Climate Change Induced Shocks, Consequent Impacts, Vulnerability and Farmers Endeavor to Adapt in Northern Highland: Implication for Designing Household and Community Level Strategies

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Abstract

Background

Despite future emissions, the world is already exposed to further warming, largely due to past emissions. If global society continues to emit greenhouse gases at current rates, the average global temperature could rise in alarming rate. The consequent shocks such as heat waves, sea level rises, storms, cyclones, flooding and droughts, which currently hit hard are also expected to be more severe and more frequent in the future across the globe. Its impacts will be very devastating to livelihoods of the world in general and farming community in particular. Therefore, adaptation appears as the best mechanisms to dampen vulnerability and increase capacity to resist to climate change.

Methodology

Mixed research approach i.e., qualitative and quantitative methods along with phenomenological design were used. While sample districts, elder farmers for focus group discussions and experts and development agents for intensive interviews were selected purposively, Kebeles and household heads for survey data selected using proportionate random sampling procedures. Quantitative data collected using semi-structured questionnaire were analysed using descriptive methods and index (Principal Component Analysis). Whereas, qualitative data collected using discussion and interview guiding checklists were transcribed, coded, organized with resembles and analysed thematically.

Major findings & Conclusion

Increase in temperature, change in rainfall including shift in raining periods, shortage and variability of rain, frequent occurrence of drought, crop pests and animal disease were major branded climate change induced shocks in the area. Land degradation, low productivity of crop and animal production caused due to loss of soil fertility, crop pests, scarcity of pasture and water, and animal disease were the key consequent impacts of climate change induced shocks affected the livelihood. Vulnerability of farmers was very high. To reduce their vulnerability farmers employed many strategies: soil and water resource conservation practices, collecting hay, use of improved seed, fertilizer, pesticides and insecticides even if its use were very poor due to lack of finance. Farmers were at the edge of survival due to interconnected impacts.

Recommendations

Therefore, government policies should emphasis on the provision of local context based farming technology packages, strengthening of watershed management practices and development and provision of well-coordinated early warning systems.

1. Background Of The Study

Regardless of future emissions, the world is already exposed to further warming, largely due to past emissions. Moreover, the 5thAssessment Report of Intergovernmental Panel on Climate Change (IPCC) warns that if global society continues to emit greenhouse gases at current rates, the average global temperature could rise between 2.6^{o}C and 4.8^{o}C by the end of 21st century [1]. During this period temperatures in the African continent are likely to rise more quickly than in other areas, particularly in more arid regions but changes in precipitation will not be uniform across the land mass. The consequent shocks such as heat waves, sea level rises, storms, cyclones, flooding and droughts, which are also expected to be more frequent and more sever in the future across the globe [2]. Besides, the trends of increasing temperature, variability in precipitation and increasingly frequent drought is predicted to endure in the tropics through the future periods [3].

Combined impacts of climate change will be severe to livelihoods of the world in general and agricultural production and food security of the farming community in particular. Because, it could lead to rise the adverse effects on various biophysical and economic activities like agriculture, water resources, forestry, human health, biodiversity and wildlife [4]. Accordingly, the consequences will be severe to developing countries where agriculture is the primary source of livelihood [5]. Because, it can affect food systems in different ways ranging from direct effects on crop production to exchange in markets, as well as food prices and disruption of supply chain infrastructures [6]. Although climate change may affect the agricultural sectors of different countries in different ways, what is clear is that these changes will bring about substantial welfare losses, especially for smallholders whose main source of livelihood derives from agriculture [7]. Regards, the changes may prove especially devastating for developing countries in two ways. In one hand the region is historically have been vulnerable to extreme climatic events such as droughts and floods [8]. On the other hand, most farm families in developing countries dependent on rain-fed agriculture for food production [9].

As one of the list developing countries agriculture is central to the survival of millions of people in many Sub-Sahara Africa (SSA) countries [10]. The evidence that the future likely impact of climate change will adversely affect agriculture in SSA has become a crucial challenge for sustainable development on the continent. This challenge is composed of the likely impacts of climate change on ecosystem services, agricultural production and livelihoods. Because, the losses in the agriculture sector due to climate change will have economy wide consequences, like loss in gross domestic output, a decline in the income level and a drop in consumption of the most vulnerable population; hence, a general deterioration in households' welfare [11]. Accordingly, the impact and loss will be gigantic in Africa. Because, agriculture remains the means of livelihood of rural communities in Africa [12] though it is rain fed [13]. The African rain-fed agriculture is observed as the most vulnerable sector to climate variability and change [14]. As a result of this Africa is expected to be one of the most exposed continents to suffer the devastating effects of climate change and climate variability, with colossal economic impacts [15]. Besides of climate change various interlocked problems mentioned as the key reason for vulnerability and overwarming impact on the content. Among these, low economic development and high poverty rates, low adoption of technology, and its resultant high exposure to climate change induced shocks and an existing low adaptive capacity are some but not all [16; 17].

