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Effects of Climate Change and Adaptation Strategies of Pastoral Communities, Sabba Boru District of *Guji Zone*, Oromia Region, Ethiopia

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Abstract

The global climate change due to increased anthropogenic and natural factors is becoming a serious threat to life on the earth, particularly in Africa. Local communities have been developing and using their own adaptation strategies to overcome the effects of climate change and to sustain their well-being. However, little emphasis has been given on the effects of climate change and adaptation strategies of pastoralist communities. Hence, this study was initiated to investigate the effects of climate change and adaptation strategies of pastoral communities in Sabba Boru district, southern Ethiopia. Five kebeles were selected using systematic sampling technique based on agro-climatic zones (three from arid and two from semi-arid). A total of 136 households were selected from the five kebeles using simple random sampling method. In this study both quantitative and qualitative data were collected. The quantitative data were analyzed using descriptive statistics while the qualitative data were organized and narrated in order to support the outputs of the quantitative analysis. Observing tree phenology, wind direction, monitoring unique behavior of some animals, bee and special bird movement, and moon and star characters were indigenous climate forecasting methods in the study area. This indigenous knowledge of pastoralists has been used to forecast the likelihood of future climatic conditions that affect their entire decisions and options for coping. The result further indicated that, Sabba Boru district pastoralists have been using indigenous knowledge-based adaptation strategies in response to the effects of climate change. These adaptation strategies include selling livestock and its product, livestock diversification, seasonal movement, gold and precious mineral mining, consuming wild food and Enset. Indigenous and scientific knowledge of adaptation strategies should be integrated to overcome effects of climate change and ensure the sustainability of pastoral livelihoods.

Keywords: Pastoralists; On-farm activities; Non-farm activities; Livelihood diversification; Indigenous Knowledge

Introduction

Background

The Intergovernmental Panel on Climate Change (IPCC) projects a global mean temperature increase of 1.1°C to 6.4°C by 2100, which is likely to cause storms and floods, and lead to a rise in sea level due to the thermal expansion of the oceans and the melting down of ice sheets and glaciers [1]. Climate change (e.g., temperature, precipitation, drought, timing of thaw, frequency of hurricanes), rising sea level and elevated storm surges are all physical processes that have negative implications on the development and human well-being [2]. Accelerated changing in climate is still expected to have a wide-ranging effect on the future sustainability of the Earth due to adverse ecological, social and economic impacts [3].

Climate change has a major challenge to livestock production in the pastoral system through its impacts on forage production, water availability, disease risks and thermal stresses [4]. Localized evidence from pastoral areas in southern and southeastern parts of Ethiopia (e.g. Borena and Shinile) highlights decreasing rainfall trends being a major cause of declining livestock production [5]. [6] also stated that drought is the most crucial climatic variable that cause decline in pastoral livestock production. Other studies also reported that drought have frequently affected Guji - Borana pastoralists of southern Ethiopia, causing substantial livestock losses, declining agricultural production, and food insecurity [7].

On the other hand, pastoral communities have an indigenous knowledge about their environment and have been implementing various adaption strategies to cope with climate related risks and environmental stresses [8]. Such adaption strategies have important cultural and religious dimensions and implications [8] but their usability and effectiveness may remain limited because of values, processes and power relations in society [9]. Studies

[10] have suggested that understanding local climate knowledge of communities can be valuable for decision-making processes.

According to Abate [11], traditional knowledge may provide new insights for improving existing scientific knowledge and a basis for designing appropriate research and development policies. Furthermore, the potential importance of local practices in enhancing socio- ecological resilience has been underestimated particularly in pastoral production system of Ethiopia including the Guji pastoral and agro-pastoral areas. In recent years, however, extreme climatic events (e.g. recurrent drought, and rainfall variability), attributed to food insecurity, poverty and exacerbate the existing vulnerability in the area.

Statement of the problem

Ethiopia is amongst the top countries in Africa that vulnerable to climate change [12]. Directly or indirectly pastoralists dependent on the natural resources are being challenged by threats from climate change impacts, such as water scarcity, the changed trend of rainfall and drought pattern, increasing of desertification and bush encroachment in the range lands, expansions of human and livestock diseases and aggravated conflicts through competition for resources mainly through water and pasture scarcities.

