address: MAadamseged@atb-potsdam.de (M.E. Adamseged).

The capacity of range land users in south Africa to cope with drought is mainly influenced by the resilience of their agro-ecosystems, the diversity of livelihood options, access to resources and institutional support (Vetter, 2009). But the current policy approach in the country does not enhance users' resilience to drought and other shocks. The works of Stringer et al. (2009) in South Africa has showed that the current approaches towards adaptation are insufficiently mainstreamed within broader development approaches. Poorly planned participatory processes and the lack of context-specific approaches Nkoana et al (2018) and policy misfit (Bunce et al., 2010) are considered as obstacles to strengthen resilience of communities. Whereas Arnall (2015) recommend to give more attention to facilitative, as well as constraining nature of structures to support vulnerable communities. Focusing on the drought and desertification problem in SSA savannas the work of Falkenmark and Rockström (2008) an integrated land/water approach to supports agricultural development to build social-ecological resilience to droughts and dry spells. While the works of Elmqvist and Olsson (2006) stated the interaction of driving forces, regional differences and a large variability in incomes between households as factors affecting the resilience of a community to drought.

However, existing studies have mainly used cross-sectional data to assess livelihoods and their relationships with rainfall variability and/or household socio-economic factors at one point in time (static point of view), without reflecting upon dynamic changes in household livelihoods. These have been criticized for lacking the ability to address shifts in rural economies (Mushongah and Scoones, 2012; Addison et al., 2009; Scoones, 2009; Loison, 2015; Liu and Liu, 2016). Static analyses have limited explanatory power (De Haan and Zoomers, 2005; Addison et al., 2009; Scoones, 2009; Thiede, 2014) and are ill-suited for livelihood studies in dynamic economic, social, political and environmental scenarios, making them tend towards unreliable conclusions which can further lead to biased economic policies and strategies. To date, only a few studies (Berg, 2010; D'haen et al., 2014) have investigated the dynamics of rural livelihoods with regard to climate variability conditions such as natural disasters or rainfall variability.

The present study examines the dynamics of non-farm livelihood activities engaged in by rural households in Ethiopia, investigating the effects of variability in rainfall and household socio-economic conditions on household decisions to participate in non-farm activities. Based upon a 15-year panel data set, a dynamic livelihoods approach (De Haan and Zoomers, 2005; Addison et al., 2009; Scoones, 2009; Thiede, 2014) is employed to investigate non-farm livelihood options and their associations with different factors. Such an approach provides powerful analytical tools through incorporating panel data livelihood activities, rainfall and household socio-economic variables. In this way, the study aims to address two research questions. First, it assesses how the dynamics of non-farm livelihood activities of rural households in Ethiopia have changed over the last 15 years. Second, it investigates how rainfall conditions and socio-economic characteristics have affected household decisions to participate in non-farm livelihood activities overtime.

2. Rural livelihoods and rainfall variability in Ethiopia

Non-farm livelihood activities may serve as additional sources of income, to complement farming, or, for some rural households, as sole livelihood sources (Ellis, 1999, 2000a; Reardon, 1997; Lanjouw and Lanjouw, 2001). For a variety of reasons, households are increasingly obliged to take on livelihood activities outside the agricultural sector, generally either to pursue improved and sustainable livelihoods (Barrett et al., 2001b) or to cope with diverse types of shocks (Ellis, 2000a; Block and Webb, 2001).

The works of Kebebe and Shibus (2017) has showed that participation in alternative livelihood activities has contributed to increment in total grain production, increased household income and adoption of natural resources management technologies. Further they showed that households with alternative livelihood consumed more diverse food across food groups and earned more income from local market sales of tree and fruit seedlings. Similarly the works of Alemu and Adesina (2017) stated that households engaged in non-farm activities have better livelihood. To this end, they further argue that policies to improve infrastructure, credit and extension, and promote rural cooperation would enhance smallholder enterprise development.

Although few in number, some efforts have been made to understand the relationships between non-farm livelihood activities and environmental, mainly rainfall variability and drought. In rural Burkina, household decisions to participate in non-farm activities are said to be determined by adverse rainfall conditions in the major staple food production zone of the country (D'haen et al., 2014). Meanwhile, Demeke et al. (2011) analyse the effect of rainfall on Ethiopian rural households' food security and vulnerability over time, with their results showing that the level and variability of rainfall are important determinants of persistent food insecurity and vulnerability. Likewise, Abegaz (2017) using the Ethiopian Rural households survey found out that households food security status is significantly affected by rain shock, lack of off-farm income and region where the households are found.

In Northern Ethiopia, Morrissey (2013) finds that environmental stress, in terms of disadvantageous rainfall patterns (variability and reduced amounts), shapes migration through its impact on migration drivers. At the household level, these impacts are principally manifested in decreased household production, but they also express themselves within the broader socio-cultural, political and economic context. Gray and Mueller (2012) provide robust evidence that drought increases long-distance and labor-related migration by men in Ethiopia.

In the central Highlands of Ethiopia, rainfall is found to be highly variable, with more extreme rainfall during the start of the Kiremt¹ season (Rosell, 2011). The conditions for growing cereal during that season have been relatively similar during the past 30 years. However, in the last decade it has become almost impossible to produce cereals during the Belg² season. According to Teka et al. (2012), rain has been extremely unpredictable and erratic with a coefficient of variation ranging from 18% in the midlands to

¹ Kiremt refers to the primary rainy season and main growing period in Ethiopia, ranging from June to September.

² Belg refers to the short rainy season, which ranges from January/February to April/May, with slight variations from place to place.

42% in the lowlands of the Eastern Tigray region. The same study also shows that livestock possession per household in the last two decades has been negatively correlated with time in most of the studied villages, although the number of pack animals has significantly increased due to farmers shifting to off-farm activities, as they are used to transport grain, salt, sand, stone, firewood and charcoal for trading in neighboring towns or market places (Teka et al., 2012). The study on Ethiopia coffee arabica has showed that production could decline dramatically in the coming decades (Hirons et al., 2018).

The literature review on livelihoods and rainfall has revealed that there is an important gap regarding the dynamic dimension of rural livelihoods in Ethiopia and a need for more studies investigating how livelihood patterns change over the years. More importantly, there has been a lack of investigation into how rainfall, or lack thereof, affects livelihood patterns and household decisions to take part in different livelihood options. This paper is, thus, particularly aimed towards filling this gap by using a 15-year panel data of rural Ethiopian households, which allows insights into dynamics of livelihood change there over time.

3. Study areas

The research is conducted in two Kebeles – Shumsheha and Harresaw. Shumsheha is located in the Lasta *woreda*³ – North Wollo zone in the Amhara region – one of the drought-prone areas in Ethiopia (Fig. 1). The total area of the Kebele is 6037 ha, of which 2679 ha is cultivated. It is located between 1500 and 2000 m above sea level (masl) and is adjacent to the tourist destination town of Lalibela. The area has one primary rainy or Kiremt and a short Belg seasons. The beginning of the main rainy season is in the first week of July, with annual average rainfall being about 600 mm. In recent years, farmers have become almost totally dependent on the main rainy season to grow crops, due to frequent failure or shortage of rain during the Belg not supplying enough water for crop production. It is one of the areas that was affected by the major droughts of 1972, 1984 and 1994 (Ali and Tafesse, 1996). The community's limited access to irrigation depends on canals constructed on small rivers. During the dry season, availability of water for irrigation is quite low, and the number of households having access to irrigated water decreases significantly.

Shumsheha has a total of population of 4530: 2240 males and 2290 females. Farming and animal husbandry are the dominant economic sectors. The main crops harvested in the area include beans, teff, sorghum, barley and wheat. In recent years, the number of households growing fruits and vegetables using irrigation has been increasing. Oxen, cows, sheep, and chicken are the main livestock in the community. Shumsheha has its own local market once per week and access to a large market in Lalibela. Most of the community has access to all-weather roads. The nearby airport, road construction and other developmental activities create a variety of job opportunities for the community outside farming.