Ethiopia is among the severely vulnerable countries to the impacts of climate induced weather extremes and with the least capacity to respond in Africa [18; 19; 20; 21]. This is mainly because of the considerably sensitive and expositive nature of rural livelihood that emanates from reliance on rain fed agriculture, under-development of water resources' high population growth rate, low adaptive capacity, weak institutions, and lack of awareness on climate change [22]. In Ethiopia crop production is dominated by small scale subsistence farmers who practice more traditional farming, accounting for 95% of the total area under crop and more than 90% of the total agricultural output [23; 24; 25]. Accordingly, in Ethiopia in particular and in other developing countries in general where agriculture is the main means of livelihood adaptation appears as the finest mechanisms to dampen vulnerability and increase capacity to resist to climate change. The poor developing countries particularly need to tailor adaptation policies to offset the specific impacts they anticipate [26], because without adaptation, climate change would be problematic for agricultural production [27]. As a result, adaptation to climate change emerged as a major concern not only to farmers who face direct impact but also to researchers and policy makers who are responsible to develop mechanisms and adaptive technologies to tackle the impact [28].

That is because adaptation helps to modify existing resources either natural or human made that enable to withstand unforeseen shocks. [29] Noted adaptation is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation lessens adverse effects and takes advantage of benefits of changes in climate variables [30]. It is a measure or strategies with which farming communities to embrace and take advantage of new circumstances and conditions presented by climate changes [31]. In many highly vulnerable poor countries, understanding farmers' response to climate change is vital to design appropriate adaptation strategies [32]. Most of the time identified adaptation strategies do not necessarily translate into practice, because adaptation strategies to climate change and physiological barriers to adaptation are local specific [15].

Since climate change and its impact are emerged as the reality of our world it is a must to develop a wide array measures and adapt them. Therefore, understanding the nature of climate change impacts, key vulnerabilities and indigenous adaptive responses at local levels, and the national institutional responses are important for developing appropriate adaptation strategies at community and farm levels [33]. Accordingly, this paper sought: (i) to explore climate change induced shocks in the study area; (ii) to investigate consequent impacts of climate change induced shocks; (iii) to determine households' and community level vulnerability to climate change induced shocks; and (iv) to identify possible local strategies used by farmers in the response to climatic shocks with the intent to reduce the vulnerability of their livelihood.

2. Methods And Material Used

2.1 Study area

This study was conducted in North Wollo and Wag Hemra Administrative Zones. The two zones are among the eleven administrative zones in the Amhara National Regional State. North Wollo zone is geographically located between 11^0N-13^0N longitudes and 38^0E – 40^0E latitude and has an estimated area of 12,706km^2, which is about 21 per cent of the Region. It is bordered in the north by Wag Hemra Zone and the Tigray National Regional State, in the south by the South Wollo Zone, in the east by the Afar National Regional State and in the west by the South Gondar Zone [13]. On the other hand, Wag Hemra zone is with an approximated area of 9,039.04 square kilometers. It is bordered in the north and east by Tigray National Regional State, in the south by the North Wollo Zone, and in the west by the South Gondar Zone. Sekota is the capital town of Wag Hemra Zone, located in 720 km North of Addis Ababa and 540 km north east of the regional state capital, Bahir Dar [34].

2.2 Sampling procedure and sample size

Both probability and non-probability sampling procedures were employed. The selections of the study zones' (north Wollo and Wag-Hemra zone) and districts (Last & Sekota) were carried out purposively, non-probability sampling producers. This was mainly because to give more emphasis on qualitative aspects of the research. Whereas, eight Kebeles (smallest administrative units) such as Genetemariam, Erfa, Bilibala and Yimrhane-kristos from Lasta district and Wollehi, Abiya, Fiqreselam and Tsemera kebels from Sekota district were considered from two sampled zones using random sampling procedure. Total of 386 household heads selected using simplified formula ($n = N/1+N(\ )^2$) provided by Yamane, (1967) to determine the required sample size at 95% confidence level for quantitative data. Then respondents for the survey data were selected from each *Kebele* using the proportionate random sampling procedure. But, elder farmers for FGD, and experts and development agents for key informant interview selected using purposive sampling procedures given their general knowledge and demonstrated experience on the trends of climate change induced shocks and its devastating impacts on their wellbeing.

2.3 Research approach and design

Mixed research approach i.e., qualitative and quantitative methods along with phenomenological design were used to achieve the objective of this study. While a mixed approach helped to collect diversified data, a phenomenological design was used to explore the phenomenon under study. However, more weight was given to qualitative data with whim to understand how people cope with the mystery climatic shocks, strive to reduce their vulnerability and adapt the continually increasing climate change. Here vulnerability to climatic shocks is entirely qualitative. [35] stated qualitative research are interested in understanding the meaning people have constructed, that is, how people make sense of their world and the experiences they have in the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them [36]. To make the study more informative a phenomenological design was used to explore the detailed subjective lived experience of the rural people with the grave impacts climate change induced shocks on their susceptible livelihood and with poor capacity to adapt. [37] noted phenomenology is an approach to explore people's everyday life experience. A phenomenological researcher investigates subjective phenomena with especial focus on the life experiences of a concept or phenomenon experienced by one or more individuals [38].

