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# Effects of Climate Change on Aquaculture Production and Management in Akure Metropolis, Ondo State, Nigeria

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**ABSTRACT**
This study examined the perception of fish farmers on the effect climate change, on fish farming in Ondo State, Nigeria. Both primary and secondary data were used. The multistage random sampling technique was used to select the communities and the number of respondents in Akure metropolis. A total of 40 fish farmers were interviewed using well-structured questionnaire, interview schedule and Focus Group Discussion (FGD) to obtain relevant information from the respondents. Climate variable data were collected from the Department of Agro climatology, Ondo State Ministry of Agriculture. Likert scale was used to determine the perception of the respondents on climate change. The effects of climate change on production were analysed descriptively. Records showed that, maximum temperature and the amount of rainfall had been to increase over the years as a result of changes in climatic pattern. However, all the respondents were aware of climate change due to changes in the climatic variables. Only 33% of the respondents were aware of adaptive strategies to mitigate the effect of climate change on fish farming. Fish production and food security is at risk in the study area if good management is not practiced. Fish farmers should be encouraged through the extension agents to keep climate variable records for future references.

**Key words:** Climate change, aquaculture, production and management.

## INTRODUCTION

Over 500 million people, mostly in developing countries depend directly or indirectly on fisheries for their livelihood out of which over 10 million people in Africa found employment in this sector (FAO, 2004; UNDP, 2005; FAO, 2008). West Africa is highly dependent on fish and fisheries as a source of food and livelihood. The average annual per capita fish consumption in the region is 15 kg per capita, (1999 to 2003).

The management of the resources and ecosystems upon which the fisheries sector depend is a major challenge for world food security. Now, the sector is threatened by external factors such as pollution, runoff, land-use transformation, competing aquatic resource use and more prominently, climate change, which is modifying fish distribution and production (FAO, 2008).

Climate change is a global problem and has become an important agenda in both public and private discourse in recent times. It has brought about much anxiety and bewilderment in the wake of global disasters perpetrated by flood, storm and other natural hazards. However, climate change has been said to impact freshwater fisheries through the increasing changes in water temperature, nutrient levels and lower dry season water levels. The implications of climate change for food security and livelihoods in many developing countries are profound.

Fishers, fish farmers and coastal inhabitants will bear the full force of this impact through less stable livelihoods, changes in the availability and quality of fish for food, and rising risks of their health, safety and home. Nigeria is not left out among the developing countries that will be affected by this precarious situation of climate change (IPCC, 2001).

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Nigeria is not producing enough fish for consumption; also, the fish industry is not providing the much needed financial empowerment for fish farmers (Molua *et al*., 2007; FAO, 2009). There is a huge supply- demand gap for fish and fishery products in Nigeria, about 400,000 tons of supply in comparison to the 800,000 tons of demand (FAO, 2006). This makes Nigeria one of the largest importers of fish in the developing world, importing 600,000 metric tons annually (Molua *et al*., 2007; Lam *et al.*, 2011).

Despite the challenges facing aquaculture in Nigeria, effect of climate change on food security ranges from the overall reduction in fish production and great changes in the quality of water (Ayanwuyi *et al*., 2012). On this basis, this paper aimed at effect of climate change on aquaculture production and management in Ondo State, Nigeria. Specifically, the socioeconomic characteristics of fish farmers were examined. In addition, the level of awareness of respondents' on climate change issues, adaptive strategies used by respondents' to mitigate the effect of climate change were assessed.

**Research methodology**

The study was carried out in Akure Metropolis in Ondo State, Nigeria. Ondo State is one of the 36 states of the Federal Republic of Nigeria. It has an approximate land area of 14, 793, 723 square kilometres with co- ordinates $5^0 45^1$ N $4^0 15^1$E this is not enough coordinating and a population of 3.441,024 million (NPC 2006). The state is made up of 18 Local Government Areas (LGAs). It lies in the tropics and the climatic condition is of two distinct seasons; the rainy season (April - October) and dry season (November – March). The State is also one of the oil producing states in Nigeria. Other minerals found in commercial quantities in the state include bitumen, limestone, kaolin, glass sand and granite. Figure 1 shows the map of the study area.

