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Factors Affecting the Choices of Coping Strategies for Climate Extremes

The Case of Farmers in the Nile Basin of Ethiopia

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ABSTRACT

This study adopted the multinomial logit model to analyze factors affecting the choice of coping strategies in response to climate extreme events for the Ethiopian Nile River Basin. Results from the multinomial logit model show that different socioeconomic and environmental factors affect coping with climate extreme events. Factors that positively influence coping include education of the head of household, gender of household head being male, farm income, livestock ownership, access to extension for crop and livestock production, farmer-to-farmer extension, temperature, ownership of radio, and better-quality house. Thus, to increase coping with covariate shocks, such as climate extreme events, policies should encourage income generation and asset holding (especially livestock), both of which will support consumption smoothing during and immediately after harsh climatic events. Moreover, government policies should focus on developing institutions that enhance access to education and extension services.

Keywords: climate extremes, coping, Nile Basin, multinomial logit model

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ABBREVIATIONS AND ACRONYMS

ACCFP	African Climate Change Fellowship Program
AEZ	agroecological zone systems
EDRI	Ethiopian Development Research Institute
GCM	Global Circulation Models
HDI	human development index
IIA	irrelevant alternatives
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
MNL	multinomial logit
MoFED	Ministry of Finance and Economic Development
SNNPR	Southern Nations, Nationalities, and People's Region
SRES	Special Report on Emission Scenarios
START	SysTem for Analysis, Research and Training

1. BACKGROUND

Ethiopia is challenged by both social and environmental problems. The main social problem is poverty. Approximately 85 percent of the total population lives under the international poverty line (MoFED 2007), and the country's human development index (HDI) is 0.406, ranking 169 out of 177 countries (UNDP 2008). Poverty in the country is associated with high population growth, a low level of institutional and infrastructural development, and low levels of technology employed, especially in the agricultural sector, which dominates the country's economy (Admassie and Adenew 2007). The country's main environmental problem is the recurrent droughts. Because the country's agriculture mainly depends on rainfall, drought highly affects agricultural production and the livelihood of the farming population. Droughts in Ethiopia can shrink household farm production by up to 90 percent in a normal year of output (World Bank 2003) and are often associated with human starvation and death, as well as livestock death. It generally takes more than one season for farmers to recuperate from seasonal droughts, as resources, including seeds, are not available for the following, non-drought season(s). Thus, recovery from droughts (and floods) can take several seasons, or may never be achieved (Michael et al. 2005).

Globally, the increasing frequency of extreme hydrologic events, both flooding and drought, could be the most adverse result of future global warming (Fowler and Hennessey 1995), particularly for agriculture. Over the last decade, records of extreme weather conditions have been broken every year. IPCC's Third Assessment Report predicts increases in droughts, floods, and other extreme events in Africa that will add to stress on water resources, food security, human health, and infrastructure and that will constrain development in this region (IPCC 2001).

In Ethiopia, the recorded history of drought dates back to 250 B.C. Since then, droughts have occurred in different parts of the country at different times (Webb, von Braun, and Yohannes 1992). Studies show that the frequency of drought has increased over the past few decades, especially in the lowlands (Lautze et al. 2003; NMS 2007). Floods and hailstorms are two other natural extreme events that affect Ethiopian farmers, though they are not as pronounced as droughts.

In response to the recurrent droughts and related environmental calamities, farmers in Ethiopia have developed different coping strategies. Belay, Beyene and Manig (2005), MoFED (2007), and Devereux and Guenther (2007) identified main coping strategies employed by farmers during climate extreme events, especially drought. For instance, a country-level study conducted by the Ethiopia's Ministry of Finance and Economic Development (MoFED 2007) on the ability of farmers to cope with shocks revealed that the main coping strategies include sale of animals (40 percent), loan from relatives (18 percent), sale of crop outputs (14 percent), and own cash (9 percent). Devereux and Guenther (2007) explored the linkages between social protection interventions and support to small farmer development in Ethiopia and suggested policy options that reduce poverty and sustain agricultural production. The study by Belay, Beyene and Manig (2005) identified drought coping strategies among the pastoral and agro-pastoral communities in eastern Ethiopia but did not explicitly model the factors that affect the choice of coping strategies.

Although informative, factors affecting the choice of any one of or combinations of these coping methods were not identified. However, knowledge of factors determining the use of coping methods could assist in targeting interventions toward increasing the effectiveness of coping mechanisms to reduce the harmful impacts of climatic extremes. Therefore, the main objective of this paper is to identify and analyze the factors affecting the choice of coping mechanisms for climate extreme events by taking the case of Ethiopia's Nile basin.

Section 2 introduces the climate system of Ethiopia. Section 3 presents a review of the literature on climatic risk management and coping strategies. Methodological approach, study area, and data are presented in Section 4. Section 5 discusses the results of the analysis, and Section 6 concludes and gives policy recommendations.

2. CLIMATE SYSTEMS IN ETHIOPIA

Agroecological Features of Ethiopia

The climate of Ethiopia is mainly controlled by the seasonal migration of the Intertropical Convergence Zone (ITCZ), which follows the position of the sun relative to Earth and the associated atmospheric circulation, in conjunction with the country's complex topography (NMSA 2001). There are different ways of classifying Ethiopia's climatic systems, including the traditional, the Köppen, the Thornthwaite, the rainfall regime, and the agroclimatic zone classification systems (Yohannes 2003).

The most commonly used classification systems are the traditional and the agroecological zone systems (AEZs). According to the traditional classification system, which mainly relies on altitude and temperature, Ethiopia has five climatic zones (Table 1).