Harresaw Kebele is located in the Atsbi Wemberta *woreda* in the Eastern Tigray zone (Fig. 1). It is located between altitudes of 2700–3000 masl, and land degradation is a serious problem for farming. Rainfall is increasingly unpredictable, unreliable and, over time, its amount has decreased significantly. The mean annual rainfall for Harresaw ranges from 300 to 500 mm, and there is only one main rainy season (July–September), as the *Belg* has often failed for the past two decades. Rivers flow mainly during the rainy season, and there are some small, private, ponds and water points in some parts of the Kebele. The area is frequently affected by drought, strong winds and frost, which severely affect crop production and animal husbandry. The community has very limited and unreliable access to irrigation, with the main source being from a dam constructed by the government two decades ago. The dam fills with water only during the main rainy season. Thus, access to irrigated water is very limited, in particular during the dry season.

The total population of the Harresaw is 6307: 3091 males and 3216 females. The main source of livelihood is mixed farming (crop production and animal husbandry). Crops such as barely, wheat, beans, lentils, peas and sorghum are the main ones harvested. Unlike the Shumsheha community, the area does not grow any fruits or vegetables. The main types of livestock include sheep, goats, oxen, cows and donkeys. The main non-farm activity which households are often engaged in is migrating far distance to find work and send remittances. Other non-farm activities like petty trade or wage employment are very limited.

4. Methods

4.1. Data set

This study used four rounds of panel data sets: three rounds of the ERHS⁴ (1999, 2004 and 2009) and primary own household survey (2015). The primary household survey was collected using the same kebeles and sample households of the ERHS. The data used for this study is collected in early 2015 from 204 households, during three months of fieldwork, using structured and semi-structured questionnaires. So as to keep the data source consistent, the same definition of terminologies is used while preparing the questionnaire and training of enumerators. A pre-test for the questionnaire was undertaken, and it was adjusted accordingly. These data sets and rounds were chosen due to their consistency and availability for comparing the livelihood activities of rural households over the course of 15 years, in order to examine the real effects of changes made over time. The five year gap between each round gives a consistent and appropriate time spacing. The ERHS data set duration, low attrition rate at the household level from one round to next round, representation of the mixed farming system, and sample size make the ERHS a unique and very important survey in Ethiopia (Dercon and Hoddinott, 2011). In addition, rainfall data sets for over 30 years (from 1983 to 2014) were collected from the

³ Woreda is the third administrative unit in Ethiopia, similar to district, which collects to make zone. It is subdivided into a number of kebele.

⁴ The ERHS is a unique longitudinal data set. It was launched in 1994 by the Department of Economics at Addis Ababa University and the Centre for the Study of African Economics at Oxford.

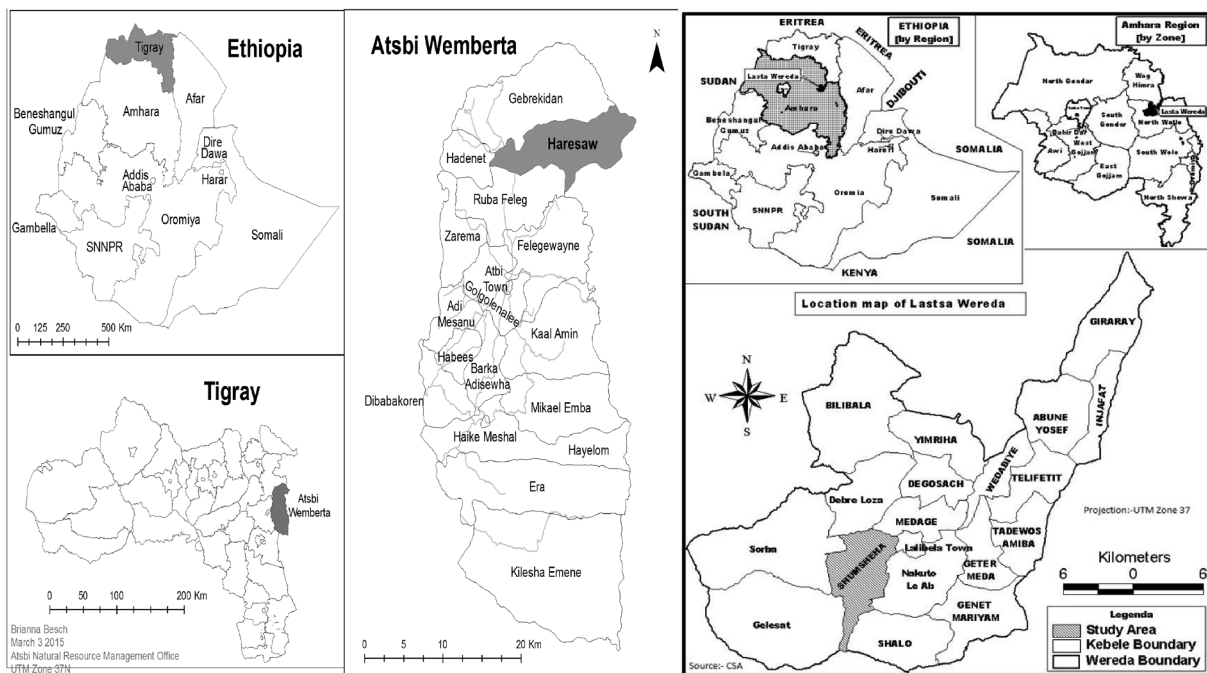


Fig. 1. Study areas map: Harresaw (Left) and Shumsheha (Right).

Ethiopian National Meteorological Agency, which provides rainfall records in ten-day intervals. The study was complemented by different secondary data set when needed.

4.2. Conceptual framework

The combination of resources endowments (or access), policy and institutional settings, and biophysical conditions (rainfall in particular) result in the ability of a household to decide which kind of livelihood or combination of livelihood to pursue (Fig. 2). A

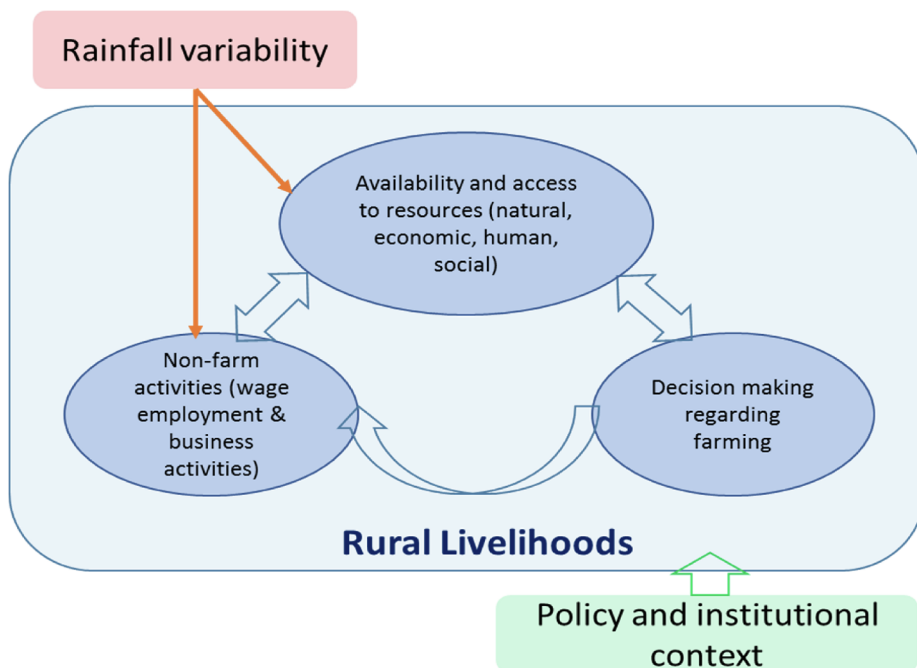


Fig. 2. Conceptual framework for the study of rural households livelihood activities in Ethiopia.

livelihood comprises of assets (resources, claims and access) and activities (farm, non-farm, migration, etc) that together determine the way of living a household can afford (Chambers and Conway, 1992; Ellis, 1999). Livelihood resources or access to them refer to assets including (1) natural (soil, water), (2) economic (cash, saving, credit, remittance and other basic production equipment or technologies), (3) human (education, skill), and (4) social (networks, social claims, social relations, affiliations, associations) resources. Livelihood activities of rural households belong to either of two broad categories: farming and non-farm activities. Farming refers to household activities from own-account farming, whether on owner-occupied land or on land accessed through cash or share tenancy. Non-farm activities refer to household participation in non-agricultural activities, including wage employment, business activities, and migration.

