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Determinants of the Adoption of Climate Change Adaptation Strategies by the Smallholder Farmers in Hiran region, Somalia

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Abstract: East Africa, notably Somalia, is one of the worst-affected regions by climate crises. Adaptation to climate change can be used to minimize many of climate change's negative consequences while maximizing its positive effects. This necessitated the need to; (i) identify the smallholder farmers' adaptation methods to the negative impact of the climate crisis and (ii) identify factors that affect farmers' adaptation practices in the Hiran region of Somalia. The study used a descriptive study design where a random sample of 222 farmers from the Hiran Region were involved. The research surveys among the selected farmers were conducted using a questionnaire. The Binary logistic regression analysis revealed that age, family size, marital status, non-farm income, off-farm jobs, access to credits, access to extension, and support from extension agencies were major predictors of the different climate change adaptation measures of the farmers. Therefore, the Federal government ought to review farmer extension systems and design farm management adoption programs based on the socio-economic and institutional characteristics of the farmers and create a favorable environment for the provision of agricultural credits to the farmers in efforts to boost farmers' climate resilience.

1 Introduction

Climate change constrained world economic growth and impacted several domestic lives, such as food security and agricultural outputs (Bhuiyan *et al.*, 2017, Bakht *et al.*, 2020). In 2017 global warming-induced anthropogenic activity reached nearly 1°C beyond levels before industrialization, growing at a rate of 0.2°C every decade (IPCC (2022). This projected change in the global climate in the future will threaten agricultural productivity (Rudel *et al.* (2020). Including low rainfall, changes in temperature, invasive species, and diseases (Etwire (2020). Furthermore, more frequent and extreme weather indicators could also be expected, leading to rainfall variation, droughts, and floods (Nangombe *et al.* (2018). Additionally, African farmers are more susceptible to deteriorating consequences of climate crises, since the majority of them practice rainfed agriculture, which is characterized by low levels of technical inputs, and a lack of support from government institutions, leading to ineffective adaptation to the unfavorable impact of climate crises (Shackleton *et al.*, 2015, Pereira, 2017). Climate change has become a significant barrier to agricultural development in Africa. Food security and rural livelihoods are currently experiencing additional pressure due to the continent's observed deterioration of its unpredictable and variable weather patterns (Muchuru & Nhamo, 2019, Ahmed, 2020, Sullo *et al.*, 2020). In particular, a rise in mean temperature could have a far-reaching effect on rainfall patterns, leading to declines in agricultural outputs (IPCC (2014). Sub-Saharan nations are more likely to be concerned by the expected negative consequences of climate catastrophe, due to reliance on a rainfed system of agriculture (Cooper & Coe, 2011, Abrams, 2018). Moreover, food security and productivity in Sub-Saharan Africa will decline, due to the deteriorating impact of climate crises (IPCC (2014). If effective and appropriate farm-level actions are not undertaken, this will exacerbate the poverty level in the African continent (Derbile *et al.* (2022). As crop productivity in Africa, is expected to decline by 2.9% by 2050 (Zougmoré *et al.* (2018).

Agriculture contributes nearly 93% of all export incomes in Somalia and around 75% of its Gross Domestic Product (GDP) (FAO & World Bank, (2018). However, Somalia is among the leading countries which highly susceptible to the effects of climate crises (Carty (2017). Moreover, due to decreased agricultural productivity and increased environmental stresses in Somalia, climate change directly jeopardizes national food security, exacerbating the condition of the country, which already facing economic and social unrest (FAO & World Bank, (2018). IPCC defined climate adaptation as activities undertaken to mitigate, the consequences of change climate by reducing susceptibility and vulnerability to its unfavorable consequences, as well as maximizing its possible benefits (IPCC (2022). Adaptation to climate crises is recognized as a critical factor for reducing susceptibility to thriving climate risks (Conway & Schipper, 2011, Aryal *et al.*, 2020). Although adaptation to climate could be used to diminish its negative effects and increase its advantages, however, its implementation is always costly (Rahut *et al.* (2021). Inadequate adaptation capabilities to climate change effects have caused food insecurity in the world, which will be a worldwide issue soon and beyond (Rosegrant & Cline, (2003).

Climate change adaptations could lead to increased farmers' food security and well-being (Kogo *et al.* (2021). These practices including, using genetically modified seeds, planting early-growing crops, pesticides and fertilizers, income diversification, and irrigation, will increase smallholder farmers' net income and food security (Asare-Nuamah & Mandaza, 2020; Ojo *et al.*, 2021; Laita *et al.*, 2024a). However, farmers are facing difficulties in their attempt at climate adaptation (Ogundeji (2022). Lack of access to agricultural advisory, credit, and support, together with a lack of education and income, among other socioeconomic and institutional factors, have all been reported as factors that make it less likely for farmers to adapt, leading to poor agricultural productivity and food security (Fosu-Mensah *et al.*, 2012, Ndambiri *et al.*, 2014, Belay *et al.*, 2017, Muriu-Ng'ang'a *et al.*, 2017, Atube *et al.*, 2021). However, comprehensive research on the adoption of climate change adaptation methods by farmers in Somalia, particularly in the Hiraan region, is scanty. Therefore, there is a need to identify the smallholder farmers' adaptation methods to the negative impact of the climate crisis and the factors that affect farmers' adaptation practices in the Hiran region of Somalia in order to assist several stakeholders in efforts to boost farmers' climate resilience; aimed at increasing food security levels.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Hiran region of Somalia. It is located in the central part of the country (Figure 1). The region is known for its rich agricultural and livestock resources, with an overwhelming area of fertile land and favorable climate and precipitation, making it suitable for cultivating crops such as corn, beans, sorghum, and different varieties of fruits such as mangoes, bananas, and papayas. Most of its products are sold and distributed within the country. The region is also home to a greater number of cattle, sheep, goats, and camels.