2.4 Types, methods and tools of data collection

To meet the pre-set study objectives, both primary and secondary data were used. The potential primary data were collected from farmers, experts and development agents using an appropriate data collection tools. Participatory field observation, focus group discussion and key informant interview were conducted using discussion or interview guiding checklists used to gather qualitative data. In addition, survey method was used to collect quantitative data using semi-structured questionnaire.

For focus group discussions elder farmers who have demonstrated experience about the issues under study were purposively selected with the help of field facilitator. For this purpose farmers from both sexes were involved. The advantage was to get full picture of the community and to understand the impact of climate change. Each group was established with the average number of eight up to twelve individuals and women and men were assigned in to different discussion groups. The rigorous discussion was managed within the limited time period, from 60 to 90 minutes and conducted.

For key informant interview experts who lived for a long period and have sufficient experience to the impact of climate change induced shocks and vulnerability of farmers and their efforts to adapt it were involved. Accordingly, 44 key informants across north Wollo and Wag Hemra zones were interviewed. In addition, observations that made by the researchers with the help of farmers and facilitators on environment (land, forest & water resources), rainfall, temperature, crop fields and livelihood sources given valuable information on the issues being studied. To avoid distortions of an idea of intensive discussion, interview and field observations voice recorder and camera were used.

2.5 Methods of data analysis

Both qualitative and quantitative data were anayised separately using appropriate tools. The bulks of qualitative data first verbally transcribed. Reading and re-reading the text of transcribed data were done to comprehend and identify various themes. Redundant reading of the text helps ensure that the data correctly categorized [39]. Then, themes were identified and thematically organized based on their reassembling ideas and concepts. Identifying salient themes, recurring ideas and patterns of belief that link people and settings together were the most intellectually challenging phase of the analysis and one that integrates the entire endeavor [40]. Next, identifying connections between categories was very important and conducted, because these relationships help to interpret the whole data [41]. Finally, the organized qualitative data were analyzed thematically and narrated in an iterative manner. A thematic analysis is very important approach in qualitative research because is one that looks across all the data to identify the common issues that recur, and identify the main themes that summarise all the views you have collected [42].

Besides, Principal Component Analysis (PCA) and descriptive methods were used to analysis quantitative data using SPSS v. 23. Particularly PCA was used to analysis the indices of various variables associated with economic, social and environmental helps to level the vulnerability of the community. [43] stated that is an important technique for extracting common information from a set of variables which are statistically unrelated linear combinations. Finally, analysed quantitative data were described and presented using figures and tables to corroborate the qualitative findings.

3. Major Findings Of The Study

3.1 Major climate change induced shocks

Climate change is anticipated to increase weather variability and incidences of extreme events, which will have an impact on livelihoods and wellbeing as it undermines development efforts [44]. Climate shocks include drought, erratic rainfall, floods, hailstorm and landslide among others [45]. Its negative impacts are mostly felt by poor people in developing countries [29], because often it causes devastating effect to their means of living and immediate environment. In the study area farmers experienced many extreme events that is the result of climate change and variability. Accordingly, 98% the respondents and discussants indicated that temperature of the area is increasing from time to time since 1984/5. To indicate the gravity of the increase in temperature discussants compared their area with *Humera* the area that they very know in their nearby which is very hot. They affirmed that they are experiencing higher temperature than they use to it. Shifting of *Belg* rainy season is also believed to be associated with increase in temperature.

Both discussants and 97% of the respondents stated that the amount of rainfall reduced as compared to the past especially starting from 1984/5 drought period. The time of rainfall is unpredictable where in most cases it comes lately and goes out early. A decrease in seasonal rainfall has devastating implications on agricultural production leading to food insecurity, malnutrition and famine [46]. That is the major problem of food insecurity in the area. Furthermore, 100% of respondent farmers and discussants confirmed as their community hardly hit by frequent drought that was mainly due to shortage of rainfall. Long-term climate change in Ethiopia is associated with changes in rainfall patterns and variability, and temperature, which could increase the country's frequency of both droughts and floods [47]. These climatic hazards, particularly drought, are becoming the major forces challenging the livelihoods of most farmers [48]. In this regard, discussants affirmed as they began to face drought from 1954/5 to 2014/5. That was also in different period and with various impact levels. The following sentence expresses their overall evaluation of the drought periods associated with climate extremes:

"We are full of extreme events. For instance, drought is here with us. To be frank we were not being free from it in our life. That is has been increasing from time to time in comparison to the past particularly in terms of its occurrence. Consequently, since, 2015 we began to see drought year after year."

Following the increase in temperature and variability in rain frequent occurrence of both crop and animal disease are also among the common climatic shocks experienced in the area, 82% of respondents reported. On the other hand, majority 93% of farmers noted their experience of flood shock that mostly led to taken away of top fertile soil and thereby led to reduction in yield. Similarly, relatively few respondents (86%) and discussants stated the occurrence of ice shock and its impact on their crop however it was not that much frequent in their area. This result is in convergence with findings of [49], who found flood and hailstorms are the other natural extreme events that affect Ethiopian farmers although not pronounced like the case of drought.

