

Article

Decision Analysis of the Adaptation of Households to Extreme Floods Using an Extended Protection Motivation Framework—A Case Study from Ethiopia

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Abstract: Private extreme flood adaptation measures are cost effective and environmentally friendly. The objective of this study is to explore the major adaptation strategies, the determinants of the decisions of households to flood adaptation, specific prophylactic measures, and the constraints of these adaptation measures. A multi-stage sampling technique was employed to select the 337 samples for the study. As the data analysis showed, farm households adopted moving to high elevation places, selling cattle, seasonal migration, flood tolerant rice, planting trees, and the construction of a dike as adaptation measures to flood. The binary logistic regression results from both the socioeconomic and protection motivation theory (PMT) showed that marital status, sex, family size, off-farm income, previous flood experience, access to credit, and the average number of extension visits had a statistically significant positive influence on the flood adaptation decision of households. On the other hand, age, educational attainment, farm size, and access to extension played a negative but statistically insignificant role in flood adaptation decision. The scientific novelty of the paper is that its results revealed that not only the socioeconomic and demographic characteristics of households play a role in the decision-making reactions related to the flood, but also the psychological preparedness of the decision makers. The analysis also drew attention that, due to the mitigation of global influences, in the coming years, households can assume a much more decisive role in the process of local food supply. Therefore, in order to ensure safe supply, climate change-related measures and adaptation strategies must be defined very precisely. Dealing with this phenomenon must be part of social and business innovation as it can cause not only food supply problems but also various migration effects, which, in the short term, would result in the most serious damage to the social system.

Keywords: extreme floods; adaptation of households to flood; climate mitigation; protection motivation theory; Ethiopia; climate change



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1. Introduction

Surfeit literature confirms that the economic damage that is attributed to extreme flood worldwide has been increasing exponentially since the middle of the 20th century [1]. In 2017 alone, an estimated global weather-related disaster loss amounted to more than USD 300 billion [2]. Flood and drought are responsible for 80% of disaster related deaths and 70% of the economic damages in Sub-Saharan Africa [3]. Flood hazard, one of the manifestations of climate change and variability, is even less predictable than climate change [4], whose brunt pressure has been manifested in Ethiopian highlands, which has damaged agriculture and ecosystems [5–7]. Flood can be triggered by the duration and intensity of rainfall and the nature of topography and manmade factors [7]. Studies by [5] and [8] reported that

there are tendencies for the frequent occurrence and negative impacts of flooding over time. Sources also reported that the changing conditions of climate change may exacerbate the flooding pressure in Ethiopia [7].

Ethiopia is still just preparing for climate change adaptation through adaptation programs at the local level [9,10]. A number of issues constrain the country's adaptive capacity to climate change and natural hazards such as flood, including the limited livelihood diversification of farm households, heterogeneous withstanding and absorbing capacity, the low level of education of smallholder farmers, and the inefficiency of government provisions [9]. The extent of flood damage can be determined by the proactive capacity of the implemented policy, response plan, changes in land use patterns, and infrastructure strength [7].

Furthermore, Ethiopia lacks real-time hazard prediction technologies as well as the capacity to recover from disasters [10]. Flooding is having a greater impact on the poorest and most vulnerable people, implying that an appropriate combination and application of adaptation measures is unquestionably necessary [2]. Few authors, including [7], have examined the historical flood events and hydrological extremities in Ethiopia since 1950. The decade from 2001 to 2010 had five flood years, making it the most flooding decade, followed by the four-year flood period from 1991 to 2000. In addition, two flood years occurred between 2010 and 2020.

Most flooding in Ethiopia is caused by river overflow emerging from prolonged rainfall that inundates lowland plains. Fogera plain is one of the most severely flooded areas in northwest Ethiopia, in general, and the Lake Tana catchment area, in particular. The frequent floods that occurred at various times in 2006/2007 and 2018/2019 severely impacted many people by degenerating ground water and destroying roads, houses, and the education sector.

Because investment is costly in developing countries, public adaptation measures are less feasible. As a result, private household adaptation measures must be encouraged. This, however, necessitates a better understanding of the socioeconomic, demographic, and psychological factors that influence households' adaptation choices [11]. The decision of households to take flood-protection measures prevents 80% of economic damage [12]. Despite this, not all households are willing to take precautionary measures against extreme flood damage. Exploring the reasons for "prophylactic actions" in response to "noxious" natural events such as flooding is critical for both private and public decision makers to effectively offset the negative effects of flooding on socioeconomic and environmental damages [12]. We hypothesize that not only the socioeconomic and demographic characteristics of households play a role in decision-making reactions to floods but also the psychological preparedness of decision makers. We wonder whether scientific studies can elucidate the origins of this connection.

Flood adaptation, according to literature reviews, is a dynamic and uncertain issue, and we recommend that it includes the interaction and coordination of social, psychological, economic, institutional, and spatial systems in order to effectively counter-balance potential flood damage. We are interested in learning how a protection motivation model can be used to describe this relationship. Identifying the various mechanisms of extreme flood adaptation in the study area has two advantages. First, it assists in distinguishing between simple mechanisms that can be handled privately by households and mechanisms that require a large sum of investment, and in assigning responsibilities accordingly [13]. Second, it serves as a reference tool for engineering method-specific policy and strategy to address flooding challenges at the lowest possible cost, because indigenous and conventional adaptation methods are both cost effective and environmentally friendly [14]. Furthermore, understanding the specific nature of adaptation mechanisms as simple and complex, private and public, ex-ante and ex-post is required to take appropriate action based on their nature [14].

Many studies in Ethiopia emphasized farmers' choice of adaptations to climate change, including [15–26]. However, much effort is required to focus and study the elements and

manifestations of climate change, such as flooding, in order to respond intelligently, as climate change adaptation takes a region-, farm-, and household-specific approach [20,21,27]. Furthermore, multi-purpose information is crucial on the most promising adaptation options available to efficiently allocate limited resources [28], as community level adaptations are the first-line preventive approaches that save from multi-dimensional damages caused by flood [13].

Using binary logistic regression, studies on flood adaptation focused on the socioeconomic and demographic characteristics of farm households as determinants of whether or not to adopt any flood adaptation strategies. Investigating the factors that influence whether or not to implement flood adaptation strategies is one thing, but examining the socioeconomic variables that influence whether or not to implement a specific adaptation measure is another. Because some of the different adaptation measures are mutually exclusive and differ in their input requirements (labor, effort, and time), investment cost, and level of potential efficacy, a household may not have the same degree (intensity) of tendency to adopt one type of precautionary measure [29]. For instance, Reference [24] found that older farmers were more likely to adopt crop diversification than younger farmers, whereas they were less likely to adopt soil conservation and temporary migration as adaptation measures. This is due to the fact that the decision to adapt to any specific measure can be influenced by a variety of socioeconomic factors [30]. As a result, we can conclude that the results of a general binary logistic regression model that estimates the relationship between determinant factors and flood adaptation decisions should not be relied on for policy orientation because they may be misleading.

Furthermore, research in Ethiopia on the determinants of household flood adaptation decisions overlooked the importance of characterizing these determinants using the protection motivation theory (PMT) framework. The protective motivation theory concept is adaptable enough to be used in a multinomial logistic regression model, and its various classes of variables can be used in a regression analysis. Because empirical results on these variables produce mixed results, the variables of the extended model are used in this study instead of the variables of the basic (traditional) model [29].

Because of its lowland and gently sloping topography, Fogera woreda is a well-known flood-affected area. This necessitates an assessment of the impact of various determinant factors on the adoption of any or a specific precautionary measure in order to effectively respond to the frequently occurring flood hazard in the study area. This is significant because adaptation intervention is not a random task and requires detailed scientific information to effectively engineer farm-specific program plans (17). Therefore, a multinomial logit model that treats the dependent variable (choice of adopting a specific adaptation measure) as having more than two responses was employed.

This study attempted to articulate the various flood adaptation approaches and socioeconomic determinants of farm households' decision to adopt or not adopt any method. Furthermore, the paper investigated the socioeconomic-economic-psychological-institutional variables that determine specific flood adaptation measures, as well as the potential barriers that prevent farm households from adopting any measure to live with flooding events without being significantly impacted. The following sub-questions were addressed in the study: (1) What are the main preventive measures for extreme flooding in the study area? (2) Do socioeconomic-economic-psychological-institutional variables have the same effect on the decision to implement any flood-prevention measure and a specific adaptation measure? (3) What are the major flood adaptation constraints in the study area?

There are numerous contributions of the study. First, it identifies the adaptation measures that are most commonly used in the study area. Second, it promotes understanding of the various ways of characterizing the various flood-prevention (adaptation) measures. Third, it contributes to the growth of literature on the empirical study of socioeconomic-psychological and institutional factors influencing flood adaptation decisions. Fourth, the study makes significant contributions to the framing of methodological approaches to flood adaptation research by clearly commenting on the nature, advantages, and limitations of

each method. Fifth, it can be used as a stepping stone for researchers as well as an input for policy makers and stakeholders in flood risk management.

2. Literature Review

Humans will either mitigate or adapt to any natural or environmental threats, such as flooding. Mitigation strategies are short-term solutions that provide an instant fix to a problem that disrupts lives and causes property damage. The permanent courses of action that help communities cope with flooding dangers are known as adaptation methods. Additionally, adaptation is described as a response to or preparation for a climate change or flood threat that has already occurred or is predicted. [31]. In flood-prone areas, household level flood adaptations are essential instruments for reducing the negative effects of floods. [32,33].