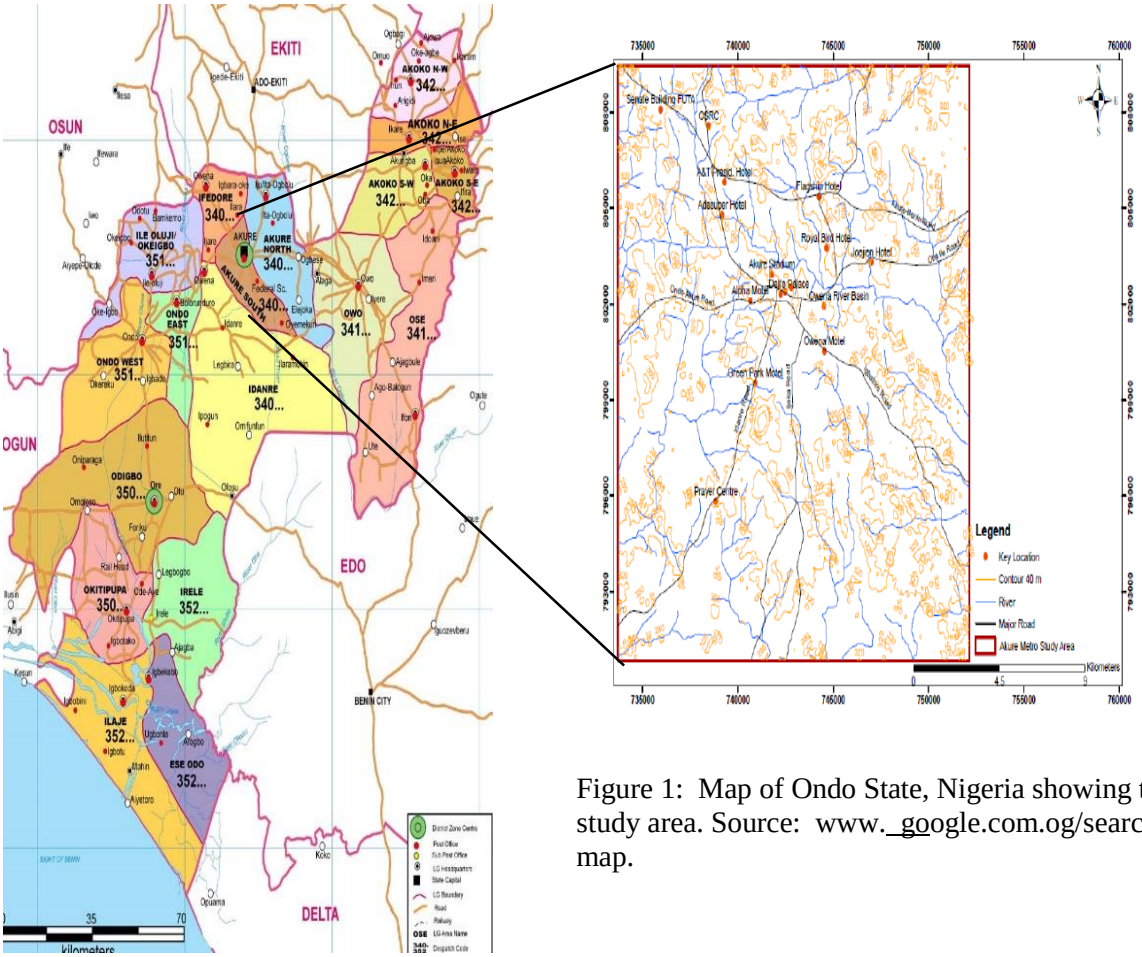


Figure 1: Map of Ondo State, Nigeria showing the study area. Source: www._google.com.og/search-map.

**Sample techniques**

The multistage random technique was used. Four communities were randomly selected from Akure metropolis; Aule, Ijoka, Road block, Alagbaka, ten respondents were selected randomly from each of the communities, making a total of forty respondents. Both primary and secondary data were used. Descriptive statistics were used to describe the socioeconomic characteristics of the respondents, Likert scale was used to determine the perception of the respondents on Climate Change and Chi Square was used to test for the hypothesis.

## RESULTS AND DISCUSSION

**Weather parameters in Ondo State, Nigeria; Akure South LGA (2002-2011)**

In Ondo State, climate change is expected to have significant impact on fisheries because of the strong variations in climatic variables experienced in recent years. It was observed that least give value amount of rainfall and temperature was experienced in 2004 and in 2005-2011 both temperature and rainfall have been increasing as shown in Table 1. This shows that there is a change in climatic pattern in the study area.