Table 1. Traditional climatic zones and their physical characteristics

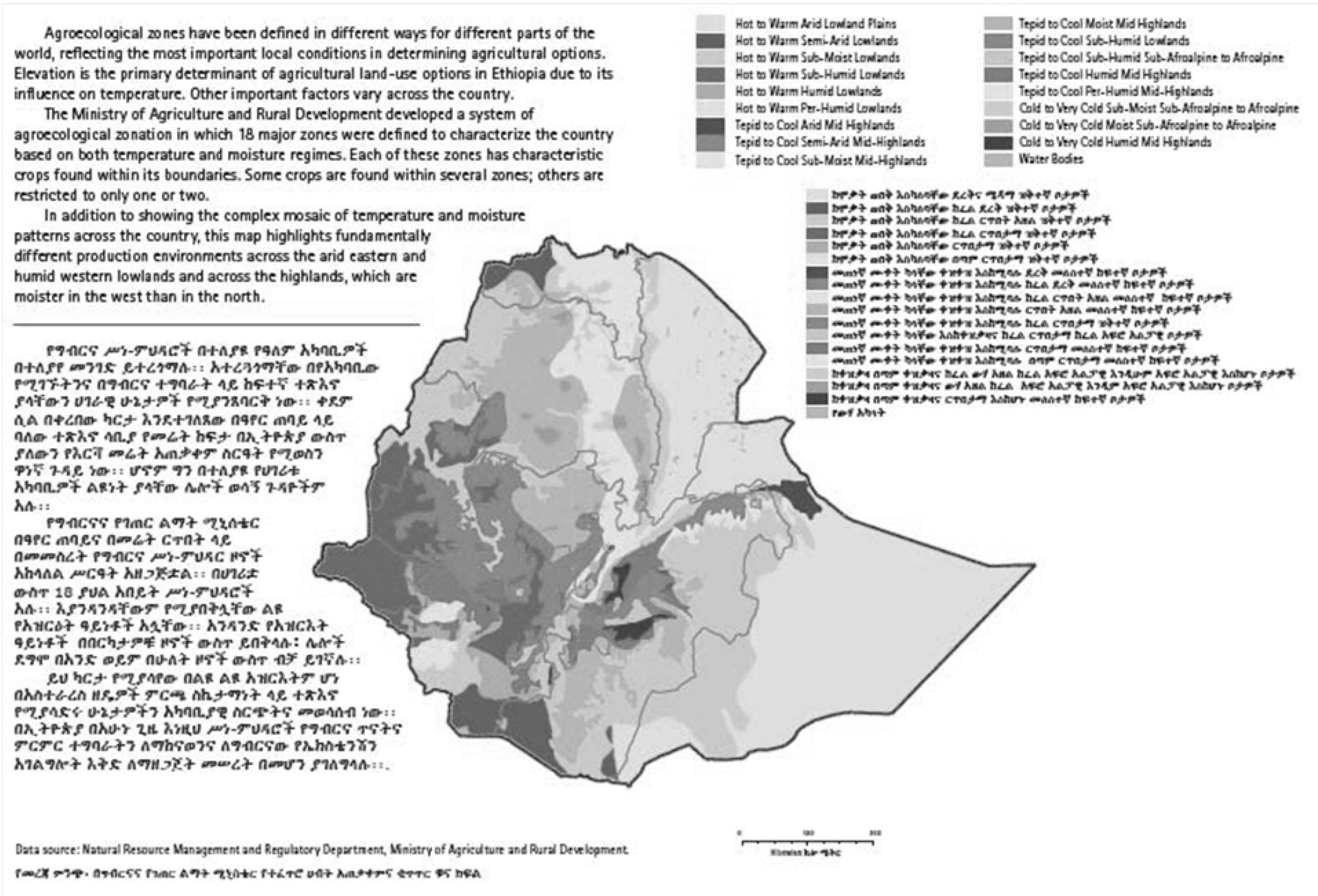
Zone	Altitude (m)	Rainfall (mm/yr)	Average annual temperature (˚C)
Wurch (upper highlands)	> 3,200	900–2200	> 11.5
Dega (highlands)	2,300–3,200	900–1,200	17.5/16.0–11.5
Weynadega (midlands)	1,500–2,300	800–1,200	20.0–17.5/16.0
Kola (lowlands)	500–1,500	200–800	27.5–20.0
Berha (desert)	< 500	< 200	> 27.5

Source: MoA 2000

The AEZ classification method, on the other hand, is based on combining growing periods with temperature and moisture regimes. According to the AEZ classification system, Ethiopia has 18 major AEZs, which are further subdivided into 49 AEZs (Figure 1). These AEZs are also grouped under six major categories (MoA 2000):

- Arid: This zone is less productive and pastoral, occupying 53.5 million hectares (31.5 percent of the country).
- Semiarid: This area, which is less harsh than the arid zone, occupies 4 million hectares (3.5 percent of the country).
- Sub-moist: This zone occupies 22.2 million hectares (19.7 percent of the country) and is highly threatened by erosion.
- Moist: This zone covers 28 million hectares (25 percent of the country) and includes the country's most important agricultural land, where cereals are the dominant crops.
- Sub-humid and humid: These zones cover 21.9 million hectares (19.5 percent of the country). They provide the most stable and ideal conditions for annual and perennial crops and are home to the remaining forest and wildlife. These zones also have the most biological diversity.
- Per-humid: This zone covers about 1 million hectares (close to 1 percent of the country) and is suited for perennial crops and forests.

Figure 1. Ethiopia's agroecological zones



Source: IFPRI, CSA, and EDRI 2006.

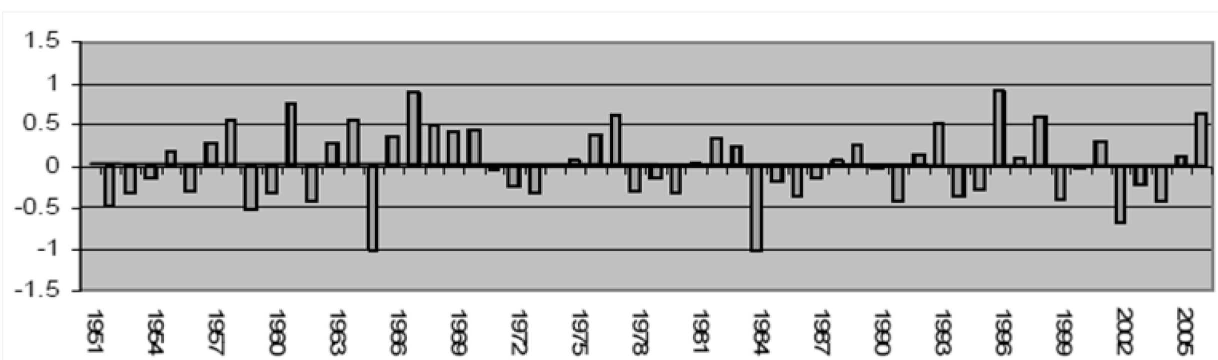
Over these diverse AEZs, mean annual rainfall and temperature vary widely, ranging from about 2,000 millimeters over some pocket areas in the southwest to less than 250 millimeters over the Afar lowlands in the northeast and Ogaden in the southeast. Mean annual temperature varies from about 10 degrees Celsius over the high tablelands of the northwest, central, and southeast to about 35 degrees Celsius on the northeastern edges.

Past Trends of Climate and Impacts in Ethiopia

In addition to variations in different parts of the country, the Ethiopian climate is also characterized by a history of climate extremes, such as drought and flood, and increasing temperature and decreasing precipitation trends. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia; moreover, recent studies indicate that the frequency of drought has increased, especially in the lowlands (Lautze et al. 2003; NMS 2007).

Studies also indicate that temperature and precipitation have been changing over time. According to NMS (2007), annual minimum temperature has been increasing by about 0.37 degrees Celsius every 10 years over the past 55 years. The country's average annual rainfall has recently shown a very high level of variability (NMS 2007). For the past 55 years, some years have been characterized by dry conditions, resulting in drought and famine, whereas others are characterized by wet conditions (Figure 2). Droughts do not only reduce agricultural production, but also result in starvation, death, and foreign aid Dependence. Droughts are a key reason for Ethiopia's large dependence on food aid. For instance, during the 1983/84 drought, about one million people died due to a drought that led to famine (Table 2).

Figure 2. Year-to-year variability and trends of annual rainfall over Ethiopia, expressed in normalized deviation (compared with 1971–2000 normal)



Source: NMS 2007.

