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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract

The varying circumstances driven by climate threats and the consequences posed on the environment and humans of dry-land regions, where pastorals and agro-pastorals dominantly live have become the prior policy concerns in Africa. Hence, this study was tended to investigate the effects of various adaptation measures on the income level of pastorals and agro-pastorals in northern Ethiopia. Data were gathered using semi-structured questionnaires including qualitative ideas obtained from group discussants and key informants. The study revealed that repeated droughts caused by climate change left the pastorals and agro-pastorals with herd decimation due to lack of animal feed. In responding this, they applied various adaptation actions such as water harvesting schemes; fodder production, feed purchase, migration, livestock diversification and animal restocking. Using such measures, cattle owners generated income from livestock, cropping, sales of fuel-wood, agricultural wages, remittance and relief aid. Thus, it is concluded that sustainable income creation via various adaptation methods is an important pathway to enable the pastoral and agro-pastoral communities while they respond to the adverse effects of climatic change.

Key words: Adaptation, cattle, climate change, income, pastoral

I. Introduction

Since long years from now, the dire effects of climate change have been observed in various forms among the livelihood options of the pastoral and agro-pastoral communities in East Africa (Tsegaye et al., 2010a). Although the livelihood sources entirely depend on land suitability for sustenance of livestock and crop productivity, land degradation attributed by human, drought and climate factors is conspicuously noticed in terms of loss of livelihood sources, biodiversity and expansion of desertification (Adger et al., 2000; Prince, 2002; Stringer et al., 2009). These have further weakened the adaptive capacity of the pastorals and agro-pastorals that are largely concentrated in the dry-land regions of East Africa (Sandford,

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2006a). For instance, traditional adaptation strategies such as livestock mobility, diversification, feed purchase and animal restocking have become unable to support their livelihood requirements as they used to get benefits many years ago (Wassie and Fekadu, 2014; Kima et al., 2015). Moreover, their dependence on livestock rearing has got much constrained by population growth, occupation of former grazing areas by human settlements (emergence of new villages) and urbanization (Tsegaye et al., 2013). Although population growth and gradual emergence of peri-urban centers seem to hold great promise as potential sources of market opportunities for livestock producers (Markakis, 2004), the future livelihoods of pastoral and agro-pastoral communities in the contemporary climatic change has critically remained among the biggest challenges (Sandford, 2006a). In responding such challenges, pastoralists and agro-pastorals have long history of involvement in various forms of adaptation methods based on their own local indigenous knowledge (ATPS, 2013).

Here, the term 'adaptation' is used to refer to any reactionary responses to a new set of conditions, either intentionally or autonomously to adjust to certain pressures posed by climatic change, which distress human wellbeing (Smit and Wandel, 2006; IPCCb, 2007; Parry et al., 2007). Adaptation is viable if applicable actions adequately reduce magnitude of vulnerability and increase people's adaptive capacity (ability to support system's structure and help functioning) towards improved level of resilience (the rate at which a system regains its structure and function after some adaptation actions) (Stringer et al., 2009). In the literature, there are two major opposite debates focused on whether pastoral way of life could serve as adaptation strategy to respond to climate change in the dry-land regions of East Africa. The first group contends with deep pessimism about pastoral way of life in the sense that pastoralism is an old mode of living by which pastoralists couldn't realize their livelihoods till to date (Sandford, 2006a). Pastoralists are highly exposed to warning changes evolved from variability in climate and weather, population pressure, land degradation, marketing, governance and access to technology (Bradburd, 1982; Hogg, 1992; COMESA, 2009). Evidently, human population growth in the Greater Horn of Africa has disproportionately affected the ecological base of rangelands, which threatened its carrying capacity to support huge livestock herds and consequently left the pastoral and agro-pastoral communities in crisis (Sandford, 2006a).

Indeed, pastoral mode of living follows communal ownership of rangeland resources (Hundie, 2008), which negatively affects the motives of individuals to invest on conservation and this further leads to unsustainable use of resources (Hardin, 1968). According to Sandford (2006a), introducing improved livestock management in ways of permanent settlement life should be prioritized and this can be credible if it is integrated with irrigation and mixed livestock-cereal production along with forage enhancement schemes. His argument went on that settling pastoral community into permanent location leads to provision of basic infrastructure including schools, health services, road accesses, veterinary services and so forth. These would further enable pastorals and agro-pastorals to adjust their mode of livestock production and crop farming based on expected livelihood improvements.

