

Research Article**Fishermen Perception and Adaptation Strategies of Fishing Communities to the Climate Change in Lake Ziwai, Ethiopia****Abdulkhikim Hussen Hebano****Article Info**

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Abstract

The impacts of climate change have negatively affected the Ethiopian agricultural production systems. In this, context fisheries have been providing alternative livelihoods for the communities around the water bodies. However, there is a knowledge gap around the responses of capture fishery fishermen to climate-related changes. Therefore this study were conducted in Adamitulu Jidokombolcha district of Oromia region onFishermen perception, adaptation strategies and their coping strategies of Fishing Communities to the Climate Change in Lake Ziwai by employing a wide range of methods for data collection and analysis. For this study Three village administration, namely Bocessa, Abbay and Walinbula were selected by the researcher and district livestock and fishery development office experts and development agents based on their potentiality and presence of the fishermen in the village administration. At the third stage the 167 sample respondent of fish producers was selected randomly using probability proportional to size using sample size determination formula developed by Cochran's (1977) formula indicated in equation 1.

The reason for choosing simple random sampling technique over other sampling techniques for selection of sample respondents was that it gives equal chances for households to be included within the sample frame. The study randomly sampled 167 household heads who owned either fishing gear or a fishing vessel or both. Content analyses for sample respondents were used to analyze the qualitative data.

Keywords: Fishers, Lake Ziwai, Climate change, impacts, adaptation strategies

1. Introduction

1.1. Background and Justification

Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries. There is an urgent need to better understand where climate change is most likely to reduce livelihood options for fishers and where there is the greatest need to invest in alternative rural and urban enterprises. Climate change is among the problems that hinder sustainable livelihoods and economic development, particularly for developing countries (Shemsanga et al., 2010). Ethiopia is highly vulnerable to climate change and low capacity to adopt and perceived. Climate change is a natural phenomenon which influences agricultural production and negative effect on the social and economic activities and lead to food insecurity in particular [1].

Climate change affects all aspect of economic growth especially in least developing countries. To reduce the impact of climate change and enhance food security, adaptation measures are urgently required. The process of adaptation options are needed to be location, integrated and flexible. This climate change affects to all agricultural sector in a multitude ways. For example, changing weather pattern such as heavy flood and storms makes the agricultural production low and leading to extreme events of poverty and slow down economic development. Climate change poses significant threats to fisheries on top of many other concurrent pressures such as overfishing, habitat degradation, pollution, introduction of new species and so on [2]. Changes in biophysical characteristics of the aquatic environment and frequent occurrence of extreme events will have significant effects on the ecosystems that support fish. Adaptation to climate change indicates processes taken to enable communities to have ability to survive with the state of climate shift. IPCC [3] defined adaptive capacity as the ability of the systems to adjust to climate change and has three components: awareness, ability and action. Adaptive capacity is among the determinants of 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 [5]. This study will be very important for identifying and formulating measures that would enable the fisheries sector to develop appropriate adaptation measures to address impacts on fishing communities, fisheries resources, and associated ecosystems. This study, therefore, seeks to identify the adaptation strategies to climate change by fisheries community living around the lake Ziwai of Oromia region, Ethiopia.

2. Objectives of the Study

- To find out how fishing communities living around the Ziwai Lake in central rift valley of Oromia region perceive climate change.
- To identify adaptation strategies used by fishing communities' in response to climate change and variability in Ziwai lake.

3. Research Methodology

3.1. Description of the Study Area

This study was conducted on the fishing communities living around the Ziwai Lake, which is found in the East Shoa zone of Oromia regional state. This water bodies are very potential in fish production in the study area. It is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 160 km South of Addis Ababa. The districts holding the lake's shoreline are A.T. J K, Dugda, and Ziway Dugda. It's watershed encompasses an area of 7032 km², falling between gradients 7° 22'36"N and 8°18'21"N latitude and 37°53'40"E and 39°28'9"E longitude. On average, the lake is located at an elevation of 1650 masl and it is shallow and has an open water area of 434 km² and shoreline length of 137 km, a maximum depth of 8.9 m and an average depth of 2.5 m. The maximum length and width of the lake is 32 km and 20 km, respectively. The climatic conditions are not uniform throughout the watershed. The minimum and maximum annual precipitation in the watershed is 729.8 mm and 1227.7 mm respectively. The mean annual temperature of 18.5 °C. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 45%. There are two main feeder rivers to Lake Ziwai; namely, Meki originating from Gurage