Rural household⁵ decisions to work in non-farm activities are broadly categorized according to endowment with resources or access to them as well as in terms of biophysical factors (especially rainfall). Thus rainfall conditions; amount and distribution in the growing season, affect primarily households' decision to engage in farming or not (Brooks, 2003; Hulme, 2001; Teka et al., 2012). This is because the households' main livelihood depend on farming and it heavily depends on rainfall conditions during the growing season. In turn, household decisions to do farm work or not directly affect their respective decisions to work at non-farm activities, mainly because of the limited available resources households own and can distribute among the livelihood activities. Policy and institutional context refers to available policies and strategies at the local level regarding property right like land, community's access to agricultural inputs and financial schemes, and availability of other schemes to households' livelihood conditions. The status of the local economy or job availability might affects household's decision to engage in non-farm activities but due to lack of panel data availability it is not considered in the estimation.

Wage employment refers to income from rural wages, where a household head or any other member of a household works for others to obtain payment in cash or in kind. It includes (1) labor payments in cash or kind, such as harvest share systems and other non-wage labor contracts that remain prevalent in the respective localities, and (2) other wage work in the local community, outside of agricultural and related activities. Business activities refer to income generated from non-agricultural activities, including (a) non-farm rural self-employment, sometimes called business income or petty trade; (b) rental income obtained from leasing land or property; (c) artisanal or handcraft work; (d) local business ownership (bar, tea shop); and (e) technician. Migration remittances refer to other income sources, including (a) urban-to-rural remittances arising from within national boundaries and (b) international remittances arising from cross-border and overseas migration. However, household income received through aid from governmental and NGOs is not considered as a remittance.

4.3. Model variables

Based on the conceptual framework presented above, this section lays out the explanatory variables for the panel regression model employed and a priori expectations about their relationships with household participation in non-farm livelihood activities. It considers participation in an activity as a dichotomous variable constructed from a households' response to a specific question regarding non-farm livelihood activities. A household is considered to be participating in a particular kind of activity if at least one of its members has generated income (in cash or in kind) during the last 12 months from that activity. The study has separately considered wage employment and business activities, as these are motivated by different institutional and policy incentives and asset capacities.

The explanatory variables of household participation in non-farm livelihood activities are categorized into rainfall conditions, asset holding and access, and demographic characteristics. The choice of these variables is based on the literature and data availability. Measuring rainfall patterns is based on the rainfall data set, on 10-day intervals (hereafter referred to as 'decades') and covering a period of over 30 years (1983–2014). Specifically, the analysis focuses on the main rainy season, Kiremt, from the beginning of June to the end of September, as this period of the year is the main and only growing season for farmers in both study areas.

For household crop production, it is not only the total amount of rainfall which matters but also its distribution and regularity across growing seasons. Thus, prior to each survey, the anomalies of decadal rainfall is calculated (Lebel and Ali, 2009), which enabled to characterize the wetness and dryness of a particular decades (e.g. 10–20 August), and the total rainfall amount of the rainy season prior to each survey (D'haen et al., 2014). The anomaly of a specific decade is the deviation of the rainfall in a particular year from the long-term mean decadal rainfall (in our case 1983–2014), calculated as shown in the following formula:

$$Anomaly = \left(\frac{Decadal\ rainfall - long\ term\ mean\ decadal\ rainfall}{Standarddeviation\ of\ long\ term\ mean\ decadal\ rainfall} \right)$$

Values between -0.49 and $+0.49$ indicate normal conditions, and values between $|0.5|$ and $|0.99|$ indicate wet/dry conditions. Decades were categorized as 'very wet' or 'very dry' if their anomaly in a particular year was greater than 1 or smaller than -1 , respectively (D'haen et al., 2014). The decadal rainfall considered for the estimation is prior the survey years so as to investigate and capture its effects in the year under consideration.

⁵ A household is defined as one or more individuals, related or unrelated, who live in the same dwelling and share meals and/or accommodation; it may consist of a single family or some other grouping of individuals.

Under the category of asset holding and access, different variables are selected to be included in the estimation, like total asset value, total livestock owned value, total land size in *Timad*⁶ and household access to loans. Farmland availability is an important source of capital for rural households, and landless households are more obliged to work off-farm and pursue other non-farm livelihood activities. So the estimation expects a negative relation between land size and household participation in non-farm livelihood activities. When households have more land, they tend to spend more time on agricultural production than earning income on casual or other low-reward business activities. Access to loans is expected to have a positive relation with non-farm livelihood activities, because it can provide the initial capital for poor rural households to undertake business activities.

Under the category of demographics, variables such as education and age of the head of a household and adult household size are included in the model. Education is expected to have a positive correlation with better payoffs for non-farm livelihood activities, whereas wage employment which is casual and with low payoffs is expected to have a negative correlation with education. Adult household size is expected to have a positive relation with wage employment. In need of a better indicator for experience the study considered household age to be a good proxy indicator for experience. Variables such as household age and education only refer to the household head with the assumption that household heads are the main decision makers. However, we consider this as a limitation because the analysis refers to the entire household members.

4.4. Econometric model

Given the overall objective of the analysis – investigating the dynamics of livelihoods in rural Ethiopia as related to rainfall variability and household socio-economic characteristics – two prominent panel econometric formulations will be tested: fixed effects (FE) and random effects (RE) models. Due to the binary nature of the dependent variables, the estimation has employed a conditional logit modeling specification (Allison, 2009).

The conditional logit model can be presented in its simplest formulation as follows:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + u_{it} \quad (1)$$

where:

- α_i ($i = 1 \dots n$) is the unknown intercept for each entity (n entity-specific intercepts);
- Y_{it} is the dependent variable observed for households, where i = entity and t = time, in this case household participation in wage employment or business activities;
- X_{it} represents explanatory variables for household i at time t ;
- β_1 is the coefficient for the explanatory variables; and
- u_{it} is the error term

The essential difference between the FE and RE models is the assumptions about X_{it} and α_i . The α_i are either correlated or uncorrelated with the regressors in X_{it} . When the u_i are correlated with some of the regressors in the model, one estimation strategy is to treat them like parameters or FE. The FE approach assumes that α_i is treated as non-random and, hence, makes a correction between the observed explanatory variables (X_{it}) and α_i . However, including a parameter for every individual is not feasible, because it would imply an infinite number of parameters in N large-sample approximations. The solution is to remove the u_i from the estimation problem by a transformation that can still identify some of the coefficients of interest. However, the RE approach is applicable under the assumption that α_i is random and not correlated with X_{it} , putting it into the error term (Wooldridge, 2002). When α_{it} is uncorrelated with everything else in the model, the individual-level effects are simply parameterized as additional random disturbances (Baum, 2006). The sum $\alpha_i + u_{it}$ is sometimes referred to as the composite error, and the model is sometimes known as an “error-components model”. The study used a Hausman test to check whether there is such correlation between the observed explanatory variables and α_i so as to determine the suitable model specification. Furthermore, specification of the model as being FE or RE has relevance for the spatial and temporal variability of the tested function. This is particularly meaningful for the empirical study, where it aims to depict the effects of rainfall variability on changing farmers’ livelihoods activities. The validation of the RE of the model would indicate temporal variability of these livelihood activities to be higher than the spatial, while the verification of the FE assumption would indicate the inverse. If regressors are correlated with the α_i , the FE estimator is consistent but the RE is not. If regressors are uncorrelated with the α_i , the FE estimator is still consistent, albeit inefficient, whereas the RE estimator is consistent and efficient (Baum, 2006).