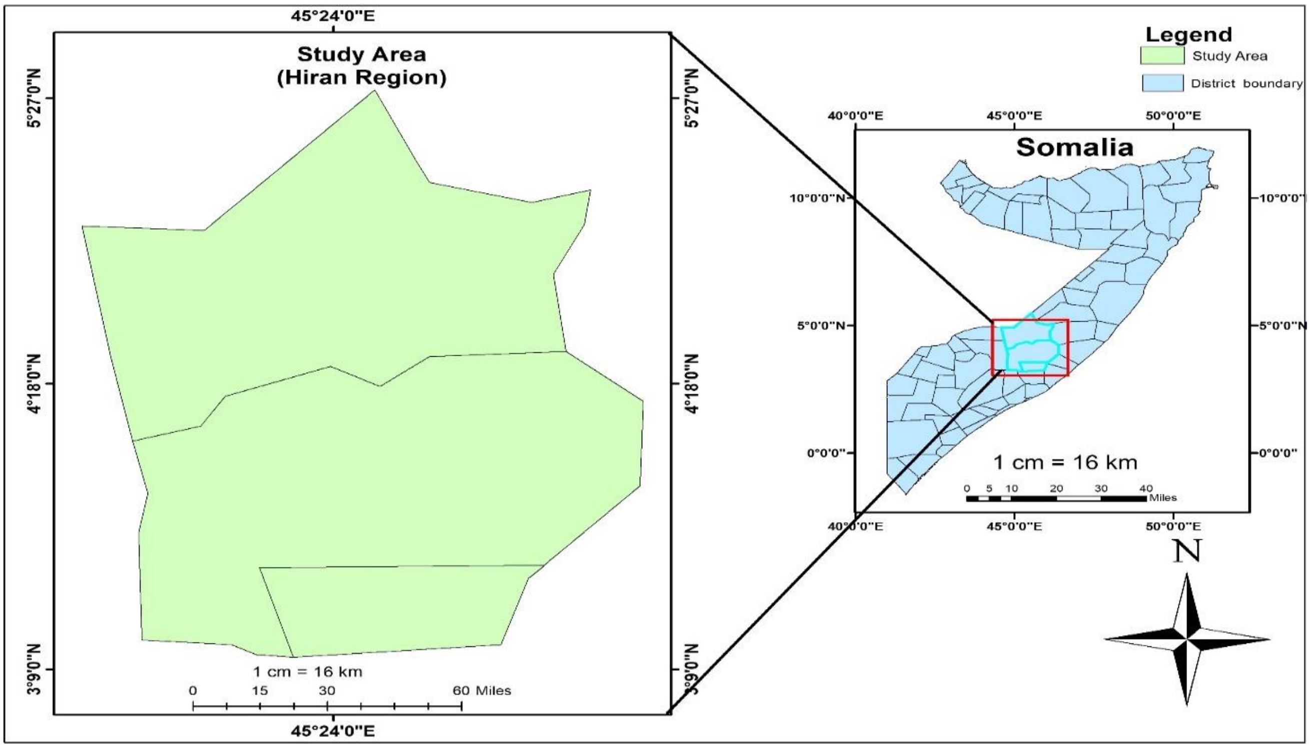

Figure 1. Map of the Federal Government of Somalia showing the location of the Hiran Region

2.2 Sampling Design and Sample Size

The study adopted a multi-staged sampling technique, where a combination of sampling techniques was used. In the first stage, two districts which are *Beledweyne and Bulaburte* were selected purposely based on their prone to climate change effects and their recent experience with climate extremes including droughts and floods. In the second stage, six villages (three from each district) were chosen randomly, and each target village's sample size was determined in accordance with its population size (**Table 1**). In the third stage, simple random sampling was applied to meet the target sample size of 222 sample farmers which were identified using Yamane's formula (Yamane (1967).

2.3 Data Collection Methods

Quantitative information was obtained using a household survey. A survey was conducted among smallholder farmers, from October 2022 to February 2023 using Semi-structured questionnaires. The questionnaire contained several questions including demographic, socio-economic, and institutional characteristics of the farmers, different adaptation methods of the farmers to climate change effects, and barriers that might hinder their adaptation methods effectively. Piloting of the questionnaire was implemented in 35 respondents (15% of n), who were excluded from the final survey. Somali language was communicated during the process and research assistants from the local people were recruited and trained before the survey.

Table 1. The distribution of the sample size by the villages

Districts	Villages	N of the households	Sample Size
Beladwein	*Baareey*	200	50
	Camalow	155	35
	Bulo-xaabley	150	30
Buloburte	*Caag-bashiir*	200	50
	Jameeco-shiin	155	35
	Galmadoobe	140	22

2.4 Data Analysis

2.4.1 Descriptive Data Analysis

The demographic, socio-economic, and institutional characteristics as well as barriers to effective climate change adaptation of the farmers were analyzed and summarized using descriptive statistics including, frequency, percentage, and mean, using SPSS version 26 and STATA version 14.1.