However, the pastoral communities sustaining and surviving their life through their knowledge-based adaptation practices, but still most researchers' do not consider pastoralists' Indigenous Knowledge as a base for scientific knowledge in every aspect [12]. Accordingly, the policies outlined in different countries were largely inadequate in addressing the pastoral communities' problems including their vulnerability reduction from the impacts of climate change [13].

Similarly, in Ethiopia, the government pastoral area policies are inadequate in the light of the frequent occurrence of droughts and climate change impacts in general [12].

Southern Ethiopia, where Guji Zone is located, and some parts of Ethiopia's Somali region relied on their IK aimed at minimizing losses from climate change or facilitating recovery thereafter [14]. Especially, the Guji pastoralists living in Sabba Boru district of Guji zone are affected by the brunt of climate change and live with a set of problems arising from it there. However, they were adapted to the impacts of climate change and reducing their vulnerability through their IK based weather forecasting, pond and well construction and management (water related practices), hay collection and storage for dry season, seasonal livestock mobility, participation on crop cultivation, livestock species diversification, livestock traditional health care systems. As a result, they are surviving in these very challenging environmental situations, in the area. So, studying the effects of climate change and adaptation strategies of pastoral communities is important, and this study is designed to addressing some of these gaps and to scale up its important role in autonomous adaptation in the local area.

Objective

General objective

The study aimed to assess pastoralists' perception on climate change and adaptation strategies of pastoral communities in Southern Ethiopia.

Specific objectives

The specific objectives of this study were;

a) Assessing pastoralists' perception on climate change and their forecasting methods to climatic conditions in the study area.

b) Identifying pastoralists' adaptation strategies to climate change in the study area.

Research Methods

Study area

The study was conducted in Guji Zone, Sabba Boru District which is located between 05∘4'0"- 05∘59'0" N and 38∘31'0" - 39∘48'0" E. It is 563km far away from Addis Ababa in Southern part of Oromia regional state (Figure 1).

The general topography of the Sabba Boru district is rugged and broken, with many hills and ridges. It has an altitude range of 800-1500m.a.s.l. There are two agro-climatic zones in the district namely arid (81%) and semi-arid (19%). Annual temperature of the district ranges from 12.71∘C to 29.6∘C, with annual rainfall of 600 - 1400mm. There are two rainy seasons: March-May (ganna) which is the long rainy season and September-October (hageyya) is short rainy season. The normal trend of rainfall pattern was changing. The mean annual temperature of the area is 20.61∘C. The district has two soil types, comprising 70% sandy soil and 30% verti soil [15].

The total population of the district is 106, 486; out of which 59, 452 are male and 57, 034 are female (CSA, 2013). About 75% of the district population livelihood based on livestock production. The remaining 25% based on sedentary farming and non-farm activities. It is characterized by subsistence type of livestock and crop cultivation practices. Livestock populations in the area were 214,456 of cattle, 255,899 goats, 16,733 sheep, 14,621 camels, 46,442 donkeys, 8,056 moles, 284 horses and 360,581 chickens. Crop types practicing in the study area were maize, teff, haricot bean and wheat are the most one [15]. The area was sparsely populated and characterized by moisture deficit, resulting on water shortages that reduced the livestock and crop production potential of the area.

Sampling and data collection

The study was carried out in Sabba Boru district which is comprised of 24 kebeles. Of these, 16 kebeles are classified under arid agro-climatic zone, while the remaining eight are

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in semi- arid agro-climatic zone [15]. Therefore, the attention was given to both agro- climatic zone of the district. To select the representative kebeles, first consultation was held with the district administrators and then three and two kebeles were systematically selected from both arid and semi-arid respectively by considering its representativeness in reflecting the realities of pastoralism and agro pastoralism in the study area. The study used the approach of Cochran's (1977) to determine the size of sample HHs for the study and the following formula was applied.

$$n_0 = \frac{Z^2 pq}{d^2}; n = 1 + \frac{n_0}{\frac{n_0 - 1}{N}}$$

Where; no = the desired sample size Cochran's (1977), when population is greater than 10,000,

n = number of sample size when population is less than10, 000 Z = 95% confidence limit i.e. 1.96.