3.2 Consequent impacts of climate change induced shocks

Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones [50]. Besides, the impacts of climate change on agriculture have significant consequences on livelihoods, food production, and the overall economy of countries, particularly those with agriculture-based economies in the developing world [51]. Surveyed and group discussant farmers and key informant development agents and experts of different offices indicated as they observe various climate change induced impacts on the lives of their community. Accordingly, they strongly articulated as its impact was far reaching on main natural resource base and environment which was their means of living.

3.2.1 Impacts of climate induced shocks on natural resource (land and tree)

Tree is very important components of natural environment that has great ability to regulate the weather condition of an environment. About 100% of respondents and all discussants stated the major impact of climate change was observed on the natural resource bases. Accordingly, they aggressively reported the impact on land was the primary impact of climate change induced shocks in the area. This was because both increase in surface temperature and reduction or abnormal increase in the amount of rain result on immense impact on land resource. While increase in temperature led to damage of micro-organisms and high evapotranspiration that result on loss of soil moisture content and nutrient, torrential rain that come after prolonged drought led to taken away of top fertile soil. The combined effects resulted on infertile soil and degraded land. Previous studies also found the same result. [52] Reported change in rainfall and temperature has a direct effect on the amount of evapotranspiration and on both quantity and quality of the surface runoff. Such extreme events mostly led threats to the system, both sudden shocks (i.e, flood and land slide, etc) and slowly occurring shocks (i.e., soil degradation, drought and variation of rainfall patterns, etc) [53].

Here the impact was very severe on the previously arid land which was the known features of their land on which they depend. Surprisingly, the loss of soil fertility was reached to irreversible state with the usual practice like soil and water conservation practice in one side and farming on the other side. Historic climatic event called drought was core reason for the depletion of natural resource base, which is the main environmental problem of Ethiopia [49]. As a result of severity of impact all the efforts to rehabilitate focused on tracing, soil and water conservation and plantation were faced problem. Because, water or available amounts of moisture content of soil is vital to plant growth [54]. But the community lacks this due to previous degradation and insufficient amount of rain.

3.2.2 Impacts of climate change induced shocks on farming

I. Impacts on crop production

Rainfall dependent farming system is the only means of living in the area. Crop production is one on which farmers mainly depends their livelihood. About 100% of respondents and all the discussants of FGD and key informants confirmed that productivity of crop was extremely reduced in comparison to the past, especially before 1984/5 drought period. Climate extreme events such as lack and shortage of rainfall (97%), late come and early out of rainfall (100%), increase in temperature (94%), flood and especially drought (100%) were identified as the major impacts of climate change induced shocks on crop production. In addition to this, crop pest, was identified as constraint for crop production according to the discussion made with all parts and 82% of respondents. As a result, farmers are facing challenge to ensure their survival because the amount of rainfall and average temperature as well as other climatic factors during the growing season are critical to crop yields and food security [55].

During the discussion with elder farmers they referred to some of the difficult time when they lost their complete field due to deficiency and early out of rain. Of those severe climate change induced shocks periods, they mentioned 1984/5, 1987/8, 1994/5 and 2014/5. Accordingly, numbers of people were died and many others were moved in to other place within the country such as *Wollega, Gojam, Elibabure, Korem* and Raya. This is the prefect features of the overwhelming impact of climate change. Because, in different areas the direct impact of climate change induced shocks on crop production ranges from reduction of yield to complete loss [56].

Serious shortage of rain in the past, and let come and early out of rain in the present have been the two key challenges of crop production in the area. The rains that comes late led farmers not to sow seeds in time and rain that out early before its normal period mostly led crop failure. As result of both causes they mostly left with only fodder for their animal than harvesting yield. [57] Stated the amount and temporal distribution of rainfall and other climatic factors during the growing season are critical to crop yields. Furthermore, fluctuation in rainfall patterns, including amount of rainfall could adversely affect the productivity of crops [58].

Crop pest damage was one of the major problems identified in the area. Discussants confirmed that the type of crop pest increased in numbers as compared to the past, that is, before 1984/5. Increased pest populations will stress crop plants and increase the risk of crop loss, reducing yield and/or quality of harvest [59]. Among prevalently occurring crop pests, armyworm caterpillar was frequently mentioned climatic shocks. As result, farmers abandoned sowing of some of the crops and they are reducing others too. Among crop type pea is not cultivated in the study area. Other crops; such as bean and lentil is marginally growing in some pockets. As result, today farmers are forced to buy crops such as bean, pea and lentil for their consumption from other area however they were highly productive in the past. Therefore, farmers depend on the minimal yield which they get from limited crop type such as barely, Teff and wheat. In convergent to this study [60] found that Ethiopia continues to grapple the effects of drought and poor performance of the *belg* season in crop producing areas but the emergence of an exotic and invasive pest has been reported as spreading at an alarming rate and leading to big impact in the sector.

