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Fishers’ perceptions and adaptation strategies to climate change and their determinants: The case of Koka reservoir, Ethiopia

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Abstract
This paper analysed the determinants of fisher`s climate change copying approaches around koka reservoir, Ethiopia. A multistage sampling technique was employed to collect cross-sectional data from 167 fishers nominated from 3 districts around the Koka reservoir in the area. Out of 10 adaptation approaches known by the fishers, the five main identified reworking strategy opportunities were subsequently used as the dependent variables in the multivariate probit model. The outcome of the Multivariate Probit Model showed that some important factors are significant and statistically influenced the choice of adaptation approaches used by the fishers in the study area. It is obvious, that the fishers are aware of long-term changes in climatic factors (temperature and rainfall, for example), but they are unable to identify these changes as climate change. However, the positive pair-wise correlation matrix from the MVP model indicated complementarities among the fishers' adaptation schemes. The government could build agricultural extension systems' capacity and make a climate change education scheme available with ICT innovations. Government policies and investment strategies must be geared towards supporting education, credit and information about adaptation to climate change in the study area.

Keywords: Fishers, fisher`s perception, climate change, determinants, adaptation strategies

1. Introduction
Climate change influences all features of economic growth, especially in the least developing countries. Adaptation methods are immediately required to diminish the effect of climate change and refine food security. The procedure of adaptation choices are required to be location, incorporated and flexible. This climate change affects all agricultural sectors in a multitude of ways [1]. Climate change poses significant fears to fisheries on top of many other concurrent pressures such as overfishing, habitat deprivation, contamination and so on [2].
[3] Defined adaptive capacity as the ability of the systems to adjust to climate change and has 3 components: awareness, ability and action. Adaptive capacity is among the determinants of the vulnerability of a system, others being exposure and sensitivity [4]. It is possible that vulnerable farmers organise livelihood resources and develop adaptation strategies, with the existing institutions being taken into the context [23].
There are no previous related to this, which were conducted on adaption strategies of fisheries in the study area. This study is very important for identifying and formulating measures that would enable the fisheries sector to develop suitable adaptation methods to address effects on f ishing societies, fisheries resources, and related ecologies.

2. Research Methodology
2.1 Description of the Study Area
This study was conducted in the Koka reservoir, which is found in the East Shoa zone of Ethiopia. This water body is very potential in fish production in the area.
Koka Reservoir is located in the Awash River Basin in central Ethiopia (8 26^0N, 39 02^0 E). The 1200 km-long Awash River, it has its` headwaters in the plateau near Addis Ababa at 2300 masl, discharges below sea level into Lake Abbe in the Danakil Desert. Koka Reservoir is located 90 km south of Addis Ababa at an elevation of 1600 m. It has a surface area of about 200 km^2 and a capacity of 1650 mm^3.

The Koka reservoir comprises of concrete with a length of 458 m and a maximum height of 47 m. It was produced by constructing the Koka Block across the Awash River. The basin has an area of 180 km^2. The basin supports a fishing industry; according to the Ethiopian Department of Fisheries and Aquaculture, 625 tones of fish are landed each year, which is the department estimates is either 52% or 89% of its sustainable amount. Both the reservoir and the dam are endangered by increasing sedimentation caused by environmental degradation as well as the disturbing water hyacinth.

2.2 Sample size and sampling technique

Primary data for this study were collected from fishing communities around the Koka reservoir. For this study, a three-stage purposive and random sampling technique was used for the selection of representative sample household heads. In the first stage, purposive sampling techniques were used for the selection of reservoir, at which the livelihood of fishing communities depends on from Rift valley. The second stage was a purposive selection of districts, kebeles and fishery cooperative from each selected water body depending on the severity of climate change and unpredictability of fish production. In this stage, Based on the potentiality of the area and consultation with the district fish experts, 3 districts namely Bora, Lume and Adama was selected purposively. Two kebeles are selected from each selected district. In the third stage, based on lists of the household heads in each kebeles, a chance proportional to sample size sampling methods was used to select respondents. Sample respondents were randomly selected and employed in the analysis, after fixing the sample frame of fish producers in the selected village administrations.