Adaptation measures, however, have different characteristics. They can be classified as private and public (on the basis of ownership), simple and complex (on the basis of investment), ex-ante and ex-post or precautionary and reactive (on the basis of timing and purpose), hard and soft, and autonomous and planned adaptations. Adaptations can also be classified on the basis of timing (short term coping strategies and long-term adaptation strategies), reasons of implementation and spontaneity. On the basis of timing, short-term coping strategies and long-term adaptation strategies can be differentiated [30]. Autonomous adaptations are taken by individuals or households while planned adaptations, on the other hand, are taken by governments, but they may sometimes hinder autonomous adaptation when individuals wait for government provisions [34]. Due to the involvement of several stakeholders in technical, institutional, social, economic, and psychological issues, decision-making about flood dangers is complex. [29].

The empirical methods that have tried to characterize the determinants of flood adaptation can be grouped in three main classes: the socioeconomic model, the protection motivation theory (PMT), and coupled agent-based model (ABM). The socioeconomic model states that the social, economic, and demographic characteristics of households, such as age, sex, education status, marital status, income, family size, and farm size, determine their adaptation decisions to private prophylactic measures to flood incidences. However, it is limited in power to better explain the adaptation decision of households since it presumes adaptation decision as a matter of material welfare. Protection motivation theory (PMT) was first applied in psychology, and it is attributed to Rogers, who developed it in 1975 [35]. Its flexibility allowed it to be adopted in the study of the reasons why individuals adopted or not any measure against any natural hazards such as flooding. The first application of the theory in adaptation decision was made by [12]. The greatest strength of the protection motivation theory was its capacity to combine the variables of the socioeconomic model and psychological variables together. Above all, it assumes that adaptation decision is a matter of behavioral change and this, in turn, depends on individuals' psychological conditions [12]. The theory also assumes that the role of socioeconomic conditions of individuals is not to directly enable adaptation decisions but to result in the behavioral change of individuals to take adaptation measures. The theory, therefore, has now two elements in it: the traditional (basic) model and the extended version [29]. The following figure (Figure 1) shows how the entity of the PMT model is enlarged.

The traditional components of the protection motivation theory are threat appraisal, which indicates whether an individual thinks the threat of flooding is high (measured by perceived likelihood of the hazard occurring, perceived severity of damage, and fear), and coping appraisal, which indicates whether an individual thinks his ability to deal with the issue is strong enough (proxied by protective response efficacy, perceived self-efficacy and protective response costs). The expanded version also covers socioeconomic and demographic factors (age, sex, educational status, marital status, off-farm income, and family size) as well as psychological factors (prior flood experience, perception of flood danger, and terror). The PMT model could yet be expanded to incorporate more

explanatory factors, such as institutional variables (access to credit and extension) and farm characteristics (farm size).

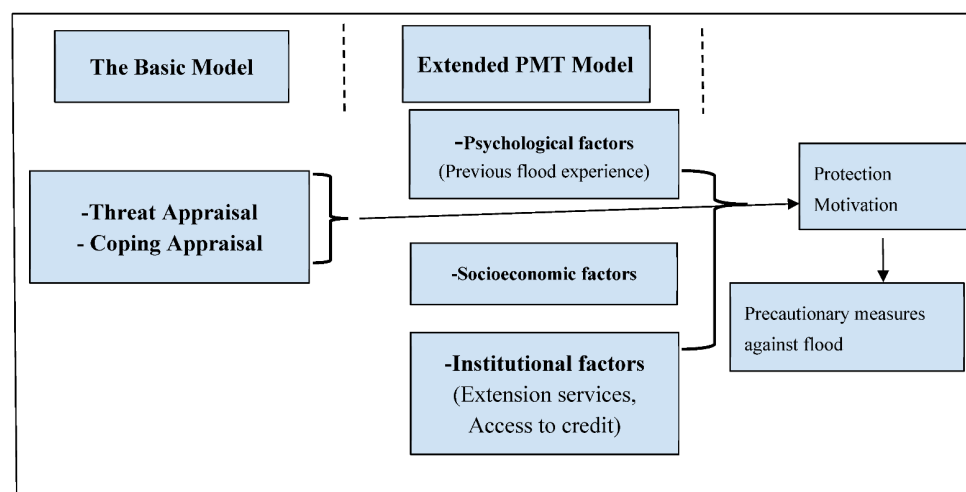


Figure 1. Protection motivation theory (Authors' own edition based on Twerefou [29]).

The coupled agent-based model (CABM) is a computational model that integrates the interaction of agents—both autonomous and heterogeneous—and their environment—flood—through controlled simulations to examine the contribution of agents' behavior and socioeconomic-institutional characteristics to people's decisions about how to adapt to flood incidence [32].

In the literature, many adaptation mechanisms have been identified across many countries. For instance, in Pakistan, References [36,37] identified that farmers used adaptation options, including elevated ground floor, crop variety, shifting sowing seasons, and maintaining food stock such as wheat. A study by [38] also reported that farmers in Ghana used sandbags, raising the foundations of their buildings, trampoline, creating pathways for flood waters, livelihood diversification, and crop varieties. In Indonesian Jakarta, raising the housing level, building terraced housing, and building small dikes were identified [39]. Furthermore, Reference [40] on households' adaptation mechanisms to flood risk, Kenya reported moving family and valuable goods to safe places, constructing flood diversion trenches, and seeking relief from government and other agencies as the main coping ways. In China, stream recovery, green levees, raised and floatable structures, ground detentions, rooftop detentions, and reservoirs were identified as landscape adaptations to flooding by [41].

In Ethiopia, Dera worda of South Gondar zone, Reference [24] informed that farmers used crop diversification, temporary migration, and soil and water conservation as adaptation measures. In Bangladesh, Reference [42] identified money borrowing, reducing consumption, migration, and receiving grants from external donors as coping mechanisms to unprecedented flood events and land-use zoning and embankments [4]. Landscape design was listed as flood adaptation in China [41]. In Namibia, Reference [30] identified gardening and selling poles, firewood, collecting wild food, and receiving food aid as short-term adaptation methods. Furthermore, selling reeds, firewood and thatching grass, charcoal production, and wild food collection for sale were identified as immediate solutions in Zambia. Long-term adaptation strategies include cattle trade, harvesting flood water, changing planting dates, applying conservation agriculture, and fish farming in Namibia, while in Zambia, conservation agriculture, acquiring preparedness skills, harvesting of flood water, and practicing flood proofing were major adaptation methods [30]. In the Bengal state of India, households were found to be used to borrowing money, selling assets and livestock, diversification of livelihoods, migration, elevating the height of their houses, and preserving food and fuel stocks [43]. Similarly, [34], in Ghana Dome, various feasible adaptation mechanisms were applied.

So far, several empirical studies have been conducted on the connection between flood adaptation decision and its determinant factors at varied regional scales and produced heterogeneous results. For instance, these studies include: in India [44,45]; in Ethiopia [46]; in Ghana [47]; in France [48]; in Pakistan [49]; in Bengal [43]; in Namibia and Zambia [30] and in Bangladesh [42]; to mention some. On the influence of previous flood experience, References [42,50] found that farmers' perception of hazards and damage from previous experience is an important driver for flood adaptation. Similarly, Reference [47] found that access to extension, farm size, and information on flood occurrence have positive derives on the adaptation decision of households in Ghana. Access to credit, education level, and farm size were found to have influenced adaptation decision positively [51,52].

A multinomial logit model result discovered that age and education level are significant drivers for adaptation decision. Similarly, [24] the same model found that male headed households, family size, age, and access to extension promote adaptation decisions. In addition, the administrative system of nations was found to hinder or promote adaptive capacities to flood risk [53]. What is more, Reference [30], in their comparative study in Namibia and Zambia, reported that age, land size, length of stay in the flood plain, the duration of floods, and marital status positively influenced the long-term adaptation decisions to flood incidences. On the other hand, Reference [47] also found that age, education, and access to credit have a negative influence on the adaptation decision of households in Ghana. Farm size was negatively correlated with migration as an adaptation strategy [24].

3. Data and Methods

The absolute geographical location of Fogera woreda is between $11^{\circ}57'$ and $12^{\circ}30'$ N and $37^{\circ}35'$ E– $37^{\circ}58'$ E. The woreda is one of the woredas in South Gondar Zone, Amhara regional state. It covers an area of 117,414.02 km² and is subdivided into 33 rural and two urban Kebele administrations. It has a total population of 226,595 (115,693 men and 110,902 women), of which 201,411 (88.89%) are rural and 25,184 (11.1%) are urban dwellers. The total area of the woreda is about 117,414.02 square kilometer with a crude population density of 206 persons per square kilometer. The study area is flat and prone to flooding. The woreda is dominated by flat land (76%), while the mountain slopes and rugged terrain account for 24%. The agro-climatic zone of the woreda is classified as woina-dega (1501–2500 masl). Total annual rainfall ranges from 1103 mm to 2400 mm/year. The mean annual rainfall is 1751.5 mm, and mean monthly values vary between 0.6 mm (January) and 415.8 mm (July). Mixed farming characterizes the woreda mainly. Figure 2 below shows the map of the study area.