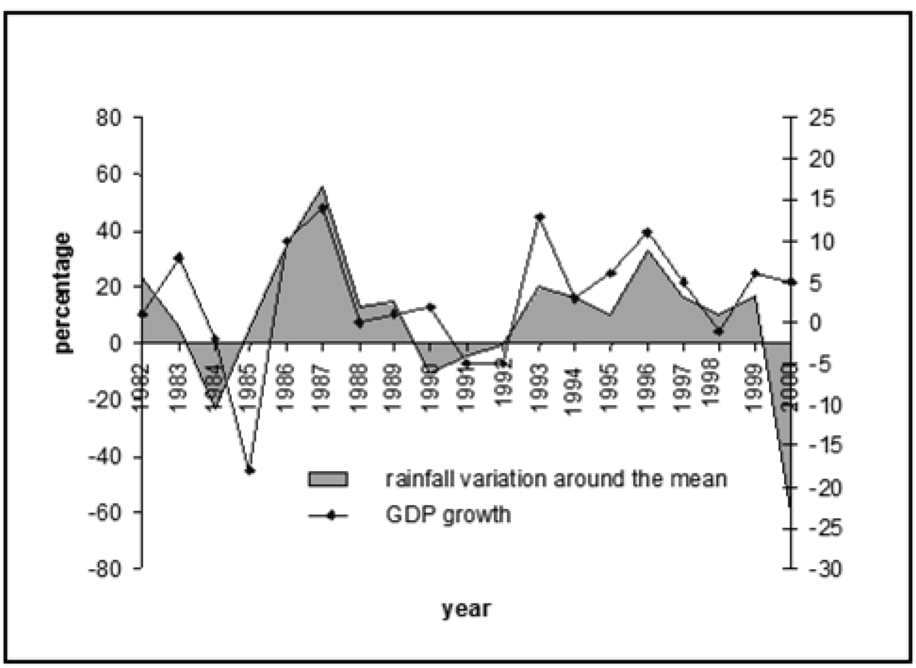
Table 2. Chronology of the effect of drought and famine on Ethiopia, 1965–2009

Years	Regions affected[1]	Effects
1964–1966	Tigray and Wello	About 1.5 million people affected
1972–1973	Tigray and Wello	About 200,000 people and 30 percent of livestock died
1978–1979	Southern Ethiopia	1.4 million people affected
1983–1984	All regions	8 million people affected, 1 million people died
1987–1988	All regions	7 million people affected
1992	Northern, eastern, and southern regions	About 500,000 people affected
1993–1994	Tigray and Wello	7.6 million people affected
2000	All regions	About 10.5 million people affected
2002–2003	All regions	About 13 million people affected
2008–2009	All regions	About 5 million people affected

Sources: Quinn and Neal 1987; Degefu 1987; Nicholls 1993; Webb and von Braun 1994; Disaster Prevention and Preparedness Agency 2009.

The trends of the contribution of agriculture to total GDP of the country clearly explain the relationship between the performance of agriculture, climate and the total economy. As can be seen in Figure 3, years of drought and famine (1984/1985, 1994/1995, 1998/1999) are associated with very low contributions, whereas years with good climatic conditions (1982/83, 1986/1987, 1996/1997) are associated with better contributions.

Figure 3. Rainfall variation and GDP growth



Source: World Bank (2006).

[1] Lost livelihoods or means of subsistence

Projected Climate in Ethiopia

Although Global Circulation Models (GCMs) predicting precipitation give controversial results of both increasing and decreasing precipitation for Ethiopia, all models agree that temperature will continue to increase over the coming years. For instance, Strzepek and McCluskey (2006) showed that precipitation is either increasing or decreasing based on different models but that temperature will increase under all models (Table 3). They used three climate prediction models based on two scenarios from the Intergovernmental Panel on Climate Change's (IPCC's) Special Report on Emission Scenarios (SRES). These models are the Coupled Global Climate Model (CGCM2; Flato and Boer 2001), the Hadley Center Coupled Model (HadCM3; Senior and Mitchell 2000), and the Parallel Climate Model (PCM; Washington et al. 2000). The two SRES scenarios used in the study are the A2 and B2 scenarios. Scenario A2 describes a world in which population growth, per capita economic growth, and technological changes are heterogeneous across regions. Scenario B2 describes a world in which population continuously increases across the globe at a rate less than that in A2, an intermediate level of economic development is oriented toward environmental protection, and social equity focuses on local and regional levels (IPCC 2001). In addition, forecasts by NMS (2007) indicate that temperature will increase over Ethiopia in the range of 1.7–2.1 degrees Celsius by the year 2050 and 2.7–3.4 degrees Celsius by the year 2080.

Table 3. Climate predictions for 2050 and 2100 (Changes from a 1961–1990 base for SRES Scenarios A2 and B2)

Model	Temperature (°C)		Precipitation change (%)	
	2050	2100	2050	2100
CGCM2				
A2	3.3	8.0	–13.0	–28.0
B2	2.9	5.1	–13.0	–28.0
HadCM3				
A2	3.8	9.4	9.0	22.0
B2	3.8	6.7	9.0	22.0
PCM				
A2	2.3	5.5	5.0	12.0
B2	2.3	4.0	5.0	12.0

Source: Strzepek and McCluskey 2006.

Given these climate extreme trends, different risk-management and coping strategies have been employed by Ethiopian farmers to reduce the harmful effects. Section 3 discusses the risk-management and coping strategies employed by Ethiopian farmers in the face of recurrent climatic extreme events, especially drought.

3. CLIMATE RISK MANAGEMENT AND COPING IN ETHIOPIA

Both households and the government undertake climate risk management through mitigation and coping practices to reduce the damages from climate change. Risk-mitigation strategies at the household level include diversifying crops, mixing crop and livestock production, keeping multiple species of livestock, and joining rotating credit groups.

Coping strategies at the household level include selling productive assets, selling livestock and agricultural products, reducing current investment and consumption, employing child labor, temporarily or permanently migrating, mortgaging land, and using interhousehold transfers and loans.

Public-level risk-mitigation strategies include water harvesting, conserving and managing resources, irrigating, partaking in voluntary resettlement programs, using household extension packages or agroecological packages, and joining productive safety net programs (Devereux and Guenther 2007). More recently, pilot studies on weather-indexed drought insurance and commodity exchange programs have been implemented (Hazell et al. 2010).

Important government-driven coping strategies include free food distribution (mainly from food aid) and food-for-work programs (MoFED 2007; Devereux and Guenther 2007). In fact, food aid has become one of the most important coping strategies for fighting drought and famine and has made Ethiopia the largest food aid recipient in Africa. For instance, Ethiopia required about 896,963 metric tons of food aid during the 2000/01 drought and about US$455 million worth of food aid during the 2008/09 drought (Disaster Prevention and Preparedness Agency 2009).

Even though they are very important for vulnerability reduction, both the household- and public-level risk-mitigation and coping strategies have limits. Household-level risk-management strategies are ineffective mainly because they only achieve partial insurance at a very high cost. These strategies are localized and are limited in scope. In addition, informal insurance (depending on relatives and neighbors for material and moral support) marginalize the most vulnerable and have high hidden costs (World Bank 2003). The limitations of public risk-management strategies include limitation of coverage, weak institutional linkages among stakeholders who deal with risk management, poor early warning mechanisms, and dependence on foreign sources for food aid (World Bank 2003, Devereux and Guenther 2007).