5. Results

5.1. Socio-economic characteristics of rural households

Table 1 provides a description of the set of variables used for the present study, with both variations of these variables – between one household and another (between) and overtime (within) – being considered. The mean age of the sample household head in both study areas is above 51 years; only 25% and 19% of farmers are younger than 40 in Harresaw and Shumsheha respectively. The

⁶ *Timad* is a local measure for farm size which is equal to 0.25 ha.

Table 1
Socio-economic characteristics of rural households.

Variable		Harresaw Kebele				Shumsheha Kebele			
		Mean	Std. Dev.	CV	Observations	Mean	Std. Dev.	CV	Observations
Household head age	Overall	51.32	14.94	0.29	N = 309	51.41	13.26	0.26	N = 355
	Between		13.18	0.26	n = 81		11.45	0.22	n = 92
	Within		7.47	0.15			7.57	0.15	
Adult household size	Overall	2.63	1.54	0.59	N = 314	2.37	1.41	0.59	N = 361
	Between		1.08	0.41	n = 81		1.14	0.48	n = 92
	Within		1.13	0.43			0.87	0.37	
Land size in Timad	Overall	2.27	1.19	0.52	N = 318	4.41	2.94	0.67	N = 366
	Between		0.85	0.37	N = 81		2.35	0.53	n = 92
	Within		0.85	0.37			1.96	0.44	
Rainfall (decadal)	Overall	-0.06	0.38	-6.33	N = 324	0.13	0.18	1.38	N = 368
	Between		0	0	n = 81		0	0	n = 92
	Within		0.38	-6.33			0.18	1.38	
Variable		Mean	%	CV		Mean	%	CV	
Illiterate household head education	1999	47	78.3	0.06	N = 282	69	67.65	0.23	N = 340
	2004	48	71.6		n = 81	76	71.7		n = 92
	2009	64	79			55	47.4		
	2015	69	83			47	46.1		
Loan taken	1999	39	48.75	0.13	N = 320	48	44.86	0.21	N = 357
	2004	43	51.2		N = 81	55	44.35		n = 92
	2009	49	59			60	50		
	2015	53	64.6			30	29.4		
<i>Iqub</i>	1999	-	-		N = 324	5	3.45		N = 368
	2004	-	-		N = 81	7	5.65		n = 92
	2009	-	-			17	14.2		
	2015	-	-			15	10		

illiteracy rate in both Kebeles is very high, with more than 78% and 59% of the sample household heads in Harresaw and Shumsheha, respectively, being illiterate. The average adult household size in Harresaw is 2.63 and that of Shumsheha is 2.37. Household farm size is quite low in both study areas, though Shumsheha, with an average farm size of 1.1 ha, has better access to land than households in Harresaw (0.57 ha).

Households in Harresaw have better access to loan, 56% of households, than Shumsheha (43%). The loan coefficient of variation (CV) for a household overtime (within) is greater than the coefficient of variation between households (between) in both Kebeles. This shows that household access to loans varies significantly over time, indicating that provision of credit to farm households is inconsistent and unreliable. *Iqub*⁷ groups are not available in Harresaw, whereas in Shumsheha over 8% of the sample households are members of *Iqub* group.

5.2. Rainfall patterns in recent decades

Between 1983 and 2014, rainfall for the main rainy season (June to September) in Harresaw ranged from 190 to 998 mm (mm) and from 296 to 937 mm in Shumsheha, with high temporal variation (Fig. 3 below). During this period, the average rainy season rainfall was 624 mm in Shumsheha, which was higher than Harresaw's 361 mm. During this period, a high CV is observed for the average main rainy season in Harresaw, with a value of 42 and Shumsheha at 22, indicating high rainfall variability from season to season, particularly in Harresaw.

The rainfall pattern of the main rainy season for the last three decades has shown significant variation among the two kebeles, with decreasing and increasing patterns in Harresaw and Shumsheha, respectively (Fig. 3). The pattern in Harresaw kebele matches the findings of Araya and Stroosnijder (2011), who observed a decreasing trend in the 1980s and a slightly above-average trend in the years after 1990. Likewise, decreasing rainfall has also been observed across selected historical-event years in the Eastern Tigray zone (Teka et al., 2012).

The anomaly decadal rainfall of the study years (1998, 2003, 2008 and 2013) indicates high degrees of variation. The number of

⁷ *Iqub* is an informal financial association in which members voluntarily form themselves into a group and make mandatory financial contributions at a regular interval. The "pot" is distributed on a rotating basis, determined by drawing lots.

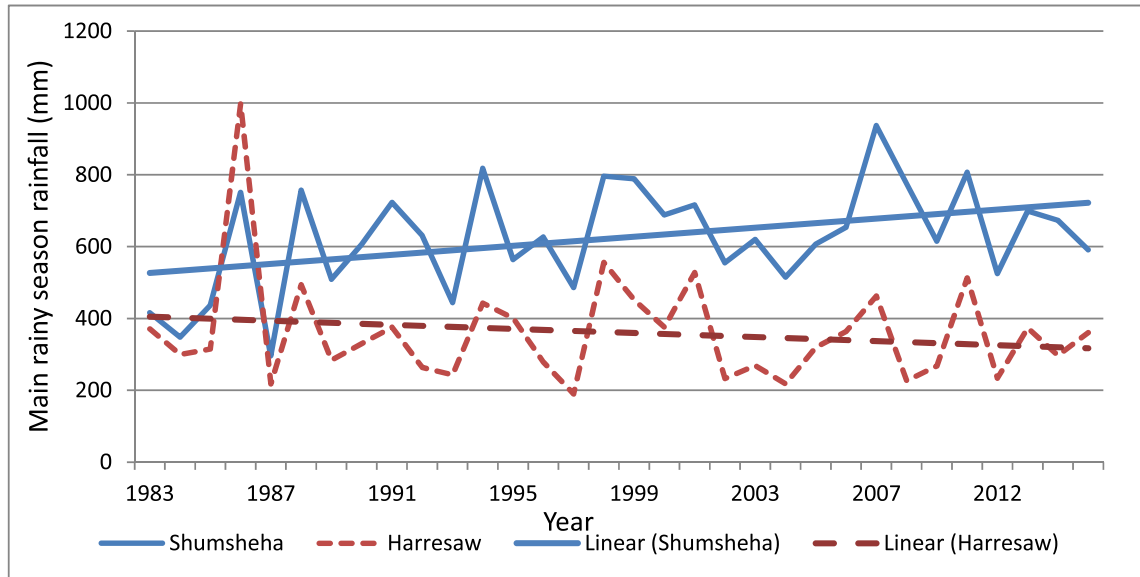


Fig. 3. Main rainy season rainfall in Harresaw and Shumsheha, 1983–2014.

very dry or very wet periods also reveals significant differences across the study years. The number of very wet anomaly decadal rainfall periods decreased significantly since 1998 in both Kebeles. In 1998, there were four and five very wet decadal rainfall periods in Harresaw and Shumsheha, respectively, which significantly decreased to 0 or 1 in the following periods. This is also confirmed by the decreasing trend line for both Harresaw and Shumsheha (Fig. 4).

The rainfall pattern for the main rainy season indicates significant change, with a decreasing trend for both study areas (Fig. 4). High variation is also observed from one to the next decadal of rainfall in the same rainy season within the same community (Table 1 and Fig. 4), further showing the uncertain and highly variable nature of rainfall in the study areas. Such rainfall patterns make it difficult for farmers to predict the nature of rainfall in the way they used to do in previous years, which was mentioned frequently during interviews with key informants, who reported that rains are becoming more erratic and difficult to predict by farmers.

