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Impacts of Climate Change on Livelihood Assets, Crop and Livestock Production and Adaptation Strategies in the Hadiya Zone, Ethiopia

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Abstract

Climate change negatively affects agricultural production, the natural resources base, and the livelihoods of communities. As such, adapting to climate change through agroforestry practices is important for sustainable agriculture. This study aimed to assess Impacts of Climate Change on Livelihood Assets, Crop and Livestock Production and Adaptation Strategies. Stratified random sampling techniques were employed. Data were collected through structured and semi-structured questionnaires. Data were analyzed using SPSS version 23 and Participatory Learning Action tools. The hierarchical multiple regression analysis revealed that climate change alone explained 27 percent of the variance in livestock production, $F (1, 290) = 104.84$, $P< .001$, $R = .52$, $R^2 =.27$; and that the climate changes alone explained 42 percent of the variance in crop production, $F (1, 290) = 213.62$, $P< .05$, $R = .65$, $R^2 =.42$. The five livelihood assets (natural, human, social, financial and physical capitals) were positively and significantly correlated with climate change, adaptive capacity, and crop and livestock production. This analysis implies that if one livelihood asset increases, the others increase too. The physical capital was negatively correlated with climate change among the five livelihood assets, $r (290) = -.04$, $p >.001$, two-tailed. Agroforestry systems and practices should be encouraged in the study area to enhance adaptation to climate change by addressing food, wood, and income needs. Consequently, this helps farmers to develop their livelihood assets and technical capability to launch ideas, experiences and information of agroforestry systems and practices.

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Introduction

Climate change is a transformation of the composition of the atmosphere worldwide change that is caused directly or indirectly by human activity- in addition, to the natural climate changes observed over comparable periods (Pachauri *et al.,* 2014). Furthermore, Ayoade (2007) defines it as changes in the average state of the atmosphere over time scales ranging from ten years to millions of years. Climate change is a long term or long-lasting shift in the state of the weather and climate (Field, 2014).

Climate change can impact billions of people as it can be to be a significant threat to agriculture, food security, and rural livelihoods. This is because agriculture is the segment most susceptible to climate changes because it is strongly dependent on weather and climate. Rural communities' mostly sustain themselves by growing crops while urban inhabitants have more access to different resources (Amsalu and Adem, 2009). Literature indicates that rural livelihoods are highly dependent on activities like agriculture and agricultural-related activities and fishing which rely on climate (Field, 2014).

Ethiopia is one of the African countries highly susceptible to climate variation. According to Perry and Thrnton (2015), chronic famine is the most significant effect associated with climate change that occasionally impacts the country. Rainfall decreases significantly in June, July, and August (JJA) over parts of the horn of Africa - the primary crop cultivation season in Ethiopia. The country has experienced significant droughts, which resulted in famine. A United States Agency for International Development (USAID) study indicated that the frequency of nationwide droughts causing severe food shortage has increased from once every ten years in the 1970s and 1980s to every two-three years now (Merrey and Sally, 2008). Ethiopian history is punctuated by drought and famine, which affected large parts of the country, covering hundreds of thousands of square kilometers and millions of households (Tadesse and Dereje, 2018). Particularly, Ethiopia's eastern and northern parts are the most vulnerable as they have the highest food security and thus there is food security.

Generally, the Ethiopian economy, the wellbeing of its people, and specifically the economy and the welfare of people in the Hadiya zone (area of study) are directly related to farming and renewable and non-renewable resources. Therefore, for the development of livelihood assets and, in turn, livelihoods improvement to happen, the responsibilities of the government and the roles of the community are unquestionable. Hence, the Ethiopian government launched a new government policy-based approach. The Climate Resilient Green Economy plan consists of the execution of agroforestry practices (integrated farming of trees with crops and livestock production system), conservation agriculture or organic farming, reforestation or afforestation of degraded land, which means land affected by gullies and steep slopes including enclosures (Engeda *et al.,* 2011). Limited information is available on climate change and adaptation issues in the Hadiya zone despite the increasing importance in studying mainly climate change and related issues in general. Therefore, this investigation assessed adaptation to climate through agroforestry practices in the Hadiya zone and collected information on the available strategies in adaptation to climate change through agroforestry practices.

Climate change is one of the main factors influencing crop and livestock production (Stakhiv *et al.,* 2013). The changing climate patterns have changed the way animals and plants are distributed in different ecosystems and how the plants and animals benefit human beings (Tschakert and Dietrich, 2010). Natural or human-made disruptions may occur that have consequences to crops and livestock production with a change in plant and livestock composition (Gough, 2017). To adapt to the climate changes related to livelihood assets, crops and livestock farmers are dealing with different climate change adaptation strategies that are available in the Hadiya zone. This study aimed on the impacts of climate change and adaptation strategies in the Hadiya zone.

Materials and methods

Descriptions of the Study Area

The Hadiya zone is geographically located between 7º07'-7º92'N Latitude and 37º29'-38º 13'E Longitude. The topography of the Hadiya zone is rugged high land and hilly areas with a range of slope angles of about 2-35 percent. Generally, the terrain is a mountainous, undulating and broken type that is very much prone to soil erosion.

The capital of the Hadiya zone is Hosanna, located North of Hawassa (the capital city of South Nations Nationalities Regional State (SNNPRS)) and 198 kilometers away from it (Fig. 1).