The productivity of land in the study area was very high as compared to the present. That means at that time they had chance to fallow land to maintain its fertility. But today this is impossible though productivity of land was extremely reduced in a very high amount, there is no optional land that is free than very limited few hectors (0.5-1hr.) on the hands of farmers. Discussants agreed and noted:

"When we see our land and its yield, it is possible to say, our land refused seed "□□□ □□□□ □□□□□". There is no production because the fertility of soil was extremely reduced. The main reason for this was loss of land cover like tree and grass due to our irresponsible action".

Among other constraints of climate change lack of *Belg* (short growing season) rains (February - May) were another challenge that affects crop production. Elder farmers' discussants and key informant experts confirmed that it is five to ten years ago when they began to face lack of *Belg* rain. *Belg* rain has many importance in their area for both crop and livestock production. For instance, when they get *Belg* rain they pass the year without any challenge because they able to sow and harvest good yield of sorghum, they don't face challenge to find water for animal. So, as compared to *kiremt* (main growing season) rain (June – September), *Belg* rain is the most important to escape food shortage.

II. Impacts on livestock production

In the face of climate change animal production is becoming a challenging sector of farming. Temperature affects most of the critical factors of livestock production, such as water availability, animal production and reproduction, and animal health (mostly through heat stress) [61]. Moreover, it is becoming very difficult to have animal. Because, its impact ranges from, challenge of productivity up to loss of animals. Shortage of pasture (100%), increase in animal diseases (86%), challenge to found water in their nearby (81%) were identified as the major causes of climate change induced shocks for livestock production.

Shortage of grass and availability of water in their nearby were challenging livestock production. Each additional number of human being in this planet comes up with one more additional need from the natural environment. Accordingly, land fragmentation due to increase in total population of the area caused no had common land for livestock to graze. [62] reported in many African countries livestock production remains low due to poor productivity that is attributed to poor husbandry practices and extension services, limited access to credit, rangeland degradation and reduced carrying capacities. Besides, low productivity of livestock is also suggested as due to the likely impact of climate change both in terms of affecting the quantity and quality of feed and by affecting the frequency and severity of extreme climate events [10].

In addition to this, all the open land is assigned for afforestation and some are under the rehabilitation programme, as result farmers forced to keep their livestock in a very limited size of land that they have. Some year's back there was free land left for livestock but today all the area is allocated for people. In addition to this farmers left one of the farm lands for their livestock but today there is no such chance for farmers. As a result they are trying to feed their animal by crop residue and collecting hay without selecting the type of plant that they found in the field. Any type of hay is collected in good season when there is grass in the area for drought period.

On the other hand, group discussants further confirmed currently the productivity of livestock is directly related with the productivity of crop production. If the condition for crop production is good, that is, the same for livestock production. This implies that, if the weather condition for crop production is favorable the situation for livestock production is not bad because, animals mainly depend on crop residue due to lack of grass. One of discussants stated:

"Surprisingly, due to lack of productivity and milk we started to use cows for plowing. Of course, previously they give birth normally and provide adequate milk but today it is not the case. As a result, we began fixing of them with ox and cultivate land".

Animal disease was affirmed as the second most serious impact of climate change induced shocks that are severely affecting their livestockIncreased temperature creates a favorable condition for the occurrence of diseases. Given increase in temperature a transboundary animal diseases that are highly contagious and easily transmitted within and between livestock populations threaten the economic health of the livestock sector, productivity of livestock, the livelihood of farmers, and ultimately food security [63]. It was about 16 years ago as they faced seriously affecting disease of livestock in their community but due to increase in type of diseases in the area they are not even sure about their name. Livestock diseases are mostly affected by increases in temperature and precipitation variation [64]. Accordingly, large number of livestock was lost due to severe historical drought occurred in the periods of 1984/5, 1987/8, 1994/5 and 2014/5.

3.3 Households and community level vulnerability to climate change induced shocks

Agriculture is the main vulnerable sector of economy to the impacts of climate change induced shocks. It is the key sources of livelihood particularly for farm households. However, it is suggested as highly vulnerable sectors to climate change induced shocks. This is because the Ethiopia agriculture mainly depends on erratic rainfall and the recurrently occurring drought highly affects agricultural production and livelihood of the farming population [49]. The first reason for their vulnerability in the study area was their dependence on previously depleted natural resource like land and water resources, and economic capital. Because, climatic shocks often deplete assets and resources of poor rural households [55], on which they makes living. Moreover, poverty and environmental stresses due to climate change such as droughts or floods have increased the vulnerability of rural households [65].

As result, all the discussants and 100% of the respondents confirmed that they have no capacity to with stand to any climatic shocks because they have either no stored cereal in their stock or money in the bank. For example, "from now onwards if drought occurred, the only chance that we have is either passing away or displacement". They do not assume as their community has ability to manage it and survive. Ability of individuals to adjust to actual or expected climate impacts or to cope with the consequence of climate change varies to various degrees [48]. [53], stated that subsistence farmers in the developing world are particularly unable to cope with climate change and variability, as they do not have the capital to invest in new adaptive practices with which to protect their homes and families. Similarly, subsistence livelihood systems currently experience a number of interlocking stressors, other than climate change and climate variability [68]. That increases the level of their vulnerability to the state not able to copes the single extreme event.