5.3. Non-farm livelihood patterns of rural households

Results from the panel data show that non-farm livelihoods are a growing and vital source of income for rural households. The two study areas have different non-farm livelihood activities, and households in Shumsheha have been found to have better access to non-farm livelihoods. Wage employment has been found to be the most common non-farm livelihood activities. In 1999, an average of 8% and 30% of the households in Harresaw and Shumsheha, respectively, engaged in wage employment (Table 2). In Shumsheha,

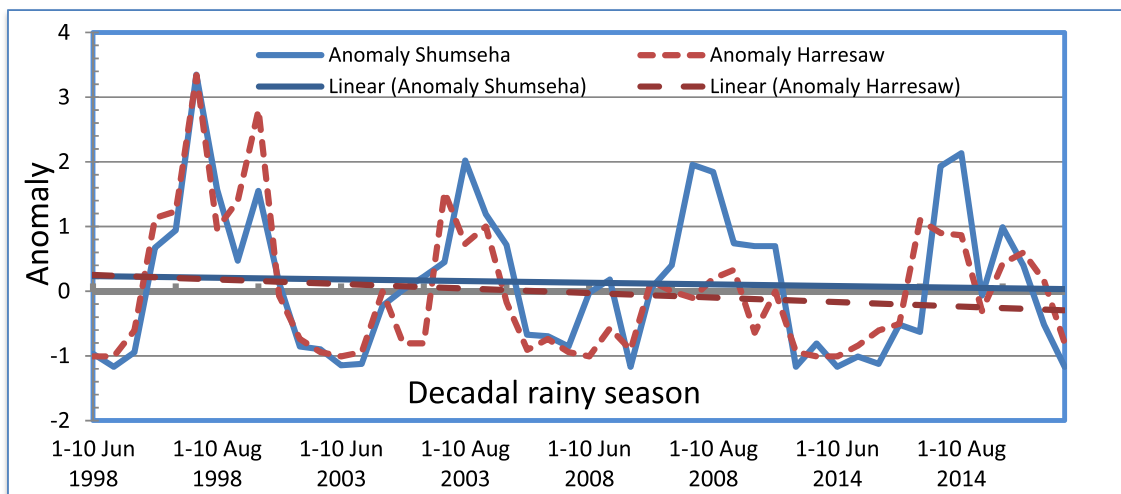


Fig. 4. Anomalies of decadal rainfall in Shumseha and Harresaw for four years – prior to the study years (1998, 2003, 2008 and 2014).

Table 2
Household engagement in non-farm sector: Shumsheha and Harresaw.

Year	Wage employment (%)		Business activities (%)		Received remittance (%)	
	Harresaw	Shumsheha	Harresaw	Shumsheha	Harresaw	Shumsheha
1999	7.4	29.8	17.3	8.3	22.2	5
2004	7.2	35.5	15.5	14.5	7	10
2009	49.4	23.3	3.6	19.2	18.1	11.7
2015	14.6	49	13.4	34.37	20.7	24.5
Pearson chi2 (P-Value)	63.36 (0.000)	17.47 (0.001)	8.47 (0.037)	26.76 (0.000)	8.24 (0.041)	21.11 (0.000)

except for the 2009 round, wage employment has exhibited a significant rising trend such that, in 2015, almost half of the respondents in the kebele reported that at least one or more members of their household were working as a wage worker. During the same study period, however, the growth trend of wage employment in Harresaw has been much slower, with only 15% of the sample households reporting wage employment as a source of income in 2015.

The trend of business activities has also exhibited different patterns for the two study areas. In Shumsheha, there has been an increasing, consistent and high growth of business activities during the study periods. In 1999, only 8% of households were engaged in business activities. This figure slightly increased to 14.5% and 19% in the 2004 and 2009 rounds, respectively, before it significantly increased to 34.4% in 2015. In contrast, business activities in Harresaw have exhibited a decreasing and inconsistent trend, and a low proportion of households were engaged in business activities in 2009 and 2015 as compared to the 1999 and 2004 rounds.

In 1999, 23% and 6% of the households in Harresaw and Shumsheha, respectively, had received remittances in the 12 months prior to the study period. In Harresaw, the trend has been both decreasing and increasing, whereas in Shumsheha the trend has been increasing throughout the study years. Thus, in 2015, almost a quarter of the respondents had received remittances from someone living outside their Kebele.

5.4. Determinants of livelihood activities

The determinants of wage employment and business activities in the study areas based upon a strongly balanced panel data set. Initially, the panel model employs FE, RE and pooled ordinary least squares (OLS) estimations separately for the two study areas: Shumsheha and Harresaw. The appropriateness of these estimations are then tested using a Hausman test and Breusch-Pagan Lagrange multiplier (LM). The null hypothesis is that unobserved household effects are not correlated with explanatory variables included in the model. In other words, the estimation tests here whether unique error terms (u_i) are correlated with the described regressors (Eq. (1)). Regarding the first model, business activities, the Hausman test rejected the hypothesis in both study areas with a p value of less than 1%. Accordingly, the initial hypothesis that the individual-level effects can be adequately modeled by a RE model is resoundingly rejected, and a FE model is the preferred specification (Wooldridge, 2002), as it can control for time-invariant differences in samples, such as macroeconomic conditions and institutions, religion, gender, and culture. By using household panel data with a FE specification, it can controls for unobserved household characteristics that do not change over time but which may be correlated with household diversification behavior. A Hausman test confirming FE specification indicates that individual differences within our sample are more significant than inter-temporal differences, also meaning that the spatial variability of our data is higher than its temporal variability.

The Hausman test applied to the second model, wage employment, provided two different results for both study areas. For Harresaw, the test rejected the null hypothesis with a p value of less than 1% and, thus, it used a FE model. However, in Shumsheha the null hypothesis was not rejected. So it runs the Breusch-Pagan LM test to decide between a RE model and a simple pooled OLS regression. The null hypothesis in the LM test was that variances across entities should be zero, meaning no significant difference across units (no panel effect). Again, it rejected the null hypothesis due to a p value of higher than 10% and concluded to use a pooled OLS regression. Table 3 reports detailed estimation results of the wage and business activities in both study areas.

The FE model enabled identification of a few relevant correlations between individual household effects and a set of explanatory variables in each case and model. The age of the household head, which represent the experience and accumulation of assets for non-farm livelihood activities, positively and significantly (at 10% level) affect household decisions to engage in business activities in Shumsheha. A unit increase in age of household head results in a 4.3% increase in the probability of a household's engagement in business activities. However, such effect was not observed in Harresaw. Similarly, age of household head does not appear to have a significant impact on household decisions to take on wage work in either study area. Differently from age, the parameter estimates of adult household size is positively and significantly (at 5% and 1% in Harresaw and Shumsheha, respectively) correlated with wage employment decision but has no effect on decisions to engage in business activities. This indicates that households with more adult members are in a better position to participate in wage employment. Regarding education, and in line with our expectations, household head's level of education was found to affect positively and significantly business activities in Harresaw. When the household head has better education, this would seem to increase its chances of being engaged in business activities. This effect was only observed in Harresaw, however, household head education level does not seem to significantly affect household participation in wage employment in either study area.

From a structural perspective, household farm size has been found to have a positive and significant effect only on wage

Table 3
Panel estimation for the two study areas.