4. EMPIRICAL MODEL

The multinomial logit (MNL) model is used to analyze the determinants of farmers' choice of coping strategies in Ethiopia's Nile basin. This model can be used to analyze crop (Kurukulasuriya and Mendelssohn 2008; Hassan and Nhemachena 2008) and livestock (Seo and Mendelssohn 2008) choices as methods for adapting to the negative impacts of climate change. The advantages of the MNL are that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories unlike the binary probit or logit models (Madalla 1983; Wooldridge 2002) and that it is computationally simple (Tse 1987).

To describe the MNL model, let y denote a random variable taking on the values {1,2…J} for a positive integer J, and let $\boldsymbol{x}$ denote a set of conditioning variables. In this case, y denotes adaptation options or categories, and $\boldsymbol{x}$ contains different household, institutional, and environmental attributes. The question is how, ceteris paribus, changes in the elements of x affect the response probabilities $P(y = j / x),\ j = 1,\ 2, \ldots J$. Because the probabilities must sum to unity, $P(y = j / x)$ is determined once we know the probabilities for $j = 2, \ldots J$.

Let $\boldsymbol{x}$ be a $1 \times K$ vector with first-element unity. The MNL model has response probabilities

$$P(y = j \mid x) = \exp(x\beta_j) / \left[1 + \sum_{h=1}^{J} \exp(x\beta_h),\ j = 1, \ldots J \right] \quad (1)$$

where Bj is K ×1,   j=2…J.

For this study, there are seven coping strategies or response probabilities for drought, floods, and hailstorms:

1. Did nothing
2. Sold livestock
3. Sold livestock and borrowed from relatives
4. Sold livestock and ate less
5. Sold livestock and engaged in food for work
6. Depended on food aid and liquidated other assets
7. Participated in off-farm opportunities

Unbiased, consistent parameter estimates of the MNL model in equation (1) require the assumption of independence of irrelevant alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household must be independent of the probability of choosing another adaptation method (that is, *Pj/Pk* is independent of the remaining probabilities). The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in equation (1).

The parameter estimates of the MNL model only provide the direction of the effect of the independent variables on the dependent (response) variable; estimates represent neither the actual magnitude of change nor the probabilities. Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables, given as

$$\frac{\partial P_j}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{J=1}^{J-1} P_j \beta_{jk}\right) \quad (2)$$

The marginal effects, or marginal probabilities, are functions of the probability itself. They measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green 2000).

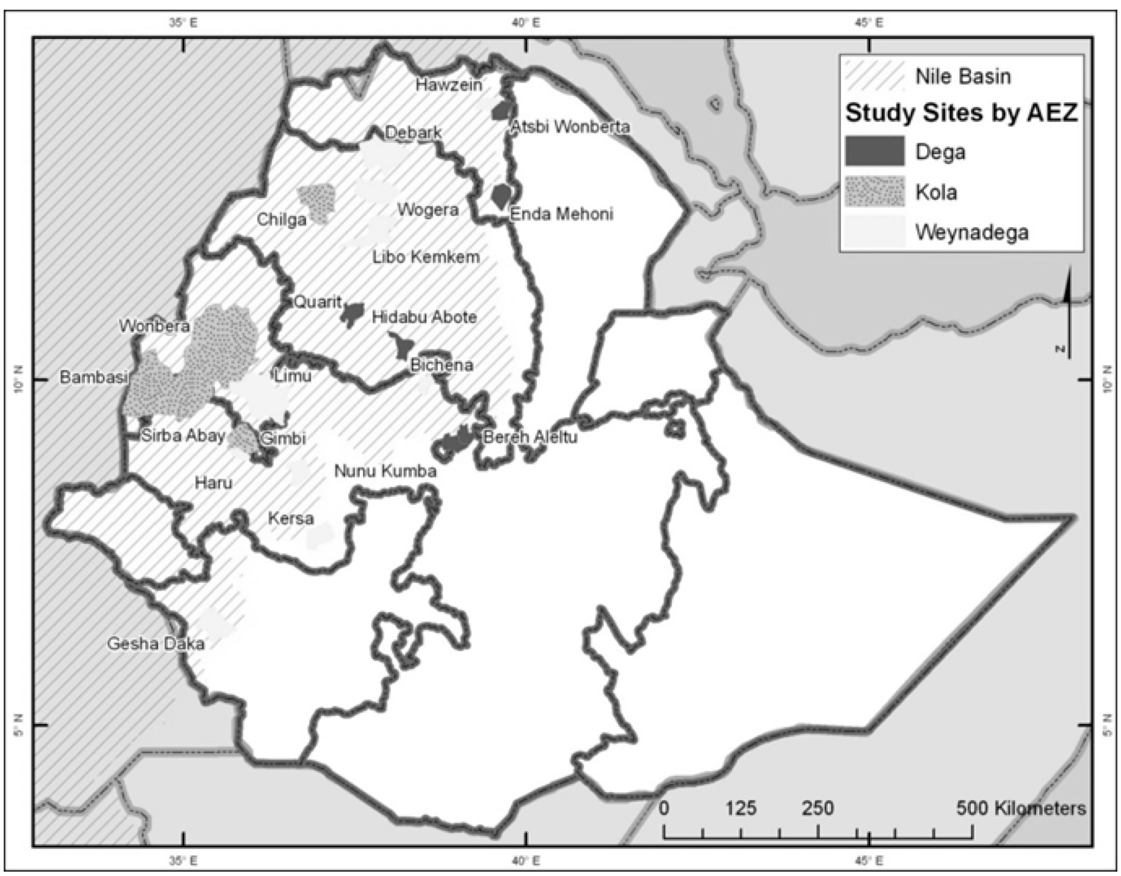
5. STUDY AREA

The Nile basin of Ethiopia was chosen as the study area for this research. This region extends over about 358,889 square kilometers, which is equivalent to 34 percent of Ethiopia's total geographic area. About 40 percent of the country's population lives in this basin, which covers six different regional states of Ethiopia in different proportions—38 percent of the total land area of Amhara, 24 percent of Oromia, 15 percent of Benishangul-Gumuz, 11 percent of Tigray, 7 percent of Gambella, and 5 percent of Southern Nations, Nationalities, and People's Region (SNNPR) (MoWR 1998).

The three major rivers in the basin are the Abay River, originating from the central highlands; the Tekezé River, originating from the northwestern parts of the country; and the Baro-Akobo River, which originates from the southwestern part of the country. The total annual surface runoff of the three rivers is estimated at 80.83 billion cubic meters per year, which amounts to nearly 74 percent of all water supplied by Ethiopia's 12 river basins (MoWR 1998).

The survey households in Ethiopia's Nile basin fall under three of the country's five traditional agroecological settings. For instance, Bereh Aleltu district is located in dega (highland), whereas Wonbera and Limu districts are located in kola (lowland) and weynadega (midland) agroecological zones, respectively. Figure 4 displays the survey districts with their agroecological classifications.

Figure 4. Survey districts and their agroecological settings in Ethiopia's Nile basin



Source: Authors using data from IFPRI/EDRI.