The formula for sample size determination adjusting the degree of precision to 0.07 due to the shortage of resource, following [6], has been used. The sample size from each village administration was determined by the proportionality formula.

$$n = \frac{Z^2 * (p)(q)}{d^2} \quad \text{------------------------------------} \ (1)$$

n - Sample size

Z – Standard normal deviation (1.81 for 93% confidence level)

p = 0.5 (The proportion of the population participating in modern beekeeping, that is 50% due to unknown variability)

q = 1-p = 0.5 (50%)

d – Desired degree of precision level, which is 0.07 in this case

Proportional sampling method has been used to select the sample from each village administrations. The sample selected from each selected village administrations was proportional to the population in each village administration and the formula for this purpose was determined by the formula (2).

$$n_i = \frac{N_{i\ (n)}}{\sum N_i} \qquad (2)$$

Where n_i – the sample to be selected from i`s village administration

Ni – the total population living in the selected i`s village administration

∑ - the summation sign

∑ *Ni* – the sum of the total population in the selected five village administrations

N – Total sample size

Table 1: Distribution of sample selected from districts and their ten selected village administrations

District	Kebele name	Name of the selected fishery the selected village	Current No. of members	Fisher`s head total number	Sample selected	(%)
Bora	Graba qorke	Malima bari	52	407	24	14
	Silase	Tube shati	20	511	30	18
Lume	Darar dambal	Darar dambala	51	463	28	17
	Qoqa	Koka Nagawo	47	476	28	17
Adama	Bate garmama	Biftu garmama	41	542	32	32
	Bate qalo	Malka qalo	35	422	25	25
Total	6	6	246	2821	167	100

Source: Own survey data, 2020

2.3 Types of data and Method of Data Collection

Secondary data sources were bureaus of District livestock and fishery resource development, Bureaus of District agricultural and natural resource development, Zonal Bureaus of livestock and fishery resource development. Primary data were collected using informal and formal surveys. The informal survey was a Focus group discussion and key informants interviews using checklists. The formal survey was commenced through proper interviews with arbitrarily selected fishermen using a pre-tested semistructured survey. Focus group discussions and key informants were also held with 10 groups based on prearranged checklists. The respondents were also asked to cite how they were coping with such changes and other socio-economic characteristics variable.

2.4 Data analyzing technique

2.4.1 Descriptive Statistics

The descriptive statistics such as minimum, maximum, standard deviation and mean, frequency and percentage were employed to analyse, describe and summarize respondents' socio-economic characteristics, perception of climate change and its adverse effects and choice of adaptation strategies. Statistical significance of the variables was used for both dummy and continuous variables using chi-square (x^2) and student t-test statistics, respectively by using Stata version 14 software to compare groups with respect to variables of interest.

2.4.2 Econometric analysis

The multivariate Probit Model was employed to investigate the factors that determine the choice of adaptation strategies. Farmers' adaptation activities to respond to climate change can be affected by various factors, including household income, market, culture, and institutions. Identification of each factor that influences the behaviour of farmers is very important. Although the multinomial probit can be used to measure the set of adaptation choices being applied by fish producers, its limitation is difficult to make interpretations for the simultaneous influences of explanatory variables on each outcome variable (endogeneity problem cannot be addressed using multinomial probit). This is because the local adaptive choices practiced by the farmers are either substitutive or supplementary of one another. A multivariate probit model is appropriate to handle such measurement problems. It also allows the user to produce more than one equation with correlated disturbances, thereby enabling examination of the relationships among the outcome variables. During estimation, the adaptation choices of dependent variables in the multivariate model do not have negative values and hence, the error terms could be correlated to several predictors. By nature, farmers are more likely to adopt a mix of adaptation strategies to deal with a multitude of climate-induced risks and constraints than a single strategy. A shortcoming of most of the previous studies on modelling choice of climate change adaptation strategies is that they do not consider the possible inter-relationships between the various strategies [7].

These studies mask the reality faced by decision-makers who are often faced with options that may be adopted simultaneously and/or sequentially as complements, substitutes or supplements. Recent empirical studies of technology adoption and climate adaptation decisions assume that farmers consider a set of possible practices and choose the particular practice bundle that maximizes expected utility [7, 8, 9, 10]. Thus, the adoption decision is naturally multivariate and attempting univariate modelling excludes useful economic information contained in interdependent and simultaneous adoption decisions. Based on this argument, the study was adopted a multivariate probit econometric technique to concurrently model the influence of the set of covariates on major adaptation strategies [11, 12, 13].