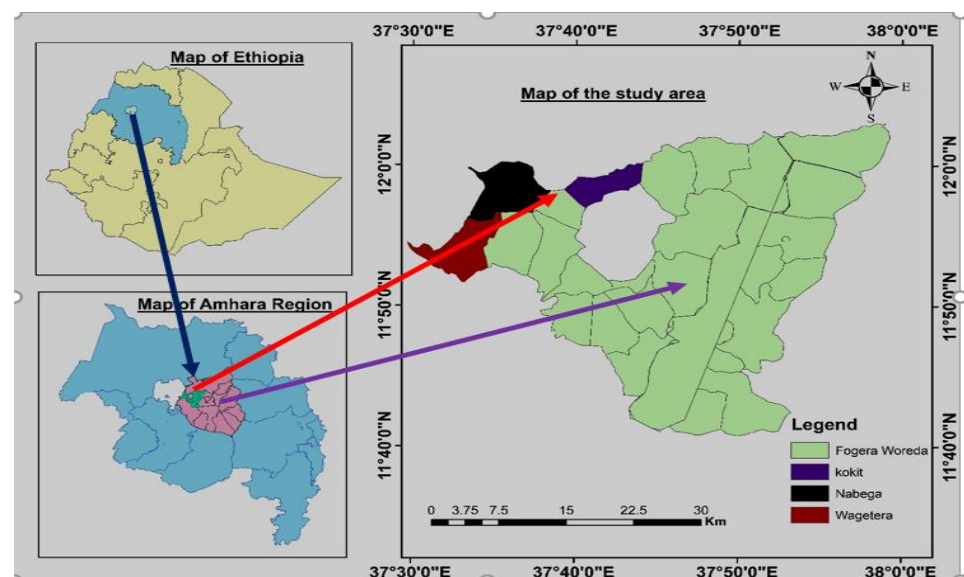


Figure 2. Location Map of the Study Area.

3.1. Sample Size and Sampling Technique

The sampling technique employed in this study was a multi-stage sampling. First, Fogera woreda was selected purposively because of its severe flood experience. Second, three kebeles (Nabega, Wagetera, and Kokit) were selected randomly from 33 kebeles (counties) of the woreda, as the areas were equally prone to flooding. Third, a total of 337 samples were taken randomly and proportionally. The three kebeles have a total of 2130 households. The total sample size was determined following Yamane's (1967) formula, which is expressed as follows:

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

where n is the sample size, N is the total household size, and e is the level of precision, which is 5%. Therefore, the sample size is determined as:

$$n = \frac{N}{1 + N(e^2)} = \frac{2130}{1 + 2130(0.05^2)} = 336.76 \cong 337$$

3.2. Data Type and Data Collection Methods

Primary cross-sectional data were gathered through questionnaire, key informant interview, and focus group discussion. Specifically, data were collected on socioeconomic and demographic variables (age, sex, educational status, marital status, off-farm income, farm size, and family size), psychological variables (previous flood experience), and institutional variables (access to credit, access to extension, and average number of extension visits per year) through structured questionnaire. In addition, data on the major adaptation strategies and constraints were obtained through key informant interviews and focus group discussions for the purpose of strengthening and complementing questionnaire data.

3.3. Methods of Data Analysis

Data were analyzed through descriptive statistics and logistic regression model using STATA15. The descriptive statistics helped to describe the existing socioeconomic conditions of the study area. The continuous socioeconomic conditions of the farm households were described in terms of mean, standard deviation, and minimum and maximum values. The categorical variables were presented in percentage. Two binary logit models were run to examine the determinants of the flood adaptation decision of households considering two model frameworks: the socioeconomic and the extended model. The multinomial logistic regression model was used to examine the main socioeconomic-psychological-institutional variables that determine household decision to adopt any adaptation measure and a specific measure employing the socioeconomic and extended PMT model for short-term and long-term adaptation strategies.

3.4. The Empirical Model: Logistic Regression Model

The logit model is used when the dependent variable is qualitative and takes more than one response value [54]. In this study, the relationship between the socioeconomic-psychological-institutional variables that affect household probability of deciding on flood adaptation measures were captured by the binary logit model. The logit model can be specified as:

$$\begin{aligned} P(y = 1 | x_i) &= f(\alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_m X_m) \\ &= f(\alpha_0 + x\beta) \end{aligned} \quad (1)$$

where, p is the probability that a household decides to adopt any flood adaptation measure; y is the adoption decision of households and takes the value 1 if a household adopted at least one measure, or takes the value 0 if it did not adopt any; $x_1, x_2, \dots, x_n$ are explanatory socioeconomic-psychological-institutional variables that affect the probability of adoption.

The log of odds at which households would be more likely to adopt any adaptation measure is expressed as the ratio of the probability to adopt or to not to adopt at all as follows.

$$\log\left(\frac{p}{1-p}\right) = \frac{e^{\alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_m X_m}}{1 + e^{\alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_m X_m}} \quad (2)$$

On the other side, the likelihood that a household will choose to use a certain adaptation measure can be expressed in the same way as the above, with the difference that the dependent variable is now the household's choice to adopt a particular adaptation measure. The use of "flood tolerant rice," "moving to high elevation sites," "selling cattle," "planting trees," "building of a dike," and "seasonal migration to safe regions" are some of the primary adaptation techniques in the research area. These responses can be divided into two categories: long-term adaptation strategies and short-term coping strategies. To put it simply, in the research region, short-term coping strategies include moving to high elevation locations, selling cattle, and seasonal migration to safe places, whereas long-term coping strategies include planting trees, cultivating flood-tolerant rice, and building dikes. To calculate the likelihood that short-term and long-term measures will be adopted, multinomial logit models were used. On the basis of the multinomial logit model, the relationship between short-term coping mechanisms and the factors that influence the likelihood that they may adapt can be modeled as shown below

$$P(y = 1|xi) = f(\alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_m X_m) \quad (3)$$

where p is probability,

$$y = \begin{cases} 1, & \text{if a household adopted moving to high elevation places} \\ & 0, \text{otherwise} \\ 1, & \text{if a household adopted selling cattle} \\ & 0, \text{otherwise} \\ 1, & \text{if a household adopted seasonal migration to safe places} \\ & 0, \text{otherwise} \end{cases}$$

X 's are socioeconomic-psychological-institutional variables, and β 's are coefficients of explanatory variables. Similarly, the relationship between long-term adaptation methods and the determinants of the probability of adapting to them can be analyzed on the basis of the multinomial logit model as above.

3.5. Description of Variables

The following table (Table 1) presents the list of socioeconomic-psychological-institutional variables, description, expected sign, and scientific literature sources.

Table 1. Description and Operational Definition of Variables.

Variables	Description	Expected Sign	Literature Sources
Socioeconomic variables	Age	±	[37,47,52]
	Sex	+	[42,50]
	Education status	±	[29,52]
	Marital status	+	[55,56]
	Family size	+	[24]
	Farm size	+	[30]
	Off-farm income	+	[15]
Psychological variables	Previous Flood Experiences	+	[47]
	Credit access	+	[51]
Institutional variables	Access to extension	+	[47]
	No. of contacts per year	+	[51]

Source: Authors' own compilation based on literature, July 2022.

4. Results

4.1. Descriptive Statistics of Continuous Variables

Continuous variables were summarized using mean, standard deviation, and minimum and maximum values (Table 2)

Table 2. Basic Descriptive Statistics of Continuous Variables.

Variables	Observation	Mean	Std. Dev.	Min	Max
Age	337	44.13353	9.72616	18	72
FamSize	337	6.14	2.22	1	12
FarmSize	337	1.2	1.8	0	3
AvrNuVisits	337	1.76	1.76	0	12

Source: Household Survey, May 2022.

The mean age of household heads in the study area is 44 years (Table 2), which implies that household heads are, on average, in their productive working age range. The average family size (FamSize) is approximately 6 people per household, with a household having just one person and with households having 12 people. The mean farm size (FarmSize) in hectare is approximately 1 hectare, indicating that households in the study are smallholder farmers. The average number of extension visits (AvrNuVisits) is approximately 2 times a year.

4.2. Descriptive Statistics of Dummy Variables

Categorical variables are presented in a tabular form for better understanding. Thus, Table 3 presents the categorical variables used in the study in percentages.

Table 3. Basic Descriptive Analysis of Dummy variables.

Variables		Freq	Percent
Sex	Male	272	80.7
	Female	65	19.3
Marital Status	Married	302	89.6
	Otherwise	35	10.4
Education Status	Literate	172	50.7
	Illiterate	165	49.3
Off-farm income	Yes	63	18.7
	No	274	81.3
Flood Adaptation	Yes	235	69.7
	No	102	30.3
Prev.Flood Exp.	Yes	185	54.9
	No	152	45.1
Access to Credit	Yes	96	28.5
	No	241	71.5
Access to Extension	Yes	198	58.8
	No	139	41.2

Source: Household Survey, May 2022.

As Table 3 above presents, 80% of the households were male-headed whereas the remaining 20% were female-headed families. Nearly 90% of household heads were married whereas just 10% were single. Only 19% of households had off-farm income. Furthermore, approximately 51% of households reported that they adopted at least one flood adaptation measure. Additionally, 55% of households reported that they had previous flood experience in the last 5 years. The statistical figures also informed that only 28% of households had access to credit services. In addition, nearly 59% households received access to extension services. From the statistical figures, it can be concluded that institutional facilities such as credit access, extension access, education, and training are weakly available in these communities.