In contrary to this view, the second group of scholars strongly advocates the importance of pastoral living style to maintain their livelihood bases through their traditional systems (Mortiz et al., 2009; Nassef et al. 2009). Research findings demonstrate that pastoral system is an easy way to adapt to climatic effects owing to its suitability to the arid and semi-arid environment through strategies of establishing strong social capital, economic cooperation among community members and clan lineage networks, herd diversification and restocking methods (Mortiz et al. 2003; Birch and Grahn 2007; Oxfam 2009). In their context, pastoral mode of production allows the community to keep their cultural systems and knowledge while responding the negative effects of climate change. This is because livelihood bases of pastoralists are determined by strong social institutions within the community that basically do not require policy replacement. Instead of changing the prolonged indigenous mode of living into the proposed new style of life, more attention is needed to enhance their mobility strategy in a way that supports their adaptive capacity to cope with climate effects.

Keeping the two debates in mind, there exist a wide divergence of opinions about the sustainability of pastoral way of life and its corresponding contribution towards climatic adaptation in the dry-land regions of Africa. However, adaptation possibilities are heavily dependent on varieties of factors such as traditional and modern institutions, market (Smit et al., 2000), resource availabilities (Sandford, 2009), human and livestock population in a specific land size (Tsegaye etal., 2013) and availability of livelihood options apart from livestock earnings (Berhanu et al., 2007; Galvin, 2009). As noted by Adger et al. (2005) and Getachew (2001), people's reaction to climatic change may vary depending on multiple factors that enable them to adjust accordingly. Considering the existence of each factor, it makes difficult to carry out the stand points of the two debates into policy actions without having sizeable evidences about the extent that the factors influence the lives of pastorals and agro-pastorals. This requires thorough investigation on how coexisting multiple factors determine the adaptive capacity of pastoral and agro-pastoral communities across various climatic regions (Adger et al., 2005). Lack of research evidences to the study of climatic adaptation on pastorals and agro-pastorals will obviously continue to widen the conceptual differences among various viewers (ATPS, 2013), which may further trigger lack of consensus across the communities (pastorals and agro-pastorals), policy makers and decision makers. This challenge may be addressed if pragmatic information on various determinant factors can clearly be identified and made available. Hence, this article attempts to explain how major factors influence the adaptive capacity of pastorals and agro-pastorals? Which adaptation methods contribute to which types of income sources? And to what extent the likely adaptation methods applied by pastorals and agro-pastorals resulted in on their income levels? With the aid of empirical information, an analysis on the multitude nature of pastoral and agro-pastoral communities against the major determinant factors helps indicate for seeking improved sustainable approaches reasonably compatible to their ways of living.

Similarly in Ethiopia, identifying major factors that affect the adaptive capacity of pastorals and agro-pastorals have recently become prior concerns while attempting to improve the livelihoods of (Tsegaye et al., 2013). This is crucial because climatic adaptation via livelihood improvement helps fulfilling the living requirement of pastoral and agro-pastoral

communities which account about 12% of the country's total population and its share to total GDP reaches nearly 16% per annum (CSA, 2008). Among the entire pastoralists in the country, about 29% of them are living in the Afar Regional State (Sara and Mike, 2008). Hence, pastoral way of living in the Afar region is one of the top livelihood sources by relying on production of diverse livestock species, notably camels, goats, cattle and sheep (Hogg, 1997; Tsegaye et al., 2013). In the due course of their engagement on animal production to meet their subsistence living, the natural resource base in the region is highly subject to overgrazing and deforestation with an increasing number of human and livestock populations (Kassahun et al., 2008; Tsegaye et al., 2010a), which apparently accelerate land degradation (Galvin, 2009). This has been compounded with unpredictable pattern of rainfall and changing temperature, mainly with its rising level (Campbell et al., 2005). Rainfall uncertainty and varying temperature exposed the pastoral and agro-pastoral communities to threats of prolonged crisis (Kassahun et al., 2008; Sandford, 2009).

While attempting to deal with the existing climate related challenges among the pastoral and agro-pastoral communities, there have been still conceptual differences on whether the sources of the challenges stemmed from natural pressures or from various factors associated to failures in implementation. Failing to address political, social, economic, cultural and ecological factors, some governments perceive the existence of these challenges as if they were the common features of arid and semi-arid regions, whereby they paid little attention to pastoral and agro-pastoral communities (OXFAM, 2008). Consequently, inadequacy of understanding about the underlying effects of each factor (Crane et al., 2011) remains puzzle to clearly verify how locally practiced adaptation strategies uphold the livelihoods of pastorals and agro-pastorals. It is unclear which adaptation strategies can fit to what sort of livelihood options depending on varying climatic zones (Sandford, 2009). The large body of previous study is focused on climate modelling techniques for identifying future threats of climate change and outlining realistic adaptation approaches (Adger et al., 2005). Some suggested sets of adaptation methods such as diversifying income options, building formal and informal institutions, adjustments in livestock holdings and species, labor mobility, engagement in small irrigation schemes and livestock mobility (Mortiz et al. 2003; Berhanu et al., 2007; Seo and Mendelsohn, 2008; Crane et al., 2011; Tsegaye et al., 2013). However, empirical knowledge dealing with the effects of each adaptation strategy on the income of households is scarce. Hence, this study looks for realizing two important objectives. The first is the analysis on perceived effects of climatic change by rural pastorals and agro-pastorals and the second is to clearly examine the major adaptation factors that attribute to the income level over the course of five years.