The study was based on the premise that there was complementarily and/or substitutability between different strategies [12]. Following [22], the multivariate probit econometric method for this study was considered by a set of *n* binary dependent variables y_{hpj} such that:

$$y^*_{hpj} = x_{hpj}\beta_j + \upsilon_{hpj} \qquad j = 1, 2, \ldots, m, \; and$$

$$y_{hpj} = \begin{cases} 1 & if \; y^*_{hpj} > 0 \\ 0 & otherwise \end{cases}$$

where j=1, 2,…,m indicates the climate change adaptation methods available; x_{hpj} is a vector of covariates; β_j denotes the vector of the parameter to be estimated; and υ_{hpj} are random error terms distributed as a multivariate normal distribution with zero means and unitary variance. It is assumed that a rational h^{th} farmer has a latent variable, y^*_{hpj} which captures the unobserved preferences or demand associated with the j^{th} choice of adaptation strategy. This latent variable was assumed to be a linear combination of observed household and other characteristics that affect the adoption of the adaptation method, as well as unobserved characteristics captured by the stochastic error term.

Dependent and independent variables

Dependent variables

The dependent variables included in the analysis were the adaptation strategies adopted by fishers in the study area, whereas Covariates included in the analysis were socio-economic, institutional, and environmental factors.

Table 2: Definitions and summary statistics of variables used in the model

Variables	Description of Variables	%	Mean	SD
Diversification to the nonfishing activities	1, if diversified, 0 otherwise	0.74		0.40
operating small businesses	1, if own small business, 0 otherwise	0.67		0.50
Increasing the fishing time on water bodies	1 if yes, 0 if no	0.62		0.52
Changing the landing site	1 if yes, 0 if no	0.45		0.60
Staying on the lake when there is a strong wind	1 if yes, 0 if no	0.35		0.64
not entering to lake when there is a strong wind	1 if yes, 0 otherwise	0.24		0.70
Planting trees around the shoreline	1 if yes, 0 if no	0.42		0.65
Praying the crater	1 if yes, 0 if no	0.40		
Changing the fishing gears	1 if yes, 0 if no	0.51		0.53
No adaptation	There is no adaptation adapted	0.31		0.53
Gender	Dummy=1 if male, otherwise		0.57	0.49
Age of the HH head	Age of household head in years		47.1	7.65
Educational Status	Years of education of household head		5	5.75
Household size	Number of household size		4.2	1.21
Fishing experience	Years of fishing experience by fishers		17	5.1
Access to credit	Dummy = 1 if accessed, 0 if not		0.59	0.47
Farm size(Ha)	Total land owned (hectare)		2	1.01
Access to climate-related information	Dummy = 1if accessed, 0 if not		0.55	0.41
Household head`s annual income	continuous (ETB)		0.54	0.50
Membership to fishery cooperative	Dummy=1 if yes, 0 if no		0.37	0.50
Access to extension contact	Dummy = 1 if accessed, 0 if not		0.53	0.25

Source: Own survey data, 2020
SD: Standard deviation

The outcomes in Table 2 shows that the mean age and years of schooling of the respondents were 47 years and 5 years, respectively. On extension access, around 53% of the households had contacts with extension agents. Access to credit services is the main factors in the adoption of reworking approaches; about 59% of the sampled respondents had access to credit. However, there are pure differences in terms of access to information; for instance, about 55% of the farmers who adopted at least one approach had access to climate-associated proof.

3. Livelihood activities of the sampled fish producers in the study area

3.1 Crop and vegetable production

It is clear that the crop and vegetable production form of an area depends mainly on agro-ecology factors namely climate, soil types, crops types, community crop and vegetables production habit and also marketing factors.

Table 3: Major crop and vegetables produced by selected fishermen in the selected study area

Crop & vegetable type		Adama		Bora		Lume		Total	
		Freq	%	Freq	%	Freq	%	Freq	%
Maize	Yes	25	43.85	34	62.96	32	57.14	91	54.5
	No	32	56.15	20	37.04	24	42.86	76	45.5
Tomato	Yes	20	35.08	40	74.07	45	80.35	105	62.87
	No	37	64.92	14	25.93	11	19.65	62	37.13
Onion	Yes	21	36.8	42	77.77	35	62.5	98	58.7
	No	36	63.2	12	22.22	21	37.5	69	41.3
Teff	Yes	22	38.6	31	57.4	33	59	86	51.5
	No	35	61.4	23	42.6	23	41	81	48.5
Wheat	Yes	3	5.2	25	46.3	25	44.64	53	31.73
	No	54	95.8	29	53.7	31	55.36	114	68.27
Sorghum	Yes	33	57.9	20	37.03	31	55.35	84	50.3
	No	22	42.1	34	62.97	25	44.65	83	49.7