6. DATA SOURCES

The data used for this study were obtained from a household survey of farmers during the 2004/05 production year in Ethiopia's Nile basin. The International Food Policy Research Institute (IFPRI), in collaboration with the Ethiopian Development Research Institute (EDRI), conducted this cross-section survey. Sample districts were purposely selected to include different attributes of the basin, including the traditional typology of agroecological zones in the country, degree of irrigation activity (percentage of cultivated land), average annual rainfall, rainfall variability, and vulnerability (food aid–dependent population).

Peasant administrations from each district were also purposely selected to include households that irrigate their farms. One peasant administration was selected from each district, so that there were 20 districts and 20 peasant administrations. The inclusion of peasant administrations, which included farmers irrigating their farms, led to the selection of 162 villages (gots). Fifty farmers were randomly selected from each peasant association, resulting in a total of 1,000 interviewed households. Of the 20 districts surveyed, three districts were found in Tigray, six in Amhara, seven in Oromia, three in Benishangul-Gumuz, and one in SNNPR. Table 4 summarizes the distribution of sampled villages.

Table 4. Distribution of sampled villages

Region	Zone	District (*Woreda*)	Peasant admin. (*Kebele*)	Number of villages
Tigray	East Tigray	Hawzein	Selam	7
		Atsbi Wonberta	Felege Woinie	9
	South Tigray	Endamehoni	Mehan	3
Amhara	North Gondar	Debark	Mekara	19
		Chilga	Teber Serako	10
		Wogera	Sak Debir	9
	South Gondar	Libo Kemkem	Angot	9
	East Gojam	Bichena	Aratband Bichena	11
	West Gojam	Quarit	Gebez	9
Oromia	West Wellega	Gimbi	Were Sayo	9
		Haru	Genti Abo	12
		Bereh Aleltu	Welgewo	5
		Hidabu Abote	Sira marase	10
	East Wellega	Limu	Areb Gebeya	11
		Nunu Kumba	Bachu	12
	Jimma	Kersa	Merewa	6
Benishangul-Gumuz	Metekel	Wonbera	Addis Alem	1
	Asosa	Bambasi	Sonka	1
	Kamashi	Sirba Abay	Koncho	1
SNNPR	Zone 1	Gesha Daka	Kicho	8
Total				162

Source: Authors based on IFPRI/EDRI data.

Collected data covered include household characteristics, incidence of different climatic and other shocks over the past five years, food aid, land tenure, machinery ownership, rainfed and irrigated agriculture, livestock production, access to credit, access to market, and access to extension, expenditure on food, income, perceptions of climate change, adaptation options and social capital. Moreover, temperature and rainfall data for the surveyed seasons were obtained from a global climate database developed by the University of East Anglia (Mitchell and Jones 2005).

Selected Socioeconomic and Climatic Conditions in the Study Districts

Household Characteristics

Family size in the study was generally high, with an average of 6.13 persons. The average age of the head of household was 44 years, and most were found male. Most of the respondents could not read and write; and only one-third of respondents had received formal education ranging from 1 to 12 years. The majority of the respondents were from the Oromo ethnic groups, followed by the Amhara. As in the case of many African traditional societies, many of the respondents were involved in numerous social activities and networking with relatives and nonrelatives; these activities involve the sharing of resources, work, and information. For instance, the number of relatives in a got (village), which is a proxy for social capital, was 13.4 persons on average (Table 5).

Table 5. Basic household characteristics of the surveyed farmers

	Mean	Standard deviation
Years of education	1.70	2.78
Size of household	6.15	2.22
Gender of household head being male		
Age of household head	0.89	0.31
Number of relatives in *got*	44.29	12.62
	13.37	19.44

Source: Authors based on IFPRI/EDRI data.

The surveyed households were generally poor in terms of income and ownership of assets. The majority of the respondents were subsistence farmers; thus, farm income was very low, with an average of 4356.2[2] Ethiopian birr per year. In addition, off-farm job opportunities were generally limited, with only 24 percent of the sample households having access to off-farm activities; these households earned an average of 218 birr per year off farm. Only 13 percent of the respondents lived in residences made of stone and concrete or brick. The remaining 87 percent lived in low-cost houses made of wood and wood products and with iron sheet, grass, or mud roofs. Moreover, less than one-third of the households had access to toilet facilities (Table 6). Average landholding was very small given the high population pressure, indicating a need for better technology to feed the growing rural and urban populations.

[2] Equal to US$445 per year.

Table 6. Basic assets of the respondents

	Average	Percent of farmers
Farm income (Ethiopian birr)	4356.20	
Nonfarm income (Ethiopian birr)	218.00	
Access to off-farm employment		24.00
Access to good-quality houses		13.00
Access to toilet facilities		31.20
Landholding (hectares)	2.02	

Source: Authors' calculations based on IFPRI/EDRI data.

Given that subsistence and mixed-crop livestock production system is the dominant production system, livestock keeping was common among the surveyed farmers. Livestock keeping is important for substance agriculture, as it serves as the source of power for traction, food, and soil management, in addition to providing fertilizer (manure). About 95 percent of the surveyed households own livestock.

Basic services and infrastructure were generally poor in the surveyed districts, as is the case with the rest of the country. For instance, about half of the respondents had access to agricultural extension, and less than a quarter had access to credit facilities. Although about half of the surveyed farmers had access to landline telephone, only a few had access to electricity. In addition, these farmers were far scattered and so remote that they had to travel long distances to reach input and output markets (Table 7).

Table 7. Access to basic services and infrastructure

	Percent of respondents	Average
Access to agricultural extension	55.00	
Access to formal/informal credit	22.00	
Access to landline telephone	47.40	
Access to electricity	17.80	
Distance to input markets (km)		5.61
Distance to output markets (km)		5.70

Source: Authors' calculations based on IFPRI/EDRI data.

Climatic Conditions, Shocks, and Coping Strategies

As described in the previous section, the survey districts were located in thee agroecological settings that differ in many attributes. Two of the major attributes that characterize the differences are temperature and rainfall. As expected, the kola agroecological zone is the hottest and driest, whereas dega is the wettest and coolest. Table 8 describes the average temperature and precipitation across agroecological settings.

Table 8. Annual average temperature and rainfall across the surveyed agroecologies

Agroecological zone	Average temperature	Average rainfall
Kola	22.00	93.42
Weynadega	17.70	113.84
Dega	17.30	119.10
Total	18.63	111.44

Source: Authors' calculations based on IFPRI/EDRI data.

The surveyed households also reported having encountered many environmental shocks, namely, drought, flood, and hailstorms. The percentages of households that reported droughts, floods, and hailstorms over the prior five years were 31 percent, 12 percent and 18 percent, respectively (Table 9). The relatively high frequency of drought-affected households is consistent with Ethiopia being a drought-prone country. These shocks resulted in a variety of reported losses, primarily consisting of crop yield declines and asset–income losses (Table 10). The majority of farmers did nothing to respond to these shocks, mainly due to their poverty.