Variables	Wage employment						Business activities					
	Harresaw			Shumshaha			Harresaw			Shumshaha		
	OLS	FE	RE	OLS	FE	RE	OLS	FE	RE	OLS	FE	RE
Household head age	-0.003* (-0.002)	0.017 (-0.027)	-0.022* (-0.013)	-0.002 (-0.002)	0.006 (-0.016)	-0.011 (-0.009)	-0.000 (-0.001)	0.034 (-0.032)	-0.003 (-0.017)	-0.000 (-0.001)	0.043* (-0.025)	0.002 (-0.017)
Adult household size	0.051*** (-0.016)	0.355*** (-0.159)	0.353*** (-0.113)	0.095*** (-0.017)	0.344*** (-0.132)	0.460*** (-0.089)	0.014 (-0.013)	-0.004 (-0.239)	0.149 (-0.143)	-0.009 (-0.0146)	0.165 (-0.211)	0.021 (-0.155)
Land size in Timad	0.022 (-0.021)	0.462** (-0.235)	0.131 (-0.138)	-0.011 (-0.008)	-0.047 (-0.059)	-0.049 (-0.041)	-0.020 (-0.017)	-0.217 (-0.305)	-0.295 (-0.226)	-0.021 (-0.007)	-0.031 (-0.101)	-0.207** (-0.085)
Illiterate household head education	0.012 (-0.03)	-0.192 (-0.254)	0.055 (-0.181)	-0.025 (-0.018)	-0.247** (-0.119)	-0.13 (-0.092)	0.053** (-0.024)	0.862** (-0.363)	0.542** (-0.231)	0.006 (-0.015)	-0.08 (-0.207)	0.046 (-0.16)
Rainfall (decadal)	-0.237*** (-0.069)	-1.803*** (-0.649)	-1.867*** (-0.574)	-0.432*** (-0.133)	-1.809** (-0.721)	-2.134*** (-0.662)	0.150*** (-0.055)	1.859*** (-0.695)	1.603*** (-0.586)	-0.290*** (-0.112)	-2.214* (-0.18)	-2.865*** (-0.505)
1.Loamtaken	-0.032 (-0.049)	0.606 (-0.457)	-0.181 (-0.336)	0.043 (-0.047)	0.033 (-0.295)	0.222 (-0.228)	0.017 (-0.04)	0.051 (-0.591)	0.197 (-0.433)	0.051 (-0.039)	1.013** (-0.505)	0.757* (-0.404)
1.Iqub	-0.293 (-0.235)			0.074 (-0.078)	0.255 (-0.512)	0.354 (-0.358)	0.486** (-0.189)		2.576 (-1.584)	0.183** (-0.065)	2.463** (-1.241)	1.503** (-0.618)
1.Remittance	0.045 (-0.062)	1.261** (-0.582)	0.386 (-0.422)	-0.044 (-0.07)	-0.389 (-0.439)	-0.208 (-0.348)	0.099* (-0.05)	0.271 (-0.61)	0.795** (-0.475)	0.120** (-0.059)	1.320** (-0.639)	1.207** (-0.513)
Constant	0.176 (-0.104)		-1.776** (-0.759)	0.312*** (-0.112)		-0.75 (-0.548)	0.125 (-0.084)		-2.410** (-1.016)	0.328*** (-0.094)		-2.075* (-1.159)
R-squared	0.096			0.113			0.095			0.095		
Observations	285	152	282	411	289	411	286	100	286	411	142	411

Robust standard errors in parentheses: Significance levels are indicated by *** p < 0.01, ** p < 0.05, * p < 0.1

employment decisions in Harresaw, seeming to indicate that households with large farms can more easily work as wage workers. Given the very low average farm size in the community (0.56 ha), having a relatively large farm might help farmers to look for wage work not only in their community but also in the neighboring communities. Farm size does not appear to have a significant impact on household participation in business activities, though, as the coefficient is negative.

Household access to loans exhibits a positive and significant impact on their likelihood of participating in business activities in Shumsheha, implying the important role of household access to loans for starting up businesses at the local level. Given that credit institutes are the sole loan providers, it also implies the essential role of credit institute support in promoting small business activities at the local level.

Remittances were found to positively and significantly impact household participation in business activities in Shumsheha. In Harresaw, meanwhile, they also have a positive but not significant effect. In contrast, remittances have a positive effect on household participation in wage employment in Harresaw, but they do not have any significant impact in Shumsheha. Membership in local saving groups, Iqub, significantly contributes to household participation in business activities in Shumsheha Kebele, indicating the importance of financing startup capital for business activities. The results further reveal that, in line with our expectation, there is no significant effect of Iqub on household participation in wage employment.

The results of our model also indicate that decadal rainfall prior to the survey year has a significant impact on household participation in wage employment and business activities in the study areas. In Shumsheha, a good amount and distribution of rainfall has a negative and significant impact on household participation in wage employment and business activities. Similarly, a good distribution of rainfall has a negative effect on household participation in wage employment in Harresaw as well. This means that, when the amount and distribution of rainfall across the growing season is good, households are less likely to engage themselves as casual wage workers or for less well-paying business activities. Rather, during such periods they prefer and decide to work on their own farm, which offers them more attractive conditions.

6. Discussion, conclusions and perspectives

6.1. Livelihood patterns

The study has explored rural household livelihood patterns and factors affecting household choices regarding non-farm livelihood activities, based on four rounds of panel data set between 1999 and 2015. The results showed that rural household non-farm livelihoods are in a state of constant dynamic change. The non-farm livelihood dynamics of households in the two study areas have exhibited an overall upward pattern over the study years, except for business activities in Harresaw, where the trend has been downward. The proportion of households engaged in non-farm livelihoods has been increasing over the years. This finding is in line with studies in Ethiopia (Carswell, 2000; Lemi, 2006) and other sub-Saharan African countries (Ellis, 2000a; Barrett et al., 2001a; Ulrich et al., 2012) that have reported an increasing proportion of rural households engaged in non-farm livelihood.

Even though the livelihood patterns have shown a rising non-farm livelihood trend, fluctuation has also been found to be common during the entire study period in both Shumsheha and Harresaw, with significant differences from one study period to another. The main reason for the great fluctuation of households becoming involved in non-farm livelihood patterns is the conditions of rainfall during the main growing season, which will be discussed in the next section.

The livelihood patterns found also exhibited significant difference between the two study areas. Shumsheha, which has its own local market, access to a larger market and all-weather roads is relatively better equipped for engaging a greater proportion of households in both wage employment and business activities. This finding is particularly revealing with regard to the importance of public investment in market infrastructure and institutions for the livelihoods of local populations. In contrast to Shumsheha, households in Harresaw have a strong tendency to migrate to neighboring regions or countries, mainly due to a lack of wage work or opportunities to start their own businesses locally.

6.2. Rainfall and socio-economic livelihood decision making

Rural household non-farm activity engagement in Ethiopia is influenced by socio-economic factors. Household characteristics, such as household head age and education and adult household members in family, appear to have a significant impact on household decisions to pursue non-farm livelihood activities or not. In particular, demographic characteristics significantly determine household participation in wage employment. A large number of adult household members has a positive and significant correlation with wage employment. This is also in line with several other studies (Berg and Kumbi, 2006; Abebaw et al., 2012) which reported that larger sized households tend to have more diverse income sources, including fuel-wood collection, honey and/or gum collection from forests, and other labor-intensive sources of income. The strong positive correlation between adult household size and wage employment in both study areas indicates that households are using wage employment opportunities as a means to occupy surplus labor away from farming. This further indicates that low-paid wage employment is the most likely option for poor households (Seaman et al., 2014) when they are not able to overcome entry barriers to more highly productive rural non-farm livelihood activities that require financial capital and skills (Reardon, 1997; Martin and Lorenzen, 2016).

Access to financial assets and means – represented by household access to loans, remittances or membership in an Iqub – significantly and positively affect household participation in business activities, a result which has also been confirmed previously (Aklilu et al., 2008). The strong association between access to financial means and assets and the ability to undertake business activities is observed in Shumsheha, where households engaging in business activities are relatively better off. This, seeming to

indicate the importance of initial capital for business activities at the local level. Meanwhile, lack of financial assets is considered one of the entry barriers for rural households, usually preventing them from engaging in self-employed non-farm activities, such as business activities. This is in line with findings of other studies (Martin and Lorenzen, 2016; Seaman et al., 2014; Woldenhanna and Oskam, 2001; Bezu et al., 2012) reporting that rich households may dominate the most lucrative rural non-farm activities, whereas the poor are generally engaged in low-paid activities. Thus, support of credit institutes to prompt small businesses at the local level may not only enable increased household participation in business activities but also high-return ones.

However, some differences exist among the study areas, likely indicating that structural differences and effectiveness of labor markets exist, even among neighboring rural areas of Ethiopia. Households in the relatively more developed Shumsheha appear to have better access to both labor markets and self-employment business activities. When opportunities for non-farm activities are low, however, the possibility that migration will occur is high. In this vein, it is found that more than 42% of the households in Harresaw reported at least one or more member of their household having migrated in search of employment—a figure reduced to only 10% in Shumsheha. Thus, the inability to address rural livelihood possibilities may result in socio-economic crises, not only in rural areas but also in urban ones where a rapidly increasing number of rural residents have migrated in search of employment (Bezu and Holden, 2014).