P = 0.1 (proportion of population to be included in the sample i.e. 10%) q = 1-P i.e. (0.9).

N = total number of populations.

d = Precision or degree of accuracy desired (0.05).

Based on the indicated formula, a total of 136 respondents were accordingly involved. Then, probability proportional to size (PPS) technique was followed to select the sampled households in the five kebeles.

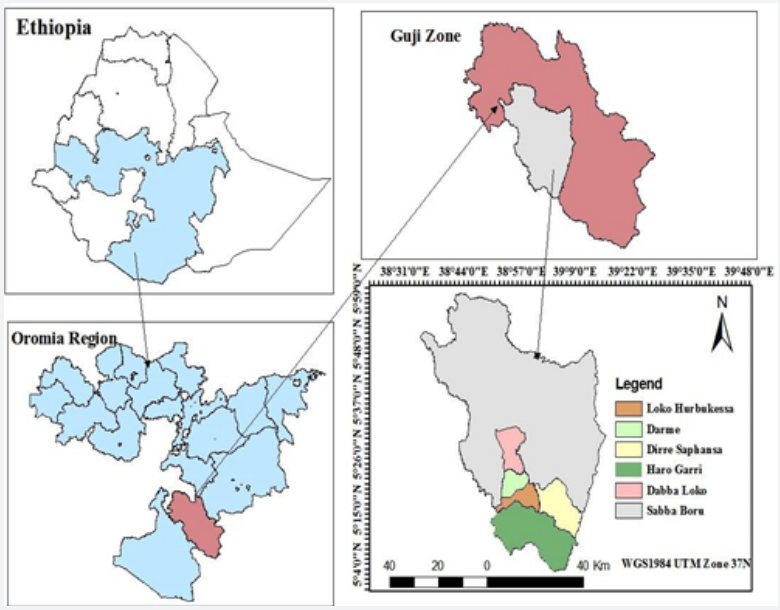

Figure 1: Location of the study Area.

The data were obtained from primary and secondary sources. The primary data sources were household survey, focus group discussion and key informant interviews. Secondary data were obtained from published and unpublished articles and reports available at kebeles and district. In addition, climate data of the study area (Nagelle station) acquired from National Meteorology Agency (NMA) of Ethiopia was used as another secondary source of data.

Data analysis

The data were summarized and coded by using Microsoft excel 2007 and then entered to Statistical Package for Social Sciences (SPSS version 20). Before running the analysis, some internal consistency checks were made to assess the quality of data. The analysis for HH characteristics and livelihood assets and activities, income, climate change evidences, and adaptation strategies based on IK practices was undertaken by using descriptive statistics: frequencies, percentages, mean and standard deviation. The data collected through open-ended questionnaire, KI interviews, FGDs and documents were narrated following the quantitative data results. Finally, the results of this study were presented by using tables and graphs.

Results and Discussion

Pastoralists' climate variability forecasting methods, their perception and meteorological evidences

Indigenous forecasting methods of climate variability

Based on the HH survey, the indigenous forecasting ways of climate variability of sample households were tree budding and

[1]Ethno-meteorology is an indigenous way of forecasting and interpreting local weather conditions in a given locality or remote community (Kolawole et al. 2014).

[2]Indigenous knowledge (IK) is, broadly speaking, the knowledge used by local people to make a living in a particular environment (Warren, 1991).

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flowering (74.26%), wind direction (72.06%), bee movement (71.32%), animal behavioral change (68.38%), special bird movement (68.38%), moon and star (25.74%) (Figure 2).

Pastoralists' perception on climate change

The survey results indicated that most of the respondents perceived an increasing trend of temperature (To) and declining rainfall in the study area. About 88.24% agreed that the T ◦ is increasing while 87.50% agreed decreasing of rainfall (Table 1). Similarly, the FGD and KI participants revealed changes in climate patterns such as radical warming, prevailing strong winds and declining and variable rainfall.