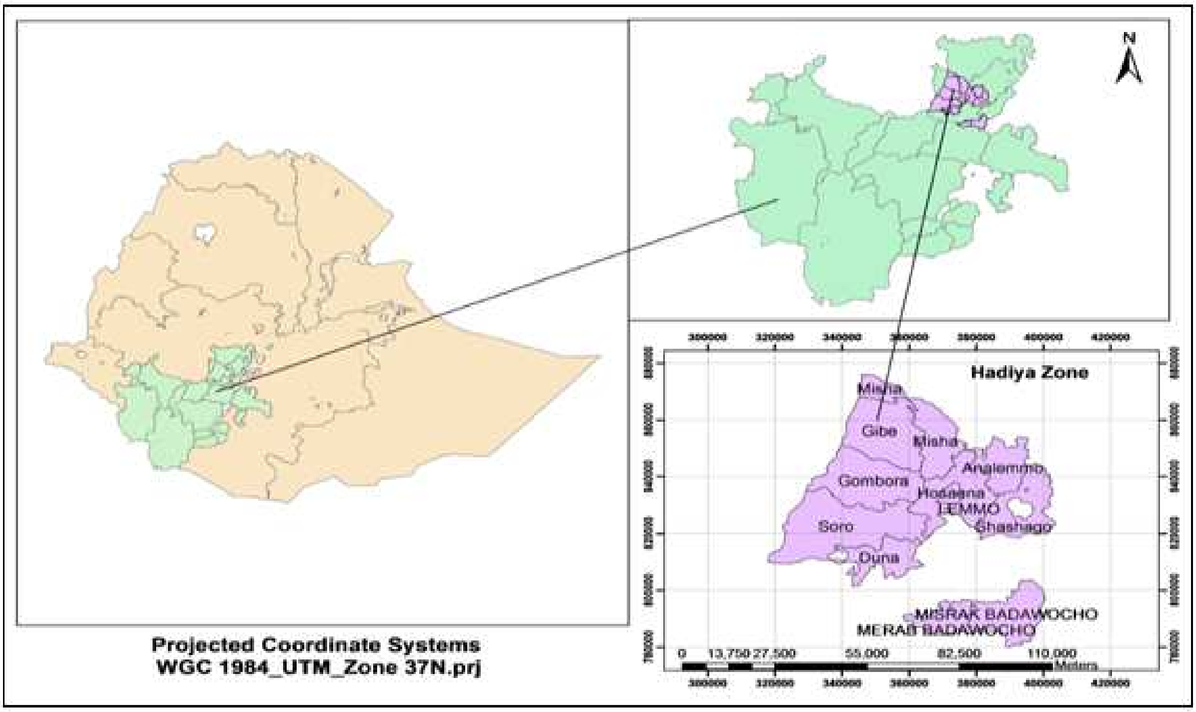

Fig. 1. Map of the Hadiya zone concerning Ethiopia and SNNPRS.
(Source: Survey of this study).

The distribution of soil units in the Hadiya zone is eutric nitosols 61 percent, chromic luvisols 23 percent, cambisols 11 percent and eutric regosols 5 percent. The zone is found in three traditional agro-climatic zones namely "Dega", "Woina Dega" and "Kolla" with an altitudinal range of 500-3200 meteres above sea level with the variability of climate elements (Hurni *et al*., 2010).

In the Hadiya zone, all-natural vegetation and grazing lands have been converted into cultivated land. What remains in the area are the retained scattered trees in all land-use types. Farmers are already acquainted with plant tree species to replace the former natural vegetation to meet wood, construction, and fuel demands. These trees are predominantly made up of the exotic *Eucalyptus* species. The zone practices mixed farming, with complete integration of trees, crop and animal components. Farmers grow major crops like wheat, "teff", maize, potatoes, "enset" and "chat" during the "maher" season from mid-June to August. The minor crops in the study area are barley, sorghum, legumes, coffee, fruit, sugarcane and vegetables (DAaNRD, 2016).

Sample size determination

Study areas that were purposively selected made up the target population indicated below. The sample size was calculated using the statistical application. The techniques for calculating the sample size and precision considerations were considered. Heads of households were listed based on wealth category. Proportional respondents were sampled randomly from each wealth category.

According to Daniel (1999), the following formula was used:

$$n = \frac{N}{1+N(e)^2}$$

Where, n= sample size, N = population size, e = the desired level of accuracy, where e equals 1– accuracy (0.05 level of tolerable error) point of accuracy = 95% (0.091 = a theoretical or statistical constant). n = 86,902/1+ 86,902 (0.091*0.091), n= 86,902 /719.635462 = 121. As shown above, the sample size calculated was 121 households. Though considering this fact, the researcher tried to take 292 households from purposively selected 4 Woredas and 12 kebeles/PAs (peasant associations) proportionally. The researcher aimed to achieve the statistical principle, which asserts that the more the population sizes, the more the precision is and to arrive at the level of idea saturation. The proportionately calculated sample size based on kebeles/PAs performance and wealth status.