Table 1: Weather parameters in Ondo State, Nigeria (2002-2011)

| Year | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Min. Temp ($^0$C) | Max. Temp ($^0$C) | Rainfall (days) | Rel. humidity % | Rain (days) | Evaporation |
| 2002 | 20.5 | 33.3 | 1,318.2 | 75.8 | 88 | NA |
| 2003 | 20.1 | 33.0 | 1,284.9 | 76.0 | 91 | 1.0 |
| 2004 | 19.9 | 32.5 | 595.6 | 75.5 | 92 | 1.7 |
| 2005 | 20.5 | 33.4 | 598.8 | 76.2 | 101 | 1.1 |
| 2006 | 20.7 | 32.9 | 1,114.2 | 77.2 | 97 | 1.2 |
| 2007 | 20.2 | 33.0 | 1,211.5 | 74.3 | 121 | 0.9 |
| 2008 | 20.6 | 32.6 | 1,749.8 | 70.5 | 91 | 1.9 |
| 2009 | 20.8 | 32.5 | 1,318.7 | 75.5 | 93 | 1.2 |
| 2010 | 21.0 | 35.6 | 1,760.4 | 76.4 | 91 | 3.4 |
| 2011 | 21.4 | 32.3 | 1,826.8 | 71.3 | 93 | NA |

Source: Ondo State Ministry of Agriculture, Department of Agro Climatology (2012).

**Socio-economic characteristics of respondents**

Table 2 shows that 90% of the respondents were men while only 10% were female. The reason might have been due to the risk and drudgery nature of fish farming or some of the females were involved in other business like trading, teaching as additional occupation. This implies a great prospect in fish production since more men were involved. 80% of the respondents were married while 20% were single. This indicates that the married were more into fish farming than the single. It implies that they were involved in fish farming for income and livelihood in order to support their family. The unemployed youths could also venture into it. As presented in Table 2 more of the respondents (55%) were into fish farming to improve household per capita income, 10% started up a fish farm because of personal interest and leisure, 10% as professional fish farmers, 3% in nutritional interest, 2% because there is no job, 5% as retirement investment and 15% of the respondents gave no response. This also indicates that most of the respondents had diverse reasons for starting a fish farm business. 38% of the respondents used both earthen and concrete pond, 55% used only earthen pond and 7% used only concrete pond. This indicates those earthen ponds are less expensive to construct, and will reduce cost of production and increase fish production. Close to half of the respondents (48%) depend on the stream / river as their source of water, while 17% use borehole and 5% depend on rainfall. Since water is very essential in fish farming and there may be a scarcity of water due to fluctuations in the climatic variables in which rainfall is one of the parameters. The fish farmers used various water sources that can ease fish

production, especially catfish which is more socially acceptable and has the ability to survive extreme weather conditions (Federal Department of Fisheries, 2007).

Table 2: Socio-economic characteristics of the respondents

| **Sex** | **Frequency** | **Perc**entage |
|---|---|---|
| Male | 36 | 90 |
| Female | 4 | 10 |
| Total | 40 | 100 |
| **Marital status** | **Frequency** | **Perc**entage |
| Single | 8 | 20 |
| Married | 32 | 80 |
| Total | 40 | 100 |
| **Purpose** | **Frequency** | **Percentage** |
| Support/improve income | 22 | 55 |
| Other reasons | 18 | 10 |
| Total | 40 | 100 |
| **Types of pond** | **Frequency** | **Percentage** |
| Earthen pond | 22 | 55 |
| Concrete pond | 3 | 7 |
| Both | 15 | 38 |
| Total | 40 | 100 |
| **Source of water** | **Frequency** | **Percentage** |
| Rainfall | 2 | 5 |
| Stream/river | 19 | 48 |
| Borehole | 7 | 17 |
| No response | 12 | 39 |
| Total | 40 | 100 |

Source: Field Survey Data, 2012.

**Awareness of respondents to climate change**

All the respondents (100%) were aware of climate change. This implies that the fish farmers in the study area were familiar with the effects of climate change in fish production and management and might familiar with the adaptive strategy to combat the adverse effects of climate change. Mendelsohn, 2009 stated that educated and experienced farmers have more knowledge and information about climate change and adaptation practices.