2.4.2 Econometric Data Analysis

To determine factors influencing farmers' adaptation measures toward climate change impacts, a binary logistic model was utilized (**Equation 1**). This model was used to analyze the correlation between several independent predictors and a single dependent predictor. Regarding this, independent predictors were smallholder farmers' adaptation strategies in the Hiran region of Somalia, while dependent variables were the various socioeconomic and institutional characteristics that may influence farmers' probability of adopting these strategies. Eight adaptation strategies, which were identified in the study area were used in the model, separately. Several studies, including (Fosu-Mensah *et al.* (2012) in Ghana, (Sanga & Elia, (2021) in Tanzania, and (Atube *et al.* (2021) in Uganda, have also employed the binary logistic regression model in their studies. The model was:

$$\frac{pi}{(1-pi)} = B_0 + B_1X_1 + B_2X_2 ... B_k X_k + e \qquad (\textbf{Equation 1})$$

Where: Pi represents the dependent variables (the different adaptation measures of the farmers). β0 is the intercept; $\beta_1, \beta_2, \ldots \beta_k$ are parameter estimates; $X_1, X_2, \ldots X_k$, represent independent variables (in this case, the socio-economic and institutional characteristics of the farmers) and the e error term. Multicollinearity can be found when there is a linear correlation among variables. Therefore, multicollinearity was tested using the Variance Inflation Factor (VIF), and the variables with values greater than ten were eliminated.

2.5 Definition of Variables

Different adaptation measures adopted by the farmers were the dependent variables and they were coded 0 if adapted, 1 Not adapted. Based on previous studies such as (Deressa *et al.*, 2009, Alem *et al.*, 2016, Atube *et al.*, 2021), the study chose the explanatory factors, for instance, gender, the size of the family members, access to agricultural services, age, level of schooling, marriage status, experience in farming, loan availability, proximity to the closest market, farm income, and income from sources other than farming, size of land possessed., farming system, land acquisition, support from extension agencies, communication devices, and types of communication devices (**Table 2**). Irrigation, using improved/resistant varieties, crop diversification, soil and water management, minimal soil tillage, planting an early-maturing crop, using inputs like seeds and fertilizer, and finding off-farm employment were some of the adaptation measures addressed in this study.

Table 2: Definition and coding of the variables

Variables		Code
Different Adaptation measures		0 = Yes, 1= No
Variables	Category	Code
Gender	Dummy	0= Male, 1= Female
Age	Continuous	Number of years
Marital status	Dummy	0=Married, 1= Unmarried
Family size	Continuous	Number of family members
Education level	Dummy	0 = Formal, 1 = non-formal
Farm income	Continuous	Monthly farm income (USD)
Farming experience	Continuous	Number of years in farming
Farm size	Continuous	Number of Hectares
Land acquisition	Dummy	1= Inherit, 2 = Purchase, 3 = Rent
Non-farm income	Dummy	0 = Yes, 1= No
Farming system	Dummy	1 = Crop production only, 2= Livestock rearing, 3 = Mixed
Communication devices	Dummy	0= Yes 1= No
Types of communication devices	Dummy	1 = Mobile and Radio, 2 = Radio and TV, 3= Mobile, 4 = Mobile, Radio, and TV
Institutional Factors		
Access to credits	Dummy	0 = Yes 1 = No
Access to extension services	Dummy	0 = Yes 1 = No
Support for extension services	Dummy	0 = Yes 1 = No
Distance to the market (KM)	Continuous	Number of km to the nearest market

3.0 Results

3.1 Socioeconomic Characteristics of the Respondents

The results indicated that most (83%) of the farmers were men, 80% were married and 29% had only formal education (**Table 3**). The average size of the family members was 6.5, whereas, the age average of farmers was 39 years. Moreover, the mean experience of farmers was 20 years, monthly farmers' income in the study area was 180$. Additionally, 77% of participants had additional off-farm income.

Table 3: Socio-economic and institutional characteristics of the farmers in Hiran Region, Somalia

Variable	Description	Frequency	Percentage(%)
Gender			
	Male	184	83
	Female	38	17
Marital status of the farmer			
	Married	178	80
	Unmarried	44	20
Educational Level of the Farmer			
	Formal Education	65	29
	Non Formal Education	157	71
Land acquisition of the farmer			
	Inherited	149	67
	Purchased	41	19
	Rented	32	14
Non-farm income of the farmer			
	Yes	170	77
	No	52	23
Farming system of the farmer			
	Crop cultivation only	116	52
	Livestock keeping only	4	2
	Mixed farming system	102	46
Communication devices			
	Yes	188	85
	No	34	15
Types of communication devices			
	Mobile and Radio	129	67
	Radio and TV	8	4
	Mobile	19	10
Access to any credits/loan			
	Yes	171	77
	No	51	23
Access to agricultural advisory services			
	Yes	161	73
	No	61	27
Support from the agricultural extension agencies			
	Yes	121	54
	No	101	46

	Mean	**Minimum**	**Maximum**
Age of the respondent (in years)	39	20	65
Number of total family members	6	2	12
Farming experience	20	2	30
Farm size in Hector	3	1	8
Monthly household income (In USD)	180	250	100
Distance from the market in Km	6.5	2	20

The average land size of the farmers in the study area was 3 hectares, the majority (67%) of them inherited the land, whereas 19% purchased, and, 14% rented. Further, most (52%) of households practiced crop production only. The majority (85%) of respondents owned communication devices, 67% had a mobile phone and radio, 19% had mobile phone, radio, and television, while, 10% had mobile phones only. The majority (77%) of farmers in the Hiran region of Somalia had access to agricultural loans, 73% had access to extension services, and the average distance from the closest market was 6.5 kilometers (**Table 3**).