Methods of data collection and tools

Generally, the methods included a collection of secondary data at three levels (Zone, district and local levels), wealth ranking (poor, medium and better off) based on the category of sample households implementing agroforestry practices and not implementing agroforestry practices. This helped to have homogenous and proportional samples. Finally, a formal survey of sample households was carried out using wealth stratified random sampling within wealth status and agroforestry practitioners. These methods helped to identify people with sufficient information about the issues concerned. The method of data collection was, key informants' interview to achieve objective.

Key informants (people who are knowledgeable about the Hadiya zone or their locality and have a good knowledge of the issues concerned) were selected with the help of development agents and peasant association administrators. As mentioned above, these informants mainly included elderly men and women, religious and opinion leaders in the selected community.

Interviews were conducted with selected key informants selected with the help of development agents and peasant association administrators. Twelve key informants groups (consisting of six to eight members per group) of community strata (male, female and youths) from four areas were interviewed. A checklist containing important topics was used to lead the discussions on farm characterization, past good and bad years, future risks, and opportunities. This agrees with Sayer (1992) who states that for a tiny number of households, perhaps fewer than ten; examine each one exhaustively in terms of its history and context, namely, the specific experiences of the respondents regarding study variables.

The Household Questionnaire Survey

Semi-structured questionnaires were developed to collect the required quantitative and qualitative data concerning the status of the households, land, livestock and crop-related information, livelihood assets, existing situations that will possibly continue in the future, available adaptation strategies, factors influencing adaptation to climate change and factors enhancing adaptive capacity. The questionnaires were pre-tested in the field. Twelve enumerators conducted the interviews. These enumerators were recruited locally, and all of them had knowledge and experience generally in agriculture and particularly in natural resources management. The primary data regarding the individual household characteristics (age, education, family size), farming experience, distance from market, distance from a nursery, farm characteristic type, agroforestry practices, perception of households and issues regarding agroforestry practices were collected. Special attention was given to capturing information on the contribution of agroforestry practices and adaptation to climate change. The semi-structured questionnaires were administered to sample sizes that were determined using Daniel (1999). It is a statistical formula to determine the sample size (n) from the population (N). The sample size was 292 households with a representative proportion from each wealth class (poor, medium and better off) based on the agroforestry practitioners' category.

Transect Walk

A transect walk across the purposively selected representative lines used to collect biophysical data through the Hadiya zone enabled understanding of ecological problems and their socio-economic linkages. This field observation was used for both qualitative and quantitative data collection. It was done by dividing the Hadiya zones into three parts that is upper, middle and lower. It was done by dividing the participants into three groups. Each group observed and discussed problems and opportunities while walking. Enumerators facilitated discussions on possible indicators of adaptation measures.

Data Analysis

Data were analysed using the Statistical Package for Social Science (SPSS) software version 23 for both descriptive and inferential statistics. In this data analysis, a step-wise multiple regression, hierarchical multiple regression, Pearson product moment correlation, within-subjects one-way repeated measures ANOVA with t-statistics and or t-test result with Bonferroni adjustment were used from the analyzed output of SPSS and sorting to address each objective. Bunferroni tests are used within subjects' ANOVA and t-tests. They were not used for Pearson correlation, regression or others. The tests were to understand the relationship between dependent or response variables (adaptive capacity, crop and livestock production) and predictors (livelihood assets, weather and climate information system and landholdings). Adaptive capacity was determined by livelihood assets (natural capita, cultural capital, human capital, physical capital and financial capital). Data were organised; results are presented as descriptive and inferential statistics showing the number of households corresponding to their answers, usually expressed as means and standard deviations. Qualitative data were analysed using PRA (Participatory Rural Appraisal) technique through pair-wise ranking analysis and comparisons, the focus group discussions using prioritizing techniques to identify critical issues, intervention points and implications on adaptation to climate change.

Ethics statement

The studies involving human participants were reviewed and approved by College of Agriculture and Environmental Science Ethics Review Committee, University of South Africa. The participants provided their written informed consent to participate in this study.

Results and discussion

Relationship between Variables

The relationship between household characteristics, factors enhancing adaptive capacity, total land holdings, total cultivated land area and adaptive capacity of households were investigated.

A step-wise multiple regression analysis was conducted to analyze the percentage of variance accounted for these variables in the adaptive capacity of a household to the possible situation that might continue (climate change).

Table 1. Descriptive statistics of variables.

Variables	*M (Mean)	*SD	*n
Adaptive Capacity	302.33	112.01	
Total Number of Households	6.00	2.07	
Resources Management	3.39	.17	
Farm Production Practices	3.00	.15	
Farm Financial Management	2.56	.16	
Weather and Climate Information Systems	3.78	.11	
Total Land Holdings	.92	.76	292
Total Cultivated Land Area	.64	.44	

*M (Mean); *SD (Standard Deviation); *n (Sample size-number) (Source: Survey results).

The results are presented in (Table 1). Among the variables (Table 1) entered into the analysis, total land holdings explained the largest variance in total percentage of adaptive capacity of a household to climate change, F (1, 290) = 88.87, p< .001, R = .48, R^2 = .24. In model two, farm financial management explained 10 percent additional percentage of total variance in adaptive capacity of a household to climate change, F (1, 289) = 44.78, p< .001, R = .58, R^2 = .34. The third variable, weather and climate information systems, accounted for additional percentage of variance in adaptive capacity of a household to climate change, F (1, 288) = 4.09, p< .05, R = .59, R^2 = .35.

