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## Impact of Climate Change on Brackish Water Aquaculture Development in the Coastal Areas of Niger Delta

O.A. Akinrotimi and O.M. Edun

African Regional Aquaculture Center, Nigerian Institute for Oceanography and Marine Research, Buguma, P.M.B. 5122, Port Harcourt, Rivers State, Nigeria

*Corresponding Author: O.A. Akinrotimi, African Regional Aquaculture Center, Nigerian Institute for Oceanography and Marine Research, Buguma, P.M.B. 5122, Port Harcourt, Rivers State, Nigeria*

### ABSTRACT

The issue of climate change has generated a lot of concern among the general public in Niger Delta region in recent time. It has been described in different ways by many people based on their views, perception and understanding. However, little considerations have been given to the impact of climate change on brackish water aquaculture in the coastal areas of Niger Delta. This study therefore, review critically, based on existing literature and field experience, the causes of climate change, impact of climate change on aquaculture production such as: increase in temperature, flooding of ponds, increase in water turbidity, heavy siltation of pond bottom, introduction of new species, collapse of farms infrastructure and fluctuations in salinity levels. Also, various adaptation and mitigation strategies that will ameliorate the impact of climate change in aquaculture operations, namely: reduction in human activities that are inimical to stable climate, selection of good site suitable for fish farming, provision of shading materials for fish cultured in tanks, raising of pond dykes, good management practices and improvement of monitoring and early warning systems are explicitly elucidated. As these strategies will go a long way in minimizing the impact of this menace, in the brackish water zone of the region. Moreover, efforts should be made by relevant institutions and agencies to come up with coordinated plans and policies that will reduce the effects of climate change on brackish water aquaculture in the coastal areas of Niger Delta.

**Key words:** Climate, fish, coastal environment, fish farming, Niger Delta

### INTRODUCTION

The Niger Delta is situated in the Atlantic coast of southern part of Nigeria and is one of the largest delta land form in the world, with vast coastal plain, rich biodiversity and abundant reserve of mineral resources (Akinrotimi, 2012). The region is known to have many streams, plethora of rivers and numerous tributaries which flow into the Atlantic Ocean through the Gulf of Guinea (Mangut and Egbefo, 2010). One of the unique features of this zone is its large expanse of coastal areas (Fig. 1), which include saline swamps, creeks and estuaries, which form an integral part of the region (Table 1).

These coastal zones are dynamic in nature and the processes that occur within them provide diverse and useful ecosystem that are essential for the populace utilization (Kay and Alder, 2005). These areas are highly productive with significant biological diversity, rich fishery resources and important sea bed minerals (Cummins *et al.*, 2005). Moreover, the region has a good capacity of



Fig. 1: A typical Niger Delta coastal environment, Source: Field survey (2013)

Table 1: Classification of the Niger Delta

Zones	Area (km <sup>2</sup> )
Low land area	7.400
Fresh water swamp	11.700
Saline swamp	5.140
Rivers	679.000
Sand barrier islands	1.000
Estuaries	688.000

Source: Ashton-Jones *et al.* (1998)

supporting a large array of flora and fauna, with a good vast land and water resources that can adequately sustain a wide range of fish farming practices such as brackish water aquaculture (Akinrotimi *et al.*, 2010a).

Generally, aquaculture like many other farming activities depends on the use of natural resources such as water, land and suitable environmental factors, as production of fish in any locality is driven by these factors (Jamu and Ayinla, 2003). The constant dynamic status of the coastal areas of Niger Delta has made it easier for it to be influenced by numerous human activities and natural phenomenon such as oil explorative and industrial activities, building, dredging, land reclamation and incidence of climate change. The concept and perception of climate change varies significantly among fish farmers in the brackish water zone. This has generated a lot of concern over the last decade. This has been defined and interpreted in so many ways, with the reality accepted by many and refuted by few people among the populace dwelling in these areas (Lomborg, 2001; Akinrotimi *et al.*, 2010b).

Conversely, it is generally believed that livelihoods of the people in the coastal areas will be affected in one way or the other by climate change and one major way will be food production system in the natural environments (IPCC., 2007). Climate change is expected to have a high impact on food security. This may specifically affect Niger Delta, since predictions indicate that the climate in the region may be subjected to more extreme conditions and food security is already at risk in many parts of the region. It is very crucial to note that little considerations have been given to the impacts of climate change on aquaculture. The responsible management of the resources and ecosystem upon which this important sector depends is a major challenge for world food security (De Silva and Soto, 2009). At the same time, fish farming activities are being threatened by some external factors such as pollution, run offs and land use transformation process, a competing aquatic resources upon which the impacts of climate could have a compounding effect (Aye *et al.*, 2007).