3.2 Adaptation Strategies of Smallholder Farmers to Climate Change

Most farmers (78%) in the Hiran region had adapted to long-term climate change using different adaptation practices in their farms and only 22% had not (**Table 4**). The most important adaptation practices used by farmers to challenge climate-related impacts on their farms were soil and water management (76%), minimal soil tillage (77%), and irrigation (61%). Other adaptation measures included; planting an early-maturing crop (65%), using improved/resistant varieties (58%), crop diversification (60%), using inputs like seeds and fertilizer (51%), and finding off-farm employment (50%).

Table 4*:* Smallholder farmers' adaptation mechanisms to climate change effects used in the Hiran Region, Somalia

Measures	**Frequency**	**Percentages (%)**
Adaptation strategies of the farmers		
Yes	173	78
No	49	22
Different adaptation measures		
Crop diversification	104	60
Irrigation	106	61
Planting an early maturing crop	112	65
Use improved/resistant variety	101	58
Find off-farm employment	86	50
Input use such as seeds/fertilizers	88	51
Soil and water management	136	76
Minimum soil tillage	134	77

3.3 Factors Influencing Farmers' Adaptation Strategies to the Effects of Climate Change

The binary regression results revealed six independent variables that significantly predicted smallholder farmers' different adaptation practices (**Table 5**). Smallholder farmers' age, number of family members, marital status, off-farm income, contact with financial credits, contact with agricultural extension services, and receiving support from extension agencies, NGOs, and other international agencies predicted farmers' different adaptation strategies. Conversely, gender, education level, distance to the nearest market, and farm size of the farmers showed no statistical significance in influencing the adaptation measures of the farmers against the negative consequences of climate crises in the Hiran region of Somalia.

3.4. Barriers Limiting Farmers' Climate Change Adaptation in the Hiraan Region

Table 6 indicates farmers' barriers to climate change adaptation. Several major drawbacks to adaptation were reported in the study by the farmers, such as limited capital (92%), low knowledge and information (82%), and limited government support (75%). Other barriers informed by farmers in the region include an absence of climate forecasting information (61%), a shortage of necessary farm inputs (59%), inappropriate technology (53%), and a shortage of labor (30%).

Table 5: Factors influencing adaptation measures of the farmers in the Hiran region

		Factors and their model coefficients and *p*-value							
Variables		**Crop diver**	**Irrigation**	**Early maturing crop**	**Soil/water mgmt**	**Minimum tillage**	**improved variety**	**Off Farm jobs**	**Input use**
Gender	coeff	1.175	-.757	-.362	.054	-.187	1.051	1.758	-1.534
	p	0.161	0.441	0.066	0.433	0.825	0.360	0.066	0.103
Age	coeff	-.098	-.048	-.004	.007	-.032	-.067	.041	-.102
	p	**0.000***	0.091	0.263	0.781	0.155	0.054	0.092	**0.000***
Total family	coeff	-.460	.069	-.008	-.285	-.152	-.131	-.088	.248
	p	**0.003***	0.715	0.751	0.074	0.289	0.562	0.568	0.152
Marital status	coeff	-.555	.205	-.176	.428	-.802	.198	-.356	.3309
	p	0.432	**0.016****	0.176	0.557	0.281	**0.044***	**0.004***	0.695
Education level	coeff	.296	.054	.081	.140	-.544	.955	-.145	.116
	p	0.522	0.921	0.266	0.756	0.211	0.179	0.760	0.813
Farm size	coeff	-.001	-.152	.002	-.141	-.040	.003	.278	-.065
	p	0.996	0.457	0.944	0.436	0.815	0.992	0.122	0.719
Non-farm income	coeff	-.274	.320	-.526	-1.92	-1.041	.548	-.257	.235
	p	0.628	**0.000***	**0.004***	0.074	0.141	**0.000***	**0.000***	**0.002***
Distance to the market	coeff	-.064	.065	-.016	-.267	-.180	-.062	.106	-.087
	p	0.533	0.572	0.394	0.053	0,154	0.626	0.369	0.461
Access to credits	coeff	.628	.256	-.328	-1.477	-1.379	.325	-.173	.291
	p	0.260	**0.000***	**0.006***	0.073	0.053	**0.000***	**0.011**	**0.002***
Access to extension	coeff	.983	1.215	-.075	-.417	.940	.193	-.521	1.370
	p	0.104	0.083	0.519	0.570	0.131	**0.036****	0.439	0.089
Support extension agencies	coeff	.603	.116	.103	.354	-.121	.220	-.115	0.129
	p	0.195	**0.032****	0.218	0.482	0.807	**0.001***	**0.019****	**0.011****
Constant		5.451	-.338	1.214	1.973	2.542	.0751	-1.746	2.268
Prob >chi^2		0.0000	0.0000	0.0000	0.0084	0.0863	0.0000	0.0000	0.0000
Pseudo R^2		0.28	0.46	0.19	0.13	0.14	0.60	0.35	0.39
N of obs		173	173	173	173	173	173	173	173

*Coeff: Coefficient, SE: Standard Error in parentheses: *, **, = significant at 1%, and 5%, probability level, respectively*

