CLIMATE CHANGE PERCEPTION AND ADAPTATION STRATEGIES OF ARTISANAL FISHER FOLKS IN COASTAL AREAS OF LAGOS, NIGERIA

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ABSTRACT

This study assessed climate change perception and adaptation among artisanal fisher folks in the coastal areas of Lagos State, Nigeria. Primary data was obtained using a structured questionnaire from a sample of 200 artisanal fisher folks selected through a multistage sampling procedure. Data were analysed using descriptive statistics, perception index and Multivariate Probit (MVP) regression model. Results showed that 98.5% of the artisanal fishers were males with mean age, household size, farming experience, and monthly income of 43.8 years, 6 persons, 23 years, and ₦53,275, respectively. The perception index was ($\bar{x}$= 0.65), with 52.0% and 48.0% of the respondents having a high and moderate perception of climate change effects, respectively. MVP shows that the likelihood of adopting an increase in fishing time in response to climate change increased significantly with the perception of climate change effects. The fishers' age, extension contact, access to climate change information, innovative training and perception of climate change effects significantly influenced the likelihood of adopting the use of highly efficient fishing gear. The likelihood of diversifying livelihood was significantly affected by total income and access to credit, while household size, membership association, and innovations training increased the likelihood of using motorised boats. The study concluded that respondents' socio-economic characteristics and climate change perception significantly influence climate change adaptation. Therefore, it was recommended that cost-effective technologies such as motorised fishing boats be made available and affordable for coping with climate change to help Lagos state's resource-poor artisanal fishers.

Keywords Perception, Adaptation, Artisanal fishing, Climate change

INTRODUCTION

Climate change is defined as an adjustment in the state of the climate that can be seen in variations in the mean and/or variability of its characteristics and that last for an extended period, typically decades or long (IPCC, 2014). The evidence that the climate system is warming is unequivocal. In consistency with global observations, Nigeria has recorded high values of precipitation intensity, frequency, and duration in the last three decades, more than any preceding decade (Akande et al., 2017). In 2021, updates on climate change were published, and scientific data support its political and economic implications. These updates provide a thorough synopsis of the generally recognised body of knowledge regarding the causes, effects, and science of climate change. According to the IPCC assessment report, emissions brought on by human activity are significantly raising atmospheric concentrations of greenhouse gases, which has resulted in severe global warming (Canadell et al., 2023).

Fish are any aquatic living resource that humans can use for food, income, recreation, and other economically beneficial purposes. As climate change endangers the global environment, aquatic ecosystems appear to be at heightened risk compared to their terrestrial counterparts. Indeed, among various organisms, aquatic species, particularly fish, exhibit heightened sensitivity to the impacts of climate change (Huang et al., 2021). Despite this vulnerability, small-scale fisheries still contribute to around 50 % of the global fish supply (Sari et al., 2021). Fish is the cheapest animal protein a typical Nigerian consumes, which constitutes as much as 50% of the nation's total animal protein consumption (Dauda et al., 2016). Fishing involves a wide range of tasks and operations, including capturing or harvesting, processing, preservation, distributing, and marketing the harvested resources. It involves every step from the time the fish is taken out of the water until it reaches the consumer. Thus, using specific tools to look for and/or catch fish or other aquatic resources might be considered to be fishing. The offshore, inshore industrial, coastal, and brackish water artisanal fisheries make up the majority of fishing activity in the Nigerian marine sub-sector (Ekpo and Essien-Ibok, 2013).

The roles of fisheries and aquaculture are crucial in ensuring the provision of food, enhancing food security, and sustaining livelihoods on a local as well as a worldwide scale. For many developing nations, aquatic foods are one of the most traded and exported food products due to their high nutritional content (Funge-Smith and Bennett, 2019). For more than 4 billion people, the majority of whom live in poor nations, aquatic foods provide at least 15.0% of animal protein (Funge-Smith and Bennett, 2019). Nigerian Environmental Study/Action Team has provided indicators to determine changes in the climate of a region. These include an increase in temperature, an increase in evapo-transpiration, an increase in rainfall in coastal areas at the expense of interior continental areas, an increase in climate pattern disruption, and a rise in the frequency and intensity of unusual or extreme weather-related events like floods, droughts, erratic rainfall patterns, sea level elevation, an increase in desertification and land degradation, the drying up of lakes and rivers, and a continual decline in forest cover all of which has been observed in the country lately (Odjugo, 2015).

Although sea level rise, storm surges, and flooding could have adverse effects on human well-being, these impacts can be both positive and negative on fish productivity. The abundance, productivity, and distribution of freshwater aquatic organisms are influenced by changes in precipitation, water availability, sea and inland temperature, sea level rise, and more (Prakash, 2021). This is particularly true in low-income countries like Nigeria, where adaptive capacity is reported to be low (Parry *et al.,* 2017). The report on the effects of climate change on fisheries and aquaculture, produced in response to the 2015 Paris climate agreement, claims that mitigation and adaptation measures need to be adopted to cope with the immediate threat of climate change while also taking into account the unique potential risks associated with food production (Barange *et al.,* 2018).