II. Materials and methods

2.1. Study area

The study was based on panel data gathered during the years 2011, 2012, 2013, 2014 and 2015 from the district, *Aba'ala*, in the Afar Regional State of north-eastern Ethiopia. The Afar Region is situated in the great East African Rift Valley, which domestically bordered by *Oromia* on the south-west and south, *Amhara* on the north-west, *Tigray* on the north-east, and Somali on the south-east. Specifically, *Aba'ala* district lies between the highland escarpments

of *Tigray* Region and the world's deepest area called "Danakil Depression." *Aba'ala* district records a highly fluctuating rainfall with an estimated coefficient of 33% relatively varying from year to year (Meze-Hausken, 2004). Its annual average rainfall ranges between 150mm and 500 mm (Tsegaye et al., 2010a), whereby it frequently receives very erratic rainfall during *'Karma'* season, which constitutes rainy season between mid June to mid September. While the district has mean temperature varying from 20°C to 48°C, its altitude ranges from 100m below sea level in *Berahle* to 1500m above sea level in *Wuhdet* (the town center of *Aba'ala* district). The district is populated with nearly 37, 943 inhabitants living over an area of about 1,188.72 square kilo meters (CSA, 2008).

While looking at the effects of various adaptation practices by pastoralists and agro-pastoralists on their income improvements, *Aba'ala* district was chosen for this study because of two reasons. First, the district is characterized by its dryness and the common phenomenon of drought occurrences for about five decades. Due to its geographical remoteness from the Awash River and other perennial rivers, *Aba'ala* is one of the districts in the northern Afar currently suffering from lack of water and grazing access during drought periods. Consequently, pastoralists and agro-pastoralists of the district have frequently been forced to move to other districts in search of livestock feed (Yakob et al., 2001). Second, the existence of indigenous experiences of climatic adaptation methods by pastoralists, agro-pastoralists and mixed farming (livestock and cropping) in the district motivated this research to make detail analysis and scale up best practices of each method to other areas having similar contexts.

In the face of climatic change, adaptation strategies pursued by the communities of Aba'ala district can be grouped into four categories, namely pastoral, semi-pastoral, agro-pastoral and mixed farming (Tsegaye et al., 2013). Each category has its own peculiarity in responding the risks of climate change. Since long period, pastoralists were the early pioneers that have been living in Aba'ala district. Tracing back to the historical connections established between the pastoralists and migrants from the highlands of neighboring Tigray, both communities started living and working together since the middle of the 20th century (Kloos, 1982b). As the result, migrants from the Tigray Region continued practicing cropping and animal husbandry in *Aba'ala*. The district became known for its rain-fed agricultural suitability for growing maize, sorghum and some cereals like tef and barley (Tsegaye et al., 2010a). This has enhanced strong linkages between the indigenous pastoralists and the highland communities in terms of their economic interests and marriage relationships. Realizing the negative effects of climatic variability on their livelihood bases, the Afar pastoralists gradually began supplementing their food gaps through farming crops along with livestock herding (Tsegaye et al., 2013).

2.2.Methods of Sampling and Data Collection

The study employed two stages of primary survey. First, a reconnaissance appraisal was conducted to have a broader understanding on adaptive behaviors of pastoralists and agro-pastoralists and livestock-crop farmers that already dwell in the study area. During the exploratory survey, series of discussions were held with various stakeholders including clan

leaders, farmers, pastoralists, agro-pastoralists, extension workers and agricultural experts. Obtaining pertinent information from the first stage, it was used to refine the study objectives, sampling methods and the survey instrument. Qualitative data were gathered to supplement data types that cannot be obtained via quantitative methods. This would validate the quantitative results to come up with storylines of information about local practices of adaptation to climate change for improving their livelihood sources. Before setting out to field work for data collection, clan leaders, religious leaders, village administrators and elders were selected to hold group discussions. The important criterion for the inclusion of such discussants in this context was based on their pertinence for substantiating the findings. During the discussion, ethnographical methods were used to explore the contribution of Afar pastoralists and highland settlers in building livelihood assets.