4.3. Flood Adaptation Strategies in Fogera Woreda

Household heads were prompted about their adaptation mechanisms to the frequent extreme flood incidence. They reported that they either used the combination of measures or sometimes just one measure. One way to reduce the agricultural damage of flooding was to plant a flood-tolerant rice variety on their farms (66%). They also shifted their movable assets and properties and families to high elevation places (63.5%) until the inundation level decreases. Where the flood incidences were high, households took temporary migration (24.63%) to safe places as an alternative method. In addition, households also reported selling cattle (41.5%), planting trees (39%), and the construction of a dike (24%) as flood adaptation measures. Figure 3 below shows the major adaptation strategies and the percentage distribution use by households.

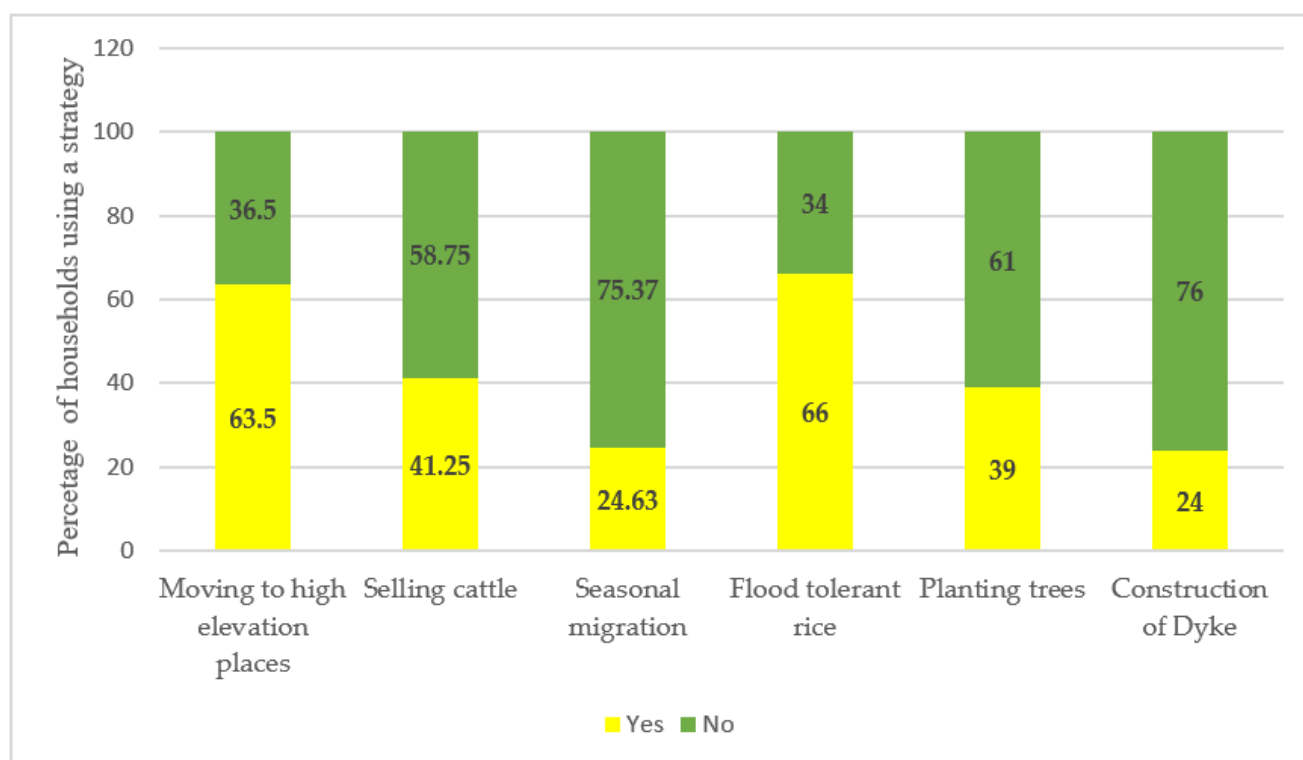


Figure 3. The Common Adaptation Strategies in the Study Area. Source: Household Survey, May 2022.

4.4. Results of Logistic Regression Analysis

Examining whether or not the socioeconomic-psychological-institutional variables have the same influence on household decisions to adopt any adaptation measure and a specific measure was one of the objectives of this study. Furthermore, the adaptation strategies used by households (70% of them) were categorized into short-term coping mechanisms and long-term adaptation strategies. To that end, separate multinomial logit models were run for the short-term and long-term adaptation strategies together with comparing the results of the socioeconomic model and the extended PMT model. According to the socioeconomic model, the socioeconomic and demographic characteristics of farm households determine their likelihood to take any flood adaptation measure. This study goes beyond this and tests whether these socioeconomic characteristics have the same influence on both the decision to take any measure and a specific short-term measure. Table 4 below presents the binary (for flood adaptation decision, see column A) and multinomial (for short-term coping mechanisms: moving to high elevation places, selling cattle, and seasonal migration, see columns B, C, and D) logistic regression results.

Table 4. Regression Results of the Socioeconomic Model (Short-term coping methods).

Flood Adaptation Decision (A)				Moving to High Elevation Places (B)			Selling Cattle (C)			Seasonal Migration (D)		
Variables	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value
Age	−0.06	0.94	0.000 ***	−0.048	0.95	0.001 ***	−0.028	0.97	0.044 **	−0.077	0.92	0.000 ***
Sex	0.06	1.06	0.867	−0.39	0.67	0.285	−0.388	0.67	0.239	0.181	1.19	0.614
EduStatus	−0.142	0.86	0.360	−0.02	0.97	0.884	−0.114	0.89	0.412	−0.160	0.85	0.301
MariStatus	0.53	1.71	0.022 **	0.55	1.74	0.014 **	−0.352	0.7	0.074 *	−0.002	0.99	0.989
FamSize	0.29	1.34	0.000 ***	0.25	1.28	0.000 ***	0.153	1.16	0.009 ***	0.155	1.16	0.029 **
OffFarmInc	0.42	1.53	0.001 ***	0.23	1.27	0.003 ***	0.303	1.35	0.000 ***	0.004	0.99	0.942
FarmSize	−0.068	0.93	0.388	−0.01	0.98	0.797	0.04	1.04	0.538	0.047	1.048	0.520
_cons	1.32	3.77	0.119	0.77	2.17	0.331	0.36	1.14	0.631	1.038	2.282	0.211
LR chi2(7)	60.86			49.27			39.13			23.01		
Prob > chi2	0.000			0.000			0.000			0.001		
Pseudo R2	0.147			0.111			0.085			0.061		
N	337			337			337			337		

Source: Household Survey, May 2022. [Note: Coef = coefficient; OR = Odds Ratio; LR chi2 = Likelihood ratio chi-square test; Prob = probability]. *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$.

As Table 4 depicts, the decision of the households to take any flood adaptation measure was significantly determined by the age, marital status (Odds Ratio = OR = 1.71), family size of the household head (OR = 1.34), and off-farm income (OR = 1.53), with age (OR = 0.94) having negative influence (column A). Interestingly, age has consistent negative influence on the household choice of specific short-term coping mechanisms (columns B, C, and D) although at varied significance levels. In addition, family size and off-farm income have consistent positive influence on the choice of specific short-term coping methods. However, marital status of a household head had heterogeneous influence. While it had a significantly positive influence on the adoption of “moving to high elevation places”, it negatively influenced the adoption of “selling cattle” and “seasonal migration” as short-term coping methods.

Furthermore, the determinants of household decision to adopt a specific long-term method were also examined. Table 5 below presents the regression results of the binary (column A) and multinomial logistic models (columns B, C, and D). The choice of the adoption of long-term adaptation methods were regressed on the socioeconomic characteristics of households.

Table 5. Regression Results of the Socioeconomic Model (Long-term Adaptation methods).

Flood Adaptation Decision (A)				Flood Tolerant Rice (B)			Planting Trees (C)			Construction of Dyke (D)		
Variables	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value
Age	−0.06	0.94	0.000 ***	−0.052	0.94	0.000 ***	0.001	1.00	0.965	−0.047	0.953	0.004 ***
Sex	0.06	1.06	0.867	−0.325	0.72	0.380	0.299	1.34	0.376	0.210	1.233	0.573
EduStatus	−0.142	0.86	0.360	−0.093	0.91	0.526	−0.003	0.99	0.980	−0.276	0.758	0.075 *
MariStatus	0.53	1.71	0.022 **	−0.297	1.34	0.140	0.137	1.14	0.427	−0.297	0.742	0.231
FamSize	0.29	1.34	0.000 ***	−0.216	1.24	0.000 ***	0.199	1.22	0.001 ***	0.100	1.105	0.140
OffFarmInc	0.42	1.53	0.001 ***	0.260	1.29	0.003 ***	0.241	1.27	0.000 ***	0.076	1.079	0.235
FarmSize	−0.068	0.93	0.388	0.012	1.01	0.860	−0.127	0.88	0.065 *	−0.042	0.958	0.571
_cons	1.32	3.77	0.119	1.49	4.45	0.064 *	−1.73	0.17	0.023 **	0.901	2.463	0.287
LR chi2(7)	60.86			42.37			30.25			15.83		
Prob > chi2	0.000			0.000			0.000			0.026		
Pseudo R2	0.147			0.098			0.067			0.042		
N	337			337			337			337		

Source: Household Survey, May 2022. *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$.