Artisanal fishers adopt numerous adaptation strategies; however, uncertainty exists regarding the determinants of choice adaptation measures and whether or not they improve catchability. Therefore, this paper aims to determine the perception of artisanal fisher folks to climate change effects and also estimate the determinants of adaptation measures in order to provide valuable insights for decision-making to support adaptation planning and initiatives.

METHODOLOGY

Study area: The study was conducted in the coastal areas of Lagos State where the major source of livelihood is fishing. The State, which is known as the commercial hub of Nigeria, is bordered by Ogun State in the east and north, the Republic of Benin in the west, and the Atlantic Ocean in the south (Kamal *et al.,* 2020). Information on socioeconomic characteristics, perception, and adaptation measures of the artisanal fisher folks in coping with climate change and the factors influencing their choice of method were obtained with a structured questionnaire.

Sampling Procedure: A multistage sampling technique was employed in this study to select a cross-section of 206 artisanal fishers. The initial step encompassed the choosing of four Local Government Areas (LGAs), which are predominantly noted for fishery activities, namely Epe, Ibeju-Lekki, Ikorodu, and Badagry (Kamal et al., 2020). The second stage of the study involved employing a method of simple random sampling to select four, five, and six significant fishing communities within the Local Government Areas (LGAs). The final step in the sampling process entailed a random selection ten artisanal fishers from each of the communities in Epe, Badagry, and

Ikorodu, while eleven fishers were chosen from each of the six communities in Ibeju-Lekki, using the lists of fisher folks from the fishing communities. This resulted in a total of forty respondents in Epe, fifty respondents in Badagry and Ikorodu, and sixty-six fishers in Ibeju-Lekki LGA, totalling 206 respondents. However, out of the 206 questionnaires that were administered, only 200 were deemed suitable for analysis.

Methods of Data Analysis: A four-point Likert scale was utilised to gauge the perceptions of artisanal fishers regarding the influence of climate change on their fishing activities. Respondents were asked to express their agreement level using a scale that ranged from High Extent (HE) to No Extent (NE), with corresponding weights of 4, 3, 2, and 1. Following the methodology of Ibrahim et al. (2015), a Perception Index (PI) was generated to evaluate the negative effect of climate change on artisanal fishing communities. This process consisted of two straightforward steps.

In the first step, participants were presented with statements outlining environmental consequences linked to indicators of climate change (Ej). These statements encompassed factors such as changes in access to fishing grounds, shifts in fish density and species distribution, equipment loss, fishing boat accidents due to waves, alterations in fish sizes, variations in the number of fish caught per trip, decline in fish species, and the reduction of fishermen. Each indicator of climate change effect was assigned a value of 1 if the fisher observed a corresponding impact and a value of 0 if not. In the second stage, participants were requested to assess the comparative significance of each effect indicator (Rm). The rating scale ranged from No Extent (assigned a score of 1) to High Extent (assigned a score of 4). These rankings were transformed into weight scores (Wq). The minimal rank (1) corresponded to a weight of 0.25, Low Extent received a weight of 0.5, Moderate Extent received a weight of 0.75, and High Extent received a weight of 1. By aggregating the scores of the impact indicators based on their respective weights, the Perception Index (PI) was computed for each individual in the manner elucidated below:

$$PI = \sum_{j=1}^{8} \sum_{m=1}^{4} \sum_{q=0}^{1} E_j R_m W_q \ldots\ldots (1)$$

Where E_j represents effect indicators of climate change on coastal fishing; j ranges between 1 and 8. R_m represents the relative level of perception of climate change effects on a four-point scale of 1-4; m ranges between 1 and 4. W_q represents the weighted score of each R_m; q ranges between 0.25 and 1

In accordance with the approach outlined by (Rahman, 2005), the perception index scores were categorised as follows:
$0.00 \geq 0.35$ – low perception
$0.36 \geq 0.65$ – moderate perception
≥ 0.66 – high perception

Multivariate Probit (MVP) was used to examine the relationship between each of the adaptation options and the explanatory variable, and to gain a comparative insight into the adaptation preferences of fisher folks, an analysis of the frequency distribution was conducted. This allows for an examination of the most favoured adaptation choices.
The dependent variables of the MVP model (the adaptation strategies identified in this study) include an increase in fishing time, the use of efficient fishing gear, livelihood diversification and the use of motorised fishing boats. Each of the adaptation measures is explained as follows;

1. An increase in fishing time: This adaptation strategy by fishermen entails investing more time than normal in order to catch more fish. Several fishermen claimed that it took them ten to eleven hours a day to get enough fish.
2. Usage of effective fishing equipment: This necessitates purchasing contemporary fishing gear to assist in their fishing process with less work, such as lift nets, trawling, dredges, etc.
3. Livelihood diversification is a key strategy for adjusting to climate change. Most of the time, the earnings from artisanal fishing are insufficient to support their household's necessities. As a result, in addition to fishing, they also engage in non-farm and crop farming activities.
4. Usage of motorised fishing boats: To improve catch while reducing fishing effort, fishermen came up with the idea of purchasing motors that use gasoline to propel their boats farther without paddling.