Table 2. Summary of a step-wise multiple regression analysis.

Variables	*B	*SE B	*β
Step 1			
Constant	237.03	9.00	
Total Land Holdings	71.35	7.57	4.8*
Step 2			
Constant	797.67	84.20	
Total Land Holdings	74.91	7.08	.51*
Farm Financial Management	-220.42	32.94	-.32*
Step 3			
Constant	1155.79	195.81	
Total Land Holdings	76.72	7.09	.52*
Farm Financial Management	-217.49	32.80	-.317*
Weather and Climate Information Systems	-97.23	48.05	-.10*

Note: R^2 = .24 for step 1, Δ R^2 = .10 for step 2 and Δ R^2 = .01 for step 3 (p< .05). *p< .05
*B (Beta), *SEB (Standard error Beta) *β (standardized Beta adjusted for population)
(Source: Survey results).

All these findings agree with Kim *et al.* (2007) who state that 'some countries are more able to adapt to climate change than others; adaptive capacity is especially limited in less-developed countries. This might be due to a lack of financial resources, resulting in a local workforce that does not have the skills or technology to adapt to climate changes efficiently and effectively. Social capital influences the adaptive capacity to collaborate (Adger *et al.* 2003; Pelling and High, 2005). Individuals or households capacity to adapt to climate change is determined by their access to resources (Adger *et al.*, 2003). Livelihood assets are the resources at the disposition of the people, and the larger the livelihood assets, the higher the adaptive capacity will be (Adger *et al.,* 2005).

Table 3. Correlation of livelihood assets, climate change, livestock and crop production.

Variables	1	2	3	4	5	6	7	8	9
1.Natural Capital	-	.83**	.83**	.70**	.75**	-.27**	.92**	.39**	.47**
2. Human Capital	-	-	.88**	.69**	.79**	-.26**	.93**	.39**	.44**
3. Social Capital	-	-	-	.74**	.81**	-.22**	.96**	.43**	.44**
4. Financial Capital	-	-	-	-	.45**	-.38**	.80**	.57**	.63**
5. Physical Capital	-	-	-	-	-	-.04	.86**	.17**	.17**
6. Climate Change	-	-	-	-	-	-	-.25**	-.52**	-.65**
7. Adaptive Capacity	-	-	-	-	-	-	-	.44**	.48**
8. Livestock Production	-	-	-	-	-	-	-	-	.77**
9. Crop Production	-	-	-	-	-	-	-	-	-

Note: **p< .001 (two-tailed) (Source: Survey results).

However, from the sign of t-statistics, we can see that the farm financial management ($t(288) = -6.69$, $p < .001$) and weather and climate information systems ($t(288) = -2.02$, $p < .05$) have a negative statistically significant impact on the adaptive capacity to climate changes in the Hadiya zone. These clearly show that the higher the climate changes, the lower the farm financial management and bad weather and climate information system.

The total land holdings ($t(288) = 10.59$, $p < .001$) has a positive and statistically significant impact on adaptive capacity which implies that the higher or the more the total land holdings, the higher or, the more the adaptive capacity will be. These results are in agreement with Rao *et al.* (2007) who stated that the impacts of climate changes on agriculture are the major concern of nearly all developing countries, predominantly in the tropics (like Ethiopia), because they mostly rely on growing crops, that is the survival level of operations in agricultural activities. However, the rest of the variables, like the total number of households, resource management, farm production practices, and total cultivated land area to the total percentage of the variance in adaptive capacity to climate changes, are not statistically significant in the Hadiya zone. The analyzed results are summarized in (Table 2).

Table 4. Analysis result of descriptive statistics.

Variables	Mean	Standard Deviation	*n
Livestock production	25690.41 ETB	21456.49 ETB	
Climate Change	31.09	9.23	292
Livelihood Assets	302.33	112.01	

Note: ETB (Ethiopian Birr) *n (sample size) (Source: Survey results).

To see the correlation among the five livelihood assets (natural, human, social, financial and physical), climate change, crop and livestock production, the Pearson product-moment correlation analysis was done, and the results between livelihood assets, climate change, and crop and livestock production are summarized in (Table 3). From the detail of the table title (correlation of livelihood assets, climate change, livestock and crop production), one can easily see how the items are correlated to each other. The relationships among the items are discussed below (Table 3).

The five livelihood assets (natural, human, social, financial and physical capitals) were positively, statistically and significantly correlated. This analysis implies that if one livelihood asset increases the others also increase. On the other hand, the five livelihood assets were correlated with climate change, adaptive capacity, and crop and livestock production. The physical capital produced a negative and statistically insignificant correlation with climate change among the five livelihood assets, $r(290) = -.04$, $p > .001$, two-tailed. This may be because of the nature of physical capital that could not be easily influenced but the long-term influence could probably affect this capital. This is contradictory to the findings of Adger *et al.* (2003); Adger *et al.* (2005); Pelling and High (2005) that state that the higher the physical capital, the lower the climate changes are. However, the correlations between the rests of the four livelihood assets with climate changes are negative and statistically significant. That is, the higher the livelihood assets, the lower the climate changes are. The correlation with adaptive capacity, crop and livestock production is positive and statistically significant, indicating higher adaptive capacity, which means that crop and livestock production are higher.