Here when they say "We are highly vulnerable to climate change induced shocks" they are affirming that they cannot survive seasonal shocks without external help as assets are not accumulated for unforeseen circumstances. Hence the help of external bodies such as government and non-governmental agencies are crucial in the study area. One of discussant farmers noted that:

"As to me I have no capacity to resist any climate induced shocks like drought. That means I am highly vulnerable to climate change induced shocks. Because, how can I say I am able to resist, since I know what I have in my hand. For example if something happen in my life at this time I have nothing to invest to reverse it".

The second source of vulnerability of farmers to climate change induced shocks is having small land size. All the discussant mentioned as they are facing shortage of land. From1993/4 onwards large number of dwellers has no farm land particularly for those who returned from displacement of the 1984/5 drought and currently for the young since land redistribution is no longer undertaken after 1993/4. In addition, their exposure to climate change induced shocks due to topographical set-up of their limited land size was also the source for their high level of vulnerability in the area. Currently, the common land size on which farmers depend is between 0.25 to 1ha. The amount of cultivated land is splitting over time from generation to generation which facilitates gradual climate change through resource depletion and population imbalance [67].

Moreover, the impact of climate change is much higher on some segments of the community. Climate change disproportionally affects the most vulnerable people, especially women and children [68]. Accordingly, women discussants mentioned that as they were highly vulnerable to climate change. Here, lack of land for those who are landless and shortage of yield even for those who have land were mentioned as a key reason for their vulnerability. Thus, the extent of vulnerability is not comparable to those who have no means of living and as result dependent on government aid. Women discussants consent on and indicated that:

"As we are women we face differentiated problem due to climate change induced shocks. Because fetching water for our domestic work is the responsibility of women. We equally go out with men for public work during the developmental work that is commonly conducted for two months, that is, from January 10 to March 30 every year. This is new type of work, today it is a must to participate equally with male. Though we do not hate the work from its positive effect to our livelihood but its impact is very high and we are suffering from it".

3.3.1. Internal causes for vulnerability of farm households

During discussion farmers mentioned many factors as a reason for high vulnerability of farm households in the study area. Of the many reasons, low level of income (91%), lack of both fixed and variable asset (94%) are among the major internal reason for vulnerability of farm households. Lack of productivity in farming was the root cause for having low income and lack of asset accumulation by farmers. [27], noted that as the quantity of agricultural products decrease, it translates into a decrease in farmers' income. Climate related shocks most often resulted in a crop yield reduction and, in some cases, loss of an entire crop [55]. That mostly led rural households to face shortage of food and resultant food insecurity and horrible poverty.

Furthermore, having limited options of income source than two activities, crop and livestock production was other internal factors that forced farmers to be vulnerable. Here also not all of the farmers in the area depend on both crop and animal production but some depend on crop and the other depend only on livestock production that was also may be one cow and one or two small ruminants. As result of this even in the normal period, when there was no variability of rainfall, they still need support of the government. Discussants agreed and noted that:

"We know ourselves and each other; no one has ability to cope with climate event like drought even with its symptoms. For example, if we face shortage of rainfall just as the situation in 2014/5 no one has capability to survive with his own capital unless the hand of government is with him. Let alone to the future but we passed the entire previous drought through the unreserved help of our government, thanks to him".

3.3.2. External causes for vulnerability of farm households

Climate change induced shocks were the major external reason for the vulnerability of farm households according to the reports of 100% of respondents and all the FGD discussants and KI informants. Drought that is caused by increase in temperature and shortage of rainfall was the core external factors as explained both by all parts included in the study. Literatures also indicate that poverty and environmental stresses due to climate change such as droughts or floods have increased the vulnerability of rural households [65]. Besides, crop pests that frequently occur following erratic nature of rainfall affected crop production. Climate change induced and other economic shocks; deplete household assets or predispose households to future asset depletion [45] and increases the level of households vulnerability. Other effects reported by farmers include increased food shortages, food price increases, death of livestock, and loss of income and assets [56].

3.4. Levels of vulnerability related to climate change induced shocks

Levels of vulnerability to climate change induced shocks were measured by principal component analysis (PCA) by employing different indicators. Accordingly, potential indices which have the ability to show vulnerability level of household as well as the community are listed under social, economic and environmental variables (Table 4.2).The variables under social and economic aspect measures adaptive capacity while the variables under section of environment measures the sensitivity and exposure to climatic shocks. During the computation of PCA in SPSS V.23 software, each aspects; social, economic and environmental aspects were analyzed separately, and components with eigen value greater than 1 was used. Consequently, the first principal component that explains majorities of variation in the data set was used to determine the indices that will help for leveling the vulnerability.

Majority of factor scores of the first PCA was negatively associated with several indicators under social, economic and environmental aspect which identified as adaptive capacity, sensitivity and exposure respectively. Here the sign and magnitude of each principal component score plays a great role because it implies two things. An indicator with the positive sign indicates its positive contribution to reduction in vulnerability of the households while indicator with negative sign implies its negative contribution to increase the level of vulnerability in the area.