Table 6: Limitations of climate change adaptation measures in the Hiraan region

Barriers	Frequency	Percentage (%)
Lack of knowledge and information	40	82
Lack of capital	45	92
Lack of climate forecasting information	30	61
Shortage of labor	15	30
Shortage of necessary farm inputs	29	59
Inappropriate technology	26	53
Lack of government support	37	75

4.0 Discussions

4.1 Adaptation Strategies of Smallholder Farmers to Climate Change

The majority of farmers in the Hiran region have adapted to long-term climate crises by adopting different climate-smart technologies such as irrigation, using improved/resistant varieties, crop diversification, and pesticide and fertilizer application (**Table 4**). This suggests that in the region, farmers are aware of the changing climate and trying to adapt to its implications based on their adaptive capacity. These approaches are anticipated to assist them in better managing their farms and protecting their standard of living amid more uncertain weather patterns and other impacts of climate crises. The farmers in the Hiraan region have taken a wide range of different adaptation measures to address the challenges posed by changing climatic conditions like their counterparts in Kenya, Ethiopia, Nigeria, and Uganda (Ndambiri *et al.*, 2014, Melka *et al.*, 2015, Belay *et al.*, 2017, Atube *et al.*, 2021).

4.2 Barriers Limiting Farmers' Adaptation Measures in the Hiraan Region

Although farmers in the Hiraan region have adapted to climate change, the adoption has encountered several challenges (**Table 6**). These barriers could serve as limiting factors to the farmer's capability to fully respond to climate change effects and adopt new agricultural technologies and practices that could improve their resilience to the negative consequences of the changing climate. Therefore, without support from local and international institutions, the efforts of farmers to address the harmful consequences of changing climate will encounter significant and potentially devastating challenges. Similar barriers to climate change adaptation to the ones that have been reported elsewhere i.e., unpredictable weather patterns in South Africa (Wilk *et al.* (2013) and Kenya (Musafiri *et al.* (2022), Lack of climate information in Ethiopia (Belay *et al.* (2017), insufficient farm inputs, and unfavorable government policies in Kenya (Musafiri *et al.* (2022).

4.3 Factors Influencing Farmers' Adaptation Strategies to the Effects of Climate Change

The findings showed that farmers' age negatively impacted the adoption of crop diversification and input use as adaptation measures *($p<0.01$).* This indicates that with each increase in age by one year the likelihood of the farmers adopting crop diversification and input use decreases by 9.8% and 10.2%, respectively. This could be due to old farmers feeling difficulty in terms of practicing agricultural new technologies and typically preferring their traditional farming techniques and finding alternative sources of income. This is in accordance with a study conducted by (Mugi-Ngenga *et al.* (2016) who found that older, more experienced farmers tended to depend more on conventional farming techniques and, thus, less open to new knowledge. On the other hand, (Manda *et al.* (2016)

also stated that younger farmers with less experience are more likely to gain chances and experiment with new technologies.

Married farmers may have a higher likelihood of implementing, irrigation, using resistant varieties, and finding off-farm employment as an adaptation strategy ($p<0.05$), compared to unmarried farmers (**Table 5**). This could suggest that getting married could increase the chances of implementing irrigation, and genetically modified crops by 20.5% and 19.8%, respectively, while decreasing finding off-farm employment by 35.6%. (Gebre *et al.* (2019) indicated that married farmers were more likely to adopt climate change-related methods such as genetically modified seeds. This could be the reason that married farmers typically manage to get better access to financial, and social capital brought by the spouse, hence allowing them to finance effective and costly adaptation methods for instance improved seeds, irrigation, and fertilizers. Further, they may also have other sources of income from the other family members, which demonish the reliance on off-farm employment. According to (Bawa *et al.* (2014) married individuals have more obligations and will therefore be more eager to look for knowledge about the climate and new technologies to improve their families' well-being. (Sanga & Elia, (2021) also argued that married farmers mean communication between the spouses and children is needed for coordination, this leads to ownership of communication devices such as cell phones as a result likelihood of accessing climate information is increased with subsequent technology uptake.

The results also revealed that the total number of families and adopting crop diversification was significantly related *($p<0.01$)*. This suggests that when family numbers rise, the possibility of the farmers applying crop diversification reduces by 46%. The result contradicts (Ndambiri *et al.* (2014) and (Muriu-Ng'ang'a *et al.* (2017) where larger households adopt novel agricultural practices more readily than small households. This could be the reason that having many family members increases labor availability and consumption challenges, leading to finding opportunities outside their farms and reducing these challenges that come with large family sizes. In Somalia, big families may be associated with high illiteracy levels for instance in the Hiran region only 39% of the respondents had access to formal education (Table 3). According to (George & Sharma, (2020) low literacy is a hindrance to crop diversification.

Off-farm income of the farmers was also correlated with their adaptation to irrigation, resistant varieties, inputs such as fertilizers and pesticides, planting early maturing crops, and finding off-farm jobs significantly (Laita *et al.* (2024b) (**Table 5**). This suggests that when farmers' income increases by a dollar, the probability of adopting irrigation, genetically modified crops, and inputs increases by 32, 54.8, and 23.5%, respectively, whereas, the likelihood of adopting early-growing crops, and farm off-job employment reduces by 52%, and 25.7%, respectively. This could be because having other sources of income other than farm income facilitates farmers' capability to finance and adopt advanced agricultural machinery and practices, leading to improved agricultural productivity. (Asayehegn *et al.* (2017) argued that higher-income farmers had a greater likelihood to adopt different adaptation practices and invent new technologies, due to their ability to overcome financial constraints. (Adimassu & Kessler, (2016) also observed that wealthier families had greater resources to counter quickly to climate change consequences compared to lower-income farmers.