Moreover, climate changes produced a negative and statistically significant correlation with adaptive capacity, crop and livestock production. This means that a higher climatic variation could bring a lower production potential on crop and livestock. Studies reported that climate changes increase uncertainty, decrease the rate of native vegetation, crop and livestock production (Huq *et al.,* 2004); similarly, to agricultural farming, the impact of climate changes and variability in the livestock production is generally negative (Gough, 2017).

Also, the adaptive capacity positively and statistically correlated with both crop and livestock production. In other words, the higher the adaptive capacity, the higher the crop and livestock production is, which is in agreement with the studies of Adger *et al.* (2003) and Adger *et al.* (2005) that stated that the higher the livelihood assets, the higher the adaptive capacity to climate changes.

Impact of livelihood assets and climate change on livestock production

As indicated in the (Table 4) the hierarchical multiple regression analysis was conducted to find out the total percent of variance accounted for livelihood assets and climate change in livestock production.

Since climate change produced the highest Pearson correlation with livestock production, it was first entered into model 1, followed by climate change (in model 2) and livelihood assets (in model 3).

Table 5. Summary of hierarchical multiple regression analysis.

Variables	*B	*SE B	*β
Step 1			
Constant	62947.12	3794.92	
Climate Change	-1198.52	117.05	-.52*
Step 2			
Constant	38029.51	5115.13	
Climate Change	-1005.27	112.71	-.43*
The livelihood Assets	62.55	9.28	.33*

Note: R^2 = .27 for step 1, Δ R^2 = .10 for step 2, (p< .05). *p<.05

B (Beta), *SEB (Standard error Beta) *β (standardized Beta adjusted for population (Source: Survey results).

The hierarchical multiple regression analysis revealed that climate change alone explained 27 percent of the variation in livestock production, F (1, 290) = 104.84, P< .001, R = .52, R^2 =.27. When the livelihood assets are added in model 2, the result showed that the inclusion of the livelihood assets to the model brought about a 10 percent increment to the variance in livestock production, F (1, 289) = 45.40, P< .001, R = .60, R^2 = .37. From the negative sign of the t-statistics, we can see that climate change (t (289) = -8.92, p< .001) has a negative statistically significant impact on livestock production, which indicate that the increase or the higher the climate variation, the lower the livestock production will be. This may be because the livestock feed and fodder (trees and shrubs) production decreases due to bad weather and climate. This is similar to the findings that agroforestry is the combination of: Woody perennials with animals' production, annual crop cultivation, which enhances farm productivity when the different elements occupy related niches and their relations or interactions effectively managed Agricultural farming, The impact of climate difference and Inconsistency in livestock production is commonly negative (Chaturvedi *et al.,* 2011).

Temperature tension and its force on recurrent water accessibility has a variety of detrimental effects on livestock and climate inconsistency induced livestock diseases (Gough, 2017); and the effects of climate variation on livestock diseases depend on the environmental location, land use land cover type, disease characteristics, and animal susceptibility (Thornton *et al.,* 2015).

On the other hand, the positive sign of the t-statistics for the livelihood assets (t (289) = 6.74, p < .001) indicate that the livelihood assets (natural capital, financial capital, human capital, social capital and physical capital) are a positive and statistically significant impact on livestock production in the Hadiya zone. This implies that the higher or the more the livelihood assets, the higher or the more the livestock production. This implies that the livelihood assets (the five capitals) improvement could simultaneously have the capacity to improve livestock production. This is ultimately similar to the findings that state that individuals or household's capacity to adapt to climate changes is dependent on their access to resources (Adger *et al.*, 2003). Livelihood assets are the resources at the disposition of the people.

The larger the livelihood assets, the higher the adaptive capacity will be (Adger *et al.,* 2005). The summary of hierarchical multiple regression analysis is summarized in (Table 5).

Table 6. Analysis result of descriptive statistics.

Variables	Mean	Standard Deviation	*n
Crop Production	1448789.04 ETB	669406.48 ETB	
Climate Change	31.09	9.23	292
Livelihood Assets	302.33	112.01	

Note: ETB = Ethiopian Birr *n (sample size) (Source: Survey results).

Impacts of Livelihood Assets and Climate Change on Crop Production

As indicated in the (Table 6) the hierarchical multiple regression analysis was conducted to observe the total percent of variance accounted for livelihood assets and climate change in crop production Since climate change produced the highest Pearson correlation with crop production, it was first entered into model 1, followed by livelihood assets (model 2).

The hierarchical multiple regression analysis revealed that the climate changes alone explained 42 percent of the variance in crop production, $F(1, 290) = 213.62$, $P< .05$, $R = .65$, $R^2 =.42$. In model 2, the inclusion of the livelihood assets increased the percentage of the variance in crop production to 52 percent, $F(1, 289) = 63.77$, $P< .05$, $R = .73$, $R^2 =.52$. This means that the livelihood assets alone explained 10 percent of the variance in crop production. According to this analysis, climate changes and livelihood assets had a statistically significant impact on crop production in the Hadiya zone. The negative sign of the t-statistics indicates that climate change ($t(289) = -13.56$, $p< .001$) had a statistically significant negative impact on crop production in the Hadiya zone. This implies that the higher the climate variation, the lower the crop production. This agrees with the findings that state that a relatively low score for the production dimension could indicate existing factors limiting agricultural production (Chitakira *et al.,* 2018). However, the impact of livelihood assets ($t(289) = 7.99$, $p<.001$) is found to be positive and statistically significant on crop production in the Hadiya zone, which implies that an increase in the livelihood asset could increase crop production.