Therefore, the expanded form of the choice to adapt a particular measure to climate change was given as follows;

$$Y^{*}{}_{j} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_{11} X_{11} + U_J \ldots \ldots . (2)$$

The dependent variable $Y^{*}{}_{j}$ can be increased fishing time, use of highly efficient fishing gear, livelihood diversification, and use of motorised fishing boats.

X_1 = age (years);
X_2 = marital status (Married = 1, otherwise = 0);
X_3 = household size (1, 2, 3…n);
X_4 = level of education (years);
X_5 = total income (₦);
X_6 = extension agent (available = 1, otherwise = 0);
X_7 = access to credit (available = 1, otherwise = 0);
X_8 = access to information on climate change through media (available = 1, otherwise = 0);
X_9 = access to training through NGO (available = 1, otherwise = 0);
X_{10} = artisanal fishers association (yes = 1, otherwise = 0);
X_{11} = perception level (high = 1, otherwise = 0).

RESULTS AND DISCUSSION

The results of the socioeconomic variables considered in this study revealed that 35.0% of the artisanal fishers were 51 years and above, and 25.0% of the respondents fell within the age bracket of 31 to 40 years. The mean age of artisanal fishers was 43.8 years. Therefore, given that the majority of the agricultural workforce in the chosen settlements is comprised of individuals under the age of 50, this suggests a young and active workforce. This result aligns with Ibeun *et al*., (2018) findings that fish farmers in the Kainji lake basin were young, active, and energetic and were more willing to adopt innovations, which is a function of labour productivity. Sex of artisanal fishers revealed that 98.5% of the respondents engaged in artisanal fishing in the study area were male, with only 1.5% female respondents involved in actual fishing. This suggests that women usually do not participate in fishing activities, especially when fish are being caught; instead, they take part in the processing and marketing of fish and fish products. This result is consistent with the findings of Lekshmi and co-workers (2022) that males dominate the ownership of artisanal fishing and make higher income.

The marital status of artisanal fishers showed that 87.0% of the artisanal fishers were married, 12.0% were single, and only 1.0% were divorced. This indicates that many of them could have family responsibilities to fulfil, as such, they have the tendency of abandoning fish farming or diversifying if the fishing business could not generate enough profit to cater for the family needs. This also agrees with the study of Ifeanyi-Obi and Iremesuk (2018), which revealed that the majority of the artisanal fish farmers in the Eastern part of Akwa Ibom were married. More than half (54.5%) of the artisanal fish farmers have household members made up of 6 persons or less. This is an indication that artisanal fishers in this study area had moderate households, which corroborates the findings of Ifeanyi-Obi and Iremesuk (2018).

The educational distribution of respondents in the study area revealed that most respondents had one form or the other of formal education. (47.0%) of the fishers had primary education, 32.5% had secondary education, 4% had tertiary education, and 16.5% had no formal education. This implies that the majority of the artisanal fish farmers were literate enough to adopt new technologies that can improve their fishing activities in the face of climatic stress since the educational attainment of a farmer tends to increase their tendency to adopt innovations or to accept alternative and improved fish farming strategies. Years of experience of artisanal fishers results showed that 36.0% of the respondents had over 31 years of artisanal fish farming experience. The average year of experience, 23.69%, indicates that most artisanal fishers have stayed long enough to have acquired the necessary knowledge and skills needed in the fishing enterprise to increase production.

The distribution of monthly income for fishers in the study area illustrated that 53.5% of the respondents earned between ₦31,000 and ₦60,000 in a month, while 23.0% earned ₦30,000 or less. Almost a quarter (21.5%) earned between ₦61,000 and ₦100,000, and 2.0% earned above ₦100,00, although monthly income varies from season to season. The average monthly income, however, of the artisanal fishers is ₦53,275, implying that most of the respondents earned below the current (Nigerian) national minimum wage, which is ₦70,000/month. Credit is an essential element for acquiring and maintaining fishing crafts and gears to boost productivity. Table 1 below shows that 86.5% of the respondents had no access to credit. This is one of the major problems confronting small-scale enterprises such as artisanal fish farming in Nigeria. This finding conforms with the study of Osondu (2015), who reported that 70.0% of artisanal fishers had no access to credit in Afiko North, Ebonyi State, Nigeria.