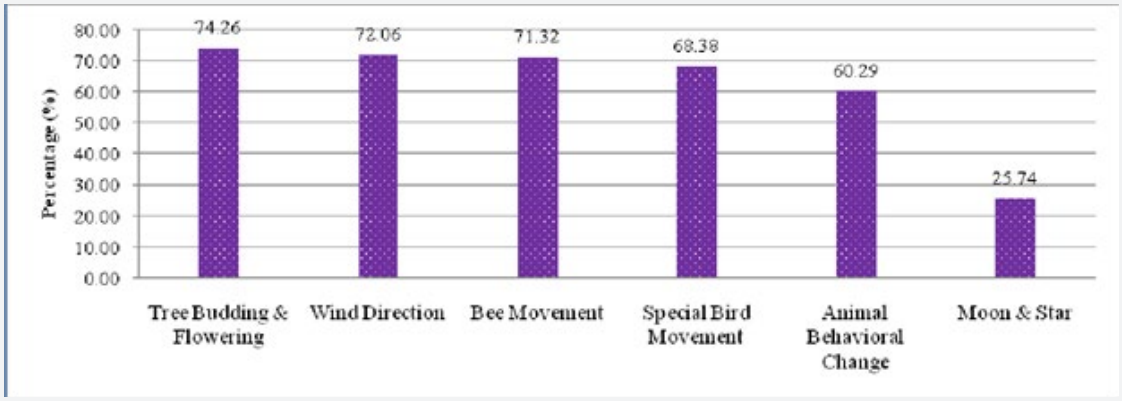

Figure 2: Indigenous climate variability forecasting methods in Sabba Boru district, southern Ethiopia.

Table 1: Perception of pastoralist on trends of temperature and rainfall in Sabba Boru district, Southern Ethiopia.

Kebeles	Temperature						Rainfall					
	Increasing		Decreasing		Remain the Same		Increasing		Decreasing		Remain the Same	
	N	%	N	%	N	%	N	%	N	%	N	%
D abba Loko	14	77.78	2	11.11	2	11.11	3	16.67	13	72.22	2	11.11
D arme	33	86.84	3	7.89	2	5.26	2	5.26	36	94.74	0	0
D irre Saphansa	26	89.66	3	10.34	0	0	1	3.45	26	89.66	2	6.9
H aro Garri	25	92.59	1	3.7	1	3.7	2	7.41	23	85.19	2	7.41
Loko Hurbukessa	22	91.67	2	8.33	0	0	2	8.33	21	87.5	1	4.17

Meteorological evidences of climate variability

Negelle station climate data depicted that there had been clear climate variability in precipitation and temperature in the study area during the past 46 years. The minimum (7mm) and maximum (1,381.70mm) annual rainfall were recorded in the years 2016 and 1972 respectively. Similarly, a minimum annual temperature of 12.71◦C was recorded in 1986 while the maximum annual temperature (29.6◦C) was recorded in the year 2016. The average mean annual temperature and rainfall of the site in the last 46 years was 20.61◦C and 666.90mm respectively. The average temperature in the area has significantly followed an upward trend with an average annual rate of increase of 0.067◦c while annual average rainfall declining in 10.11% in the last 46 years.