For instance, participants broadly explained about the *Damhoita* clan, which dominantly serves the Afar people in setting local rules to manage pasture areas and natural resources and mobilize the community during droughts. The *Damohita* leaders take leading roles in making their clan members collaborate to other communities within the Afar region and other community members in neighboring districts of the highland areas (e.g. *Tigray, Amhara, Oromia* and others). Besides, the *Damhoita* leaders are responsible to resolve any incidents of conflict together with other clans and neighboring communities. Revealing the livelihood sources on which the communities in *Aba'ala* district have relied largely to respond to the adverse effects of climatic change, the group discussants expounded the main mode of strategies in respect to the pursuance of each group of community. Following Tsegaye et al., (2013), we classified the *kebeles* (lowest administrative villages) into four communities; namely pastorals, semi-pastorals, agro-pastorals and mixed farming.

In the context of Afar, pastorals refer to people pursuing on rearing animals mainly of camel, small ruminants and cattle. They use natural grazing through extensive mobility in search of animal feed and water. Semi-pastorals in the Afar region are also originally pastoralists, whose livelihoods principally depend on animal rising. Besides to animal rearing, they own cultivable land which entirely shared out to farmers coming from Tigray highlands. According to key informants, semi-pastoralism started during the 1970s to respond to occurrences of recurring droughts. Agro-pastoralists are farmers that directly involve themselves in growing crops and rising animals with their prior focus for animal production, dominantly cattle and small ruminants. In the fourth group, namely mixed farming is the group of people engaged mainly on cropping and rising small number of livestock originally migrated from the Tigray highland areas (Tsegaye et al., 2013).

Based on the four community classifications, we went on sampling across 11 *kebeles* (villages) of the district in *Aba'ala*. Out of the 11 *Kebeles*, five are pastorals, three are semi-pastorals, one is agro-pastoral and the remaining two are farming communities. To ensure appropriate representation of each group, two-stage stratification sampling methods were applied to minimize heterogeneities among groups (strata). In total, there were about 2224 household heads across the four groups. Proportionately, the number of households in each stratum (group) constitutes 760 pastorals, 284 semi-pastorals, 505 agro-pastorals and 675

farming communities. In sum, about 313 representative sampled interviewees were drawn from each group; 107 pastorals (33.3%), 40 semi-pastorals (12.8%), 71 agro-pastorals (22.7%) and 95 farming (31.2%). A survey of panel data was gathered from 313 sampled households. So as to preclude seasonal variations, data collection was conducted every November of each year.

2.3. Conceptual Framework

Rural income can be affected by numerous factors such as rural policies, household's adaptive behavior, natural pressures like drought and temperature, resource availabilities including infrastructure, access to market and information, and so forth. In situations where pastoral, agro-pastoral and farm communities confront multiple effects of climate change and whose income level over a number of periods is thought to be highly fluctuating due to unknown factors, this study tends to distinguish the effect of various adaptation methods on household income levels. Panel data was gathered from individual households and estimated using fixed effect model. The application of this model captures the extent of various explanatory variables that affect the income level of households over time. Fixed effect model helps to avoid the effects of independent variables that never vary over the panel years such as sex, topographic location, religion, type of community, race and others (Wooldridge, 2002).

Hence, any effect that may originate due to the influence of fixed variables is controlled by fixed effect model (Verbeek, 2004). Then, fixed effect model removes the influence of those time-invariant characteristics from the independent variables and the net effect of each independent variable that varies over the panel years is estimated by the model (Baltagi, 2005). Another important quality of the fixed effect model is that those time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics (Wooldridge, 2002). If the error terms are correlated, the estimating model has to be tested whether it requires random-effects or fixed effects and this necessitates applying the Hausman test (Baltaji, 2005). In this case, our dependent variable, income, was measured in Ethiopian Birr. Based on Baltagi (2005) and Wooldridge (2002), the following equations are to show how fixed effect estimation eliminates the time invariant unobserved effects as given below:

$$Y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + x_{tik} + a_i + u_{it} \qquad (1)$$

Where:

Y_{it} represents the dependent variable (*Income measured* in Ehiopian Birr),

X_i refers the vector of explanatory variables

t refers time period (t=1, 2, 3, 4)

a_i represents fixed effect (a vector of unobserved effects)

u_{it}= error terms across years

β_i = estimated coefficients

The correlation between the fixed effect a_i and the explanatory variables (X_i) will cause biases in the estimated coefficients. Thus, we need to eliminate the effects of fixed variables represented by a_i from the estimation. First, we computed the sample average variables for each individual. That is, for i^{th} individual, we divided equation (1) by time "t" to obtain equation (2) in the following form:

$$\bar{y}_i = \beta_0 + \beta_1 \bar{x}_{i1} + \beta_2 \bar{x}_{i2} + \cdots + \beta_k \bar{x}_{ik} + a_i + \bar{u}_i \qquad (2)$$

Since a_i is constant over time, a_i term in equation (1) does not have an over-bar. Now, subtract (2) from (1) to get the following equation called the within fixed effect transformation (Baltagi, 2005).

$$(y_{it} - \bar{y}_i) = \beta_1 (x_{it1} - \bar{x}_{i1}) + \beta_2 (x_{it2} - \bar{x}_{i2}) + \cdots + \beta_k (x_{itk} - \bar{x}_{ik}) + (u_{it} - \bar{u}_i) \qquad (3)$$

The net effect captured by equation (3) is free from effects of time invariant variables that we cannot measure in farming practices across years. Thus, this estimation allows us to observe the pure effect of applying various adaptation methods on income levels during the four consecutive years.