There is a strong scientific evidence of the incidence of climate change in Niger Delta. However, information on its impact on brackish water aquaculture, a common practice in the coastal area of Niger Delta is limited. This study therefore, reviewed critically the meaning, importance and impacts of climate change on brackish water aquaculture production. Also various strategies for mitigating the effects of these were clearly elucidated. This will provide vital information to fish farmers on various aspects of their vulnerability to the phenomena of climate change and possible strategies for adaptation.

## **BRACKISH WATER AQUACULTURE PRODUCTION**

Brackish water fish farming is a system of aquaculture that focuses on the production of quality fin and shell fishes that are found in the creeks, lagoons and estuaries through rational rearing (Akinrotimi *et al.*, 2011). In Niger Delta, the practice of brackish water aquaculture is viable, because of large expanse of saline mangrove swamps suitable for development of commercial fish farming. The potential of brackish water aquaculture production in Niger Delta is tremendous, because of numerous culturable species of fish that abound in the region (Table 2).

These species easily moves from brackish to marine or fresh water depending on the month of the year (Akinrotimi *et al.*, 2009a). Moreover, Ezenwa (2006) reported that the Niger Delta region can raise aquaculture production to about 1,200, 000 Mt of fish (Table 3) and further observes that the region can actually be the food basket of the nation if proper attention is given to the area. In addition to culture of fin fishes, there are numerous shell fishes such as oysters, shrimps, clams, cockles and periwinkles, these are extremely abundant in the brackish water zone and can be cultured with minimal capital input in most communities located the coastal areas (Ansa and Bashir, 2007; Akinrotimi *et al.*, 2009b). Despite the tremendous potential of brackish water aquaculture in this region, there are myriads of problems facing the development of aquaculture production in this region, slowing down the pace of its advancement, one of such challenges in recent times is climate change (Akinrotimi, 2012).

Table 2: Culturable fin and shell fish species in brackish water zone of Niger Delta

Species	Market value	Potential yield
<b>Fin fishes</b>		
<i>Tilapia guineensis</i>	Very good	Very high
<i>Sarotherodon melonotheron</i>	Low	Very high
<i>Lutjanus goreensis</i>	Very good	Low
<i>Mugil cephalus</i>	Good	Very high
<i>Liza falcipinnis</i>	Good	Moderate
<i>Liza grandisquamis</i>	Good	Moderate
<i>Megalops atlanticus</i>	Low	Moderate
<i>Chrysichthys nigrodigitatus</i>	Very good	High
<i>Pomadysis jubelini</i>	Low	Low
<b>Shell fishes</b>		
<i>Crassostrea gasar</i>	Good	Very high
<i>Tympanotronus fuscatus</i>	Good	Culture still experimental
<i>Anadara senilis</i>	God	Culture still experimental
<i>Penaeus monodon</i>	Very good	Very high
<i>Thais coronata</i>	Good	Culture still experimental

Source: Anyanwu *et al.* (2007)

Table 3: Potential yield of aquaculture production from different water bodies in Niger Delta

Water body	Potential yield (Mt year <sup>-1</sup> )
Fresh water	500,000
Brackish water	400,000
Marine water	300,000
Total	1,200,000

Source: Ezenwa (2006)

## INCIDENCE OF CLIMATE CHANGE IN NIGER DELTA

Climate change is one of the most remarkable challenges confronting the global community today and such has been given different definitions by different people based on their perception and the way it affects them (Ifeanyi-Obi *et al.*, 2012). However, the most universal definition was the one by intergovernmental panel on climate change, which defined climate change, as a change in the state of climatic conditions which can be measured and identified through changes in the mean of its properties that persists for a period of time. It also refers to any change in climate over a period of time as a result of anthropogenic or human activity (IPCC., 2007). The subject of climate and predicted impacts on the environment and socio-economic system now constitute one of the most devastating environmental problems facing humanity.

In a recent survey conducted by the author recently, the level of awareness of the impact of climate change especially among fish farmers is very high (Table 4). Although many of them do not have the full knowledge of the impacts brought about by climate change (Table 5). Also, many of the fish farmers came to know about this, through personal experience and mass media (Table 6), due to some negative occurrence caused by climate change, which they have experienced on their farms in recent times.

## CAUSES OF CLIMATE CHANGE

There are four major causes of climate change namely: astronomical causes, volcanic eruptions, variations in solar output and human activity, among these, human activity has been recognized as the most prominent factor responsible for climate change (IPCC., 2002). This normally happens through the emissions of green house gases (mainly carbon dioxide, methane, halocarbon and nitrous oxide). In Niger Delta region, human activity changes the amount of green house gases in the atmosphere in three important ways.