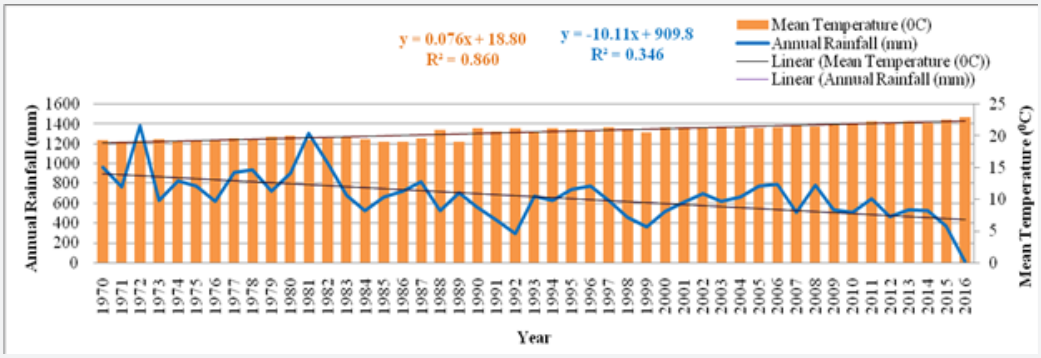

Figure 3: Forty-six years Annual Rain-fall and Mean Temperature of Sabba Boru district, southern Ethiopia.

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Furthermore, the climate variability pattern further revealed that there were specific years with above average mean annual temperature and below average mean annual rainfall (Figure 3).

Linkages of pastoralist' perception and meteorological observation

It is depicted in Figure 4 that the pastoralists' perception on climate pattern showed trend of increasing in temperature and decreasing rainfall. Similarly, the metrological observation revealed that trends of increase in temperature and decline in rainfall pattern (Figure 5). Therefore, both observations strongly confirmed the variability of climate in the study area.

Ethno-meteorological knowledge plays a key role in farmers' ability to devise climate variability and change adaptation measures due to significant gaps in scientific knowledge. The pastoralists' forecasting method is based on skillful art of observing the natural environment as expressed in the timing or flowering of plants, hatching of insects, arrival of migratory birds, etc., which enables farmers to make adjustments in farming calendar and livestock and crop types selection in any given season [16]. They rely on historical patterns, weather observations and signs to formulate expectations on weather and climate [17].

This indigenous knowledge was often passed down from one generation to the other. The KI and FGDs participants reported that most pastoralists particularly the elders had a profound knowledge on their seasonal weather condition forecasting (monitoring and prediction) using their indigenous knowledge. Based on HH survey findings, observing tree/plant phenology, wind direction, bee movement, animal behavioral change, special bird movement, moon and star were indigenous methods of seasonal weather situation forecasting in the study area (Figure 4).

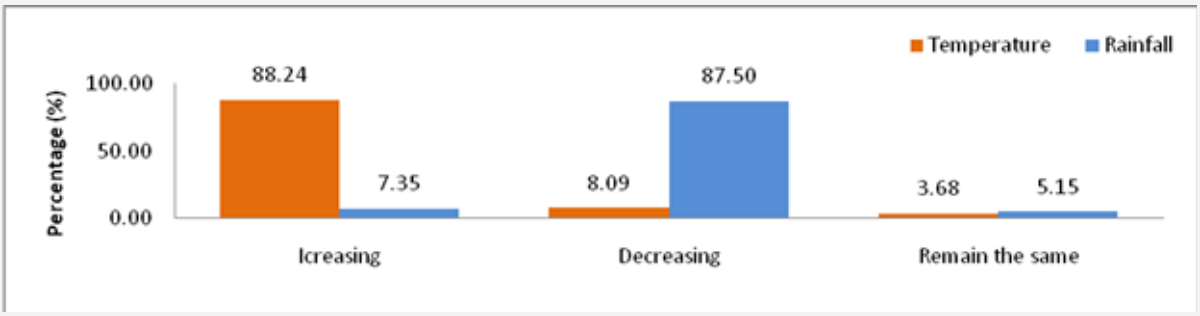

Figure 4: Perception of pastoralist on trends of temperature and rainfall in Sabba Boru district, southern Ethiopia.