Mountains in the Northwest and Ketar from the Arsi Mountains in the East; and it has one out flow in the south through Bulbula River, draining into Lake Abijata. Lake Ziwai contains five main Islands: Tullu Guddo (4.8 km²), Tsedecha (2.1 km²), Debresina (0.3 km²), Funduro (0.4 km²) and Gelila (0.2 km²). Debresina and Gelila have only a few inhabitants, the other three are inhabited by several hundreds of people. Technologies such as fish smoking technology was demonstrated at Tullu Gudo under Lake Ziway condition. The lake has high economic importance for its natural resources (such as water, fish, wildlife, etc.), bio-diversity, recreational value and horticultural crops production as it is easily accessible and situated near the main asphalted highway, which is extended from the southern part of the country to Addis Ababa market outlets. The Lake exhibits fresh water quality and is an important element of the Ethiopian Central Rift Valley region because it currently serves as the water source for closed and open farm irrigation, and as the only potable water supply for the Town of Batu. It also supports the livelihoods of the fishing community. It is a habitat for biological diversity, such as fish, birds, and mammals like hippopotamuses, among others. The marshes around it also support several bird species and provide roosts for several thousand cranes, herons, ducks, geese, etc..

Lake Ziwai fishery was the most fishery Contributor Lake having a maximum contribution of all Lakes in Oromia Region. This is because of the support it received from phase I (1981 – 1984) and phase II (1991 –1998) fishery development projects of the EDF. Lake Ziwai harbors the indigenous African catfish, *Clarias gariepinus*, and other commercially important fish species (*Oreochromis niloticus*, exotic *Carassius carassius*, *Cyprinus carpio* and *Labeobarbus intermedius*), in which some are native and others exotic that were introduced into the Lake by the Ministry of Agriculture with the aim of fishery sector development. The potential yield of all species of Lake Ziwai is estimated between 3,000 - 4500 tons per year. The total production in 1987 was estimated at 2070 tons in which 1944 tons of the landing were composed of *Tilapia*.

3.2. Sample size and Sampling Technique

For this study, a multiple stage random sampling technique was used for the selection of

representative respondents. In the first stage, Ziwai Lake was selected through purposive sampling technique. At the second stage strata sampling were used to select three Village administrations from each selected water bodies depending on livelihood activities of households of surrounding Lake. In third stage, based on lists of the household heads in each Village administration, a probability proportional to sample size sampling procedure was employed to select respondents. Sample households were randomly selected and used in the analysis, after preparing sample frame of fish producers in the selected village administrations.

To determine the sample size from the study area, 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 proportionality formula.

$$n = \frac{z^2 * (p)(q)}{d^2} \tag{1}$$

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).

$$n_i = \frac{N_i (n)}{\sum N_i} \tag{2}$$

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

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

∑ - the summation sign

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

N – Total sample size

Table1. Distribution of sample selected from districts and their ten selected village administrations

District	Kebele name	Fisher`s head total number	Sample selected	(%)
Adami Tulu Jido Kombucha	Bocesa	247	60	35.9
	Abbay	265	47	28.14
	Waliinbula	259	60	35.9
	Total	771	167	100

Source: Own survey data, 2023

3.3. 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 sources were selected fishermen from selected districts of surrounding Ziwai Lake. Primary data were collected using informal and formal surveys. The informal survey was Rapid Market Appraisal (RMA) technique like Focus group discussion and key informants interviews using checklists. The formal survey was undertaken through formal interviews with randomly selected fishermen using a pre tested semi structured questionnaire. Focus group discussions and key informants were also held with 10 groups based on predetermined checklists. The respondents was also asked to cite how they were coping with such changes and others socio-economic characteristics variable.

3.4. Data analyzing technique

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

Variables	Description of Variables	%	Mean	SD
Diversification to the no fishing 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 strong wind	1 if yes, 0 if no	0.35		0.64
not entering to lake when there is 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

3.4.1. 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 (χ^2) and student t-test statistics, respectively by using Stata version 14 software to compare groups with respect to variables of interest.

3.4.2. Dependent and independent variables

3.4.2.1. Dependent variables

The dependent variables included in the analysis were the adaptation strategies adopted by fishers in the study area

3.4.2.2. Independent variables

Independent variables include in the analysis were socio-economic, institutional, and environmental factors.

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, 2023**SD:** Standard deviation

The results in Table 2 show that the average age and years of education of the household head were 47 years and 5 years, respectively. On extension access, about 53% of the respondents had contacts extension agents. Access to credit is major determinants in adoption of adaptation strategies; about 59% of the sampled households had access to credit. However, there are clear differences in terms of access to information; for instance, about 55% of the farmers who adopted at least one strategy had access to climate related information.