Everyone needs information for decision-making, which influences development. This study revealed that 74.5% of artisanal fish farmers never benefitted from extension service, while 25.5% benefitted from extension service. The low level of extension contact could have a detrimental effect on fishing as there will be no extension guides on the sustainable exploitation of fishery resources in the study area. These findings also corroborate Unekwu et al. (2020) results on drivers, perception and adoption of aquaculture innovations in Kogi State. In addition, 66.5% of the respondents belonged to the artisanal fishing association, while 33.5% did not belong to the artisanal fishers association. This indicates that the majority of the respondents did have a social affiliation within their environment. Membership in a social group will enlarge the respondents' opportunities for information, credit facilities and extension services. Other occupations of respondents revealed that 55.5% of the respondents had only artisanal fishing as a source of livelihood, and 35.5% had off-farm activities like carpentry, plumbing and civil service. A few of the respondents were involved in livestock (4.0%) and crop farming (5.0%) as other means of sustenance.

Description of respondents by perception of effects of climate change on artisanal fishing: Figure 1 revealed the overall perception scores of the artisanal fishers, which ranged from 0.44 to 0.84. The mean and standard deviation were 0.65 and 0.08, respectively. The result revealed that 52.0% of the artisanal fish farmers had a high perception of the effects of climate change. Similarly, 48.0% of the respondents had moderate perception and none of the respondents fell in the low perception category. The implication of this is that the majority (52.0%) of the fisher folks perceived the changing climate and its effects on their fishing activities. This finding agrees with that of Effiong and Ogbonna (2017) that the majority of Bakassi fish farmers perceived climate change's impact on the ecosystem on artisanal fishing.

Also, the Howlader et al. (2015) study revealed that most farmers have low to medium perceptions of the effects of climate change in Bangladesh on coastal agriculture. Furthermore, Ibrahim et al. (2015) study perception of causes opined that half of sampled farmers perceived the causes and effects of climate change.

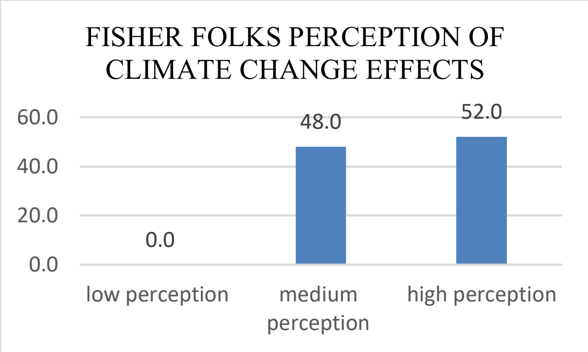

Figure 1: Distribution of Respondents based on Perception of Climate Change Effects

The climate change perceptual index was computed in order to have a better understanding of the view of the artisanal fishers on the eight selected perceptual statements. The result revealed that the most prominent effect of climate change was felt on fish population density. Fisher folks complained about the drop in fish population, probably, as a result of climate-induced variation in oceans affecting the growth processes of aquatic life. Distance to the fishing ground takes the second rank. The respondents explained that to have a good catch, they have to go several fathoms unlike when they newly started the enterprise where fish catch occurs at the seashore. This is associated with seawater intrusion and changes in species distribution. Loss of fishing equipment and capsizing of the fishing boat were ranked third and fourth, respectively. This can be associated with sea-level rise and storms occurring as a result of biodiversity; these events lead to the loss of fish stocks and also damage fish cages or traps. Extinction of fish species and fish catch take fifth and sixth rank, respectively, possibly resulting from the rise in ocean temperature and acidification. The changing temperature may affect the migratory behaviour of fish. The fish size difference was ranked seventh, while the loss of fishers took the last rank. Increased sea salinity and sedimentation pose a significant risk to the growth processes of aquatic life. All these climate change indicators were perceived in the study area.

Factors Influencing Climate Change Adaptation Measures by Artisanal Fishers: In Table 4, the findings indicated that among the various adaptation strategies employed to address the impacts of climate change on artisanal fishing, the most commonly utilised option was the use of motorised fishing boats (73.0%). Extending fishing operations (72.0%) was the second most prevalent approach while diversifying livelihood opportunities (46.5%) emerged as the third most implemented measure. On the other hand, the adoption of modern (40.0%), efficient fishing gear was the least frequently chosen among the four adaptation options examined in the study.

The results of the multivariate Probit model is presented in Table 5 below. The likelihood ratio (Wald χ^2) was highly significant (p<0.01), indicating that the variables sufficiently explain the model, and the overall relationship between the artisanal fishers' probability of adopting specific adaptive practices and explanatory variables was also significant.

Factors influencing the increase in fishing time: In order to cope with the effects of climate change, artisanal fishers adopt an extension of fishing hours for a good catch. Fisher's age, training on innovation and perception positively influenced fishers' decision to extend fishing time, while marital status, fishing income, and membership in fishers association significantly reduced the number of hours fishers used in fishing. That is, older artisanal fishers are likely to extend their fishing time so as to have a good catch; this positive relationship might be due to experiences, cumulative knowledge, and skill since farmers' physical capabilities, knowledge, and skills are likely to get better with age (Ahmed, 2016). Training on innovation significantly increased fishers' fishing time this could be due to access to instruction from non-governmental organisations. This indicates that the information given to the fishermen may have aided the decision-making process as fishers considered various adaptation options under their various conditions.