Table 9. Major shocks encountered by surveyed farmers

Shock	Number of farmers	Percent of farmers
Drought	380	31.0
Hailstorm	225	18.3
Flood	142	11.6
Animal disease	112	9.1
Pest damage to crops before harvest	84	6.8
Illness of family member	71	5.8

Source: Authors' calculations based on IFPRI/EDRI data.

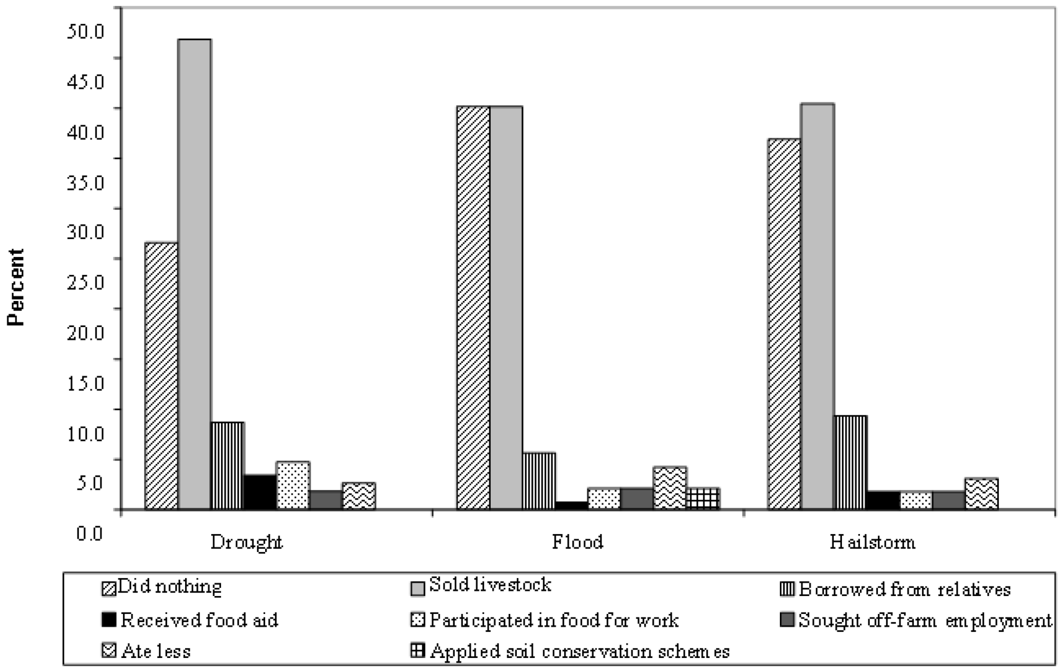
Table 10. Effects of shocks on surveyed farmers

Result	Number of farmers	Percent of farmers
Decline in crop yield	403	32.8
Loss of assets	213	17.4
Loss of income	201	16.4
Food insecurity/shortage	140	11.4
Death of livestock	128	10.4
Decline in consumption	124	10.1

Source: Authors' calculations based on IFPRI/EDRI data.

In general, most of the surveyed farmers who reported experiencing shocks over the past five years sold livestock to cope. This result suggests that in addition to serving as a source of power for farming and manure for fertilizing soil, livestock can also serve as asset and insurance against shocks (Yirga 2007). The other coping strategies included borrowing from relatives, eating less, depending on food aid and food-for-work programs, and looking for off-farm employment. Figure 5 describes the types of coping strategies employed under different climatic shocks by percentage of farmers who used the particular coping strategy.

Figure 5. Coping strategies for major environmental shocks



Source: Created by authors using data from IFPRI/EDRI.

7. EMPIRICAL SPECIFICATION OF MODEL VARIABLES

The dependent variable in the empirical estimation is the choice of a coping strategy (or combination of strategies), as described in Table 11. The choice of the explanatory variables is based on data availability and literature. The explanatory variables for this study include household characteristics, such as education, gender, age of household head, household size, farm and nonfarm income, and livestock ownership; farm size institutional factors, such as extension services on crop and livestock production, access to credit, social capital (which includes farmer-to-farmer extension services), and the number of relatives in the got[3] ; local area and environmental characteristics, such as temperature, rainfall, and agroecology; ownership of assets, such as radio; and houses having roofs with corrugated sheets of iron and access to electricity. Table 12 describes the explanatory variables used for the estimation.

Table 11. Description of coping strategies

Coping strategies	Number of farmers	Percent of farmers
Did nothing	503	51.33
Sold livestock	263	26.84
Sold livestock and borrowed from relatives	106	10.82
Sold livestock and ate less	35	3.57
Sold livestock and engaged in food for work	34	3.47
Depended on food aid and liquidated other assets	21	2.14
Sought off-farm opportunities	18	1.84
Total farmers	980	100

Source: Authors' Calculations from IFPRI/EDRI data.

Table 12. Description of independent variables

Explanatory variables	Description
Education of household head	In number of years
Size of household	Number of people in the household
Gender of household head	Dummy, takes the value of 1 if male and 0 otherwise
Age of household head	Number
Farm income	Amount in Ethiopian Birr
Non-farm income	Amount in Ethiopian Birr
Livestock ownership	Dummy, takes the value of 1 if owned and 0 otherwise
Extension on crop and livestock	Dummy, takes the value of 1 if visited and 0 otherwise
Farmer-to-farmer extension	Dummy, takes the value of 1 if there is and 0 otherwise
Access to credit	Dummy takes the value of 1 if there is access and 0 otherwise
Relatives in *got*	In number
Farm size	In hectares
Local agroecology *kola* (lowland)	Dummy, takes the value of 1 if *kola* and 0 otherwise
Local agroecology *weynadega* (midland)	Dummy, takes the value of 1 if *weynadega* and 0 otherwise.
Local agroecology *dega* (highland)	Dummy, takes the value of 1 if *dega* and 0 otherwise
Temperature	Annual average for the 2004/05 survey period (°C)
Precipitation	Annual average for the 2004/05 survey period (mm)
Ownership of radio	Dummy, takes the value of 1 if owned and 0 otherwise
Type of roof	Dummy, takes the value of 1 if owned roof with corrugated sheets of iron and 0 otherwise
Access to electricity	Dummy, takes the value of 1 if there is access and 0 otherwise

Source: Authors' calculations from IFPRI/EDRI data.

[3] *Got* means ìa village î

8. MODEL RESULTS AND DISCUSSION

The estimation of the multinomial logit model for this study was undertaken by normalizing one category, which is normally referred to as the reference state or the base category. In this analysis, the first category ("did nothing") is the reference state. The model was run and tested for the validity of the independence of irrelevant alternatives (IIA) assumption by using the seemingly unrelated post estimation procedure (SUEST)[4] . The test failed to reject the null hypothesis of independence of the climate extreme coping strategies, indicating that the multinomial logit model (MNL) specification is appropriate to model coping strategies of smallholder farmers ($\chi 2$ ranged from 8.05 to 12.36 with probability values ranging from 0.87 to 0.98).

The results of the MNL model indicate that different socioeconomic and environmental factors affect the ability to cope with different climate extreme events. These factors include gender of household head being male, age of household head (which approximates experience), farm income, farm size, livestock ownership, extension on crop and livestock production, farmer-to-farmer extension, local agroecology kola, local agroecology weynadega, temperature, and precipitation (Table 13).