Considering the nature of rural income variables, they are dynamically interrelated each other and this further requires verifying the effect of lagged income (income of previous year) on current income. Hence, limitation of fixed effect model that may arise due to the inclusion of lagged variable (income) was checked using dynamic panel model as shown in equation (4).

$$Y_{it} = \theta Y_{i,}\, t-1 + x_{it}\beta_i + \varepsilon_{it} \qquad (4)$$
$$where\ i = 1,\ldots,N;\ t = 1,\ldots,T\ and\ \ \varepsilon_{it} = \varepsilon_i + \mu_{it}$$

Here, the dependent variable i. e. the income of pastorals, agro-pastorals and farming communities, depend on observed explanatory variables signified by x_{it}, latent effects represented by ε_{it} and the coefficient of lagged dependent variable ($Y_{i,}\, t-1$) is designated by θ. The error term, ε_{it}, is the overall time effect, which arises from heterogeneous behavior of individuals (ε_{it}) and time invariant variables (μ_{it}) (Baltagi, 2005). In situations where time effect is considerable, the use of dynamic panel modeling is needed because the inclusion of lagged dependent variable as a regressor may result in autocorrelation problem which in turn leads to biased estimates of Fixed Effect model. In this case, the dependent variable (Y_{it}) is a function of μ_{it}, which means the lagged variable ($Y_{i,}\, t-1$) is serially correlated to the error term (μ_{it}) where the use of Fixed Effect model becomes questionable (Nickell, 1981; Kiviet, 1995).

III. Results and Discussion

3.1.Perceived Effects of Climate Change

Table 1 presents the percentage of pastoralists and agro-pastoralists that perceived the major effects of climatic change. Out of the total respondents, 88.31% significantly perceived repeated frequencies of drought occurrences, which evolved due to climatic change. They

explained that prolonged drought was their major challenge that largely damaged the natural resources, and finally followed by lack of feed and water for people and animals. Masih et al. (2014) also noted that drought severely harms the ecosystem and worsens considerably human crisis. Moreover, 94.95% of the interviewees confirmed the effects of climate change, which widely destroyed crop farming twice or more times within a five years' period (Table 1). During drought period, 99.1% of the respondents reported lack of animal feed as their critical challenge. In the study area, majority of the respondents sensitized the effects of climate change in terms of rainfall variability (96.86%), temperature change (68.88%), untimely raining and flooding (94.96%), scarcity of water (96.23%), shortage of food for human (97.96%) and drying of streams and other water sources (94.63%) (Table 1).

During drought times, many livestock owners altogether obliged to use the same water sources (rivers, ponds, wells, and streams) to drink their animals. As elucidated by the key informants, cattle herds that mainly compete for similar grazing land and water sources were likely to be liable to enormous diseases. This shows the need to introduce better cattle management such as zero grazing, which may address problems related to disease prevalence due to the influx of a large number of livestock used to drink the same water sources.

Table 1: Perception of Respondents on Climatic Change

No.	**Perceived Climate Change Effects**	**Cattle Owners Felt the Effects of Climate Change in Percent (n=313)**			
		I don't know	I don't feel any	I felt it moderately	I felt it significantly
1	Recurrent drought	0.32	4.09	7.80	88.31
2	Rainfall variability	2.43	0.7	6.13	90.73
3	Temperature change	27.41	3.71	8.24	60.64
4	Prevalence of human disease	1.21	2.11	5.69	90.99
4	Prevalence of animal diseases	3.00	1.79	5.18	90.03
5	Untimely raining and flooding	2.78	2.81	7.28	87.54
7	Scarcity of water	1.60	2.17	7.28	88.95
8	Lack of human food	1.98	0.06	1.15	96.81
9	Lack of animal fodder	0.64	0.26	1.90	97.20
10	Crop failure	1.85	3.19	10.81	84.15
11	Noticeably drying of streams and rivers	1.88	3.51	10.80	83.83

3.2. **Socioeconomic Characteristics of pastorals and Agro-pastorals**

Following the economic labor force age category grouped by International Labor Office (2011), the pastoral group whose age between 15 and 64 years were found as active labor force population, whereas people whose age below 15 and greater than 64 years were named as dependent labor force group. As shown in Table 2, the interviewees were entirely in the age category between 25-77 years. The finding indicates that majority of the cattle owners were found to be in the age category of productive labor force. This would entail the possibility of applying various adaptation methods in responding the adverse effects of

climatic change. With proper management and planned implementation of community members across rural villages, concerted adaptation actions can be the means to instigate rural youths for creating various income options (Melaku and Hoag, 2014). Hence, the presence of the working age population in the area is the potential resource for developing sustainable income options and minimizes climate-related risks.