Table 4: Awareness of climate change impacts among fish farmers in Niger Delta

Awareness	Frequency	Percentage
Yes	99	82.5
No	17	14.2
Indifferent	4	
Total	120	100.0

Source: Field survey (2013)

Table 5: Level of knowledge about climate change impacts in the coastal area of Niger Delta

Knowledge level	Frequency	Percentage
None	25	20.8
Low	63	52.5
High	20	16.7
Very high	12	10.0
Total	120	100.0

Source: Field survey (2013)

Table 6: Information sources on climate change to fish farmers in the coastal area of Niger Delta

Sources	Frequency	Percentage
Commercial effect	1	0.83
Internet	28	6.67
Religions bodies	1	0.83
Friends/relations	4	3.33
Personal experience	45	37.50
Newspapers	10	8.33
Radio/television	30	25.00
None	21	17.50
Total	120	100.00

Source: Field survey (2013)

**Burning of fossil fuels:** When fossil fuels such as coal, wood and petroleum products burn, they release green house gases, also human activities such as driving automobiles, cooking food, bush burning, gas flaring and industrial operations equally releases these obnoxious, gases into atmosphere (Anyadike, 2009). In Niger Delta, oil explorative activities are very common and predominant. One major way this industry is impacting on the climate of the region is through gas flaring. Niger Delta is reported to have over 123 gas flaring sites scattered all over the region, consequent of oil exploration, making the Niger Delta one of the highest emitters of green house gases in Africa (Akinro *et al.*, 2008).

**Removal of mangrove forest:** Mangrove forest is an important segment of the ecosystem in the coastal areas of Niger Delta; it serves many purposes, which ranges from stabilization of coastal environment to nursery for some shell fish and filtration of nutrient and sediments (James, 2008). The area covered by mangroves is influenced by a number of factors such as land position, rainfall pattern, sea level, sedimentation, storms and tidal regime. Removal of mangrove forests, where forests are cut down faster than they are replaced is a major contributor to climate change (James *et al.*, 2007). In Niger Delta, the loss of mangrove is a major cause of climate change. The mangrove that was hitherto more than 1,000, 000 ha had been reduced to 977,700 ha. Aggressive utilization for fire wood, clearing of new site for building or road construction and procurement of oyster spat (attached to mangrove root) has been majorly responsible for its exploitation (Idowu *et al.*, 2011). Depletion of mangroves has reduced the stabilization of ecosystem and further made the coastal areas prone to the effects of climate change (Akinrotimi, 2012).

**Increasing population:** There is population explosion in most of the Niger Delta states, as a result of the assumed lucrative opportunities in oil and gas industry. This phenomenon has led to increase in human activity, which invariably has led to more emissions.

#### **IMPACTS OF CLIMATE CHANGE ON BRACKISH WATER AQUACULTURE**

On the issue of climate change, not all climatic changes are likely to have impact on aquaculture directly or indirectly (De Silva and Soto, 2009). In Niger Delta, the impact of climate change on fish farming activities can not be attributed to one single factor of climate change, it is usually a combination of two or more factors producing effects at a particular time. The impact of climate change in any area depends mainly on various factors such as: level of pollution, season, location, population and some level of industrial activities. Some of the impacts of climate change on aquaculture development in the coastal areas of Niger Delta are as following:

- **Increase in temperature:** Fish like other aquatic animals are poikilothermic i.e. their internal temperature are regulated and controlled by their external surroundings. Therefore, any change in the temperature will have a significant effect on their general metabolism, growth and adaptive capacity in the culture medium. In Niger Delta, the bulk of aquaculture productions are from earthen pond, concrete and plastic tanks culture system. The increase in air temperature will cause increase in vaporization in these rearing facilities. Moreover, increased temperature will also result in reduction of oxygen level and increase the incidence of algal bloom in the culture medium, which subsequently in extreme cases, lead to mortality of fish

- **Flooding of ponds:** One of the major impacts of climate change in the brackish water zone of Niger Delta is excessive flooding (Table 7). This is a situation where rearing ponds are partially or completely submerged under water for a period of time, this phenomenon leads to the escape of stocked fish, which will bring loss to the farmers (Fig. 2)
- **Increase in water turbidity and heavy siltation of ponds:** Consequent of rise in sea level as a result of climate change, there is turbulence action in waters found in this zone, this leads to increase turbidity of water, that flows into the pond at high tide, after some time, the sediments in the water column will settle at the pond bottom, which results in quick build up of silts, thereby enhances the pond siltation and thereby making the ponds shallower and unsuitable for fish culture
- **Introduction of new species and refuse wastes:** Climate change in the coastal areas will results in increase soil erosion, which will lead to introduction of some new species i.e. both flora and fauna into the area. For instance in recent times, new species such as *Nypa* palm and some refuse wastes were reported in some fish farms located in Buguma and Degema area of Rivers State (Fig. 3), which in past time has not been observed (Akinrotimi, 2012)
- **Collapse of pond dyke and sluice gate:** In the coastal areas of Niger Delta, the tidal water, which flows into the ponds, exerts much pressure on the pond components such as dykes and sluice gate as a result of tremendous increase in sea level. This phenomenon has led to broken dykes and collapsed sluice gates in many fish farms located in the brackish water environment (Fig. 4)