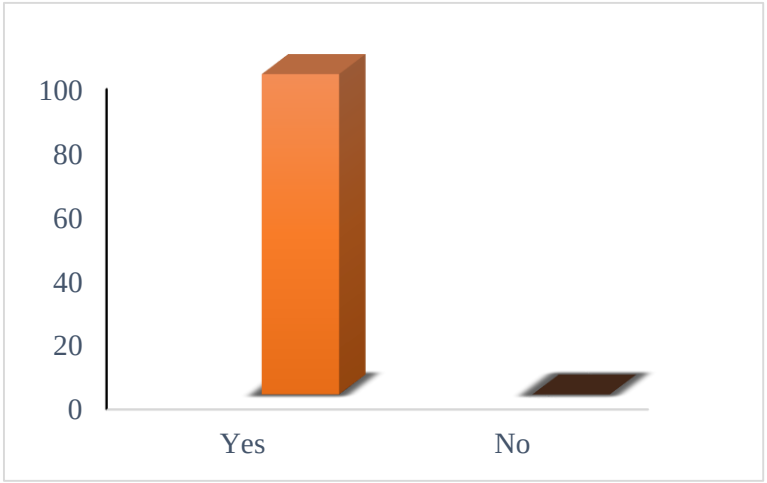


Fig. 3: Awareness of climate change by fish farmers. Source: Field Survey Data, 2012.

Table 3 shows that 30% of the respondents observed unpredictable rainfall, 30% observed an increase in temperature, 28% observed flood, 22% observed increase in the amount of rainfall, 15% observed harsh and unusually long period of dry season. This result conforms to the study of Apata *et al*., (2009), Adebayo (2012) on climate variables as indicators of climate change.

Table 3: Distribution of respondents according to climate variables observed

| Climate variables | *Frequency | Percentage |
|---|---|---|
| Unpredictable rainfall | 12 | 30 |
| Increased rainfall | 9 | 22 |
| Flood | 11 | 28 |
| Increased temperature | 12 | 30 |
| Harsh and unusually long dry season | 6 | 15 |
| Wind action | 3 | 8 |
| Disease outbreak | 2 | 5 |

*Multiple responses recorded. Source: Field Survey Data, 2012.

**Perception of fish farmers on the effect of climate changes on fish farming**

Likert scale result in Table 4 revealed that the respondents agreed that increase in rainfall has a positive impact on fish farming and this agrees with the findings of Adebayo (2012) on climate change perception and adaptation strategies on catfish farming in Oyo State, Nigeria that increase in rainfall have a positive impact on fish production. From Table 4, 48% of the respondents strongly agree that an increase in rainfall has a positive impact on fish farming, 35% agree, 5% were undecided, 13% disagree. While 13% strongly agree that an increase in rainfall have a negative impact on fish farming, 25% agree, 15% disagree, 37% disagree and 10% strongly disagree. This implies that an increase in rainfall has a positive impact on fish production. 55% of the respondents strongly agree, that when raining season starts earlier, it will increase fish production while 3% strongly disagree. Also, 70% of the respondents strongly agree that the occurrence of flood in the fish farm area will decrease fish production while 30% disagreed. It implies that the flood would wash away fish from earthen ponds, destroy the ponds by tearing down its embankments and wash/deposit toxic materials into ponds which will invariably reduce fish production in the area. From the study, 53% of the respondents strongly agree that long period of hot/dry season will decrease fish production while 42% strongly disagree. This implies that there will be no adequate water supply for fish production. Some of the respondents adapt to this by providing alternative water source. Thirty-eight (38) percent of the respondents strongly agree that an increase in temperature will have a negative impact on fish production, 27% agree, 13% undecided, 12% disagree, and 10% strongly disagree. The responses as indicated by a Likert scale showed that most of the fish farmers agree that increase in temperature have a negative impact on fish production because the water will be warm as a result of increase in temperature which will affect the fish activeness in feeding, reproduction and other metabolic processes.

**Adaptive strategies employed by fish farmers in the study area.**

Table 5 shows various adaptive strategies employed by the fish farmers in the study area to combat the effect of climate change on fish farming, 23% employed flood control by constructing more water outlets, 10% stock the pond when the favourable weather condition is noticed, 13% provided alternative water outlets, 10% plant trees to reduce the effect of wind action on fish ponds. This indicates that the respondents are carrying mitigation measures to reduce the effect of climate change on fish farming. This agreed with Adeleke, *et al.* (2013) in the assessment of the current knowledge of the fisher folks on climatic variables that, fisher folks had different perception and attitude towards increase or decreases the climatic variables, hence, the various inadvertent and intentional methods of climate change adaptation.