In terms of gender composition, 82.11 percent of the respondents were males and the remaining 17.89 percent were females. Based on ideas obtained from key informants and group discussants, females in the Afar region were generally burdened with indoor family management tasks, which deterred them from accessing to various income generating activities such as possible benefits from livestock rearing and off-farm activities. The result is consistent with other studies conducted by Chala et al., (2012) and FAO (2012) in the sense that females in Ethiopia have cultural hindrances that obstructed their involvement in various developmental activities outside their home. This indicates women's engagement in family management of daily house tasks such as cooking, washing, and taking care of their children. In most cases, women are deprived of formal education and working outside homes to supplement their financial requirements.

Table 2: Socio-economic Characteristics of the Cattle Owners (n=313)

Socio-economic Characteristics of Households (n=313)	Observation	Mean	Standard Deviation	Minimum	Maximum
Overall age in years	313	48.86	10.74	25	77
Age group in years less than 15	0	0	0	0	0
Age group in years between 15-64	282	46.71	8.90	25	64
Age group in years above 64	30	68.82	3.15	65	77
Agricultural working experience in years	313	24.78	11.56	3	53
Size of cattle holding	313	6.77	2.61	1	25
Size of goat	313	15.49	22.99	0	96
Size of sheep	313	0.03	0.31	0	4
Size of camel	313	0.3	1.15	0	11
Family size	313	6.70	2.20	2	24
Annual income	313	4, 924.05	2, 299.53	532	15, 717

Among the respondents, 66.90 percent did not get any chance to get formal education, 19.62 percent could write and read, 13.48 percent reached primary level, and nobody went to secondary school (Table 2). It was presumed that more educated people were possibly to have awareness about the effects of climate change and to apply various adaptation measures to respond to the effects. With respect to experiences of the respondents on agricultural practices, the mean year was about 24.79. The major animal holdings by the interviewees were cattle (ox and cow), goat, sheep and camel as shown in Table 2.

3.3.Adaptation to Climatic Change via Creating Various Income Options

Table 3 depicts some major income options by which the Afar pastoralists and agro-pastoralists attempted to adapt to multiple effects of climatic change. Given indigenous coping mechanisms the community possessing, pastorals and agro-pastorals dynamically apply various adaptation options by engaging on creation of various income alternatives. Among the options, the contribution of livestock accounted for about 65.73 percent of the

total income. In the due course of estimating net income obtained from livestock, we squeezed the total gross income by deducting all expenses made on purchase of fodder, payments for hired labor and fees for veterinary services. In the estimation, we included the major components of livestock income sources such as sales of live animals, milk, butter oil, hides and skins.

Considering the above cost outlays, nearly 14.08 percent of the income portion of the respondents was supplemented from cropping, which largely is pertaining to the semi-pastorals, agro-pastorals and mixed farming communities (Table 3). While the income part of the respondents obtained from sales of firewood and charcoal reached about 4.10 percent of the total, it has important implication that many of them were found to be dependent in exploiting the natural resource forests for commercial purpose (Table 3). This may be taken as an indication of how income constraints can pressurize the rural people to keep on selling firewood and charcoal for meeting their short-term needs without considering the long-term burdens on the natural resource base. Hence, continual damage of the natural forest can accentuate the negative effects of climatic change in the area. In this context, the key informants further recommended urgent measures to enable the fuel-wood sellers to shift to compatible income diversification alternatives like honey production, commercial tree plantation, livestock rearing, and trading, which are eco-friendly livelihood alternative sources. Similar conclusions made by Habibah (2010) indicate that farmers can be active participants in protecting the natural resources if they find that the resources offer them any kind of perceived benefits in sustainable ways. Consistently, Hagos (2003) posited that income diversification in environment friendly way could be a means to reduce poverty and ensure resource stewardship.