Fishers' perceived impact of climate change positively influenced the decision to increase fishing time, which implies that awareness of artisanal fishers on climate change impacts increased the likelihood of spending more time in other to have a good catch. This result contradicts Sajise et al. (2017) finding that perception was uncorrelated with none of the adaptation measures. However, marital status reduced the likelihood of fisher folks increasing fishing time, which could be a result of having family responsibilities to fulfil. As such, fishers tend not to increase fishing time as an adaptation measure of coping with climate change. An increase in fishers' total income significantly reduced the likelihood of extending fishing time. That is, wealthier fishermen may lower their fishing time and, hence, their chances of extending their fishing season by combining their revenue from various sources. This conforms with Kamba et al. (2020) study in Malawi on drivers of climate change adaptation in artisanal fishery.

Furthermore, membership in the fishers' association is less likely to influence the extension of artisanal fisher folks' fishing time as a measure of coping with climate change. This suggests that membership in organisations did not necessarily influence farm households' adoption of climate adaptation strategies. This corroborates Thoai et al. (2018) finding on determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam.

Factors influencing the use of efficient fishing gear: The use of modern, efficient fishing gear was positively influenced by age, extension contact, access to climate change information, training on innovations by non-governmental organisations and perception of climate change effects. Artisanal fishers' age heightens the likelihood of adopting the use of modern fishing gears to mitigate the effects of climate change. This could be explained by the fact that the older artisanal fishers are less energetic, and using old fishing tools can be more stressful and might as well affect the level of fish catch. Thus, they adopt the use of efficient fishing gear. GC and Yeo (2020) also suggest that the age of the household head mostly influences all choices of adaptation measures. That is, older fisher folks are better positioned to adopt less tedious methods of fishing than their younger counterparts because they understand and appreciate the benefits more.

Government extension services significantly increased the adoption of modern fishing gears; this confirms the increasing role of extension in climate risk management, which supports better and more effective agricultural management decisions; the findings corroborate Kamba et al. (2020). Also, access to climate change information through media increases artisanal fishers' likelihood of acquiring efficient fishing gear. This shows that artisanal fisher folks can make more informed decisions about competing adaptation options by having access to climate change information through all accessible communication channels. Access to training on innovations by non-governmental organisations also enhances artisanal fishers' likelihood of investing in modern, efficient fishing gear in other to cope with climate change.

Artisanal fishers' perceived climate change effect in the study area increases the likelihood of adopting efficient modern fishing gear. This is consistent with *a priori* expectation that fisher's perception of the effects of climate change influences the decision to take up adaptation measures in other to cope with climate change. Similarly, previous studies have asserted that adaptation to climate change is a two-step process that necessitates first having the perception that the climate is changing before adapting to those changes (Wang *et al.,* 2009; Aggarwal, 2009). However, artisanal fisher folk's total income and marital status significantly reduced the likelihood of acquiring efficient modern fishing gear; this contradicts the finding of Kassie (2017) that wealthier farmers adopt measures to mitigate climate change effects more readily than their poorer counterparts. Marital status was also negatively associated with investing in modern fishing gear. This could be a result of having domestic financial responsibilities to fulfil, and as such, married fishers are not able to adopt the use of modern fishing gear as a measure of coping with the changing climate.

Factors Influencing Livelihood Diversification: The likelihood of diversifying livelihood was significantly affected by total income, access to credit and household size. Artisanal fishers' household size diminished the likelihood of diversifying their livelihood, suggesting that artisanal fishers with large household sizes were less likely to diversify their livelihood. This may be due to the fact that fishers with large household sizes have family labour to handle the enterprise in other to have a good catch. Hence, there will be less need for diversifying from the enterprise. This finding is contradictory to what was revealed by Kamba et al. (2020). The study observed insignificant effects of household size on livelihood diversification strategy in artisanal fishers' adaptation to climate change in Malawi.

On the other hand, total income and access to credit had a positive influence on the likelihood that artisanal fishers will adopt livelihood diversification as a climate change adaptation strategy. This indicates that artisanal fishers' diversification of sources of income is influenced by increased household monthly income, which implies that households with sufficient financial resources have a strong capacity for adaptation to cope with environmental changes by implementing diverse income-generating activities. This result is consistent with Eluriaga et al. (2020) findings regarding the influence of risk preference on small-scale fishermen's decisions regarding adaptation techniques in response to reduction in fishery. Furthermore, access to credit also positively enhances the likelihood of diversifying livelihood options, which implies that artisanal fisher folks with access to credit have a high tendency to diversify their enterprise. With more financial resources at their disposal, fishers can seek livelihood alternatives with the changing climate, which is a pathway to reducing poverty.