As Table 5 above clearly shows, age has heterogeneous influence on the adoption of long-term adaptation strategies (see columns A, B, C, and D); while it negatively and significantly influenced the adoption of both “flood tolerant rice” and “construction of a dike”, it promoted “planting trees” as a long-term adaptation option, although it was not statistically significant. Marital status also had heterogeneous influence. It positively and statistically significantly influenced flood adaptation decision. However, its influence

on the adoption of long-term adaptation strategies is insignificant, although at different causation direction. Family size influenced the adoption of flood tolerant rice negatively and statistically significantly, whereas it had a statistically significant influence on the planting of trees. Interestingly, off-farm income was the only consistent variable. It positively influenced flood adaptation decision and the adoption of both flood tolerant rice and planting trees.

The other regression was run on the influences of the socioeconomic-psychological-institutional variables on flood adaptation decision and short-term coping methods, which is based on the extended protection motivation theory (PMT). Table 6 shows the regression results of both the binary (for flood adaptation decision (column A)) and multinomial (short-term coping methods (columns B, C, and D)) logistic regression results.

Table 6. Regression Results of the Extended PMT Model (Short-Term Coping Methods).

Flood Adaptation Decision (A)				Moving to High Elevation Places (B)			Selling Cattle (C)			Seasonal Migration (D)		
Variables	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value	Coef.	OR	p-Value
Age	−0.053	0.94	0.011 **	−0.036	0.96	0.036 **	−0.016	0.98	0.291	−0.069	0.93	0.001 ***
Sex	0.363	1.43	0.525	−0.414	0.66	0.358	−0.261	0.76	0.463	0.356	1.42	0.364
EduStatus	−0.393	0.67	0.094 *	−0.060	0.94	0.745	−0.164	0.84	0.285	−0.187	0.828	0.266
MariStatus	0.653	1.92	0.034 **	0.610	1.84	0.020 **	−0.380	0.68	0.076 *	−0.012	0.987	0.955
FamSize	0.132	1.14	0.123	0.125	1.13	0.103	0.087	1.09	0.20	0.088	1.09	0.30
OffFarmInc	0.400	1.49	0.007 ***	0.195	1.21	0.039 **	0.279	1.32	0.000 ***	−0.039	0.96	0.586
FarmSize	−0.058	0.94	0.592	−0.014	0.98	0.872	0.037	1.03	0.605	0.033	1.03	0.684
Prev.Fl.Exp	3.962	52.6	0.000 ***	2.545	12.75	0.000 ***	1.078	2.93	0.000 ***	1.95	7.04	0.000 ***
AccessCredit	1.31	3.72	0.004 ***	1.023	2.78	0.005 ***	0.566	1.76	0.041 **	0.183	1.20	0.55
AcExtension	−0.639	0.52	0.404	−0.326	0.72	0.55	1.03	2.82	0.012 **	0.779	2.18	0.100
AvrNuVisits	0.587	1.80	0.019 **	0.345	1.41	0.038 **	−0.014	0.98	0.896	−0.012	0.98	0.918
_cons	−0.320	0.72	0.785	−0.795	0.45	0.42	−1.16	0.31	0.173	−0.774	0.46	0.427
LR chi2(7)	222.48			164.9			88.8			76.66		
Prob > chi2	0.000			0.000			0.000			0.000		
Pseudo R2	0.538			0.373			0.194			0.20		
N	337			337			337			337		

Source: Household Survey, May 2022. *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$.

Table 6 presents clearly that age has consistent influence on flood adaptation decision, as well as on the choice of specific short-term measures, despite the fact that this is at different significance levels. This tells us that older people are less likely to take any adaptation measure (note that all ORs < 1), including moving to high elevation places, selling cattle, and seasonal migration. The education status of household heads influences flood adaptation decision and the choice of specific measure negatively, although it is not statistically significant. Marital status positively and significantly triggered flood adaptation decision and “moving to high elevation places” at the same time. However, it restricted the adoption of “selling cattle” and “seasonal migration” as short-term coping mechanism. In the extended PMT model, surprisingly, there is no evidence that family size has anything to do with adaptation decision as well as short-term coping methods. In this regression, households who had off-farm income option were more likely to take flood adaptation measures than those who did not. This also allowed households to adopt “moving to high elevation places” and “selling their cattle”, whereas it had influence on “seasonal migration.”

One can clearly witness that psychological and institutional variables have statistically significant influence on flood adaptation decision and the choice of specific measures; psychology and institutions do play a role. To be more specific, households with previous flood experience were more likely to adopt the three short-term coping methods. Access to credit also played a crucial role in changing the decision-making behaviors of households in the study area. Furthermore, access to extension influenced households to sell their cattle, although the average number of extension visits has a negative insignificant influence on this measure. It can be seen that the average number of extension visits had a significantly positive effect on household decision to take adaptation measure together with “moving to

high elevation places” as a specific coping mechanism. In this regression result sex, family size, and farm size were insignificant. Table 7 below clearly presents the regression results of the extended PMT model on flood adaptation decision (column A) and on the long-term adaptation strategies (column B, C, and D).

Table 7. Regression Results of the Extended PMT model (Long-Term Adaptation Strategies).

Flood Adaptation Decision (A)				Flood Tolerant Rice (B)			Planting Trees (C)			Construction of a Dike (D)		
Variables	Coef.	OR	<i>p</i> -Value	Coef.	OR	<i>p</i> -Value	Coef.	OR	<i>p</i> -Value	Coef.	OR	<i>p</i> -Value
Age	−0.053	0.94	0.011 **	−0.045	0.955	0.017 **	0.012	1.01	0.412	−0.034	0.965	0.057 *
Sex	0.363	1.43	0.525	−0.354	0.701	0.489	0.405	1.50	0.254	0.303	1.35	0.447
EduStatus	−0.393	0.67	0.094 *	−0.230	0.793	0.27	−0.0181	0.98	0.903	−0.306	0.735	0.066 *
MariStatus	0.653	1.92	0.034 **	0.240	1.272	0.367	0.102	1.10	0.573	−0.298	0.742	0.249
FamSize	0.132	1.14	0.123	0.0224	1.022	0.789	0.134	1.14	0.038 **	−0.000	0.99	0.994
OffFarmInc	0.400	1.49	0.007 ***	0.203	1.225	0.054 *	0.217	1.24	0.001 ***	0.027	1.02	0.691
FarmSize	−0.058	0.94	0.592	0.066	1.068	0.50	−0.145	0.864	0.05 **	−0.049	0.95	0.553
Prev.Fl.Exp	3.962	52.6	0.000 ***	3.48	32.75	0.000 ***	1.260	3.52	0.000 ***	1.43	4.18	0.000 ***
AccessCredit	1.31	3.72	0.004 ***	0.979	2.66	0.017 **	0.249	1.28	0.367	−0.328	0.719	0.299
AcExtension	−0.639	0.52	0.404	0.012	1.012	0.984	−0.525	0.591	0.225	0.897	2.24	0.057 *
AvrNuVisits	0.587	1.80	0.019 **	0.382	1.465	0.056 *	0.283	1.32	0.014 **	0.100	1.10	0.382
_cons	−0.320	0.72	0.785	0.186	1.205	0.866	−2.786	0.062	0.001 ***	−0.655	0.519	0.499
LR chi2(7)	222.4			205.6			67.40			61.22		
Prob > chi2	0.000			0.000			0.000			0.000		
Pseudo R2	0.538			0.477			0.150			0.165		
N	337			337			337			337		

Source: Household Survey, May 2022. *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$.

Regression results presented by Table 7 above shows that older household heads are less likely to adopt flood tolerant rice and construction of a dike as long-term adaptation strategies (see columns B and D). However, as the age of a household head increases by one year, it induces farm households to plant trees, although it is not statistically significant. The results also showed that literate household heads were less likely to take any adaptation measure ($OR < 1$). Marital status positively influenced flood adaptation decision but not for any long-term adaptation measures. The size of the household promoted planting of trees. Similarly, off-farm income availability induced the adoption of flood tolerant rice and planting of trees.

However, farm size significantly and negatively influences planting of trees as long-term adaptation method. Furthermore, the psychological effect of exposure to previous flood incidence has an important implication. It positively and statistically significantly triggered the adoption of long-term adaptation strategies. Households with credit access were more likely to adopt flood tolerant rice and planting trees. Access to extension service promoted the construction of a dike. On the other hand, the average number of extension visits had a statistically significant positive influence on the adoption of flood tolerant rice and planting of trees. In this regression result, as well, education status negatively determines long-term adaptation strategies.

4.5. Constraints to Flood Adaptation in Fogera Woreda

Identifying the major constraints to flood adaptation in the study area was one of the objectives of this study. The respondents who reported that they had not used any flood adaptation method to offset the negative effects of flooding mentioned major barriers that restricted them not to adapt to flood hazard. Figure 4 below presents these major barriers and the corresponding percentage distribution.