Table 3: Ways to Adapt to Climate Change via Improving Income Options

Income Options Pursued by Households (n=313)	Income Share (%)	Mean	Standard Deviation	Minimum	Maximum
Income from cropping	14.08	3646.00	1143.64	1200	8000
Income from agricultural wage	1.03	1328.99	2083.22	0	7411
Sales of fuel-wood	4.10	870.22	210.52	0	3121
Income from livestock	65.73	17015.00	268.26	0	39012
Income from non-agricultural wage	0.62	161.23	542.80	0	3500
Income from remittance	0.23	600.57	449.47	0	5120
Income from relief	14.11	3653.80	1242.23	0	7960
Income from self employment	0.08	21.60	157.72	0	2310
Others	0.56	381.10	109.19	0	1521

3.4.Adaptation via Cattle Management

In the history of the Afar community, natural pasture has continued serving as the dominant source of feed for their cattle. But later, the influx of migrated people from highland areas along with the indigenous Afar began settling in specific villages during the 1960s (Tsegaye et al., 2013). It was since this period cropping was introduced in Aba'ala. Owing to repeated droughts over series of years, rural farmers realized that storing animal feed such as straws and hay would paramount essential to save the lives of their livestock. As shown in Table 4, farmers in Aba'ala Woreda (district) harvested hay and straw across the five years (2011 to

2015). In Table 4, the least harvest of hay and straw during 2015 may be because of the severe drought currently Ethiopia is facing. In this period, crop growers, agro-pastoral and semi-pastoral communities in Aba'ala district did not produce any crop. Despite the harsh drought in 2015, cattle owners purchased much less hay and straw than they purchased in the preceding years. This might be because of the reason that purchase of animal feed for whole is costly and unaffordable to the locals, thereby, households opt to move their livestock to eastern Afar in search of feed during drought times.

Table 4: Adaptation to climatic change through cattle feeding

Year	Amount Produced in kg		Amount Purchased in kg		
	Hay	Straw	Hay	straw	Formula feed
2011	214.69	1020.57	0	42.08	13.48
2012	166.39	986.83	0	12.78	7.76
2013	211.34	787.57	76.68	398.55	197.26
2014	242.87	826.58	196.75	681.01	374.85
2015	10.06	762.27	103.64	174.90	157.54

3.5.**Major Effects of Various Adaptation Actions on Income of Households**

Table 5 illustrates the effects of various adaptation measures on the income levels of the respondents using fixed effect model. The basis of the model applied for this analysis stems from the assertion that unobservable effects of households in the panel data are captured by fixed effect model (Baltaji, 2005). The model controls for all time-invariant differences between the individual farmers by correcting time-invariant characteristics. Hence, fixed effect model was used to determine whether the application of several adaptation measures had any effect on the income of the households. To ensure that the regression estimates satisfy the minimum variance properties, we repeatedly checked model adequacy for the fitted fixed effect model. It basically tests whether the unique errors (*ui*) are correlated with the regressors and the null hypothesis claims that errors are not correlated with regressors. Following Wooldridge (2002), the statistical justification for the use of the fixed effects model over the random effects model was verified using the Hausman test which finally indicated that the fixed effects model gave consistent estimates at 1% probability level and the null hypothesis which claims no effect has been rejected. In the regression, some of the major adaptation actions are found to contribute a decisive role in influencing the income level of the households in the Afar, Aba'ala district. Among the major adaptation measures are water harvesting, livestock diversification, migration, cattle restocking, hay production and purchase of hay.

In dry-land regions like the Afar areas, **access to water sources** have positive effects on the livelihoods of the community. The coefficient with respect to water harvesting actions against income is positive and statistically significant at 5% probability level (Table 5). This shows that households accessing to water sources are more likely to maintain their annual income in the face of climate change. Delgado et al. (2011) asserted that water conservation is the basis for agricultural productivity, without which, it would be unthinkable to feed the growing population of our world. The key informants similarly highlighted about the necessity of water sources for the Afar communities, wherein they are highly exposed to frequent

droughts and intense temperature. As reported by Tsegaye et al. (2013), most community groups residing near Aba'ala town are better off comparing to the pastorals and semi-pastorals. This is because there are some water streams, rivers and wells near the town, on which nearby community members rely largely.

With regard to **livestock diversification**, it is found to have a significant relationship with income level of households at 5% probability level (Table 5). Such positive association may have an explanation that pursuance of households on diversified income strategies might enable them to build their adaptive capacity in alleviating problems related to climatic risks and uncertainties. Degefa (2005) reported that people that follow diversified income sources are more likely to achieve sustainable livelihoods. In this context, diversified livestock production in Aba'ala district of northern Afar is the common practice in terms of rearing animals such as cattle, goats, sheep and camels.

Looking at Table 5, **migration** of pastorals and semi-pastorals is another variable expected to influence the income level of the households that actually involved over the last five years. The results obtained from the fixed effect regression indicate that migration of cattle owners was positively and significantly related to their income level at 5% probability level. Among the cattle owners that keep moving their cattle herds to potential areas, where animal feed can be accessible the ones that used mobility as their permanent strategy got more income than those did not migrate. In contrary to this finding, other researchers argue that pastoral mode of life is an outdated system, which is currently in crisis (Markakis, 2004) owing to "Too many people, few livestock", which further created imbalances among humans, livestock and the environment (Snadford, 2006b). However, recently reported research findings indicated that pastoralists in western and eastern African countries have continued to respond to climate related challenges successfully (Moritz et al., 2009).