Table 7: Impact of climate change commonly experienced by fish farmers in the coastal areas of Niger Delta

Impact	Frequency	Percentage
Excessive temperature	5	4.17
Flooding	60	50.00
Introduction of new fish species	2	1.67
Irregular tidal regime	7	5.83
Introduction of new plant	3	2.50
Damaging of pond dyke and sluicagate	30	25.00
Excessive garbage in the ponds	3	2.50
Water turbidity/siltation of pond	10	8.33
Total	120	100.00

Source: Field survey (2013)



Fig. 2: Flooding of a fish farm in the coastal areas of Niger Delta, Source: Field survey (2013)



Fig. 3: *Nypa* palm observed in some fish farm in Niger Delta coastal areas, Source: Field survey (2013)



Fig. 4: Collapse sluice gates and dykes consequent of climate change, Source: Field Survey (2013)

- **Fluctuations in salinity levels variations:** Recently, there has been a variation in the levels of salinity in the coastal areas which has adversely affected the culture of fish in this zone. In the areas that are close to the sea, the salinity levels have increased, consequent of sea water incursions into these areas, where in areas far from the sea the salinity becomes usually too low, making it unsuitable to culture some species of fish (Akinrotimi, 2012)

#### **ADAPTATION AND MITIGATION STRATEGIES TO CLIMATE CHANGE IN AQUACULTURE**

The term adaptation and mitigation are two important terms that are very crucial in the climate change debate. Adaptation has been defined as adjustment in natural or human systems in response to actual or expected climatic change or their effects. While mitigation tackles the causes of climate change, adaptation tackles the effects of the phenomenon (IPCC., 2002). Some of the adaptation and mitigation strategies are highlighted below.

**Reduction in human activities:** Human activities such as gas flaring should be reduced drastically to minimum possible level, so as to minimize the impact of climate change in the region. Government should begin the process of implementing policies to reduce the emissions of green house gases, through oil explorative activities.

**Good site selection:** Good site should be selected when establishing a fish farm, low lying areas prone to flooding should be discouraged. Also areas close to the sea and flood plains of a major river should equally be avoided.

**Provision of shading materials:** Shading materials such as palm fronds should be used to reduce the incidence of high temperature and direct impact of sun induced by climate change in tank culture systems, so as to achieve optimum performance of fish in the culture medium (Fig. 5).

**Raising of dykes and regular reinforcement:** The dykes should be raised very high to about 4.0-6.0 ft, above the ground level so as to prevent fish from escaping during flooding. This will go a long way increasing availability food fish and increase yield (Fig. 6).



Fig. 5: Shading material to reduce impact of sunlight, Source: Field survey (2013)



Fig. 6: Elevated dykes to control flooding in a fish farm, Source: Field survey (2013)

**Effective management practices:** Fish farmers should be encouraged to be more efficient in day to day management of their fish farms, with the use of better feed and should be more careful in handling of fish in culture medium so as to reduce the effects of excessive temperature and also to desilt the pond bottom at least once in a year.

**Improve monitoring and early warning systems:** Government should improve weather monitoring and early warning systems across the country, so as to give signal to fish farmers about impending climatic change and the significance of climate change to the region ecosystem, so that there will be adequate preparation on the part of the farmers on what to do to salvage the situation.

## CONCLUSION

The effect of climate change on brackish water aquaculture in the coastal areas of Niger Delta is increasing. There is the need for government agencies and relevant institutions to come up with coordinated plans and policies that will ameliorate the effects of climate on aquaculture production in Niger Delta. The context for which these policies can accommodate climate change and still addressing issues of poverty alleviation and food security across the region is urgent and crucial for the sustainable development of aquaculture and achievement of millennium development goals.

However, integrated approach policy should be adopted, in solving the issue of climate change, this approach should be recognized the effects of climate change on the local fish farmers and design an all-encompassing strategy to meet these needs. The approach should also take into consideration existing coping strategies of the local fish farmers to changes in their environment and build on them through policy formulation, with adequate participation of the fish farmers in the coastal areas.

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