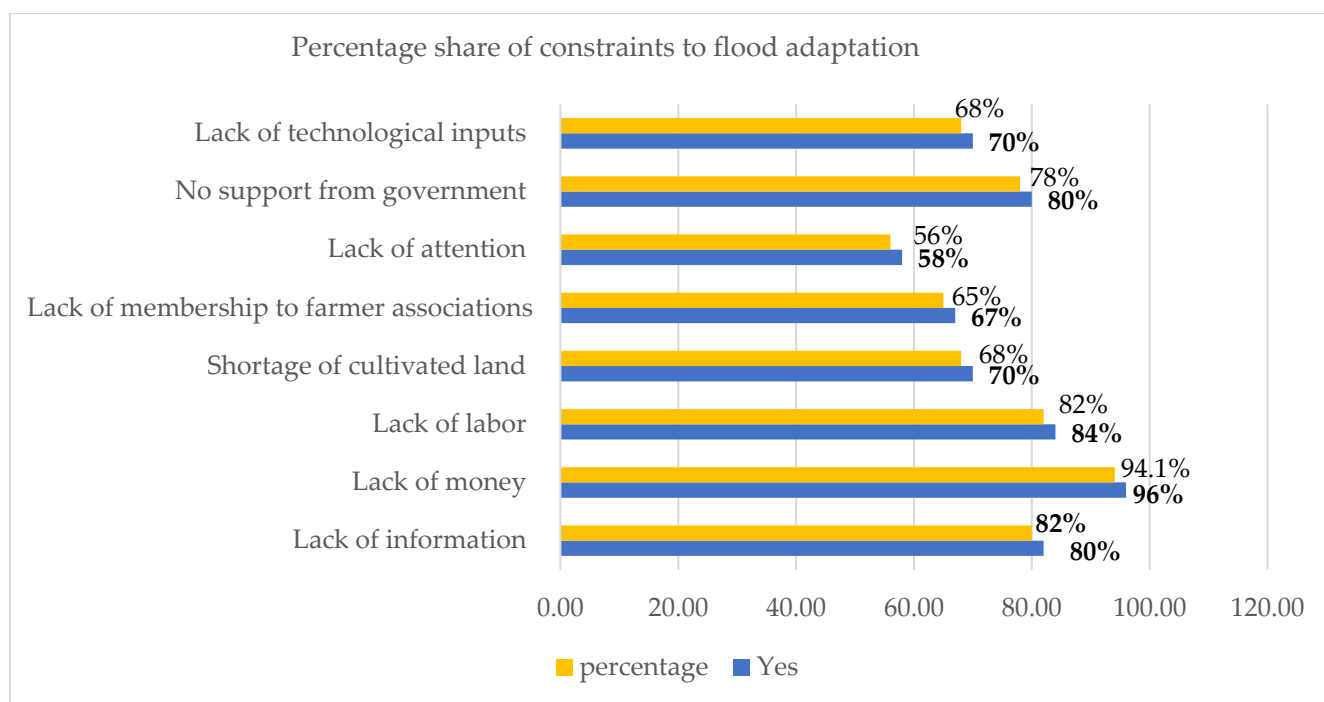


Figure 4. Major Constraints to Flood Adaptation in the Study Area. Source: Household Survey, May 2022.

As it is clear from Figure 2 above, non-adopting respondents reported that lack of money (94.1%), lack of labor (82%), lack of information (80%), lack of support from government (78%), shortage of cultivated land (68%), lack of technological inputs (68%), lack of membership to farmer associations (65%), and lack of attention (56%) were the major constraints that hold them back from adapting to flood hazards. Since the constraints are critical issues to tackle the negative effects of flooding on the socioeconomic conditions of households, stakeholders should not overlook the role of these variables in their endeavor to flood mitigation and adaptation.

5. Discussion

In both the socioeconomic and extended PMT models, the age coefficient is negative and statistically significant, with the exception of its positive but insignificant influence on the adoption of “planting trees” (See Tables 5 and 7). This means that as a farmer ages, he becomes less likely to experiment with new agricultural technologies and procedures. Young farmers, on the other hand, are curious and eager to test out new technology in the goal of increasing the return on their agricultural investment. Furthermore, younger farmers are more willing to take risks than older farmers. This is due to the ability to transform losses into revenues as people live longer lives. Time gives young farmers more flexibility in decision making. This finding is supported by the results of [47] who reported that young farmers are more curious to try on new technologies to increase their productivity, and [37] who found that younger farmers are more likely to adapt to flood events. Furthermore, older farmers are less informed of recent breakthroughs in new technology and are more hesitant to use them. To summarize, growing older is connected with decreased physical capacity, a worse likelihood of obtaining credit, limited mobility to new locations, and less demand in the work market [42]. On the other hand, age was found to determine adaptation decision positively [52]. This is due to the fact that the older the farmer, the more farming experience and opportunity the farmer has to become acquainted with the significance of various adaptation mechanisms.

In this study, it was hypothesized that the gender of the household head would have a favorable influence on flood adaptation decisions as well as specific short-term and

long-term adaptation techniques. Male-headed families were expected to be more likely to take any adaptation strategy than female-headed households. However, it was found to have a heterogeneous but statistically insignificant effect both in the socioeconomic and PMT model in the study area. This suggests that there is no evidence that men and women have different chances of adapting. However, gender analysis by [50] confirmed that men and women played different roles, with women being less likely to adapt to floods. The reason for this is that women are more prone to health risks, sexual harassment, and increased responsibilities.

The protective motivation theory can explain the negative coefficient of educational status for literate household heads. Individuals (households), according to this idea, tend to respond to any threat (even flood) if two conditions are met: the hazard is perceived higher risk, and their capacity to handle the hazard is greater [29]. As a result, even if the individual is well aware of the potential threat from the hazard as a result of being educated and able to use information, the household may ignore the threat (decide not to adopt any strategy) if one of the conditions is missed, particularly due to barriers such as money and the cost of adaptation.

The marital status variable was also predicted to have a favorable impact on flood adaptation decisions and specific measures. As expected, it influenced adaptation decision positively; however, it resulted in heterogeneous results on specific adaptation strategies. It had a consistent influence on short-term coping mechanisms in both the socioeconomic and the extended PMT model. While it promoted “moving to high elevation places” it discouraged cattle selling and seasonal migration. However, as it had a negative influence on flood tolerant rice in the socioeconomic model, it had a positive influence in the extended PMT model framework. It had consistent effects on both tree planting (positive) and the construction of a dike (negative) in the two model frameworks. This finding supports the view that households do not have the same tendency to adopt specific adaptation measures as these measures vary in cost, time, effort, and input requirement [29].

Married household heads have a higher social and economic position and are hence less vulnerable to flooding damage. Short-term coping methods are more common in bigger family households. However, they had different influence on long-term adaptation strategies while only on planting trees had consistent influence. It negatively influenced the use of flood tolerant rice in the socioeconomic model, but it also positively influenced the adoption of the same method in the extended PMT model. This could be explained by the addition of psychological and institutional elements to the PMT model. It was expected that household size had a favorable influence on flood adaptation decisions because larger families have more labor available for farm work [19,56].

Off-farm income opportunities to households are important since it allows them to engage in activities that are less prone to climate change and therefore to flooding damage, which further motivates individuals to take prophylactic measures. A study in Ghana by [38] also found that households who had alternative sources of income were more likely to adopt protective measures to reduce flood risk. This is because, if the livelihood system of households is fragile, they utilize every resource for daily consumption, not for investments on adaptation measures. In this study, off-farm income was a positive determinant of flood adaptation decision and to any short-term and long-term adaptation measure, except seasonal migration. Since an off-farm income option allows flexibility in decision making and protects from severe damage from flooding, households are less likely to make seasonal migration, as they can tackle the problem while staying in their original residence.

Previous flood experience was one of the previously mentioned elements in the PMT framework as a psychological variable, and it was expected to have positive influence on flood adaptation decision. As expected, it had positive and statistically significant influence. Previous flood experience positively determines current flood adaptation decision. This is because flood adaptation is a dynamic, not a static, problem in which the extent of damage from previous flood determines the level of motivation and preparedness for anticipated

flooding hazard by farm households. A result from [57], the study also concludes that a first flood event can serve as a wake-up call by creating awareness, preparedness, and improvements in institutional responses.

Adaptation to flooding is uncertain, as the consequences of climate change are complex, since it involves the interactions of social, economic, demographic, spatial, and natural systems that vary across space and time. There are a lot of issues that explain the dynamism of flood adaptation. For instance, the higher the return (income) from the investment on flood adaptation measures, the better the economic status of households to take additional and relatively complex measures. The more effective the adaptation measures taken on a single farm, the greater extent the household would be encouraged to adopt adaptation methods on other farm plots, too.

This further implies that adaptation is an investment form whose level of return determines individuals' willingness to take action to offset the negative effects of flooding. The positive and significant sign of previous flood experience also implies that as the frequency of flooding experiences increases, farmers decide to adapt and live together with the incidence. As flood happens repeatedly, this pushes farmers to be alert for the next harvesting time. The more aware households are of the occurrence of previous flood hazards, the earlier and quicker they take adaptation and mitigation measures against flooding.

Access to credit was one of the institutional variables included in the PMT model framework, and it was expected to promote flood adaptation decision behavior. As expected, except the construction of a dike as a long-term adaptation strategy, it had significant positive influence on flood adaptation decision regarding both short-term and long-term strategies.