Since crop production is integrated with trees and experienced as parkland agroforestry practice, the finding is similar to Syampungani *et al.* (2010) and Cramb *et al.* (2009) who assert that agroforestry systems, when well designed and properly managed, have a positive effect on yield capacity for continuous production. For example, trees that can fertilize soil are widely documented to substantially increase maize yields compared to maize production without fertilizer in Zambia.

This is also closely related to the findings that state that maize yields were more stable when grown with *Leucaena leucocephalla* hedgerows than mono-cropped (Kalaba *et al.,* 2010); agricultural vulnerability to climate change will lead to unsteady crop production, and food security will be threatened (Rao, 2010). Also, agroforestry generates (i) employment by growing crops and marketing the trees and tree-derived products, and (ii) has both ecological and economic importance to increase the productivity of land and sustainability of the environment in developing countries (Leakey, 2012). Furthermore, certain evidence of the rapid climate changes is increased uncertainty in weather, reduced native vegetation and crop rate, and reduced livestock production (Huq *et al.,* 2004). These all seem convincing as the nature of agroforestry integrated the three necessary components (a tree that is an integral part, a crop that is an associated or companion part and livestock that plays an essential role in the system). In summary, the relationship between crop production and climate change is apparent and quite important to investigate because crops are more sensitive to climate changes than livestock and trees.

This agrees with findings that changes in crop production-related climatic variables possibly have significant influences on local and worldwide food production (Abraha and Savage, 2006). The summary of this analysis is presented in (Table 7).

Table 7. Summary of hierarchical multiple regression analysis.

Variables	*B	*SE B	*β
Step 1			
Constant	2917868.87	104832.52	
Climate change	-47259.15	3233.47	-.65*
Step 2			
Constant	2123609.43	137574.53	
Climate change	-41099.10	3031.50	-.57*
Livelihood assets	1993.76	249.67	.33*

Note: R^2 = .42 for step 1, Δ R^2 = .10 for step 2 ($p < .001$). *$p<.05$

B (Beta), *SEB (Standard error Beta) *β (standardized Beta adjusted for population)

(Source: Survey results).

Adaptation Strategies

Eighteen possible and available adaptation strategies (Table 8) were exhaustively used to investigate adaptation strategies to climate change in the study location (the Hadiya zone). These are common adaptation strategies available in the study location.

A total of 18 major adaptation strategies were rated by the respondents for their existence and significance in the Hadiya zone. The results indicated that, the higher or, the more the scores for the ratings, the higher or the more the available adaptation strategies to climate changes in the Hadiya zone. These significant factors were identified, designed, interviewed, analyzed, and the results are indicated in (Table 8). As indicated in this table, the one-way repeated measures ANOVA was used to observe the difference between the 18 adaptation strategies as existing and statistically significant in the Hadiya zone. This analysis revealed that the difference between the 18 adaptation strategies in the Hadiya zone is statistically significant, $F(13.48, 3923.71) = 121.10$, $p< .05$.

From (Table 8) one can see that animal rearing (M=3.13, SD=.73), crop diversification (M=3.10, SD=.70), vegetable cultivation (M=3.06, SD=.47) and drainage on a farm (M=3.11, SD=.50) were listed as highly and statistically significantly existing adaptation strategies. Whereas, the others like woodlots for fuel (M= 3.01, SD=.71), bush fire control (M= 2.98, SD=.77), seasonal forecast (M= 2.90, SD=.49), soil conservation practices (M= 2.94, SD=.46), water harvesting (M= 2.54, SD=.87), adopt irrigation (M= 2.38, SD=.82), non-timber forest products (M= 2.37, SD=.76) and drought-tolerant crops (M= 2.34, SD=.90) were statistically significantly existing adaptation strategies in the Hadiya zone. These findings are in agreement with those of James *et al.* (2014) which stated that the highest number of documented adaptation initiatives were reported in Kenya (n = 59), followed by Ethiopia (n = 54), India (n = 51), South Africa (n = 42), Bangladesh (n = 41), Malawi (n = 40), and Rwanda (n = 36). Dhaka *et al.* (2010) found in their study that most farmers were using various adaptation strategies in response to climate changes.

The existence of the adaptation strategies to climate changes like wells and boreholes (M= 2.26, SD= .80), post-harvest technology (M= 2.10, SD= .77), adjustment of planting date (M= 2.24, SD= .76), improved varieties of crops (M= 2.11, SD= .50), improved roofing and foundation (M= 2.11, SD= .54) and crop insurance (M= 2.08, SD= .61) are not statistically significant strategies available in the Hadiya zone. These indicated that the adaptation strategies are more or less there, but their statistical significances are different as indicated. These results agree with findings that explained that the most problematic impacts occur in developing countries that are heavily dependent on climate-re susceptible economies like crop growing and have the least adaptive strategies to the changes (Taye, 2022).

Table 8. Analysis result of available adaptation strategies to climate change.