Rainfall conditions also have significant implications for household participation in wage employment and business activities. The study's negative and high correlation (at 1%) between rainfall and wage employment strengthens previous evidence (Ulrich et al., 2012; Barrett et al., 2001b; Woldenhanna and Oskam, 2001) that many available non-farm activities offer low returns. Similarly, rainfall has a negative and significant effect on business activities in Shumsheha. When households only have access to very low paying casual wage employment, their main focus will tend to be on farm activities (Ulrich et al., 2012). Such low-wage employment is, then, rather be used as a supplementary sources of income. This would seem to indicate that a good amount of rainfall during the growing season will cause households to prefer working on their own farm rather than becoming engaged in low-return non-farm livelihood activities. This result is in line with the work of D'haen et al. (2014) in rural Burkina Faso, which reported household participation in non-farm activities being determined by adverse rainfall conditions in the major staple-food production zone of the country. Thus, the motivation of rural households to diversify into non-farm livelihoods can be seen as being mainly driven by rainfall conditions during the main growing season. When these conditions are adverse, rural household production from farming becomes significantly low. During such period, household members prefer to pursue non-farm livelihood activities within the community. In areas where such non-farm livelihood opportunities are low at the local level, they rely on migration as a way out for accessing additional sources of income.

6.3. Conclusions and perspectives

The study has aimed to reveal the livelihood dynamics of rural households in Ethiopia and their association with rainfall conditions and household socio-economic characteristics. It has observed an upward livelihood patterns but fluctuating over the study period. The econometric estimations have shown that rainfall conditions during the main rainy season in Ethiopia significantly and negatively affect household decisions to engage in non-farm livelihoods, specifically wage employment. This result has two implications: First, wage employment in rural Ethiopia is mainly casual and generally offers a low return. Second, household decisions to engage in non-farm livelihoods are primarily driven by expected low returns from farming, due to adverse climatic conditions (mainly rainfall).

The analysis has also indicated that household socio-economic characteristics strongly influence decisions about pursuing non-farm livelihoods. Household demographic characteristics such as adult household members appear to positively and significantly determine their decisions regarding whether to engage in wage employment or not. Whereas, access to financial resources from credit institutes, remittances or Iqub have been found to play a role in positively and significantly determining their decisions about undertaking business activities. The study has observed high and significant variation between the study communities with regard to the proportion of households engaged in non-farm livelihoods. These differences are primarily driven by structural differences in terms of access to all-weather roads, markets or developmental activities being available in the community.

The study has demonstrated that the main reason for household decisions to pursue non-farm livelihoods is adverse rainfall conditions during the main growing season, which consequently affect farming. It has also observed the potential that non-farm livelihoods offer to rural households: either as the main source of income or as a substantial supplement during adverse rainfall conditions. D'haen et al. (2014) suggest, however, that non-farm livelihoods should not be viewed as a buffer during adverse climate conditions but rather as a core strategy for rural development. However, our study restrains itself from such claims until deep societal and economic change is observed, as such significant changes need policy and strategic interventions towards non-farm livelihood in rural communities.

For policy-making, it is important to understand how designing policy and strategic interventions contribute towards the enhancement of non-farm livelihoods and the ways in which they can, in turn, make significant contributions to rural development. Their contribution could be either as a supplement to farming through enabling rural households' to invest in farming or as a core livelihood activity by themselves. The findings of this study have a variety of policy implications. First, increasing the access of households to financial schemes through local credit institutes or local groups, such as Iqub, may enable them not only to take part in non-farm livelihood activities but also to be able to readily choose the profitable ones which offer the highest returns. This may, in turn, improve household capacities to invest in agriculture and, subsequently, improve overall income (Bezu et al., 2012). Second, there is a need to increase household-member skills through vocational training and education to increase competitiveness, which would enable rural households to more successfully pursue business activities and increase their chances of getting well paid wage

work. Third, increasing household access to markets, through developing appropriate institutions, communication technologies, and infrastructure, would likely generate important livelihood opportunities.

Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.crm.2019.100195>.

References

- Abebaw, D., Kassa, H., Kassie, G.T., Lemenih, M., Campbell, B., Teka, W., 2012. Dry forest based livelihoods in resettlement areas of Northwestern Ethiopia. *For. Policy Econ.* 20, 72–77.
- Abege, K.H., 2017. Determinants of food security: evidence from Ethiopian Rural Household Survey (ERHS) using pooled cross-sectional study. *Agric. Food Secur.* 6 (1), 70.
- Addison, T., Hulme, D., Kanbur, R., 2009. *Poverty Dynamics: Interdisciplinary Perspectives*. Oxford University Press, Oxford & New York.
- Agrawal, A., 2008. The Role of Local Institutions in Adaptation to Climate Change. Social Dimensions of Climate Change. Social Development Department, The World Bank, Washington DC.
- Aklilu, H.A., Udo, H.M.J., Almekinders, C.J.M., Van der Zijpp, A.J., 2008. How resource poor households value and access poultry: village poultry keeping in Tigray, Ethiopia. *Agric. Syst.* 96, 175–183.
- Alemu, A.E., Adesina, J.O., 2017. In search of rural entrepreneurship: non-farm household enterprises (NFEs) as instruments of rural transformation in Ethiopia. *Afr. Dev. Rev.* 29 (2), 259–271.
- Ali, K., Tafesse, M., 1996. *Ethiopian Village Studies – Shumsheha – Lasta – Wollo*.
- Allison, P.D., 2009. *Fixed Effects Regression Models – Quantitative Applications in the Social Sciences*, first ed. SAGE Publications, pp. 160.
- Araya, A., Stroosnijder, L., 2011. Assessing drought risk and irrigation need in northern Ethiopia. *Agric. For. Meteorol.* 151, 425–436.
- Arnall, A., 2015. Resilience as transformative capacity: exploring the quadripartite cycle of structuration in a Mozambican resettlement programme. *Geoforum* 66, 26–36.
- Baird, T.D., Gray, C.L., 2014. Livelihood diversification and shifting social networks of exchange: a social network transition? *World Dev.* 60, 14–30.
- Barrett, C.B., Bezuneh, M., Aboud, A., 2001a. Income diversification, poverty traps and policy shocks in Cote d'Ivoire and Kenya. *Food Policy* 26, 367–384.
- Barrett, C.B., Reardon, T., Webb, P., 2001b. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy* 26, 315–331.
- Baum, F., 2006. *An Introduction to Modern Econometrics Using Stata*. A Stata Press Publication.
- Berg, M.v.d., Kumbi, G.E., 2006. Poverty and the rural nonfarm economy in Oromia, Ethiopia. *Agric. Econ.* 35, 469–475.
- Berg, M.v.d., 2010. Analysis Household income strategies and natural disasters: dynamic livelihoods in rural Nicaragua. *Ecol. Econ.* 69, 592–602.
- Berkes, F., Colding, J., Folke, C. (Eds.), 2003. *Navigating Social–Ecological Systems. Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge.
- Berkes, F., Folke, C., 1998. Linking social and ecological systems for resilience and sustainability. In: Berkes, F.F., Folke, C. (Eds.), *Linking Social and Ecological Systems*. Cambridge University Press, Cambridge, pp. 414–436.
- Bezu, S., Barret, C.B., Holden, S.T., 2012. Does the nonfarm economy offer pathways for upward mobility? Evidence from a panel data study in Ethiopia. *World Dev.* 40 (8), 1634–1646.
- Bezu, S., Holden, S., 2014. Are rural youth in Ethiopia abandoning agriculture? *World Dev.* 64, 259–272.
- Block, S., Webb, P., 2001. The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy* 26 (4), 333–350.
- Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., Yanda, P., 2007. 2007: Africa. Climate change 2007: impacts, adaptation and vulnerability. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, pp. 433–467.
- Brooks, N., 2003. *Vulnerability, Risk and Adaptation: A Conceptual Framework*. Tyndall Centre for Climate Change Research, Working Paper 38.
- Bryceson, D.F., 1999. African rural labour, income diversification & livelihood approaches: a long-term development perspective. *Rev. Afr. Political Econ.* 26 (80), 171–189.
- Bryceson, D.F., 2002. Multiplex livelihoods in rural Africa: recasting the terms and conditions of gainful employment. *J. Mod. Afr. Stud.* 40 (1), 1–28.
- Bunce, M., Brown, K., Rosendo, S., 2010. Policy misfits, climate change and cross-scale vulnerability in coastal Africa: how development projects undermine resilience. *Environ. Sci. Policy* 13 (6), 485–497.
- Carpenter, S., Walker, B., Marty Anderies, J., Abel, N., 2001. From metaphor to measurement: resilience of what to what? *Ecosystems* 4 (8), 765–781.
- Carswell, G., 1997. *Agricultural Intensification and Rural Sustainable Livelihoods – A Think Piece*. IDS Working Paper 64.
- Carswell, G., 2000. *Livelihood Diversification in Southern Ethiopia*. Institute of Development Studies IDS Working Paper 117.
- Chambers, Conway, G., 1992. *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*. IDS Discussion Paper 296.
- De Haan, L., Zoomers, A., 2005. Exploring the frontiers of livelihoods research. *Dev. Change* 36 (1), 27–47.
- Demeke, A.B., Keil, A., Zeller, M., 2011. Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. *Clim. Change* 108, 185–206.
- Dercon, S., Hoddinott, J., 2011. *The Ethiopian Rural Household Surveys 1989–2009 – Introduction*.
- D'haen, S.A.L., Nielsen, J.Ø., Lambin, E.F., 2014. Beyond local climate: rainfall variability as a determinant of household nonfarm activities in contemporary rural Burkina Faso. *Clim. Dev.* 6 (2), 144–165.
- Egeru, A., 2016. Climate risk management information, sources and responses in a pastoral region in East Africa. *Clim. Risk Manage.* 11, 1–14.
- Ellis, F., 1999. In: *Rural Livelihood Diversity In Developing Countries: Evidence And Policy Implications*. Overseas Institute Development, pp. 40.
- Ellis, F., 2000a. The Determinants of rural livelihood diversification in developing countries. *J. Agric. Econ.* 51 (2), 289–302.
- Ellis, F., 2000b. *Rural Livelihoods and Diversity in Developing Countries*. Oxford University Press, Oxford.
- Ellis, F., Kutengule, M., Nyasulu, A., 2003. Livelihoods and rural poverty reduction in Malawi. *World Dev.* 31 (9), 1495–1510.
- Elmqvist, B., Olsson, L., 2006. Livelihood diversification: continuity and change in the Sahel. *GeoJournal* 67 (3), 167–180.
- Falkenmark, M., Rockström, J., 2008. Building resilience to drought in desertification-prone savannas in Sub-Saharan Africa: the water perspective. *Nat. Resour. Forum* 32 (2), 93–102.
- Gray, C., Mueller, V., 2012. Drought and population mobility in rural Ethiopia. *World Dev.* 40 (1), 134–145.
- Hilson, G., 2016. Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: a critical overview. *Extract. Ind. Soc.* 3, 547–563.
- Hiron, M., Mehrabi, Z., Gonfa, T.A., Morel, A., Gole, T.W., McDermott, C., Boyd, E., Robinson, E., Sheleme, D., Malhi, Y., Mason, J., Norris, K., 2018. Pursuing climate resilient coffee in Ethiopia – a critical review. *Geoforum* 91, 108–116.