Access to extension services is believed to promote better information dissemination for farm households. However, it was found to have negative insignificant influence on households' decisions on flood adaptation. This study, however, strived to note that the negative coefficient of access to extension does not necessarily imply the irrelevancy of the service. It may rather imply that the extension service is not properly practiced either by the practitioners or the households [47]. However, the average number of extension visits per year promotes flood adaptation decision by farm households, especially the application of long-term adaptation strategies.

6. Conclusions

The study relied on primary data on socioeconomic, psychological, and institutional variables to examine the determinants of flood adaptation decisions through the socioeconomic and protection motivation theory (PMT) model framework. The paper also aimed to explore the major flood adaptation strategies and constraints to adaptation in Fogera woreda. The study identified moving to high elevation places, selling cattle, seasonal migration, flood tolerant rice, planting trees, and construction of a dike as the most important prophylactic measures in the study area. On the other hand, farm households reported constraints such as lack of money, lack of labor, shortage of cultivated land, lack of membership to farmer associations, lack of attention, no support from government, and also lack of technological inputs to effectively respond to flood incidence.

The binary logistic regression results from both the socioeconomic and the PMT model on the determinants of flood adaptation decision showed that sex of the household head, marital status, family size, off-farm income, previous flood experience, access to credit, and average number of extension services have a positive and statistically significant influence on the household selection of flood adaptation.

Contrary to this, the age of a household head, education status, farm size, and access to extension have a negative but statistically insignificant influence on flood adaptation choice. The multinomial logistic regression model also showed that older farmers are less likely to take any flood adaptation measure except planting trees. The sex of a household head had heterogeneous influences on the selection of short-term coping methods and

long-term adaptation mechanisms. Literate household heads were found to have lower level of willingness to take any adaptation measure. The results also showed that family size had positive influence on household decision behavior to flood adaptation strategies, both in the socioeconomic and PMT models.

Off-farm income was found to have a consistent statistically significant positive influence on the adoption of both short-term and long-term adaptation approaches. Farm size available for households had heterogeneous results. Previous flood experience was also another important psychological variable with a consistent positive influence on the adoption of both approaches of adaptations. On the other hand, access to credit had positive influence on the adoption of short-term coping methods and long-term adaptation mechanisms, except the construction of a dike. Access to extension was found to have perplexing results. It negatively influenced flood adaptation decision in the first place, but had a positive influence on the adoption of selling cattle, seasonal migration, flood tolerant rice, and construction of a dike, whereas it negatively influenced moving to high elevation places and planting trees. Similarly, the average number of extension visits also had heterogeneous influence on the choice of flood adaptation methods. From this, it can be concluded that households do not have the same demand to adopt any adaptation measure because of the peculiar nature of each measure.

Therefore, the study recommends that concerned stakeholders in the flood risk management system shall give ample and coordinated attention on the quality and effectiveness of training and education and access to extension services provided for households. The heterogeneous results of socioeconomic and institutional variables also imply that flood adaptation investment shall take into account the features, natures, and costs of each available prophylactic measure.

When analyzing the results of the study, it can clearly be established that the previous risk management strategies no longer work for households. The phenomena caused by extreme effects related to climate change cannot be treated with previous knowledge and experience. The need for external support, whether in the form of state intervention, community cooperation, or professional extension service, must be part of the lives of households. Rapid changes in environmental conditions, including water management (be it floods or droughts), manifest themselves in such an unpredictable way that households cannot follow adaptation patterns without professional data management and extension services.

However, problems related to the sustainability of international or global supply systems show that local supply systems (farm to fork), including households, can be the basis of a safe food supply in the next decade. According to the above, in the coming years, households can assume a much more decisive role in the process of local food supply, in which case the actions related to climate change and the adaptation strategies must be defined very precisely. Dealing with this phenomenon must be part of social and business innovation because it can already cause profoundly serious food supply problems in some parts of Africa or Asia. These phenomena, which can also result in various migration effects, are already associated with the most serious damage to the social system in the short term.

For future research directions and gaps, we suggest the following. Agricultural publications related to climate change primarily reveal the problem ethics of the phenomenon of drought and water scarcity, which represent extreme challenges in almost any part of the world. The frequent floods appearing in certain agricultural areas received much less emphasis in the development of adaptation strategies, which is why the specialized literature is also more modest. So that weather anomalies and water treatment issues are properly emphasized and provide professional answers, many analyses are needed in these areas in the future as well. Although the sample area we analyzed and the households located there are not representative of other flood-prone areas, they clearly show that traditional agricultural tools are not sufficient to overcome the challenges associated with rapid changes and adaptation.

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References

1. Sheckels, T.F. The Year of the Flood. In *The Political in Margaret Atwood's Fiction*; Routledge: London, UK, 2016; pp. 153–162. Available online: <https://www.taylorfrancis.com/chapters/mono/10.4324/9781315554471-17/year-flood-theodore-sheckels?context=ubx&refId=9e36a87c-c730-4c46-8450-94a29011c5b9> (accessed on 12 August 2022).
2. Jongman, B. Effective adaptation to rising flood risk. *Nat. Commun.* **2018**, *9*, 1986. [CrossRef]
3. Moges, S.A.; Gebrie, G.S.; Habtamu, G.; Raschid-Sally, L. Built Environment, flooding regime change, and its effect on adaptation to climate change in the cities of developing countries: Learning a lesson from Addis Ababa City, Ethiopia. In *Extreme Hydrology and Climate Variability*; Elsevier: Amsterdam, The Netherlands, 2019; pp. 445–456. [CrossRef]
4. Wasson, R.; Saikia, A.; Bansal, P.; Joon, C.C. Flood Mitigation, Climate Change Adaptation and Technological Lock-In in Assam. *Ecol. Econ. Soc. INSEE J.* **2020**, *3*, 83–104. [CrossRef]
5. Frederick, K.D.; Major, D.C. Climate Change and Water Resources. *Clim. Chang.* **1997**, *37*, 7–23. [CrossRef]
6. Fox, K.M.; Nelson, S.; Frankenberger, T.R.; Langworthy, M. Climate change adaptation in Ethiopia. In *Resilience: The Science of Adaptation to Climate Change*; Elsevier: Amsterdam, The Netherlands, 2018; pp. 253–265. [CrossRef]
7. Mamo, S.; Berhanu, B.; Melesse, A.M. Historical flood events and hydrological extremes in Ethiopia. In *Extreme Hydrology and Climate Variability*; Elsevier: Amsterdam, The Netherlands, 2019; pp. 379–384. [CrossRef]
8. Conway, D. The climate and hydrology of the Upper Blue Nile river. *Geogr. J.* **2000**, *166*, 49–62. [CrossRef]
9. FDRE-NAP. *Ethiopia's Climate Resilient Green Economy Strategy*; National Adaptation Plan: Addis Ababa, Ethiopia, 2019.
10. Bishaw, K. Application of GIS and Remote Sensing Techniques for Flood Hazard and Risk Assessment: The Case of Dugeda Bora Woreda of Oromiya Regional State, Ethiopia. In *Proceedings of the 2012 Berlin Conference on the Human Dimensions of Global Environmental Change*, Berlin, Germany, 1 April–31 October 2012; pp. 1–17.
11. Mashi, S.A.; Inkani, A.I.; Obaro, O.; Asanarimam, A.S. *Community Perception, Response and Adaptation Strategies towards Flood Risk in a Traditional African City*; Springer: Dordrecht, The Netherlands, 2020; Volume 103.
12. Grothmann, T.; Reusswig, F. People at risk of flooding: Why some residents take precautionary action while others do not. *Nat. Hazards* **2006**, *38*, 101–120. [CrossRef]
13. Wedawatta, G.; Ingirige, B. Resilience and adaptation of small and medium-sized enterprises to flood risk. *Disaster Prev. Manag.* **2012**, *21*, 474–488. [CrossRef]
14. Pathak, S. Determinants of flood adaptation: Parametric and semiparametric assessment. *J. Flood Risk Manag.* **2021**, *14*, e12699. [CrossRef]
15. Belay, A.; Recha, J.W.; Woldeamanuel, T.; Morton, J.F. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agric. Food Secur.* **2017**, *6*, 24. [CrossRef]
16. Teshager, M.; Adgo, E.; Tilahun, T. Investigating the Determinants of Adaptation Strategies to Climate Change: A Case of Batti District, Amhara Region, Ethiopia. *Int. J. Agric. Res.* **2014**, *9*, 169–186. [CrossRef]
17. Asaminew, A. *Climate Change, Growth and Poverty in Ethiopia*; The Robert S. Strauss Centre, The University of Texas at Austin: Austin, TX, USA, 2013; pp. 1–30.
18. Robinson, S.; Strzepek, K.; Cervigni, R. *The Cost of Adapting to Climate Change in Ethiopia: Sector-Wise and Macro-Economic Estimates*; International Food Policy Research Institute: Washington, DC, USA, 2013; pp. 1–26.
19. Yalaw, A.W.; Hirte, G.; Lotze-Campen, H.; Tscharaktschiew, S. *Economic Effects of Climate Change in Developing Countries: Economy-Wide and Regional Analysis for Ethiopia*; Centre for Public and International Economics, Technical University of Dresden: Dresden, Germany, 2017.
20. Baylie, M.M.; Fogarassy, C. Examining the economic impacts of climate change on net crop income in the Ethiopian Nile basin: A ricardian fixed effect approach. *Sustainability* **2021**, *13*, 7243. [CrossRef]
21. Deressa, T.T.; Hassan, R.M.; Ringler, C.; Alemu, T.; Yesuf, M. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Glob. Environ. Chang.* **2009**, *19*, 248–255. [CrossRef]
22. Deressa, T.T. Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach. *Soc. Sci. Res. Netw.* **2007**, *4342*, 32. [CrossRef]