Table 4: Distribution of respondents according to perception on the effect of climate change on

| Perceptual statements | SA | A | UD | DA | SD | Mean | Summary |
|---|---|---|---|---|---|---|---|
| Increase in rainfall have a positive impact on fish farming | 19(47.5) | 14(35.0) | 2(5.0) | 5(12.5) | - | 4.20 | Agree |
| Increase in rainfall have a negative impact on fish farming | 5(12.5) | 10(25.0) | 6(15.0) | 15(37.5) | 4(10.0) | 2.93 | Undecided |
| Raining season starting earlier increase fish production | 22(55.0) | 16(40.0) | 1(2.5) | - | 1(2.5) | 3.35 | Undecided |
| Raining season starting earlier decrease fish production | 1(2.5) | - | 2(5.0) | 26(65.0) | 11(27.5) | 1.85 | Disagree |
| Occurrence of flood in fish farm area increases fish production | 2(5.0) | 1(2.5) | 2(5.0) | 12(30.0) | 23(57.5) | 1.68 | Disagree |
| Occurrence of flood in fish farm area decreases fish production | 28(70.0) | 7(17.5) | 3(7.5) | 1(2.5) | 1(2.5) | 4.50 | Agree |
| Long period of hot season decrease fish production | 21(52.5) | 12(30.0) | 4(10.0) | 3(7.5) | - | 4.28 | Agree |
| Long period of hot season increase fish production | 3(7.5) | 3(7.5) | 2(5.0) | 15(37.5) | 17(42.5) | 2.00 | Disagree |
| Increase in temperature have a positive impact on fish production | 5(12.5) | 6(15.0) | 4(10.0) | 17(42.5) | 8(20.0) | 2.58 | Undecided |
| Increase in temperature have a negative impact on fish production | 15(37.5) | 11(27.5) | 5(12.5) | 5(12.5) | 4(10.0) | 3.72 | Agree |

Source: Field data, 2012. Key: SA=strongly agree, A = Agree, UD, Undecided, SD = strongly disagree.

Table 5: Distribution of the Adaptive Strategies employed by the respondents

| Variables | *Frequency | Percentage |
|---|---|---|
| Stocking in favourable condition | 4 | 10.0 |
| Flood control/provision of water outlet | 9 | 23.0 |
| Providing alternative water supply | 5 | 13.0 |
| Planting trees | 4 | 10.0 |

* Multiple responses recorded. Source: Field Survey Data, 2012.

The impact of environmental factors on monogenean communities have been stressed by many authors (Koskivaara, 1992; Mackenzie *et al*., 1995; Galli *et al*., 2001; Sures 2004; Marcogliese 2005; Hudson *et al*., 2006; Bayoumy *et al*., 2008) and found that several factors including water temperature, dissolved oxygen, pH, and total ammonia-nitrogen could influence monogenean proliferation in different fish species. In this study, water chemistry investigated from the two ponds in relation to monogenean prevalence has revealed some considerable changes in monogenean infestation among the two fish species examined. Very few studies have considered interaction between monogenean and water quality parameters especially in field-based study. For example, Koskivaara *et al*. (1991) demonstrated a correlation between Gyrodactylids diversity with roach and water quality. Bayoumy *et al*. (2008)

correlated five monogenean species with water temperature and heavy metals in some Egyptian Rea Sea fishes and confirmed that water quality especially temperature enhanced monogenean life cycle.

A rise in water temperature accelerates chemical reaction, reduces the solubility of gases, amplifies test and odour, and elevates the metabolic activity of organisms (Chandrasekhar, 2006). The water temperatures observed in these ponds were considerably lower when compared to natural water bodies in the region (e.g. Kenyir Lake). The maximum water temperature recorded in pond 'A' and pond 'B' were 31.9 and 30.2$^{O}$C while the highest temperature of Kenyir Lake was 32.83$^{O}$C (Modu *et al*., 2012). This variation may be attributed to several factors such as human activity, pond inputs like feeds and fertilizers. Ponds in the study site were mechanically aerated to increase oxygen content and such process can easily decrease the water temperature, as the pond water bubbles the free atmospheric oxygen is being mixed thereby increasing the oxygen content in the pond water, conversely it may influence the proliferation of monogeneans (Bayoumy *et al.*, 2008). In all cases of monogenean species investigated, prevalence was higher during non-monsoon (April to July) period and lower during monsoon (November to February). According to Boyd and Tucker, (1998), seasonal pond water temperature changes may impair immune function of fish, even if changes occur within the range considered optimal.