Adaptation Strategies	Mean	Standard Deviation
Animal rearing (AR)	3.13************	.73
Crop diversification (CRD)	3.10************	.70
Vegetable cultivation (VC)	3.06************	.47
Drainage on farm (DF)	3.11************	.50
Woodlots for fuel (WLF)	3.01**********	.71
Bush fire control (BFC)	2.98**********	.77
Seasonal forecast (SF)	2.90**********	.49
Soil conservation practices (SCP)	2.94**********	.46
Water harvesting (WH)	2.54******	.87
Adopt irrigation (AIR)	2.38****	.82
Non-timber forest products (NTFP)	2.37****	.76
Drought tolerant crops (DTC)	2.34***	.90
Wells and boreholes (WB)	2.26	.80
Post-harvest technology(PHT)	2.10	.77
Adjustment of planting date (AP)	2.24	.76
Improved varieties of crops (IVC)	2.11	.50
Improved roofing and foundation (IRF)	2.11	.54
Crop insurance (CI)	2.08	.61

n=292, *$p < .05$ (Source: Survey results)

Climate changes will affect developing countries more harshly because of their low capacity for adaptation (IPCC, 2001). The results revealed that implementing available strategies for adaptation to climate changes is insufficient to successfully encourage climate change adaptation in the Hadiya zone. These findings are inconsistent with the report that stated that the maximum quantity of adaptations were also leaders that put into practice the actual adaptations planned to deliberately decrease susceptibility or increase adaptive capacity to climate changes.

Conclusions

The five livelihood assets (natural, human, social, financial and physical capitals) were positively and significantly correlated. This analysis implies that if one livelihood asset increases, the others increase too. On the other hand, the five livelihood assets were correlated with climate change, adaptive capacity, and crop and livestock production. The higher the livelihood assets, the lower and the climate changes. The correlation between adaptive capacity, crop and livestock production are positive and statistically significant, indicating that higher adaptive capacity means higher crop and livestock production.

Adaptation strategies to climate changes like wells and boreholes, post-harvest technology, adjustment of planting date, improved varieties of crops, improved roofing and foundation, and crop insurance are not statistically important strategies available in the Hadiya zone.

In this regard, the government institutions and concerned stakeholders should be committed to supporting agroforestry systems and practices (integration of tree, crops and livestock on the same piece or plot of land) by strengthening local capacity (improving livelihood assets), training and encouraging the farmers to invest more. In general, it is suggested that natural resources conservation and development agents should work more intimately with the local community to achieve better trees integration on farm fields. To sustain trees planting experience, particular emphasis should be put on the training of farmers as trainers and partner staff. As a result, trees planting could offer a high potential to improve the livelihood of smallholder farmers sustainably and at the same time contribute more for livelihood improvement and consecutively adaptation to climate change through agroforestry practices.

Data availability statement

The datasets presented in this article are not readily available because Ethical clearance given may not permit sharing of datasets with a third party. Requests to access the datasets may be directed to yohannesh2005@gmail.com or john@wcu.edu.et

Author contributions

Yohannes Horamo (YH) (Ph.D.) and Munyaradzi Chitakira (MC) (Professor): project conception. YH, MC and Kowiyou Yessoufou (KY) (Associate professor): draft and final manuscript. MC and KY: manuscript quality control and supervision. YH: data collection and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

We all authors would like to confirm that no conflict of interest.

References

Abraha MG, Savage MJ. 2006. Potential impacts of climate change on the grain yield of maize for the midlands of KwaZulu-Natal, South Africa. Agriculture, Ecosystems & Environment **115(1-4),** 150-160 p.
https://doi.org/10.1016/j.agee.2005.12.020

Adger WN, Huq S, Brown K, Conway D. Hulme M. 2003. Adaptation to climate change in the developing world. Progress in development studies **3(3),** 179-195 p.
https://doi.org/10.1191/1464993403ps060oa

Adger WN, Arnell NW, Tompkins EL. 2005. Successful adaptation to climate change across scales. Global environmental change **15(2),** 77-86 p.
https://doi.org/10.1016/j.gloenvcha.2004.12005

Taye D. 2022. Impact of Climate Variability and Vulnerability on livelihood. Journal of Agricultural Science & Engineering Innovation (JASEI), 2(2), 18-27 p.
http://doi.org/10.5281/zenodo6426220

Amsalu A, Adem A. 2009. Assessment of climate change-induced hazards, impacts and responses in the southern lowlands of Ethiopia. Addis Ababa Forum for Social Studies/Cordaid.
ISBN 13: 978-99944-50-29-9.

Amsalu A, Gebremichael D. 2010. An overview of climate change impacts and responses in Ethiopia in 2009. In Forum for Environment: Addis Ababa, Ethiopia
www.ffe-ethiopia.org

Ayoade JO. 2007. The impact of climate change on the ecosystems and coastal resources of Nigeria. In National Stakeholder workshop on climate change holding in Abuja. Nigeria November 7-9 p.

Chaturvedi OP, Palsaniya SK, Yadav DR, Singh RS, Tewari R, Dhyani RK. 2011. Resource appraisal of Garhkundar Dabar catchment in Bundelkhand Region of Central India. Indian Journal of Soil Conservation, **39(3),** 263-270 p.