23. Legesse, S.A. Ethiopian summer temperature from the global circulation model output data and its outlooks. *Environ. Syst. Res.* **2016**, *5*, 26. [CrossRef]
24. Atinkut, B.; Mebrat, A. Determinants of farmers choice of adaptation to climate variability in Dera woreda, south Gondar zone, Ethiopia. *Environ. Syst. Res.* **2016**, *5*, 6. [CrossRef]
25. Gebreegziabher, Z.; Stage, J.; Mekonnen, A.; Alemu, A. Climate Change and the Ethiopian Economy: A Computable General Equilibrium Analysis. In *Environment and Development Economics*; Cambridge University Press: Cambridge, UK, 2011.
26. Solomon, R.; Simane, B.; Zaitchik, B.F. The Impact of Climate Change on Agriculture Production in Ethiopia: Application of a Dynamic Computable General Equilibrium Model. *Am. J. Clim. Chang.* **2021**, *10*, 32–50. [CrossRef]
27. Vo, H.H.; Mizunoya, T.; Nguyen, C.D. Determinants of farmers' adaptation decisions to climate change in the central coastal region of Vietnam. *Asia-Pacific J. Reg. Sci.* **2021**, *5*, 327–349. [CrossRef]
28. Wobus, C.; Porter, J.; Lorie, M.; Martinich, J.; Bash, R. Climate change, riverine flood risk and adaptation for the conterminous United States. *Environ. Res. Lett.* **2021**, *16*, 094034. [CrossRef]
29. Twerefou, D.K.; Adu-Danso, E.; Abbey, E.; Dovie, B.D. Choice of household adaptation strategies to flood risk management in Accra, Ghana. *City Environ. Interact.* **2019**, *3*, 100023. [CrossRef]
30. Mabuku, M.P.; Senzanje, A.; Mudhara, M.; Jewitt, G.P.W.; Mulwafu, W.O. Strategies for coping and adapting to flooding and their determinants: A comparative study of cases from Namibia and Zambia. *Phys. Chem. Earth Parts A/B/C* **2019**, *111*, 20–34. [CrossRef]
31. Lal, P.N.; Mitchell, T.; Aldunce, P.; Auld, H.; Mechler, R.; Miyan, A.; Romano, L.E.; Zakaria, S.; Dlugolecki, A.; Masumoto, T.; et al. National systems for managing the risks from climate extremes and disasters. In *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*; Cambridge University Press: Cambridge, UK, 2012.
32. Abebe, Y.A.; Ghorbani, A.; Nikolic, I.; Manojlovic, N.; Gruhn, A.; Vojinovic, Z. The role of household adaptation measures in reducing vulnerability to flooding: A coupled agent-based and flood modelling approach. *Hydrol. Earth Syst. Sci.* **2020**, *24*, 5329–5354. [CrossRef]
33. Olorunfemi, F.B. *Managing Flood Disasters Under a Changing Climate: Lessons from Nigeria and South Africa*; Nigerian Institute of Social and Economic Research (NISER): Ibadan, Nigeria, 2011.
34. Boakye, W.; Bawakyillenuo, S.; Agbelie, I. Diagnoses of the adaptive capacity of urban households to floods: The case of dome community in the greater Accra region of Ghana. *Afr. J. Online* **2018**, *10*, 1–22. Available online: <https://www.ajol.info/index.php/gjg/article/view/181160> (accessed on 9 August 2022).
35. Rogers, R.W. A Protection Motivation Theory of Fear Appeals and Attitude Change. *J. Psychol.* **1975**, *91*, 93–114. [CrossRef]
36. Ahmed, A. *Climate Change and Community Resilience*; Springer: Singapore, 2022.
37. Ali, A.; Erenstein, O. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Clim. Risk Manag.* **2017**, *16*, 183–194. [CrossRef]
38. Cudjoe, S.; Alorvor, S.K. Indigenous Knowledge Practices and Community Adaptation to Coastal Flooding in Ada East District of Ghana. *Hydrology* **2021**, *9*, 13. [CrossRef]
39. Marfai, M.A.; Sekaranom, A.B.; Ward, P. Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia. *Nat. Hazards* **2015**, *75*, 1127–1144. [CrossRef]
40. Maseke, A.; Neyole, E.; Ombachi, N. Household's Adaptation Mechanisms to Flood Risk: A Case of Lower Nyando Basin, Kisumu County, Kenya. *Int. J. Thesis Proj. Diss.* **2016**, *4*, 291–302.
41. Palazzo, E.; Wang, S. Landscape Design for Flood Adaptation from 20 Years of Constructed Ecologies in China. *Sustainability* **2022**, *14*, 4511. [CrossRef]
42. Mondal, M.S.H.; Murayama, T.; Nishikizawa, S. Determinants of household-level coping strategies and recoveries from riverine flood disasters: Empirical evidence from the right bank of teesta river, Bangladesh. *Climate* **2021**, *9*, 4. [CrossRef]
43. Bhattacharjee, K.; Behera, B. Determinants of household vulnerability and adaptation to floods: Empirical evidence from the Indian State of West Bengal. *Int. J. Disaster Risk Reduct.* **2018**, *31*, 758–769. [CrossRef]
44. Padhan, N.; Madheswaran, S. Determinants of farm-level adaptation strategies to flood: Insights from a farm household-level survey in coastal districts of Odisha. *Water Policy* **2022**, *24*, 450–469. [CrossRef]
45. Bahinipati, C.S. Determinants of farm-level adaptation diversity to cyclone and flood: Insights from a farm household-level survey in Eastern India. *Water Policy* **2015**, *17*, 742–761. [CrossRef]
46. Ezemonye, M.N.; Emeribe, C.N. Flood Characteristics and Management Adaptations in Parts of the Imo River System. *Ethiop. J. Environ. Stud. Manag.* **2011**, *4*, 56–64. [CrossRef]
47. Alhassan, H. Farm households' flood adaptation practices, resilience and food security in the Upper East region, Ghana. *Heliyon* **2020**, *6*, e04167. [CrossRef]
48. Champonnois, V.; Erdlenbruch, K. Willingness of households to reduce flood risk in southern France. *J. Flood Risk Manag.* **2021**, *14*, e12696. [CrossRef]
49. Qazlbash, S.K.; Zubair, M.; Manzoor, S.A.; Haq, A.u.; Baloch, M.S. Socioeconomic determinants of climate change adaptations in the flood-prone rural community of Indus Basin, Pakistan. *Environ. Dev.* **2021**, *37*, 100603. [CrossRef]
50. Tu, T.T.; Nitivattananon, V. Adaptation to flood risks in Ho Chi Minh City, Vietnam. *Int. J. Clim. Change Strateg. Manag.* **2011**, *3*, 61–73. [CrossRef]

51. Ao, Y.; Tan, L.; Feng, Q.; Tan, L.; Li, H.; Wang, Y.; Wang, T.; Chen, Y. Livelihood Capital Effects on Famers' Strategy Choices in Flood-Prone Areas—A Study in Rural China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7535. [[CrossRef](#)]
52. Dasmani, I.; Darfor, K.N.; Karakara, A.A.-W. Farmers' choice of adaptation strategies towards weather variability: Empirical evidence from the three agro-ecological zones in Ghana. *Cogent Soc. Sci.* **2020**, *6*, 1751531. [[CrossRef](#)]
53. van Buuren, A.; Lawrence, J.; Potter, K.; Warner, J.F. Introducing Adaptive Flood Risk Management in England, New Zealand, and the Netherlands: The Impact of Administrative Traditions. *Rev. Policy Res.* **2018**, *35*, 907–929. [[CrossRef](#)]
54. Wooldridge, J.M. *Introductory Econometrics*, 6th ed.; Cengage Learning: Boston, MA, USA, 2015; Volume 42.
55. Mohamed, A.A.; Ojwang, R.A. Impact of Climate Change and Vulnerability Assessment of Pastoralists Located in South Central Somalia Based on Income and Marital Status. *Int. J. Environ. Clim. Chang.* **2020**, *10*, 101–112. [[CrossRef](#)]
56. van Aelst, K.; Holvoet, N. Intersections of Gender and Marital Status in Accessing Climate Change Adaptation: Evidence from Rural Tanzania. *World Dev.* **2016**, *79*, 40–50. [[CrossRef](#)]
57. Kreibich, H.; Di Baldassarre, G.; Vorogushyn, S.; Aerts, J.C.J.H.; Apel, H.; Aronica, G.T.; Arnbjerg-Nielsen, K.; Bouwer, L.M.; Bubeck, P.; Caloiero, T.; et al. Adaptation to flood risk: Results of international paired flood event studies. *Earth's Future* **2017**, *5*, 953–965. [[CrossRef](#)]