As explained earlier, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable; they do not represent actual magnitude of change or probabilities. Thus, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases, the estimated coefficients should be compared with the base category of doing nothing in response to climate extreme events. Table 14 presents the marginal effects, along with the levels of statistical significance.

Results show that age, education, and sex of the head of household, farm income, livestock ownership, access to extension services, farmer-to-farmer extension, temperature, ownership of radio, and better-quality houses positively influence the use of one, or a combination, of the coping strategies identified by farmers. Results also show that non-farm income, farm size, local agroecology kola, and precipitation negatively affect the use of one, or a combination, of the identified coping strategies.

As the marginal values show (Table 14), increasing the education of the household head by one unit increases the probability of selling livestock as a coping strategy by 1.2 percent. Livestock ownership is an indicator of wealth in rural Africa (Langyintuo 2005). Studies show that education is also positively related to wealth (Filmer and Pritchett 1999). Male-headed households have a higher probability of selling livestock and borrowing from relatives as coping strategies during climate extreme events than do female-headed households. For instance, male-headed households have a 16.5 percent higher probability of selling livestock only and a 5-percent higher probability of selling livestock and borrowing from relatives than do female-headed households. Moreover, the age of the household head positively influences selling livestock, whereas farm income positively influences selling livestock and eating less during climate extreme events.

Nonfarm income is negatively related to depending on food aid and liquidating other assets as coping strategies. This shows that farmers who have off-farm incomes depend less on food aid and the need to dispose of assets at times of climate extreme events. This result implies the need for creating off-farm job opportunities for farming communities to better enable them to cope. In addition, farm size is negatively related to selling livestock and borrowing from relatives. This result could be because farmers with larger land sizes are also wealthier farmers who can depend on other sources, such as savings, than on selling livestock and borrowing from relatives.

Livestock ownership significantly increases selling livestock only and the combination of borrowing from relatives and selling livestock as coping strategies to climate extreme events. As the marginal values indicate, increasing the ownership of livestock by one unit increases the probability of selling livestock only and the combination of borrowing from relatives and selling livestock as coping

[4] SUEST is a generalization of the classical Hausman specification test useful for intramodel and cross-model hypotheses tests

strategies by 21 percent and 5 percent, respectively. Access to extension on crop and livestock production increases the probability of selling livestock and borrowing from relatives and of selling livestock and eating less as coping strategies. On the other hand, access to credit is negatively related with off-farm opportunities as a coping strategy, perhaps because farmers who can afford to borrow have less incentive to work off farm.

Farmer-to-farmer extension positively influences selling of livestock and borrowing from relatives as coping mechanisms during climate extreme events. Moreover, higher temperature positively influences selling livestock and borrowing from relatives and selling livestock and engaging in a food-for-work program. On the other hand, precipitation negatively influences selling livestock only, selling livestock and eating less, and selling livestock and engaging in a food-for-work program. These results are in line with the fact that Ethiopia is a drought-prone country and that increasing precipitation relives farmers from drought constraints. Ownership of radio and better-quality houses are indicators of wealth in rural Africa (Langyintuo 2005; Vyas and Kumaranayake 2006), meaning that wealthier farmers can better cope. Thus, owning a radio increases the probability of selling livestock and borrowing from relatives, whereas having a better-quality house increases the probability of selling livestock and eating less as coping strategies during climate extreme events in Ethiopia’s Nile basin.

Table 13. Parameter estimates of the multinomial logit model of climate coping strategies

Explanatory variables	Sold livestock	Sold livestock and borrowed from relatives	Sold livestock and ate less	Sold livestock and engaged in food for work	Depended on food aid and liquidated other assets	Sought off-farm opportunities
Education of household head	1.057	0.991	0.909	0.970	0.968	1.065
	(0.143)	(0.869)	(0.429)	(0.755)	(0.755)	(0.543)
Size of household	1.036	1.002	1.118	0.857	0.939	1.153
	(0.433)	(0.976)	(0.286)	(0.225)	(0.590)	(0.285)
Gender of household head	3.066**	2.740*	1.604	6.605	2.098	0.753
	(0.003)	(0.038)	(0.513)	(0.092)	(0.358)	(0.741)
Age of household head	1.024**	1.013	1.012	0.959	1.004	1.006
	(0.004)	(0.238)	(0.551)	(0.079)	(0.850)	(0.819)
Farm income	1.000	1.000	1.000*	1.000*	1.000	1.000
	(0.194)	(0.679)	(0.021)	(0.034)	(0.219)	(0.851)
Nonfarm income	1.000	1.000	1.000	0.999	0.998	1.000
	(0.113)	(0.611)	(0.471)	(0.082)	(0.240)	(0.875)
Farm size	0.843	0.736*	0.840	1.184	0.773	0.812
	(0.054)	(0.023)	(0.430)	(0.365)	(0.302)	(0.488)
Livestock ownership	4.555***	2.988*	2.401	1.970	0.924	0.420
	(0.001)	(0.046)	(0.292)	(0.446)	(0.925)	(0.224)
Extension on crop and livestock	2.333***	3.141***	6.271**	3.847*	1.421	2.850
	(0.001)	(0.001)	(0.009)	(0.037)	(0.560)	(0.146)
Access to credit	1.436	1.281	1.234	0.282	1.089	0.000
	(0.112)	(0.425)	(0.694)	(0.127)	(0.888)	(1.000)
Farmer-to-farmer extension	2.508***	2.957**	2.712	10.054***	2.157	2.140
	(0.000)	(0.002)	(0.082)	(0.001)	(0.231)	(0.278)
Relatives in *got*	0.998	1.002	0.999	1.005	0.967	0.991
	(0.715)	(0.789)	(0.899)	(0.613)	(0.294)	(0.594)
Local agroecology *kola*	0.596	0.079***	0.525	0.015**	0.274	0.658
	(0.118)	(0.000)	(0.412)	(0.003)	(0.147)	(0.699)
Local agroecology *weynadega*	0.935	0.604	0.437	0.142**	0.468	0.959
	(0.803)	(0.150)	(0.177)	(0.001)	(0.256)	(0.955)

Table 13. Continued

Explanatory variables	Sold livestock	Sold livestock and borrowed from relatives	Sold livestock and ate less	Sold livestock and engaged in food for work	Depended on food aid and liquidated other assets	Sought off-farm opportunities
Temperature	1.176	1.398*	1.373	2.411**	1.577*	0.600*
	(0.050)	(0.011)	(0.130)	(0.001)	(0.020)	(0.033)
Precipitation	0.980***	0.987**	0.961***	0.944***	0.984	0.983
	(0.000)	(0.004)	(0.000)	(0.000)	(0.073)	(0.107)
Ownership of radio	0.999	1.797	0.890	1.597	0.581	0.280
	(0.997)	(0.109)	(0.839)	(0.448)	(0.455)	(0.110)
Type of roof	1.094	0.940	3.030	1.103	1.571	0.836
	(0.713)	(0.852)	(0.063)	(0.866)	(0.481)	(0.806)
Access to electricity	1.069	1.060	1.159	0.783	2.125	0.839
	(0.761)	(0.846)	(0.760)	(0.627)	(0.227)	(0.776)
Constant	0.004***	0.000***	0.000*	0.000**	0.000*	3051.708
	(0.001)	(0.000)	(0.028)	(0.005)	(0.015)	(0.087)
Observations	791					
Ll	–831.109					
chi2	410.318					