Access to agricultural extension services positively related to farmers' adaptation strategies, particularly, the usage of genetically modified crops ($p<0.05$). This shows that obtaining advisory services enhances the probability of farmers practicing and using improved or resistant varieties by 19.3%. Farmers' access to extension services boosts adaptation to modern farming practices and technologies, which contribute to greater agricultural productivity (Deressa *et al.*, 2011, Mudombi *et al.*, 2014). The result corresponds with prior research by (Mabe *et al.* (2014) and (Muriu-Ng'ang'a *et al.* (2017) who reported that farmers' access to agricultural advisories increases the probability of to adjusting the consequences of changing climate, due to their exposure to additional information and advanced technology. Furthermore, (Nhemachena & Hassan, (2007) and (Atube *et al.* (2021), also highlighted farmers' adaptation techniques were positively impacted by their extension services access.

Access to credit for the farmers correlated with several adaptation strategies, for instance, access to credits related positively to irrigation, improved/resistant varieties, and input use. This means that access to financial resources by the farmers enhances the probability of implementing irrigation, genetically modified crops, and input use by 25.6, 32.5, and 29.1%, respectively. However, it negatively correlated with the likelihood of finding off-farm employment and planting early maturing crop adaptation strategies. This means that farmers' access to credits reduces the probability of finding off-farm employment and planting early maturing crop adaptation strategies by 17.3 and 32.8%, respectively. This supports the findings of (Deressa *et al.* (2008) and (Tesso *et al.* (2012), that the availability of credits substantially influences the chances of employing irrigation, modifying planting schedule, and conserving soil. This due to better financial resources such as access to credit and cash flows, increases farmers' investment and practices of more expensive and effective adaptation strategies such as fertilizer and pesticide uses, irrigation, and improved seeds, leading to more profitable output and reduced climate change effects.

Receiving support such as training through agricultural extension, NGOs, and international agencies significantly influenced the adoption of irrigation, improved/resistant varieties, input, and, off-farm employment (**Table 5**). Receiving support increases the likelihood of adopting irrigation, improved/resistant crops, and input, by 11.6, 22, and 12.9%, respectively, and reduces, the off-farm employment adaptation strategy by 11.5%. Farmers' engagement in formal training increased their ability to employ new technologies (Muriu-Ng'ang'a *et al.*, 2017, Gebre *et al.*, 2019, Muchai *et al.*, 2020). These findings corroborate those of (Mabe *et al.*, (2014) and (Atube *et al.* (2021), who established that accessibility of information and support from agricultural extension services will raise the possibility of adopting climate crises, due to exposure to information and skills by the farmers.

5.0 Conclusions

Smallholder farmers in the Hiran region of Somalia have adopted climate change adaptation strategies such as irrigation, minimum soil tillage, planting early-growing crops, using genetically modified seeds, and crop diversification. Financial limitations, insufficient understanding, and information, and inadequate assistance from the federal and state institutions, were the main drawbacks to farmers adapting to climate crises. The adoption of these adaptation methods among the farmers was determined by age, marital status, family size, non-farm income, access to credit, support from agricultural extension agencies, NGOs, and international agencies, and access to extension services. Therefore, we recommend that the Federal government review farmer extension systems and design farm management adoption programs based on the socio-economic characteristics of the farmers and create a favorable environment for the provision of agricultural credits to the farmers.

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References

Abrams L. (2018). Unlocking the potential of enhanced rainfed agriculture. In *Report no. 39. SIWI, Stockholm*. www.siwi.org/publications

Adimassu Z., & Kessler A. (2016). Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift valley of Ethiopia. *Environmental Systems Research 5*(1), 1–16. https://doi.org/10.1186/S40068-016-0065-2

Ahmed S. M. (2020). Impacts of drought, food security policy and climate change on performance of irrigation schemes in Sub-saharan Africa: The case of Sudan. *Agricultural Water Management*, *232*, 106064. https://doi.org/10.1016/j.agwat.2020.106064

Alem K., Kibebew K., Jemma H., Muktar M., & Yosef A. (2016). Farmers perception towards climate change and their adaptation measures in Dire Dawa Administration, Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development*, *8*(12), 269–283. https://doi.org/10.5897/JAERD2016.0800

Aryal J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., & Jat, M. L. (2020). Climate change and agriculture in South Asia: adaptation options in smallholder production systems. *Environment, Development and Sustainability*, *22*(6), 5045–5075. https://doi.org/10.1007/S10668-019-00414-4/TABLES/7

Asare-Nuamah P., & Mandaza, M. S. (2020). Climate Change Adaptation Strategies and Food Security of Smallholder Farmers in the Rural Adansi North District of Ghana. In *Handbook of Climate Change Management* (pp. 1–20). Springer International Publishing. https://doi.org/10.1007/978-3-030-22759-3_142-1

Asayehegn K., Temple, L., Sanchez, B., & Iglesias, A. (2017). Perception of climate change and farm level adaptation choices in central Kenya. *Cahiers Agricultures*, *26*(2), 25003. https://doi.org/10.1051/cagri/2017007

Atube F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agriculture & Food Security*, *10*(1), 6. https://doi.org/10.1186/s40066-020-00279-1

Bakht S., Safdar K., Khair K.U., Fatima A., *et al*. (2020). The Response of Major Food Crops to Drought Stress: Physiological and Biochemical Responses. In *Agronomic Crops* (pp. 93–115). Springer Singapore. https://doi.org/10.1007/978-981-15-0025-1_6