Source: own survey of 2020

3.2. Livestock production of the fishers in the selected study area

Livestock plays significant role in the economy of the fishermen in the study area. Farmers' kept livestock for food, cash, draught power and manure production and used as a source of income to purchase fishing equipment. As indicated in Table 4, on average about 2 oxen were holds by sampled households in study area. On average fishermen have 2.82 local cows. Goats and sheep are also kept by fishermen to meet the need of money and source of meat for home consumption.

Table 4: Livestock production of the fishers in the selected study area

Livestock type	Adama		Lume		Bora		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Oxen	1.83	0.83	2.06	0.99	2.25	1.34	2.04	1.09
Cows	2.77	1.92	3.29	1.65	2.41	1.33	2.82	1.39
Heifer	2	1.41	1.55	0.73	1.92	1.04	1.82	1.69
Calf	4.5	2.12	2.71	1.11	1.36	0.50	2.85	1.69
Goat	6.75	4.27	7.41	5.66	3.25	2.37	5.80	1.71
Sheep	7.33	3.05	6.5	6.36	6.33	4.41	6.72	1.72
Horse	-	-	-	-	1	-	1	0.54
Mule	-	-	-	-	1	-	1	0.71
Donkey	2.14	2.19	2	1.31	1.5	1.07	1.9	1.06
Poultry	13.71	15.71	15.2	1.8	11	7.84	13.3	3.32

Source: own survey of 2020

3.3 Fishing activities

Fish activities are a source of human diet and a source of income for fishermen in the study area. The importance of fishing in terms of economics, food security and employment opportunity for people lives near lakes and reservoirs are enormous. Artisanal fishery is one of the most significant economic activities in the study area. Fishery is practiced in a traditional way and tools as part time activity. At this time, the majority of fishermen have been structured into fishermen cooperatives, consistent with the policy of the Government. The Ministry of Agriculture has approved commercial fishing rights only to fishermen cooperatives, each of which has to pay in return for the pleasure of take advantage of the lake resource). The cooperatives have bylaws and these could be developed to cover fisheries managing matters bearing in mind that cooperatives have the potential to participate in co-management measures with government provided that they are strengthened (Fish II, 2013). Fishermen cooperative actions are coordinated by a governing board including a chairman, a vice-chairman, a secretary and a treasurer chosen by the cooperative memberships, who accomplishes the cooperative according to the annual plan approved by its general assembly.

3.4. Season of fishing activities

Fishing activity is seasonal and the supply of fish is mostly available during fasting time. As indicated in Table 5, about 26.35% of fishermen were involved in fishing activities year round. The primarily livelihood of those fishermen involved in fishing activity was catches fish year round. Besides, about 33.53% of selected fishermen were involved on fishing activities during fasting time. Peak of fishing is during the fasting months (January, February, March, April and May) when meat markets are falling.

Table 5: season of fishing activities in selected water body with their selected district

Variables	Adama	Lume	Booraa	Total	Chi-square
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	
Year round	10 (17.54)	17(30.35)	17 (31.5)	44(26.35)	157.2^{***}
During fasting time	18 (31.58)	19 (33.93)	19(35.18)	56(33.53)	
September-April	14(24.56)	12(21.43)	11 (20.37)	37(22.15)	
January-May	15 (26.31)	8(14.3)	7 (12.96)	30(17.96)	
Total	57(100)	56(100)	54(100)	167 (100)	

Source: Own survey results, 2020

3.5. Type of fishing equipment used for fishing activities in the study area

According to this study, wooden boat and yebela/bofofe were the major types of boats fishermen were used for fish catch at selected water body. Gears in use include gillnets, beach seines and hook/long-line on selected water body. The use of gillnets, Beach seines and hook gear is widespread in the selected water body. On average fishermen hold 1.07, 1.33, 5.56 and 4.98 number of beach seines, wooden boat, gillnet and hook/long line, respectively.

3.6. Current Fish species and their catch per day in the study area

The main commercial fish species at Koka reservior are Nile Tilapia, African Catfish, Common Carp and Curcian Carp. The average fish species Catch per day by kilogram in case of Koka reservoir were less than 15 kg per day for all species (figure 1).