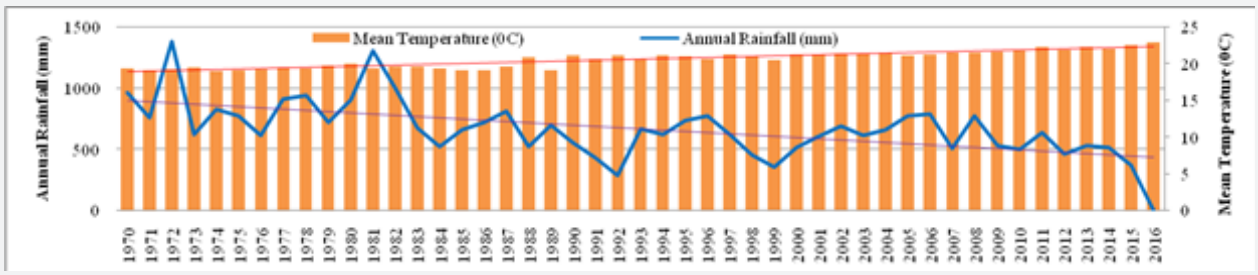

Figure 5: Trends of Rain fall and Temperature in Sabba Boru district, southern Ethiopia.

For stance, when broadleaf tree/plant removed or budding their leaves naturally, pastoral communities forecast the rain condition (going and coming time) and even they predict whether it normal, above or below the normal through observing that how much those trees covered by leaves. When trees leaved enough on its all branches, they expect that the coming rain will likely a good enough, whereas it leaved less, the rain will also likely below normal. On the other hand, pastoral communities were followed /mobile to the direction of the area where the bee moved. Because, they believed that those areas will likely having a good condition for their livestock production. A wind direction was also one of indicator that local communities used to forecast a rain. According to HH survey, FGD and KI interview report, in the study area wind blowing to the direction of South East and North West for long rain (Badheessaa) and short rain season (Hageyya) respectively. But, when the directions of wind changed from the normal, pastoral communities predict that the rainfall will likely be changed from the normal trends. Especially, when

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livestock leaved their home area and research for more pasture even during nighttime, local communities forecast that shortage of pasture (drought) will facing them. Finally, moon and star were also meaning of forecasting method in the study area. Pastoral communities predict the rain condition based on color of mood and star. When moon makes its full moon (fully circled) and reddish color, the rain will likely good enough. Based on all these, they make adjustments in all their livelihood activities.

In line to this finding [18] reported that the Borana pastoralists in the southern Ethiopia and northern Kenya forecast the future climate situation of their area based on different features, such as cow intestine reading and interpretation, livestock behavior patterns, birds, stars, clouds observation. [8] also depicted that IK enabled the traditional people in France to build ability to predict weather phenomena based on plant and animal behaviors and the movements of stars or other natural phenomena available in the area.

Adaptation strategies of pastoralists

On-farm activities

Livestock based activities

Table 2: On farm activities for overcoming the effects of climate change on livestock in Sabba Boru district, Southern Ethiopia.

Kebele	Livestock Diversification		Livestock Sharing & Gift		Selling Livestock & its Product		Changing Feeding Time		Saving Calves		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Dabba Loko	4	22.22	1	5.56	4	22.22	4	22.22	5	27.78	18	100
Darme	6	15.79	9	23.68	14	36.84	7	18.42	2	5.26	38	100
Dirre Saphansa	11	37.93	8	27.59	5	17.24	4	13.79	1	3.45	29	100
Haro Garri	11	40.74	6	22.22	7	25.93	2	7.41	1	3.7	27	100
LokoHurbukessa	4	16.67	2	8.33	8	33.33	2	8.33	8	33.33	24	100
Total	36	26.47	24	17.65	38	27.94	19	13.97	17	12.5	136	100

According to the finding from analysis of HHs, livestock-based activities were the major adaptation strategies of climate change in the study area. It was understood that selling livestock and its product and livestock diversification were the most common activities practiced as a copping strategy to climate change in the study area. Other similar activities include livestock sharing and gift for households who lost their livestock due to natural and manmade disasters; changing feeding time and saving calves (Table 2).

Crop based activities

Based on HH survey results, crop-based activities were common options of adaptation strategies of climate change in the study area. From crop based on farm activates, most of the agro-pastoral community practice planting drought tolerant crops and early maturing crops. While the rests practice buying harvested crops (19.12%), changing amount of food and feeding time (18.38%) and disease & pest control (13.97%) to cope up the effects of climate variability in the study area (Table 3).