- Hulme, M., 2001. Climatic perspectives on Sahelian desiccation: 1973–1998. *Global Environ. Change* 11, 19–29.
- Kebebe, E., Shibru, F., 2017. Impact of alternative livelihood interventions on household welfare: evidence from rural Ethiopia. *For. Policy Econ.* 75, 67–72.
- Lanjouw, J.O., Lanjouw, P., 2001. The rural non-farm sector: issues and evidence from developing countries. *Agric. Econ.* 26 (1), 1–23.
- Lebel, T., Ali, A., 2009. Recent trends in the Central and Western Sahel rainfall regime (1990–2007). *J. Hydrol.* 375, 52–64.
- Lemi, A., 2006. The Dynamics of Income Diversification in Ethiopia: Evidence from Panel Data. Economics Faculty Publication Series 10.
- Liu, Z.X., Liu, L.M., 2016. Characteristics and driving factors of rural livelihood transition in the east coastal region of China: a case study of suburban Shanghai. *J. Rural Stud.* 43, 145–158.
- Loison, A.S., 2015. Rural livelihood diversification in Sub-Saharan Africa: a literature review. *J. Dev. Stud.* 51 (9), 1125–1138. <https://doi.org/10.1080/00220388.2015.1046445>.
- Martin, S.M., Lorenzen, K., 2016. Livelihood diversification in rural Laos. *World Dev.* 83, 231–243.
- Morrissey, J.W., 2013. Understanding the relationship between environmental change and migration: the development of an effects framework based on the case of northern Ethiopia. *Global Environ. Change* 23 (6), 1501–1510.
- Mushongah, J., Scoones, I., 2012. Livelihood change in rural Zimbabwe over 20 years. *J. Dev. Stud.* 48 (9), 1241–1257.
- Nkoana, E.M., Verbruggen, A., Hugé, J., 2018. Climate change adaptation tools at the community level: an integrated literature review. *Sustainability* 20 (3), 796.
- Reardon, T., 1997. Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Dev.* 25 (5), 735–747.
- Rosell, S., 2011. Regional perspective on rainfall change and variability in the central highlands of Ethiopia, 1978e2007. *Appl. Geogr.* 31, 329–338.
- Scoones, I., 1998. Sustainable Rural Livelihoods: A Framework for Analysis. IDS Working Paper 72.
- Scoones, I., 2009. Livelihoods perspectives and rural development. *J. Peasant Stud.* 36 (1).
- Seaman, J.A., Sawdon, G.E., Acidri, J., Celia Petty, C., 2014. The household economy approach. Managing the impact of climate change on poverty and food security in developing countries. *Clim. Risk Manage.* 4–5, 59–68.
- Speranza, C.I., Rist, S., 2014. An indicator framework for assessing livelihood resilience in the context of social–ecological dynamics. *Global Environ. Change* 28, 109–119.
- Stringer, L.C., Dyer, J.C., Reed, M.S., Dougill, A.J., Twyman, C., Mkwambisi, D., 2009. Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. *Environ. Sci. Policy* 12 (7), 748–765.
- Teka, K., Van Rompaey, A., Poesen, J., Welday, Y., Deckers, J., 2012. Impact of climate change on small-holder farming: a case of Eastern Tigray, Northern Ethiopia. *Afr. Crop Sci. J.* 20 (2), 337–347.
- Tesfaye, Y., Roos, A., Campbell, B.M., Bohlin, F., 2011. Livelihood strategies and the role of forest income in participatory-managed forests of Dodola area in the bale highlands, southern Ethiopia. *For. Policy Econ.* 13 (4), 258–265.
- Thiede, B.C., 2014. Rainfall shocks and within-community wealth inequality: evidence from Rural Ethiopia. *World Dev.* 64, 181–193.
- Ulrich, A., Speranza, C.I., Roden, P., Kiteme, B., Wiesmann, U., Nüsser, M., 2012. Small-scale farming in semi-arid areas: Livelihood dynamics between 1997 and 2010 in Laikipia, Kenya. *J. Rural Stud.* 28 (3), 241–251.
- Vetter, S., 2009. Drought, change and resilience in South Africa's arid and semi-arid rangelands. *S. Afr. J. Sci.* 105 (1–2), 29–33.
- Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., Lebel, L., Norberg, J., Peterson, G.D., Pritchard, R., 2002. Resilience management in social–ecological systems: a working hypothesis for a participatory approach. *Conserv. Ecol.* 6 (1), 14.
- Woldenhanna, T., Oskam, A., 2001. Income diversification and entry barriers: evidence from the Tigray region of northern Ethiopia. *Food Policy* 26, 351–365.
- Wooldridge, J.M., 2002. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Cambridge Massachusetts.
- Ziervogel, G., Calder, R., 2003. Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. *R. Geogr. Soc.* 35 (4), 403–417.
- Thulstrup, A.W., 2015. Livelihood resilience and adaptive capacity: tracing changes in household access to capital in Central Vietnam. *World Dev.* 74, 352–362.