The pH values recorded in pond 'A' and pond 'B' were not similar. Pond 'A' is an alkaline pond as observed in the water quality analysis (pH >9). This pond had some vegetation cover, and photosynthetic processes possibly added some nutrients, while death and decay of plants might have enhanced build-up of microbes which in turn changed the water chemistry. pH in pond 'B' did not reach 8.5 and hence considered as ideal pond for the stocked cat fish to survive. In both ponds, relation between pH and five gill monogeneans prevalence are not significant (P>0.05).

The dissolved (DO) concentration recorded in the ponds were within the safe level (range 5.5 – 8.4 mg/L) as suggested by Svobodova *et al*. (1993). During the non-monsoon DO tend to be low due to increase in metabolic activity and diurnal fluctuation due to respiration. At this season, aeration activity was observed in both fish ponds because it is the only possible means to increase the DO level in the ponds. Monogenean prevalence at this time was observed to be higher. However, this condition usually favours monogenean infestation. But any deviation from this act or depletion in DO and sudden decrease in water temperature tend to reverse the condition (Bauer *et al*., 1973). Unlike their temperate counterpart, tropical monogeneans can easily proliferate faster during high DO and high temperature period. This situation was clearly observed in this work, where four among the five monogenean species recovered (*D. hampali, D. macrolepidota, C. malayensis* and *C. sundanensis*) from two fish species examined at AEC, Perlok showed high peak of infestation (> 75%) during non-monsoon period (Table 1). At monsoon period constant rain and air turbulent enhanced solubility of free oxygen to the ponds thereby increase the level of DO.

Total ammonia-nitrogen (TAN) in aquatic ecosystem is a by-product of fish protein metabolism and bacterial decomposition of organic matter (Francis-Floyd *et al*., 2009). TAN is the combined measures of its two forms; un-ionized ammonia ($NH_3$-N) and ammonium ion (NH4+). The decay of uneaten food and organic matter create small amounts of ammonia, but in most aquaculture systems, fish themselves are the primary source of the compound. The more feed a fish receives, the more ammonia it will produce (Francis-Floyd *et al*., 2009). The concentrations of TAN observed in both fish ponds are subject to the increase in the pond water temperature and pH as suggested by Boyd (1982). In the present study, the results showed that concentrations of TAN and Un-ionized ammonia in pond 'A' (Hampala pond) increased as pond water temperature and pH increased. This condition might influence monogenean proliferation and in certain instance it might reduce their population especially during the non-monsoon period. According to Colt and Armstrong (1979), as ammonia level increases in water, ammonia excretion by fish decreases and levels of ammonia in blood and tissues increases. Boyd (1982) added that the outcome of such situation can adversely affect enzyme-catalysed reactions and membrane stability, thus fish immune capability reduces (Perpana, 1996) which favour parasites and other

microbes to build up in the affected fish. In general, according to Boyd and Tucker (1998), the rate of ammonia production in a cultured pond is proportional to the feeding rate. In a nutshell, about 0.03 Kg of ammonia-nitrogen is excreted by fish per 1kg of high quality (25 – 40% crude protein) feed consumed (Boyd and Tucker, 1998). Elevated levels of ammonia in the ponds at AEC, Perlok presented in this study might be due to the postulated theory by Boyd and Tucker, (1998) in that fish from this organization are apparently fed with high quality feed supplement (45% crude protein).

**Conclusion**

This study examined the effects of climate change on aquaculture production and management in Akure Metropolis of Ondo State, Nigeria. Fifty (55) percent of the respondents were into fish farming for improved living standard through increase income and livelihood and 48% depended on the stream / river as a source of water. All the respondents were aware of climate change and observed various changes in climatic parameters. Most of the respondents agreed that increase in rainfall had a positive impact on fish farming and the occurrence of flood in fish farms will result in a decrease in fish production. However, 33% of the respondents were aware of adaptive strategies to mitigate the effects of climate change on fish farming.

Finally, the results of the present study showed that there are significant correlations between all species of monogenean parasites and water temperature from both ponds ($P < 0.05$). This condition was observed where management, prevalence and intensities were more pronounced at higher temperatures ($> 29^{O}C$), particularly during the non-monsoon (dry season, March to July) in contrast to those observed during monsoon time (November to January) in both fish species. The present finding also statistically justified that the water temperature and dissolved oxygen are the two major water quality parameters influencing the proliferations of most of the management species recovered on the two fish species investigated.

Based on the findings of this study, the following recommendations were made in order to increase fish production and productivity of fisher folks in the study area: Government should bring up a policy that would favour fish farmer and provide credit for them in order to enhance their production; and Extension services should be made available to the fish farmers to encourage them to keep climate variable records which will be useful for climate variable forecast.

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