Fluctuations of fish yield are there in selected water body due to different internal and external factors.

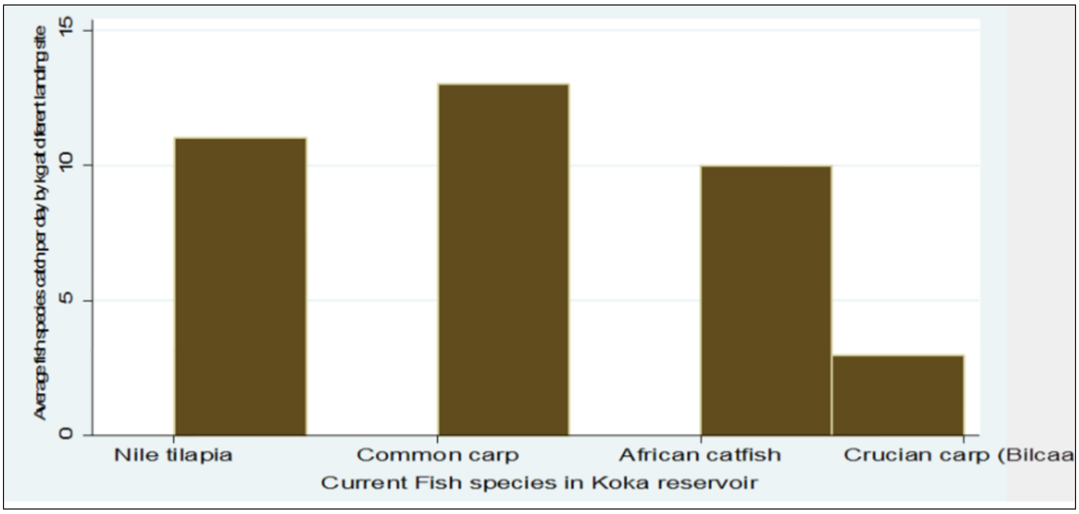

Fig 1: Average fish species catch per day by kg at different landing site of Koka reservoir

3.7 Purpose of fishing in selected water body

All of the fishermen indicated that, fishermen were involved in fishing activities for the source of income by selling whole fish, filleted fish and gutted fish and for family consumption to fulfill their family balanced diet in all study districts. In terms of acceptance in the market, the Nile Tilapia species is an important species in the Koka reservoir. According to the Focus Group Discussion, the catch of Nile Tilapia species was decreasing from time to time as compared to the other fish species due to overfishing and use of illegal fishing net (Monofilament net), which is imported from Dubai.

4. Fishers` perception of climate change in the study area for the last 20 years (2002-2021 G.C)

The way the indigenous people think and behave in relation to the environment in which they live has a very important role in addressing climate change. In this study, the Majority (96.4%) of fisher respondents responded that they are aware or heard about climate change in their surroundings.

They allied climate change with increase in temperature, floods incidence, strong wind, drought occurrence, and decreased in rainfall in the area. The fishers reported that an increased drought incidence (34%), extremely hot temperature (25%), increased flood incidence (9.1%), erratic rainfall and late rains (18.9%), strong wind (10%) and others in the selected water bodies. The higher proportion (59%) of the fish producers were reported that, there was extremely hot temperature and incidence of drought in 2005, 2013, 2020 and 2021 GC in the study area within the selected districts. Most of the fishers revealed experiencing these extreme weather events in the 21st century. These events occurred repeatedly in the years between 2000 and 2021, as reported by 94.4% of the fishers. The respondents also stated that, wet season was started from June to September while dry season were start from December to March in the study area around the selected water bodies.

During the household assessment, key informant discussions, most (69%) of the participants suggested that the perceived exposures revolved around precipitation and temperature.

The key discussant of the focus group discussion are also said that climate change is defined differently between respondents and it is affected by time lived in the area.

4. 1. Sources of information for weather forecasting in the study area

Table 7 below shows that the main source of information on the climate change was through personal experiences (19.76%), Farmer/fish producers` cooperative (17.36%), neighbour farmers (16.76%), Religious home (14.97%), Radio/mass media (11.37%), extension workers (8.38%), newspaper (7.18%), and Nearby metrology station (4.19%)respectively, were the top ranked sources of information on climate change in the study area.