Chitakira M, Torquebiau E, Ferguson W, Mearns K. 2018. Analysis of landscape performance assessment by key stakeholders in a transfrontier conservation area. Landscape Research **43(5),** 665-678 p.
https://doi.org/10.1080/01426397.2017.1355052

Cramb RA, Colfer CJP, Dressler W, Laungaramsri P, Le QT, Mulyoutamiet E. 2009. Swidden transformations and rural livelihoods in Southeast Asia. Hum Ecol **37,** 323-346.
http://dx.doi.org/10.1007/s10745-009-9241-6.33

Daniel WW. 1999. Probability and t distribution biostatistics: A foundation for analysis in health science. 83-123. John Wiley and Sons.

DAaNRD (Department of Agricultural and Natural Resources Development) 2016. Five Years Development Report.

Dhaka BL, Chayal K, Poonia MK. 2010. Analysis of farmers' perception and adaptation strategies to climate change. Libyan Agricultural Research Center Journal International **1(6),** 388-390 p. ISSN 2219-4304.

Engeda E, Tamru S, Tsehaye E, Debowicz D, Dorosh P, Robinson S. 2011. Ethiopia's Growth and Transformation Plan: A Computable General Equilibrium Analysis of Alternative Financing Options.
http://dx.doi.org/10.2139/ssrn.2161408

Field CB. ed. 2014. *Climate change 2014–Impacts, adaptation and vulnerability: regional aspects.* Cambridge University Press.
http://www.ipcc.ch

Gough I. 2017. The social dimensions of climate change: Climate Change, Capitalism and Sustainable Wellbeing. In Heat, Greed and Human Need (19-37 p). Edward Elgar Publishing.
https://doi.org/10.4337/9781785365119.00009

Huq S, Reid H, Konate M, Rahman A, Sokona Y Crick F. 2004. Mainstreaming adaptation to climate change in least developed countries (LDCs). *Climate Policy*, **4(1),** 25-43 p.
https://doi.org/10.1080/14693062.2004.9685508

Hurni H, Abate S, Bantider A, Debele B, Ludi E, Portner B, Yitaferu B, Zeleke G. 2010. Land degradation and sustainable land management in the highlands of Ethiopia.

James D. Ford, Lea Berrang-Ford, Anna Bunce, Courtney McKay, Maya Irwin 2014. The status of climate change adaptation in Africa and Asia. Springer, Netherlands.
https://doi.org/10.1007/s10113-014-0648-2

Kalaba KF, Chirwa P, Syampungani S, Ajayi CO. 2010.Tropical Rainforests and Agroforests under Global Change.
http://dx.doi.org/10.1007/978-3-642-00493-3.

Kim BS, Kim HS, Seo BH, Kim NW. 2007. Impact of climate change on water resources in Yongdam Dam Basin, Korea. Stochastic Environmental Research and Risk Assessment, **21(4),** 355-373 p. http://dx.doi.org/10.1007/s00477-006-0081-2

Leakey RR. 2012. Participatory domestication of indigenous fruit and nut trees: new crops for sustainable agriculture in developing countries. Biodiversity in agriculture: domestication, evolution and sustainability. Cambridge University Press, Cambridge, 479-501 p.

Merrey DJ, Sally H., 2008. Micro-agricultural water management technologies for food security in southern Africa: part of the solution or a red herring?Water Policy, **10(5),** 515-530 p. https://doi.org/10.2166/wp.2008.025.

Pachauri RK, Allen MR, Barros VR, Broome J, Cramer W, Christ R, Church JA, Clarke L, Dahe Q, Dasgupta P, Dubash NK. 2014. Climate change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. © Intergovernmental Panel on Climate Change, 2015 ISBN 978-92-9169-143-2

Pelling M, High C. 2005. Social learning and adaptation to climate change. Benfield Hazard Research Centre, Disaster Studies Working Paper **11,** 1-19 p. http://www.swan.ac.uk/cds/research/ESRC.htm

Rao KPC, Verchot LV, Laarman J. 2007. Adaptation to climate change through sustainable management and development of agroforestry systems. Journal of SAT Agricultural Research **4(1),** 1-30 p. http://oar.icrisat.org/id/eprint/2561

Rao PK. 2010. Institutions and Policy Design. In The Architecture of Green Economic Policies (pp. 65-86). Springer Berlin Heidelberg. http://dx.doi.org/10.1007/978-3-642-05108-1

Sayer A. 1992. Radical geography and Marxist political economy: towards a re-evaluation. Progress in Human Geography, *16*(3), 343-360 p. https://doi.org/10.1177/030913259201600302

Stakhiv EZ eds, Frederick KD, Major DC. 2013. Climate change and water resources planning criteria. Springer Science & Business Media. https://doi.org/10.1007/978-94-017-1051-0

Tadesse G, Dereje M., 2018. Impact of climate change on smallholder dairy production and coping mechanism in Sub-Saharan Africa-review. Climate Change, **4(15),** 299-313 p.

Thornton PK, Boone RB, Ramirez-Villegas J. 2015. Climate change impacts on livestock. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Working Paper No. 120. http://dx.doi.org/10.1111/gcb.12581

Tschakert P, Dietrich KA. 2010. Anticipatory learning for climate change adaptation and resilience. Ecology and Society **15(2),** p, 11. https://www.jstor.org/stable/26268129