Factors influencing the use of motorised fishing boat: Artisanal fishers' marital status, total income, household size, membership in fishers association, and training on innovations were the determinants of use of motorised fishing boats by the respondents. Total income and marital status were found to negatively influence the use of motorised fishing boats. This implies that higher income decreased the likelihood of artisanal fishers acquiring motorised fishing boats as a climate change adaptation measure. This contradicts Gbetibouo (2009) finding in the Limpopo basin of South Africa that household income was positively related to adaptation. That is, wealthier fishers are more likely to use adaptation practices in response to climate change than poor fishers.

The likelihood of a married fisher acquiring a motorised fishing boat in order to cover a longer distance on shore so as to have a good catch is reduced. This could be due to the fact that married fishers are saddled with more financial responsibilities and, as such, might be financially handicapped in acquiring one. Also, artisanal fisher households will be less likely to embrace the usage of motorised fishing boats as a climate change adaptation method. This might be due to large households with more people expending more money, and thus, the need for financial resources increases, thereby prompting the use of engines for their boats in other to cover longer distances since sea shore tends to be over-fished and also fish do not stay in shallow area of the water. Therefore, artisanal fishers need to possess motorised fishing boats in order to have a good fish catch.

It was observed that membership in fishers associations increased the likelihood of fishers adopting the use of engines for fishing boats, which is in line with Bandiera and Rasul (2016) study, which suggests that membership in cooperatives, groups, or other community organisations help households integrate into local and regional social networks, allowing families and individuals to learn and share information about new technologies and adaptation practices, which can affect the potential of these technologies and practices for adoption. Furthermore, training on innovations by non-governmental organisations increased the likelihood of artisanal fishers adopting the use of engines for fishing. The use of paddles decreases with increasing eye-opening training on innovations such as marine engines, which are considered faster and more efficient in covering a large area onshore and time-saving.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are being suggested.

First, due to the decrease in fish population caused by climate change, leading to lower catches and income for artisanal fishers, the stake holders must implement strategies that enhance alternative livelihood opportunities available to them. This approach would enable artisanal fisher folks to supplement their earnings and transition towards a more sustainable livelihood. Secondly, affordable climate change adaptation technologies, like subsidised motorised fishing equipment, should be provided. This would make it easier for fishers to travel longer distances in search of displaced fish species, improving their catch efficiency. Supplying motorised boats would not only alleviate the challenges faced by fisher folks but also incentivise ongoing fishing activities in the area. This approach would contribute to alleviating hardships and meeting the demand for fish at local, national, and international levels.

REFERENCES

Ahmed, M. H. (2016). Climate change adaptation strategies of maise producers of the Central Rift Valley of Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 117(1), 175-186.

Akande, A., Costa, A. C., Mateu, J., & Henriques, R. (2017). Geospatial analysis of extreme weather events in Nigeria (1985–2015) using self-organising maps. *Advances in Meteorology*. Article ID 8576150, https://doi.org/10.1155/2017/8576150

Barange, M., Holsman, K., Hollowed, A., Ito, S., Bograd, S., Hazen, E., King, J., Mueter, F., & Perry, R. I. (2018). Climate change impacts, vulnerabilities and adaptations: North Pacific and Pacific Arctic marine fisheries. In *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options,* Vol. 627, FAO 2018.

Brander, K. (2010). Impacts of climate change on fisheries. *Journal of Marine Systems*, 79(3-4), 389–402.

Ciais, P., Sabine, C., Bala, G., Bopp, L., Brovkin, V., Canadell, J. , Chhabra, A., DeFries, R., Galloway, J., Heimann, M., Jones, C., Le Quéré, C., Myneni, R. B., Piao, S., & Thornton, P. (2013). Carbon and Other Biogeochemical Cycles. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Cochran, W. G. (1963). Sampling Techniques. 2nd Edition, John Wiley and Sons Inc., New York.

Dauda, A. B., Ojoko, E. A., & Fawole, B. E. (2016). Economic analysis of frozen fish demand in Katsina metropolis, Katsina State, Nigeria. *Journal of Fisheries and Aquatic Science*, 11(1), 93–99.

https://doi.org/10.3923/jfas.2016.93.99

Effiong, M. O., & Ogbonna, C. U. (2017). Ecosystem perception among artisanal fishermen: A case study of Akpabuyo and Bakassi coastal fishing communities in cross River State, Nigeria. *Annual Research and Review in Biology*, 19(1), 1–11. https://doi.org/10.9734/ARRB/2017/37431

Huang, M., Ding, L., Wang, J., Ding, C., & Tao, J. (2021). The impacts of climate change on fish growth: A summary of conducted studies and current knowledge. *Ecological Indicators,* 121, 106976. https://doi.org/10.1016/j.ecolind.2020.106976.

Sari, I., Ichsan, M., White, A., Raup, S. A., & Wisudo, S. H. (2021). Monitoring small-scale fisheries catches in Indonesia through a fishing logbook system: Challenges and strategies. *Marine Policy,* 134, 104770. https://doi.org/10.1016/j.marpol.2021.104770

Ekpo, I. E., & Essien-Ibok, M. A. (2013). Development, prospects and challenges of artisanal fisheries in Akwa Ibom State, Nigeria. *International Journal of Environmental Science, Management and Engineering Research*, 2(3), 69–86.