Table 7: Sources of information on climate change to fishermen

No	Sources	Frequency (n=167)	Relative proportion (%)
1	Radio/Mass media	19	11.37
2	Extension workers	14	8.38
3	News paper	12	7.18
4	Personal experiences	33	19.76
5	Neighbour farmers	28	16.76
6	Farmer/fishery cooperative	29	17.36
7	Nearby Metrology station	7	4.19
8	Religious home	25	14.97

Source: Own survey data, 2020

The respondents` perception to the extreme weather events could be attributed to their levels of exposure and experience [14, 15, 16]. Age and fishing experience could be responsible for increasing the probability of recalling major climate incidences [17]. However, what the fishers` perceive to be climate change is not direct [18]. For this reason, 20 years' time series metrological data were used to confirm this study.

4.2. Impact of the Perceived Climatic Changes on Fish production in the selected water body

Majority (72%) of the fishers said that the change in climate was the main driver of low fish production and species composition changes. However, some fishers (15%) accredited low fish harvesting to overfishing and chemical disposal to the water bodies (13%) in the selected water body. The specific extreme weather events cited by the respondents as being accountable for low fish production were augmented incidences of drought (25%), erratic rainfall (20.5%), strong winds (13.5%), extreme hot temperatures (8%) and flooding incidence (5%) and others like over fishing and presence of illegal fishing net in the selected district.

4.3 Adaptation schemes used by the fishing people in response to climate change

Table 8 below shows that adaptation strategies used by the fisher respondents to diminish against the effect of climate change in their isolated district were diversification to the non-fishing activities (High value crops and livestock rearing) (31.56%), operating small businesses (28.56), increasing the fishing time on the water bodies (28%), changing the landing site (9%), changing the fishing gears and targeting fish species and boats(11.40%), planting trees (7.80%), staying on the water bodies until strong wind became stable (3.60), praying the crater(5.40%), not entering to the water bodies until the climate change events (strong wind) leave the water bodies (1.80%) and no adaptation. As showed in table 8 below, majority (97%) of fisher's respondents had adjusted to to climate change in order to increase fishing.

The choice of an adaptation options from the set of adaptation measures said above by the fishers is the dependent variables in this study. Out of 10 adaptation schemes acknowledged by the fish producers, the 5 main known adaptation approach cho ices are used in the selected district for observed estimation.T able 8 relative proportion (%) of Adaptation Strategies of fish ers in the selected water bodies.

Adaptation strategies option	Frequency	Percentage
Diversification to the non-fishing activities	36	31.50
operating small businesses	31	28.56
Increasing the fishing time on the water bodies	30	28.00
Changing the landing site	15	9.00
Changing the fishing gears	19	11.40
Planting trees around the shoreline	13	7.80
Praying the crater	9	5.40
not entering to the lake when there is strong wind	3	1.80
Staying on the lake when there is strong wind	5	3.60
No adaptation	5	3.00

Table 9: Adaptation measures to the low fish production matched with their perceived climate exposure in the selected area

Exposure	Diversification	Business	Increase fishing time	Change landing site	Change fishing gears	Tree panting	Praying the crater	Not entering to the lake	Staying on lake	No strategy
Drought incidence	11	5	4	0	5	4	5	0	0	1
Hot temperature	7	7	5	0	3	4	0	0		2
Strong wind	8	5	8	8	0	2	0	3	6	
Flood incidence	0	7	3	7	4		4	0	0	1
Rainfall decrease	10	6	10	0	7	3	0	0		1
Total no of fishers	36	31	30	15	19	13	9	3	6	5

Source: Survey data of 2020

Table 10: Correlation matrix of the choice of coping strategies from MVP model

	The main Dependent variables				
	Operating small businesses	**Increasing fishing time on the water**	**Changing the landing location**	**Diversification to the high value crop & livestock**	**Changing the fishing gears**
Operating small businesses		0.457(0.115)	0.437(0.069)*	0.637(0.078)*	0.944(0.073)*
Increasing fishing time on the water bodies			0.831(0.057)*	0.934(0.039)**	0.887(0.057)*
Changing the landing location				0.654(0.071)*	0.541(0.064)*
Diversification to the non-fishing					0.928(0.025)**
Changing the fishing gears					
Joint Probability (Success)		0.488			
Joint Probability (Failure)		0.187			
P-value		0.001			
Likelihood ratio test (Chi^2)		$chi^2(12) = 257.071$			
Linear Predictions					
Water shade management		0.77			
Increasing fishing time on the water bodies		0.74			
Changing the la-nding location		0.67			
Diversification to the non-fishing		0.81			
Changing the fishing gears		0.62			