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

Crop & vegetable type		Bocesa		Abay		Walinbula		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 2023

3.5. 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. In general they provide food (milk, meat, egg, hides and skin) as power for cultivation, serve as means of transportation, and manure production for soil fertility management. 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

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

3.5.1. Crop and vegetable production

It is clear that crop and vegetable production pattern 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.

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	Bocesa		Abay		Walinbula		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 2023

3.5.3. Fishing activities

Fish activities are a source of human diet and 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 or non-motorized 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. Currently the majority of fishermen have been organized into fishermen cooperatives, in line with the policy of the Government. The Ministry of Agriculture has granted commercial fishing rights only to fishermen cooperatives, each of which has to pay in return for the privilege of exploiting the lake resource). The cooperatives have bylaws and these could be developed to cover fisheries management issues considering that cooperatives have the potential to participate in co-management

arrangements with government provided that they are strengthened. Fishermen cooperative activities are coordinated by a governing board including a chairman, a vice-chairman, a secretary and a treasurer elected by the cooperative members, who manages the cooperative according to the annual plan approved by its general assembly.

3.5.3.1. 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 June) when meat markets are falling.

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

Variables	Bocesa	Abay	Walinbula	Total	Chi-square
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	
Year round	10 (17.54)	17(30.35)	17 (31.5)	44(26.35)	157.5
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-June	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, 2023

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

According to survey results, 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 Ziwaitake are Nile Tilapia, African Catfish, Common Carp and CurcianCarp. The average fish species Catch per day by kilogram in case of Ziwai Lake were less than 27 kg per day for all species.

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

3.7. Purpose of fishing in selected water body

All of the fishermen indicated that, fishermen involved in fishing activities for source of income by selling whole fish, filleted fish and gutted fish and for family consumption to fulfil their family balanced diet in all study districts. In terms of acceptance in the market Nile Tilapia species is the important species in Lake Ziwai. According to Focus Group Discussion and KII 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 and Overfishing problem.

4. Fishers` perception of climate change in the study area for the last 20 years (2004-2023 G.C)

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

drought occurrence, and decreased in rainfall in the study area. In this study, 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 frequently in the years between 1997 and 2020, as reported by 94.4% of the fishers. The respondents also reported 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 survey, focus group discussion and key informant interviews, most (69%) of the participant suggested that the perceived exposures revolved around precipitation and temperature.

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

On the other hand, during a key informant interview, 55% of the discussant reported that, “by now 20 years ago, we should have planted crops and the rains would have been falling with good intensity. Currently, it is very hot, dry and people are not even sure as to when the rains will fall” in the study area.

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

Table 6 below shows that the main source of information on the climate change were 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.

Table6: 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, 2023

The respondents' perception to the extreme weather events could be attributed to their levels of exposure and experience [7]; [8]; [9]. Age and fishing experience could be responsible for increasing the probability of recalling major climate incidences [10]. However, what the fishers' perceive to be climate change is not straightforward [11]. For this reason, 20 years' time series metrological data were used to validate this study.

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

Majority (72%) of the fishers responded that the change in climate was the main driver of low fish production and species composition changes. However, some fishers (15%) attributed 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 responsible for low fish production were increased 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 strategies used by the fishing communities in response to climate change

Table 8 below shows that adaptation strategies used by the fisher respondents to mitigate against the effect of climate change in their respective district were diversification to the non-fishing activities (High value crops and livestock rearing) (29.56%), operating small businesses (18.56), increasing the fishing time on the water bodies (18%), 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 indicated in table 8 below, majority (97%) of fisher's respondents had adjusted to climate change in order to supplement fishing. However, some fishers (3%) did not adjust to the perceived changes to accept lo fish production.

The choice of an adaptation options from the set of adaptation measures mentioned above by the fishers in this study. Out of ten adaptation strategies identified by the fish producers, the five main identified adaptation strategy options are used in the selected kebele for empirical estimation.

Table 7: relative proportions (%) of Adaptation Strategies of fishers in the selected water bodies

Adaptation Strategies option	Frequency	percentage
Diversification to the non-fishing activities	36	29.50
operating small businesses	31	18.56

Increasing the fishing time on the water bodies	30	18.00
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 8. 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 planting	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 2023

5. Conclusion and Recommendation

Various sources of extension information significantly inform adoption decisions. Key among these is government extension; awareness of climate change and measures to mitigate its effects is thus depicted as a key factor in the adaptation process. The study identifies many explanatory variables as a key factor to 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 challenge of adopting the adaptation measures.

- 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.

- The government could build the capacity of agricultural extension systems and make climate change education a priority through ICT innovations.
- 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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Informed Consent Statement: Respondents provided written informed consent included in study, whereas those who did not agreed were excluded from the study.

Data Availability Statement: Data will be available by corresponding author on reasonable request.

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