Table 3: Crop based activities for overcoming climate change & variability effects in Saba Boru district, southern Ethiopia.

Kebele	Changing Amount of Food and Feeding Time		Buying Harvested Crops		Planting Drought Tolerant Crops		Planting Early Maturing Crops		Disease & Pest Control		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Dabba Loko	4	30.22	2	15.11	4	30.22	4	30.22	4	30.22	18	100
Darme	6	21.47	8	28.63	11	39.37	7	25.05	6	21.47	38	100
Dirre Saphansa	5	23.45	5	23.45	7	32.83	10	46.9	2	9.38	29	100
Haro Garri	7	35.26	8	40.3	5	25.19	4	20.15	3	15.11	27	100
LokoHurbukessa	3	17	3	17	10	56.67	4	22.67	4	22.67	24	100
Total	25	18.38	26	19.12	37	27.21	29	21.32	19	13.97	136	100

N = Number of respondents, % = percent number of respondents.

Non-farm activities

Based on the finding, the non-farm activities to overcome climate change effects were seasonal movement (25%), mining gold & precious minerals (21.53%), consuming wild food (21.32%), consuming Enset (16.18%) and motorcycle rent (13.97%) (Table 4).

Adaptation strategy is the actual responses to crisis on livelihood systems in the face of unwelcome situations and is

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considered as short-term and long-term response [19]. It is a strategy for climate extremes taken to reverse the evil outcome of climate extremes [18]. Based on the HH survey findings and discussion with KI and FGDs participants most pastoralists were copping with the effects of climate change by livelihood diversifying (Table 2-4). The livelihood activities include on-farm and non-farm activities to overcome disaster risks related to climate change. As the results indicated, the livestock based on-farm activities to overcome disasters related to climate variability were selling livestock and its product and diversifying livestock type; livestock sharing and Gift; changing feeding time and saving calves. Whereas planting drought tolerant crops and early maturing crops, buying harvested crops and disease & pest control were crop based on-farm activates to minimize disasters related to climate variability. This finding revealed that the non-farm activities that support the households to overcome effects of climate variability were seasonal movement, mining gold and other precious minerals, consuming wild food, consuming Enset and motorcycle renting [20].

Table 4: Non-farm activities for overcoming climate variability.

Kebele	Consuming Enset		Consuming Wild Food		Manning Gold & Precious Mineral		Motorcycle Rent		Seasonal Movement		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Dabba Loko	2	11.11	2	11.11	5	27.78	2	11.11	7	38.89	18	100
Darme	7	18.42	7	18.42	8	21.05	4	10.53	12	31.58	38	100
Dirre Saphansa	4	13.79	6	20.69	8	27.59	8	27.59	3	10.34	29	100
Haro Garri	6	22.22	6	22.22	6	22.22	2	7.41	7	25.93	27	100
Loko Hurbukessa	3	12.5	8	33.33	5	20.83	3	12.5	5	20.83	24	100
Total	22	16.18	29	21.32	32	23.53	19	13.97	34	25	136	100

Conclusion and Recommendations

This study concludes that pastoral communities used many adaptation mechanisms which encompass selling of livestock and its product, livestock diversification, livestock sharing and gift; changing amount of food and feeding time and saving calves; planting drought tolerant and early maturing crops, buying harvested crops and disease and pest control and looking alternative livelihood diversification options used as mutual supporting system.

The indigenous weather forecasting methods were effective early warning knowledge of the pastoralists through generation to generation in the study area. Tree budding and flowering, wind direction, bee movement, animal behavioral change, special bird movement, moon and star were major one.

Livestock restocking with good variety breed is needed to overcome the effects of climate change. It is important to address drought and disease resistant early matured crop variety to improve the livelihood of pastoralists in the study area.

Participatory range land management and integrated disasters risk reduction strategy should be implemented to reduce the scarcity of pasture and water in the study area. This situation could enable pastoralists to cope the effects of climate change. Integrating indigenous and scientific knowledge on adaptation strategies is vital to overcome effects of climate change and ensure the sustainability of pastoral livelihoods' well-being.

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