Funge-Smith, S., & Bennett, A. (2019). A fresh look at inland fisheries and their role in food security and livelihoods. *Fish and Fisheries*, *20*(6), 1176–1195. https://doi.org/10.1111/faf.12403

Hiddink, J. G., & ter Hofstede, R. (2008). Climate induced increases in species richness of marine fishes. *Global Change Biology*, 14(3), 453–460. https://doi.org/10.1111/j.1365-2486.2007.01518.x

Howlader, M. S., Akanda, M. G. R., & Zaman, A. (2015). Adaptation towards climate change effects on coastal agriculture by the farmers of Patuakhali district of Bangladesh. *International Journal of Agricultural Innovations and Research*, 3, 1560–1566.

Ibeun, B., Ojo, A., Mohammed, U., & Adewumi, A. (2018). Profitability and technical efficiency of cultured fish farming in Kainji Lake Basin, Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology,* 4(2), 53-61.

Ibrahim, S. B., Ayinde, I. A., & Arowolo, A. O. (2015). Analysis of arable crop farmers' awareness to causes and effects of climate change in south western Nigeria. *International Journal of Social Economics,* 42(7), 614-628.

Ifeanyi-Obi, C. C., & Iremesuk, P. (2018). Environmental Factors Influencing Artisanal Fishing in Eastern Obolo Local Government Area of Akwa Ibom State. *Journal of Agricultural Extension,* 22(1), 55-66.

IPCC. (2014). Climate change 2014 synthesis report, Contribution o Working Groups I, II and III to the Fifth Assessment Report of Core. *IPCC: Geneva, Szwitzerland*, 151.

Kamal, A., Olayinka, O. F., & Kehinde, O. L. (2020). Analysis of Factors influencing Vulnerability of Fishing Systems to Climate Change among Artisanal Fisherfolks in Coastal area of Lagos, Nigeria. *African Journal on Land Policy and Geospatial Sciences,* 3(1), 2657–2664.

Kassie, G. W. (2017). Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. *Environmental Systems Research*, 6(8), 1-114, https://doi.org/10.1186/s40068-017-0085-6

Odjugo, P. A. O. (2009). Quantifying the Cost of Climate Change Impact in Nigeria: Emphasis on Wind and Rainstorms. *Journal of Human Ecology*, 28(2), 93–101. https://doi.org/10.1080/09709274.2009.11906223

Lekshmi, P. S., Radhakrishnan, K., Narayanakumar, R., Vipinkumar, V. P., Parappurathu, S., Salim, S. S., Johnson, B., & Pattnaik, P. (2022). Gender and small-scale fisheries: Contribution to livelihood and local economies. Marine Policy, 136, 104913. https://doi.org/10.1016/j.marpol.2021.104913

Osondu, C. (2015). The market performance and determinants of net returns to artisanal fish in ndibe beach, Afikpo North LGA, Ebonyi State, Nigeria. *Agrosearch*, 15(1), 1-28.

Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (2007). Climate change 2007-impacts, adaptation and vulnerability. *Working Group II Contribution to the Fourth Assessment Report of the IPCC,* Cambridge University Press, UK, 976pp

Prakash, S. (2021). Impact of Climate Change on Aquatic Ecosystem and Its Biodiversity: an Overview. *International Journal Biological Innovations*, 3(2), 312-317. https://doi.org/10.46505/ijbi.2021.3210

Rahman, S. (2005). Environmental impacts of technological change in Bangladesh agriculture: Farmers' perceptions, determinants, and effects on resource allocation decisions. *Agricultural Economics*, 33(1), 107–116. https://doi.org/10.1111/j.1574-0862.2005.00284.x

Sajise, A. J. U., Ramirez, P. J. B., Perez, M. L., & Arias, J. K. B. (2017). Determinants of Climate Change Adaptive Behavior in Coastal Communities in Southeast Asia. *Asian Journal of Agriculture and Development*, 14(2), 50-61.

Thoai, T. Q., Rañola, R. F., Camacho, L. D., & Simelton, E. (2018). Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. *Land Use Policy*, 70, 224–231. https://doi.org/10.1016/j.landusepol.2017.10.023

Unekwu, O., Mojisola, A. O., Tina, E., & Ogala, D. (2020). Perception and uptake of aquaculture technologies in Kogi state, central Nigeria: imperative for Improved Management practices for sustainable aquaculture development. *African Journal of Agricultural Research*, 16(6), 819–828. https://doi.org/10.5897/ajar2019.14558

Table 1: Description of the socioeconomic characteristics of artisanal fishers

Variable	Frequency	Relative frequency (%)	Mean
Age			
≤ 30	42	21.0	
31-40	50	25.0	
41-50	38	19.0	
≥ 51	70	35.0	43.8
Sex			
Male	197	98.5	
Female	3	1.5	
Marital status			
Married	174	87.0	
Single	24	12.0	
Divorced	2	1.0	
Household size			
1-6	109	54.5	
7-10	67	33.5	
≥ 11	24	12.0	6
Educational qualification			
No formal education	33	16.5	
Primary	94	47.5	
Secondary	65	32.5	
Tertiary	8	4.0	
Total	200	100.0	