Bawa D. B., Ani, A. O., & Bzugu P M. (2014). *Influence of Sources of Agricultural Information on Maize Farmers in Southern Borno, Nigeria*. *31*. www.iiste.org

Belay A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture & Food Security*, *6*(1), 24. https://doi.org/10.1186/s40066-017-0100-1

Bhuiyan C., Saha, A. K., Bandyopadhyay, N., & Kogan F. N. (2017). Analyzing the impact of thermal stress on vegetation health and agricultural drought – a case study from Gujarat, India. *GIScience & Remote Sensing*, 54(5), 678–699. doi.org/10.1080/15481603.2017.1309737

Carty T. (2017). *A Climate in Crisis: How climate change is making drought and humanitarian disaster worse in East Africa*. https://climexp.knmi.nl/.

Conway D., & Schipper, E. L. F. (2011). Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. *Global Environmental Change*, *21*(1), 227–237. https://doi.org/10.1016/j.gloenvcha.2010.07.013

Cooper P. J. M., & Coe, R. (2011). Assessing and Addressing Climate-Induced Risk in Sub-Saharan Rainfed Agriculture. *Experimental Agriculture*, *47*(2), 179–184. https://doi.org/10.1017/S0014479711000019

Derbile E. K., Chirawurah, D., & Naab, F. X. (2022). Vulnerability of smallholder agriculture to environmental change in North-Western Ghana and implications for development planning. *Climate and Development*, *14*(1), 39–51. https://doi.org/10.1080/17565529.2021.1881423

Deressa T., Hassan, R. M., Alemu, T., Yesuf, M., & Ringler, C. (2008). *Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia*. www.ifpri.org/pubs/otherpubs.htm#dp.

Deressa T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, *149*(1), 23–31. https://doi.org/10.1017/S0021859610000687

Deressa T. T., Rashid, M. H., Claudia, R., Tekie, A., & Mahmud, Y. (2009). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia | IFPRI : International Food Policy Research Institute. *Global Environmental Change*, *19*, 248–55. https://www.ifpri.org/publication/analyzing-determinants-farmers-choice-adaptation-methods-and-perceptions-climate-change

Etwire P. M. (2020). The impact of climate change on farming system selection in Ghana. *Agricultural Systems*, *179*, 102773. https://doi.org/10.1016/j.agsy.2019.102773

Food agricultural organization & World Bank. (2018). *Rebuilding Resilient and Sustainable Agriculture in Somalia SOMALIA OVERVIEW*. http://www.fao.org/3/i8842en/I8842EN.pdf.

Fosu-Mensah B. Y., Vlek, P. L. G., & MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: A case study of Sekyedumase district in Ghana. *Environment, Development and Sustainability*, *14*(4), 495–505. https://doi.org/10.1007/s10668-012-9339-7

Gebre G.G., Isoda H., Rahut D.B., Amekawa Y., Nomura H. (2019). Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia. *Women's Studies International Forum*, *76*, 102264. https://doi.org/10.1016/j.wsif.2019.102264

George G. P., & Sharma, H. O. (2020). Determinants of crop diversification in Kerala- a temporal analysis. *Journal of Tropical Agriculture*, *58*(1), 99-106. http://jtropag.kau.in/index.php/ojs2/article/view/882

IPCC (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 [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)*. https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_Front_matters.pdf

IPCC (2022). Framing and Context. In *Global Warming of 1.5°C* (pp. 49–92). Cambridge University Press. https://doi.org/10.1017/9781009157940.003