In the north east of the Afar region, the occurrences of persistent droughts over the course of many years have resulted in death of livestock herds. However, communities usually tend to restock the number of their cattle when promising raining season is expected. Looking on Table 5, **cattle restocking** in the study area was found to be statistically and positively significant at 1% probability level in affecting the income level of the households. But, this statistical report is not supported by local discussants. According to their explanation, immediate restocking following to preceding drought can bring unnecessarily lose if another drought comes by the next year. Local discussants went on to elucidate their experiences what to do during restocking. Decision for livestock restocking depends on what type of livestock breed should the individual opt to pursue and in which farming community (pastoral, semi-pastoral, agro-pastoral and farming). Cattle restocking are more appropriate by farming and agro-pastoral communities, where cattle are highly important for farm tilling. On the other side, restocking camel and goat is more compatible when undertaken by pastoralists and agro-pastoralists. This is because camels and goats can easily survive in harsh environments via grazing and browsing leaves and tree branches. Thus, the effect of livestock restocking on the income of the communities mainly requires prudent decisions where to be done using what species.

Getting access to animal feed either through **hay production** or **hay purchase** was found to have statistically and significantly positive effect on the income levels of the respondents at 5% and 1% probability levels respectively (Table 5). Compared to local respondents having minimum access to hay stocking, cattle owners with a wider level of hay stocks are more likely to feed their cattle, which in turn gives them high better income (Table 5).

Table 5: Effects of Adaptation Actions on Annual Income Using Fixed Effect Regression

Variables	**unit**	**Coefficient**	**Standard Error**	**t**
Working experience in agriculture	Year	-19.9328	10.96683	1.82
Family size of the household	Number	-66.48029	138.1242	0.48
Family members whose age between 15 and 64 years	Number	99.34005	136.3085	0.73
Family members whose age above 64 years	Number	477.0332	456.9791	1.04
Access to water sources	Dummy	1021.037	443.411	2.30**
Stocking fodder	Dummy	253.9862	326.9086	0.76
Irrigation Access	Dummy	274.8597	333.6605	0.82
Cropping	Kg	167.835	263.043	0.64
Diversification	Dummy	783.2368	337.6591	2.32**
Zero-grazing	Dummy	-176.0066	280.0474	0.63
Pasturing in own village	Dummy	164.5703	275.2336	0.60
Use of selected breeds	Dummy	214.3019	333.8805	0.64
Migration	Dummy	976.0952	450.5405	2.17**
Forage production	Kg	741.9497	412.1161	1.80
Restocking	Kg	984.7472	330.822	2.98***
Destocking	Kg	147.2765	289.8335	0.51
Number of cattle	TLU	-102.2118	61.6185	1.55
Timber production	Number	146.8368	410.7294	0.36
Hay production	Kg	0 .4613762	0.2204127	2.09**
Straw production	Kg	0.1058963	0.0833971	1.27
Purchase of hay	Kg	6.059224	2.253921	2.69***
Purchase of Straw	Kg	959.9722	0.0833971	1.27
Purchase of Formula feed	Kg	0.536117	1.242155	0.43
Lagyear	Number	2.2711	7.3843	0.21
Constant		2647.221	721.0562	3.67
F(24, 312) = 219.40 Prob > F = 0.0000				

III. Conclusions

The intention of this study was to make analysis on the effects of various adaptation actions pursued by pastorals, semi-pastorals, agro-pastorals and mixed farming communities. While responding the adverse effects of climatic change, the intertwined dependence among different adaptation methods necessitated to explore the perception of households and to verify whether various adaptation actions can bring about improved income sources. The study revealed that repeated drought left the rural poor with crop failure due to lack of rain; followed by herd decimation because of lack of animal feed. Majority of them perceived the adverse effects of climate change in terms of rainfall variability, temperature change, and

lack of animal fodder, untimely raining and flooding, scarcity of water, shortage of human food and drying of water sources.

The regression result of fixed effect model shows that adaptation methods such as cattle management practices like water accessing schemes; fodder production, feed purchase, livestock diversification and restocking have statistical and significant effect on the income of the households. Moreover, the existing dependency of cattle owners on sales of firewood and charcoal need to be replaced by providing them with sustainable income options such as beekeeping, production of commercial trees (eucalyptus tree), fodder production, and cattle fattening. Pursuing on such alternatives are environmentally compatible and better ways for creating supplementary income sources using the hillside areas.

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