The above table 10 discusses the results from the multivariate probit model. The likelihood ratio test (chi^2 (12) =257.071, P > 0.001) of the independence of the error terms of the different adaptation equations is rejected (Table 10). Thus, this study assumes the alternative hypothesis of the mutual interdependence among the multiple adaptation approaches. The result therefore supports the use of multivariate probit model. All the pairwise coefficients are also positively correlated indicating complementarity among these strategies. The results show that the joint probability of adopting the choice of adaptation strategies is approximately 49% while not adopting the choice is 19%. It can also be inferred from the linear predictions of the result that the likelihood of adopting operating small businesses is 77%, while it is 74%, 67%, 81%, and 62% for increasing fishing time on the water bodies, Changing the landing location, Diversification to the non-fishing activities (to the high value crop production and livestock rearing) and Changing the fishing gears respectively.

4.4 The Determinants of Adaptation Strategies of fishers to Climate Change around Koka reservoir

Table 11: Estimates of the MVP for the Determinants of Adaptation Strategies to Climate Change

Variables	Operating small Businesses		Increasing fishing time		Changing the landing location		Diversification to high value crop and livestock		Changing the fishing gears	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
HH Age	0.007	0.128	0.039	0.257	0.012	0.909	-0.035	0.851	0.075	0.642
Household head`s sex	-18.760	27. 933	-23.100	21.127	0.260	0.700	0.086	0.18	0.097	0.193
Education level	-0.0761	0.894	0.024	0.911	-0.015	0.079	0.029***	0.011	0.065	0.121
monthly fish income	0.035	0.952	0.568	0.690	0.087	0.090	0.180***	0.075	0.758**	0.38
Fish cooperative member	-0.790	0.851	0.026**	0.013	0.568	0.429	0.778	0.567	-0.713	0.510
Credit access	0.095	0.172	0.547	0.871	0.476	0.452	0.0790	0.540	0.734**	0.369
Farm size	0.065	0.590	-0.257	0.927	0.072	0.080	1.215 **	0.598	-0.165	0.435
Fishing experience	-0.009	0.025	0.110 *	0.065	2.174 **	0.774	0.009	0.021	0.022	-0.013
Household size	0.0002 **	0.00008	0.045	0.088	0.087	0.090	10.10 ***	3.34	0.137	0.675
Access to extension contact	0.048	0.900	7.029 *	3.767	1.415*	0.566	0.012	0.157	0.780	0.880
Access to weather information	-0.399	0.781	0.904*	0.235	0.533**	0.246	0.0770	0.171	-0.722	0.897
Mean annual precipitation	0.667	0.890	0.028	0.034	0.0850	0.153	0.011	0.011	0.233	0.178
Mean annual temperature	2.872	3.008	-2.075	2.351	-3.418	2.784	-3.651	2.542	-2.90	1.970
Constant	121.31	53.64	99.58	70.53	90.82	77.02	84.989	66.73	23.91	72.39

4.4.1 Sample respondents Features

Among fishers` socio-economic characteristic variables, Family size has a significant and positive effect on climate change adaptation, increasing the probability of diversification to non-fishery activities (high value livestock rearing and crop production) adaptation strategies. The probable reason is that larger family size and a larger number of productive household members increase agricultural production because it is associated with labour-intensive agricultural practices. Thus, household size has a significant association with some of the adaptation categories.

The result in Table 11 shows that household head education level has a positive effect on farmers' adaptation strategies (high value crop and livestock adaptation option) and hence, it significantly increases adaptation options. This is because educated farmers are expected to adopt new technologies based on their awareness of the potential benefits from the proposed climate change adaptation measures.

Household size has a significant and positive effect on climate change adaptation, increasing the probability to adopt operation of small business adaptation strategies. This means that, relying on fishing alone is not enough to obtain more household income to support the life of large family size. Therefore, household head who has large family size should have to adapt ''small business 'Adaptation strategies to overcome the negative impact of climate change on the fishing communities in the study area.

Fishing experience: This variable has a positive effect on some climate change adaptation strategies (changing the fishing location & increasing the fishing time on the ground). This means, it helps to stimulate response to the negative effects of climate change (incidence of flood & strong wind during fishing) on fishing activities. This is because more experienced fishermen are assumed to have better knowledge about weather information and its implication on fishing practices. More experienced fishers can easily overcome the problem of strong wind and flood incidence created during the fishing time on the water bodies. It helped to stimulate response to the negative effects of climate change on agriculture. This is because more experienced farmers are assumed to have better knowledge about weather information and its implication on agricultural practices.