Source: field Survey, 2021

Table 2: Description of the socioeconomic characteristics of artisanal fishers

Variable	Frequency	Relative frequency (%)	Mean
Artisanal Fishing experience			
1-10	34	17.0	
11-20	34	17.0	
21-30	60	30.0	
≥ 31	72	36.0	23.39
Monthly income			
≤ ₦30,000	46	23	
₦31,000-₦60,000	107	53.5	
₦61,000-₦100,000	43	21.5	
≥ ₦101,000	4	2.0	₦53,275
Use of credit			
Yes	173	86.5	
No	27	13.5	
Extension contacts			
Yes	149	74.5	
No	51	25.5	
Farming association			
Yes	67	33.5	
No	133	66.5	
Other occupation			
Only artisanal	111	55.5	
Livestock farming	8	4.0	
Crop farming	10	5.0	
Off-farm activities	71	35.5	
Total	200	100.0	

Source: field Survey, 2021

Table 3: Fishers' Perceived Climate Change Effects on Coastal Fishing

Perceptual statement	Perceptual index	Rank
Distance fishing ground	0.89	2
Fish density	0.96	1
Loss of fishing equipment	0.84	3
Capsizing of the fishing boat	0.66	4
Fish size difference	0.47	7
Level of fish catch	0.51	6
Level of extinction of fish species	0.58	5
Loss of fishermen	0.34	8

Source: Field Survey, 2021

Table 4: Distribution of Artisanal Fishers According to Adaptation Measures Adopted

Adaptation Measures	Frequency	*Relative frequency (%)
Increase in fishing time	144	72.0
Use of efficient fishing gear	80	40.0
Livelihood diversification	93	46.5
Use of motorised fishing boat	146	73.0

Source: Field Survey, 2021 * implies multiple responses frequency

Table 5: Determinants of Artisanal Fish Folks' Adaptation Options to Climate Change in Lagos State

Variables	**Increase fishing time**		**Use of efficient fishing gear**		**Livelihood diversification**		**Use of motorised fishing boat**	
	Coef.	**Std. error**	**Coef.**	**Std. error**	**Coef.**	**Std. error**	**Coef.**	**Std. error**
Age	0.0107*	0.0062	0.0228***	0.0071	-0.0003	0.0059	0.0047	0.0068
Marital status	-0.7601***	0.2386	-0.5891**	0.2380	0.1382	0.2350	-0.8193**	0.3478
Household size	-0.0099	0.0259	0.0257	0.0251	-0.0406**	0.0233	0.0519**	0.0231
Education	0.0047	0.0160	-0.0180	0.0162	0.0183	0.0156	-0.0023	0.0165
Total income	-0.4940***	0.1531	-0.3487**	0.1544	0.4402***	0.1439	-0.9696***	0.1900
Extension contacts	-0.2537	0.1769	0.6045***	0.1784	-0.2211	0.1740	0.0401	0.1767
Access to credit	-0.2668	0.2299	0.2481	0.2289	0.5860**	0.2379	-0.1364	0.2290
Fishers' association	-0.3303**	0.1597	0.2318	0.1616	0.2039	0.1472	0.2705*	0.1627
Climate change information	-0.3033	0.2759	1.5713***	0.2594	0.0825	0.2675	0.3307	0.3484
Training on new innovations	0.8994*	0.5263	3.7318***	0.4330	0.1352	0.4929	4.0514***	0.5091
Climate change perception	0.7587***	0.2985	1.0429***	0.2763	0.0226	0.2825	-0.1992	0.3193
Constant	5.8775	1.6191	1.5426	1.5750	-5.0884	1.5029	11.4834	2.0382
rho21	-0.0914	0.0847						
rho31	0.1842**	0.0839						
rho41	0.6683***	0.0593						
rho32	-0.1420**	0.0831						
rho42	0.3481***	0.0844						
rho43	0.0927	0.0818						
Predicted probability	0.7141		0.3971		0.4619		0.7203	
Joint probability (success)	0.1196	0.09119						
Joint probability (failure)	0.0705	0.0450						
Number of Observations	200							
Log pseudolikelihood	-412.06362							
Wald $\chi^2(44)$	441.81							

Likelihood ratio test of $\rho(\mathrm{Rho})_{ij} = 0$ i.e. $(\mathrm{Rho\ 21} = \mathrm{Rho31} = \mathrm{Rho41} = \mathrm{Rho32} = \mathrm{Rho42} = \mathrm{Rho43} = 0)$, $\chi^2(6) = 63.441$, $\mathrm{Prob} > \chi^2 = 0.0000$

Source: Field Survey, 2021 *** Significant at 1%; ** Significant at 5%; * Significant at 10%