Of the total indicators, that is 21, about six variables are negatively associated with vulnerability i.e., four are under adaptive capacity and the remaining two variables are under sensitivity and exposure. A negative index here indicates that the household or community has relatively lower adaptive capacity in comparison to a household or community with a positive index value, keeping exposure and sensitivity constant. Because, adaptive capacity is considered as positively contributing to vulnerability reduction while exposure and sensitivity are negatively contributing to vulnerability reduction, since they are external in their character.

Finally, the vulnerability index to determine the levels of individual households or community was determined by employing the definition of Intergovernmental Panel to Climate Change (IPCC, 2012). Vulnerability is seen as the net effect of adaptive capacity (socio-economic) and sensitivity/exposure (biophysical):

Vulnerability = (adaptive capacity) – (sensitivity + exposure).

In this relationship, higher net value indicates lesser vulnerability and vice versa. Accordingly, **vulnerability level (V)** of Lasta district = [-0.272 + 0.872 + 0.455 + (-0.147) + 0.146 + 0.926 + 0.632 + 0.998 + 0.023 + 0.080 + (-0.066) + (-0.128) + (-0.592) + (-0.264) + (-0.310)] – [0.906 + 0.895 + 0.847 + (-0.209) + 0.894 + (-0.245) + 0.227] = **-0.962.** Similarly the **vulnerability level (V)** for the Sekota district V = [-0.491+ 0.832+ 0.374+ (-0.098) + (-0.363) + 0.843 + 0.742 + 0.671 + 0.333 + (-0.466) + (-0.222) + (-0.110) + (-0.409) + (-0.235) + (-0.032)] – [0.689 + 0.566 + 0.680 + 0.445 + (-0.190) + (-0.004) + (-0.336)] = **-1.481.** The net effect of the index is negative to both districts; this implies that communities in the study area needs urgent support to cope with climate change induced shocks. The analysis results of index are also what the farmers affirmed during their group discussion at the field.

Table 1: Factor scores of the principal component analysis

	Lasta district		Sekota district	
S/N	Social Variables	Factor score	Social Variables	Factor score
1	Gender of the household head	-0.272	Gender of the household head	-0.491
2	Age of the household head	0.872	Age of the household head	0.832
3	Family size household head	0.455	Family size household head	0.374
4	Educational level of household head	-0.147	Educational level of household head	-0.098
5	Agricultural extension service	0.146	Agricultural extension service	-0.363
6	Farmers experience on farming	0.926	Farmers experience on farming	0.843
	Economic Variables		Economic Variables	
1	Land size	0.632	Land size	0.742
2	Rain fed agriculture	0.998	Rain fed agriculture	0.671
3	Irrigation practice	0.023	Irrigation practice	0.333
4	Information	0.080	Information	-0.466
5	Credit crevice	-0.066	Credit crevice	-0.222
6	Livestock	-0.128	Livestock	-0.110
7	Improved seed	-0.592	Improved seed	-0.409
8	Use of chemical fertilizer	-0.264	Use of chemical fertilizer	-0.235
9	Use of insects and pesticides	-0.310	Use of insects and pesticides	-0.032
	Environmental Variables		Environmental Variables	
1	Reduction in the amounts of rainfall	0.906	Reduction in the amounts of rainfall	0.689
2	Frequent occurrence of drought	0.895	Frequent occurrence of drought	0.566
3	Damaging flooding	0.847	Damaging flooding	0.680
4	Unusual rainfall	-0.209	Unusual rainfall	0.445
5	Increase in temperature	0.894	Increase in temperature	-0.190
6	Vegetation cover	-0.245	Vegetation cover	-0.004
7	Soil infertility	0.227	Soil infertility	-0.336

2.5. Framers response strategies to climate change induced shocks

The current climate change scenarios demand adaptation to temperature increases, changing amounts of available water, climatic instability and increased frequency of extreme weather events [69]. Accordingly, in the response to climate change induced shocks farmers use many strategies to reduce the vulnerability to climate change induced shocks. Accordingly, to reduce soil erosion and to improve the productivity of their limited farm land they were doing watershed management practices. The practice includes terracing, construction of stone and soil bund, planting seedling on degraded mountains and

collecting rain water. The watershed management was practiced by both public workers through productive safety net programme (PSNP) and in the form of campaign mostly conducted from January to March every year's according to the government schedule. Farmers in developing nations are practicing diverse adaptation strategies to develop resilience to climate change-related risks like droughts and floods [70].

As a result of these watershed management strategies very little improvement was observed in soil fertility and water availability. This indicates that the contribution of watershed practice for the reemerging of dried pond and for increasing the discharging potential of the existing one. Discussants agreed:

"Before the last five years we spent much time in search of water for all our domestic work. But today this is not the case and we do not spend much time to find water. This is because we started to rehabilitate our area which was degraded in the past and as result previously dried water point is started to provide water.