4.4.2 Household Assets

The coefficient of fisher`s monthly income is positively and statistically significant for the choices of ''changing to the efficient fishing gears'' adaptation policies. The copping tactics can be expensive with some demanding the purchase of upgraded fishing gears. Thus, when there is a high fisher`s monthly income from fishing, fishers may find it probable to implement any reworking strategy even when provided with information on climate change, as they might not be able to purchase the expensive fishing gear.

The study also observed that the magnitude of a fisher's monthly income increased the likelihood of adjusting to the climate change. High-income levels build adaptive capacity [19] that could enable fishers to diversify into non fishers` activities (high value crops and livestock enterprises). Families with high income levels are responsive to climate change [20]. High income from fishing promotes the willingness to invest into other initiatives that provide a cushion against household emergencies caused by future low fish catches [21].

Farm size has positive and significant association with diversification to non-fishing activities (crop and livestock production). Large farm sizes provide an opportunity for diversification of their crop and livestock enterprises, and it can help to distribute risks associated with unpredictable weather. Therefore if the fishers own a farm land, it can easily adopt diversification to crop and livestock enterprises to overcome the risk of unpredictable weather impacts on fishing activities

4.4.3 Access to services and social groups

The coefficient of access to credit is positively and statistically significant for the choices of ‘‘changing to the efficient fishing gears’’ adaptation strategies. Adaptation approaches can be expensive with some demanding the purchase of improved fishing gears. Thus, in the absence of credit, farmers may find it challenging to adopt any adaptation strategy even when provided with information on climate change, as they might not be able to purchase the expensive fishing equipment.

The coefficient of membership of fishery cooperative is positive and statistically significant in influencing “increasing the fishing time and stay on the water bodies for a long time” adaptation strategies. This could be attributed to the fact that members of cooperative ‟ groups can share experiences and exchange information about how to overcome the problem of strong wind created during the fishing time on the water bodies. Participating in fishers’ groups made the fishers more likely to apply the adaptation strategies. A fishers’ group is associated with comprehensive information about the fishing activities, including adaptation to climate change.

Access to climate-related information is an important variable that affects adaptation options. The results in Table 11 show that, access to climate information had impacted adaptation to climate change. That is, a farmer who had better access to weather information (i.e., seasonal or mid-term forecasting) made a better informed adaptation decision. Small-scale fishers who had access to weather information had a higher probability of implementing climate change adaptation strategies such as changing the landing location and increasing the fishing time on the fishing ground.

5. Conclusion and Recommendation

The study analysed the determinants of climate change adaptation strategies, using the multivariate probit model. The study rejected the null hypothesis of the independence of the different adaptation strategies. Thus, the alternative hypothesis of inter-dependence among the different adaptation strategies, which justifies the use of the multivariate probit for this analysis was adopted for the study.

The findings from the multivariate probit model revealed that the fishers` choice of adaptation strategies are statistically significantly affected by factors such as household head education level, monthly fish income, being a member of a fish cooperative, credit access, farm size, household head fishing experience, household size, access to extension services and access to weather related information of the fish producers. Various sources of extension information significantly inform adoption decisions. Key among these is government extension; mindfulness of climate change and measures to diminish its effects is thus depicted as a key factor in the adaptation process. The study identifies many covariates as a key factor to the adaptation of climate change in the study area. Resource availability enables farmers to implement adaptation decisions, the lack of which presents the household with a significant constraint of adopting the adaptation procedures. With the estimates of the multivariate model showing complementarities between the variation strategies choices used by the rice fishers.

The complementarities among these strategies shows that farm-level policies that affect a choice of adaptation strategies can have a trickle-down effect on others. It is therefore, recommended for the stakeholders in the fishing activities to ensure that decisions that support all the choices of adaptation strategies are put in place. Government policies and investment strategies must be geared towards the support of education, credit facilities and information about adaptation to climate change, including technological and institutional methods, particularly for smallholder fishers and farmers in the study area. There is a need also for new institutions, such as Public-Private-Partnerships organized, which can take research findings, into the field and help smallholder farmers and fish producers adapt to a changing and varying climate elements.

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