Kogo B. K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environment, Development and Sustainability*, *23*(1), 23–43. https://doi.org/10.1007/s10668-020-00589-1
Laita, M., Sabbahi, R., Azzaoui, K., Hammouti, B., Nasri, H., Messaoudi, Z., Benkirane, R., & Aithaddou, H. (2024a). Optimizing water use and crop yield with deficit irrigation techniques: A comprehensive overview and case study from Morocco. *Multidisciplinary Reviews,* 7 Issue 4 (2024), e2024074 https://www.malque.pub/ojs/index.php/mr/article/view/1981
Laita M., Hammouti B., Sabbahi R., Messaoudi Z., Benkirane R. (2024b) Effect of Water Regime and Soil Maintenance Mode on Vegetative Growth and Peach Tree Production, Indonesian Journal of Science & Technology, 9(1), 33-44
Mabe F. N., Sienso, G., & Donkoh, S. A. (2014). Determinants of Choice of Climate Change Adaptation Strategies in Northern Ghana. *Research in Applied Economics*, *6*(4), 75. https://doi.org/10.5296/rae.v6i4.6121
Manda J., Alene A. D., Gardebroek C., Kassie M., Tembo G. (2016). Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes: Evidence from Rural Zambia. *Journal of Agricultural Economics*, 67(1), 130–153. https://doi.org/10.1111/1477-9552.12127
Melka Y., Kassa H., Ketema M., Abebaw D., Schmiedel U. (2015) The effect of drought risk perception on local people coping decisions in the Central Rift Valley of Ethiopia. *Journal of Development and Agricultural Economics*, *7*(9), 292–302. doi.org/10.5897/JDAE2015.0674
Muchai S. W. K., Ngetich, F. K., Baaru, M., & Mucheru-Muna, M. W. (2020). Adoption and utilisation of Zai pits for improved farm productivity in drier upper Eastern Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, *121*(1), 13–22. https://doi.org/10.17170/KOBRA-202002281030
Muchuru S., & Nhamo, G. (2019). A review of climate change adaptation measures in the African crop sector. *Climate and Development*, *11*(10), 873–885. https://doi.org/10.1080/17565529.2019.1585319
Mudombi S., Nhamo, G., Muchie M. (2014). Socio-Economic Determinants of Climate Change Awareness among Communal Farmers in Two Districts of Zimbabwe. *African Insight*, 44(2), 1–15. https://www.researchgate.net/publication/275330550_Socio-Economic_Determinants_of_Climate_Change_Awareness_among_Communal_Farmers_in_Two_Districts_of_Zimbabwe
Mugi-Ngenga E. W., Mucheru-Muna, M. W., Mugwe, J. N., Ngetich, F. K., Mairura, F. S., & Mugendi, D. N. (2016). Household's socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. *Journal of Rural Studies*, *43*, 49–60. https://doi.org/10.1016/j.jrurstud.2015.11.004
Muriu-Ng'ang'a F. W., Mucheru-Muna, M., Waswa, F., & Mairura, F. S. (2017). Socio-economic factors influencing utilisation of rain water harvesting and saving technologies in Tharaka South, Eastern Kenya. *Agricultural Water Management*, *194*, 150–159. https://doi.org/10.1016/J.AGWAT.2017.09.005
Musafiri C. M., Kiboi, M., Macharia, J., Ng'etich, O. K., Kosgei, D. K., Mulianga, B., Okoti, M., & Ngetich, F. K. (2022). Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: do socioeconomic, institutional, and biophysical factors matter? *Heliyon*, *8*(1), e08677. https://doi.org/10.1016/j.heliyon.2021.e08677
Nangombe S., Zhou, T., Zhang, W., Wu, B., Hu, S., Zou, L., & Li, D. (2018). Record-breaking climate extremes in Africa under stabilized 1.5 °C and 2 °C global warming scenarios. *Nature Climate Change*, *8*(5), 375–380. https://doi.org/10.1038/s41558-018-0145-6
Ndambiri H.Ritho, C., & Mbogoh, S. (2014). (PDF) An Evaluation of Farmers' Perceptions of and Adaptation to the Effects of Climate Change in Kenya. *International Journal of Food and Agricultural Economics.*, *1*, 75–96.

Nhemachena C., Hassan R. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa, *IFPRI: International Food Policy Research Institute*. https://www.ifpri.org/publication/micro-level-analysis-farmers'-adaptation-climate-change-southern-africa

Ogundeji A. A. (2022). Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture*, 12(5), 589. doi.org/10.3390/agriculture12050589

Ojo T. O., Adetoro, A. A., Ogundeji, A. A., & Belle, J. A. (2021). Quantifying the determinants of climate change adaptation strategies and farmers' access to credit in South Africa. *Science of The Total Environment*, *792*, 148499. https://doi.org/10.1016/j.scitotenv.2021.148499

Pereira L. (2017). Climate Change Impacts on Agriculture across Africa. In *Oxford Research Encyclopedia of Environmental Science*. Oxford University Press. https://doi.org/10.1093/acrefore/9780199389414.013.292

Rahut D. B., Aryal, J. P., & Marenya, P. (2021). Ex-ante adaptation strategies for climate challenges in sub-Saharan Africa: Macro and micro perspectives. *Environmental Challenges*, *3*, 100035. https://doi.org/10.1016/j.envc.2021.100035

Rosegrant M. W., & Cline, S. A. (2003). Global Food Security: Challenges and Policies. *Science*, *302*(5652), 1917–1919. https://doi.org/10.1126/science.1092958

Rudel T. K., Meyfroidt, P., Chazdon, R., Bongers, F., Sloan, S., Grau, H. R., Van Holt, T., & Schneider, L. (2020). Whither the forest transition? Climate change, policy responses, and redistributed forests in the twenty-first century. *Ambio*, *49*(1), 74–84. https://doi.org/10.1007/s13280-018-01143-0

Sanga E.E., Elia E.F. (2021). Socio-demographic determinants of access to climate change information among tomato growing farmers in Mvomero district, Tanzania. *University of Dar Es Salaam Library Journal*, 15(2), 121–136. https://journals.udsm.ac.tz/index.php/lj/article/view/3991

Shackleton S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *WIREs Climate Change*, *6*(3), 321–344. https://doi.org/10.1002/wcc.335

Sullo C., King, R. S., Yiridomoh, G. Y., & Doghle, K. (2020). Indigenous knowledge indicators in determining climate variability in rural Ghana. *Rural Society*, *29*(1), 59–74. https://doi.org/10.1080/10371656.2020.1758434

Tesso G., Emana, B., & Ketema, M. (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. *International Research Journal of Agricultural Science and Soil Science*.

Wilk J., Andersson, L., & Warburton, M. (2013). Adaptation to climate change and other stressors among commercial and small-scale South African farmers. *Regional Environmental Change*, *13*(2), 273–286. https://doi.org/10.1007/s10113-012-0323-4

Yamane T. (1967). *Statistics An Introductory Analysis*. (2nd Editio). Harper and Row. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=1440506

Zougmoré R. B., Partey, S. T., Ouédraogo, M., Torquebiau, E., & Campbell, B. M. (2018). Facing climate variability in sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks. *Cahiers Agricultures*, *27*(3), 34001. https://doi.org/10.1051/cagri/2018019