Source: Authors' calculations from IFPRI/EDRI data.
Notes: *p*-values in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 14. Marginal effects from the multinomial logit model of climate coping strategies

Explanatory variables	Sold livestock	Sold livestock and borrowed from relatives	Sold livestock and ate less	Sold livestock and engaged in food for work	Depended on food aid and liquidated other assets	Sought off-farm opportunities	Did nothing
Education of household head	0.01205*	–0.00201	–0.00152	–0.00017	–0.00069	2.87E-07	–0.00766
	(0.096)	(0.638)	(0.358)	(0.645)	(0.654)	(1.00)	(0.983)
Size of household	0.007147	–0.00077	0.001418	–0.00066	–0.0011	7.54E-07	–0.00604
	(0.992)	(0.997)	(0.979)	(0.262)	(0.530)	(1.00)	(0.996)
Gender of household head	0.1649***	0.047853**	0.001825	0.003644	0.00523	–4.5E-06	–0.22345
	(0.000)	(0.050)	(0.989)	(0.152)	(0.555)	(1.00)	(0.987)
Age of household head	0.004448***	0.000483	5.73E-05	–0.0002	–6.3E-05	–1.3E-08	–0.00473***
	(0.005)	(0.584)	(0.834)	(0.141)	(0.833)	(1.00)	(0.008)
Farm income	–5.11E-06	9.78E-07	1.09E-06**	3.50E-07	6.16E-07	6.96E-11	2.08E-06
	(0.113)	(0.477)	(0.025)	(0.118)	(0.234)	(1.00)	(0.990)
Nonfarm income	–3E-05	3.45E-06	–1.20E-06	–4.33E-06	–3.6E-05*	9.03E-10	0.000068
	(0.283)	(0.991)	(0.750)	(0.189)	(0.083)	(1.00)	(0.980)
Farm size	–0.02508	–0.02068*	–0.00129	0.001004	–0.00266	–7.2E-07	0.048704**
	(0.980)	(0.053)	(0.980)	(0.250)	(0.483)	(1.00)	(0.013)
Livestock ownership	0.207831***	0.049425*	0.00566	0.00106	–0.00822	–1.3E-05	–0.25574
	(0.000)	(0.054)	(0.980)	(0.991)	(0.993)	(1.00)	(0.994)
Extension on crop and livestock	0.128329	0.068309***	0.020306**	0.003763	–0.00034	3.7E-06	–0.22037***
	(0.980)	(0.008)	(0.041)	(0.200)	(0.998)	(1.00)	(0.000)
Access to credit	0.072185	0.012029	0.001271	–0.00403	–0.00052	–0.01292**	–0.06802
	(0.115)	(0.638)	(0.864)	(0.146)	(0.952)	0.029	(0.182)
Farmer-to-farmer extension	0.145102***	0.062989**	0.008285	0.008832	0.00547	2.02E-06	–0.23068***
	(0.002)	(0.022)	(0.314)	(0.132)	(0.569)	(1.00)	(0.000)
Relatives in got	–0.00028	0.000242	–7.02E-06	2.38E-05	–0.00049	–4.8E-08	0.000509
	(0.995)	(0.631)	(0.997)	(0.550)	(0.287)	(1.00)	(0.994)
Local agroecology kola	–0.04849	–0.13267***	–0.00388	–0.00939*	–0.01129	–4.8E-07	0.205717***
	(0.415)	(0.000)	(0.660)	(0.086)	(0.249)	(1.00)	(0.001)
Local agroecology weynadega	0.008809	–0.03757	–0.01042	–0.00859	–0.01018	3.23E-07	0.057952
	(0.983)	(0.176)	(0.256)	(0.101)	(0.361)	(1.00)	(0.316)

Table 14. Continued

Explanatory variables	Sold livestock	Sold livestock and borrowed from relatives	Sold livestock and ate less	Sold livestock and engaged in food for work	Depended on food aid and liquidated other assets	Sought off-farm opportunities	Did nothing
Temperature	0.019966	0.022411**	0.003152	0.00315*	0.005514	–3.4E-06	–0.05419
	(0.994)	(0.029)	(0.265)	(0.062)	(0.126)	(1.00)	(0.994)
Precipitation	–0.00354***	–0.00044	–0.00044***	–0.0002*	–0.00013	–5E-08	0.004746***
	(0.000)	(0.983)	(0.007)	(0.054)	(0.375)	(1.00)	(0.000)
Ownership of radio	–0.01266	0.048475*	–0.00225	0.001651	–0.00936	–8.8E-06	–0.02585
	(0.999)	(0.073)	(0.996)	(0.980)	(0.988)	(1.00)	(0.999)
Type of roof	0.013582	–0.00962	0.014527*	0.000223	0.006072	–1.3E-06	–0.02478
	(0.987)	(0.985)	(0.093)	(0.984)	(0.516)	(1.00)	(0.992)
Access to electricity	0.008565	0.002015	0.001541	–0.00115	0.010579	–1.2E-06	–0.02155
	(0.992)	(0.994)	(0.807)	(0.598)	(0.270)	(1.00)	(0.993)

Source: Authors' calculations from IFPRI/EDRI data.
Notes: p-values in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

9. CONCLUSIONS AND POLICY IMPLICATIONS

Ethiopia is one of the poorest countries in the world, with the majority of its population living under the international poverty line. One of the major reasons for this high poverty is the dependence of the economy on low-productivity agriculture, which has failed to meet the growing food demands of the population and left the nation dependent on food aid. Although many factors contribute to the poor performance of the agricultural sector, poor climatic conditions, in particular recurrent droughts, are a major contributor. Moreover, recent trends of increasing climate variability and higher temperatures are expected to sustain in the future. As a result, the country's agriculture will have to cope with further warming, higher crop evapotranspiration demands, and more frequent climate extremes (such as drought and flood).

The multinomial logit (MNL) model was used to analyze the determinants of farmers' choice of coping strategies based on data obtained from a household survey of farmers during the 2004/05 production year in the country's most productive Nile basin region. Results from the MNL model show that different socioeconomic and environmental factors affect coping with climate extreme events. Factors that positively influence coping include education of the head of the household, gender of household head being male, the age of the household head, farm income, livestock ownership, access to extension on crop and livestock production, farmer-to-farmer extension, temperature, ownership of radio, and better-quality homes.

Policies should encourage income generation and asset holding, especially livestock, both of which will support consumption smoothing during and immediately after harsh climatic events. Moreover, government policies should focus on the provision of agroecology-based technology packages and the strengthening of productive safety net programs to support coping.

Government policies and investment strategies that support the provision of and access to education, extension services on crop and livestock production, and information on climate and coping measures are necessary to better cope with climate change. In addition, policy interventions that encourage informal social networks (financially or materially) can promote group discussions and better information flows, thus enhancing the ability to cope with climate change.

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