Despite the efforts made on watershed management practices and optimism in obtaining water and grass, still it is not promising. Besides of this they began to adapt many other strategies because adaptation activities can be of different types; from the purely technological (such as sea defence construction), through behavioural (such as shifts in choice of food or recreation), managerial (such as changes in farming methods) and policy (such as planning regulations) [71]. Accordingly, improved seed (87%), fertilizers (72%), inter cropping: wheat and barley (63%), using manure (34%), preparing and distributing compost (47%), pesticides (66%), and insecticides (66%) to increase the yield and to control loss due to crop pests and insects were the potential adaptation strategies used. Despite the reduction in yield of crop production due to shortage in rainfall and low soil fertility the use of fertilizer increased production. In comparison to fertilizer using of compost or manure was better to improve the fertility of soil but the problem with it is creating favorable condition for invasion of weed and time consumption during its preparation.

Discussants stated the problem for fully adapting fertilizer was increasing price of fertilizer. Today, they are challenged to use it because they have their level of capital to afford. Accordingly, one of discussants forwarded "I want to give one message to the government in with regard to fertilizers price, corrective measures must be taken for the future unless it is not affordable".

With regard to livestock production discussants stated that during dry period they begin to collect hay and try fattening by feeding goat at the home (feed their animal at home beginning half of December to Jun) and reducing meal per consumption. The harvesting of hay is conducted during good seasons when there is grass in the field. Altering animal species and breeds, giving adequate water supply, producing pasture, altering rotation of pastures, and modifying the time of grazing and reproduction are among agricultural adaptation options [72].

During the discussion period with the farmers researchers were asked to know whether they able to adapt climate change with already employed strategies or not. Accordingly, they confirmed that they are using all the above mentioned strategies to adapt or reduce the impact of climate change induced shocks they didn't rather to survive in their area instead of displacement as previous. For this they indicated as their strategies were not enough to tackle the problem. "The reason for not able to adapt with the strategies we employed was because we have no other income source and asset to depend on it". Food insecure households face a limited choice set due to the costs and perceived risks of adaptation, imperfect access to input and output markets, and lack of insurance and credit [73].

In addition to this the impact of climate change was still becoming very serious that has ability to damage their livelihood asset and further their productive base. For example, for numbers of disease they didn't found medicine, to treat both their crop and animal. So, with having this entire problem they didn't say the strategies that they employed were enough either to adapt or reduce the impact. As result of this they were in need for any other strategies because they were still striving to survive and to build the adaptive capacity of their living for the future climate change.

4. Conclusion And Policy Implications

Ethiopia is one of the poorest countries in the world with majority of its population live in rural area depending on subsistence farming. In addition to the subsistence nature of farming, it is highly vulnerable to climate change induced shocks. Especially, in the study area food insecurity and extent of poverty were very high and left the people dependent on food aid. One of the major reasons for a high food insecurity and poverty in the community is the dependence of farmers on the rain fed agriculture which had failed to meet the growing food demands of the people and generate income for other needs of living.

Although many factors contribute to the poor performance of the agriculture and resultant food insecurity in the area, poor climatic conditions especially recurrent droughts caused by both shortage and variability of rain and increase in temperature are the major ones. Besides, land degradation caused by soil erosion was the other key reason for the low productivity of crop production and consequent food insecurity of the area. Animal production is also another wing of livelihood which was severely affected due to climate change through scarcity of pasture and water, and animal disease.

The analysis result of Principal Component Analysis (PCA) index revealed the vulnerability level of the farmers to climate change induced shocks in the study area is very high. This implies that farmers are at the edge of risk margin. To reduce the level of vulnerability and increase the resistance farmers were strived a lot of strategies on their farming. These includes tracing, construction of stone and soil band both in the field and degraded mountainous, planting seedling especially in degraded mountains, digging rain water collection scheme at the top of the field and within the field were among the watershed management practices. In addition to these; improved seed, fertilizers, pesticides, insecticides to improve the productivity of crop and collecting of hay and crop residue and feeding animals within home especially at dry period were the major practice farmers employed to enhance the adaptation of their livestock sector to climate change induced shocks. However, they used all these strategies the level of their vulnerability was very high and capacity to adapt the impact of future climate change was very low. This is because all the current effort they exert is just to cop rather to enhance their capacity to the climate change impacts to come.

Polices that focus on improving the productivity of their land on which they make their living should be encouraged. Because, on top of the impact of climate change induced shocks particularly drought and shortages of rainfall the implication of current degradation of their land to the existing low productivity of

their farming was very high. Therefore, government policies should emphasis on the provision of local context based farming technology packages, strengthening of watershed management practices and development and provision of well-coordinated early warning systems.

Declarations

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Authors' contributions

Daniel Assefa designed the data collection tools, undertook fieldwork and most of the analysis, and developed the manuscript. Firafis Haile contributed in developing the data collection tools, survey design and writing of the manuscript. Both authors contributed to the research design, analysis, reviewed and made editorial comments on the draft manuscript. All the authors read and approved the final manuscript.

Competing interests

The authors declare they have no competing interests.

Consent for publication

The authors obtained permission from all participants in North Wollo and Wag Hemera zone, to publish their data.

Ethical approval and consent to participate

Consent to participate was received from everyone interviewed in North Wollo and Wag-hemera zone, Ethiopia. A research committee from Ethiopia's Ambo University and the World Vision Ethiopia was the active participant and close follower of the study so that they are well informed of the study.

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