Offshore aquaculture practice; a potential for meeting Nigeria fish demand – a review

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Abstract. The demand for fish in Nigeria is still not met, despite having a domestic production estimated at about 800,000 metric tonnes. The demand stands at about 2.1 million metric tonnes per year. There is a shortfall of about 1.3 million metric tonnes. To solve this problem Nigeria has turned to fish importation while several other policies are being put in place by successive administrations to improve on local production. However, none of the efforts has been successful so far. The aim of this paper is to assess the potentials of offshore aquaculture within the exclusive economic zone (EEZ) of Nigeria with the view of meeting the fish demand of Nigerians. The paper develops a framework for the operation of offshore aquaculture. The implications of climate change on offshore fish production along the coastal area were highlighted. Strategies and policy measures needed to combat the challenges facing offshore aquaculture in order for it to live to its full potentials in protecting the living welfare of the fishermen and ensuring food security are also discussed.

KEY WORDS: Offshore, climate, livelihood, Mariculture, Exclusive Economic Zone.

1 INTRODUCTION

The oceans have huge potentials to support aquaculture. The oceans of the world are laid with aquaculture potentials that provide enough space that can produce 15 million metric tons of fin fish every year [1]. According to [2 and 3], this value is above 100 times the current global seafood consumption. If the oceans are to be used for aquaculture, it would not take up to 1% of the total ocean surface to produce the same amount of seafood that is currently produced worldwide through fishing in the wild [4].

Nigeria has a maritime country has many aquatic resources that makes significant contributions to food security and the overall economy of the nation [5]. The country’s marine fisheries resources are enormous.
and offered many opportunities for fish production through capture and culture fisheries. Nigerians exploit fisheries resources in the coastal water bodies largely by artisanal fisheries. In the process, they employ simple fishing gear and equipment [6]. The artisanal sub-sector employs over 8 million fishermen, another 18 million people engage in fish processing, distribution and marketing [7]. Despite a domestic production pegged around 800,000 metric tonnes, Nigeria is still left with about 1.3 million metric tonnes to cover, with national fish demand standing at about 2.1 million metric tonnes yearly. To solve this problem, Nigeria has turned to fish importation which is estimated at 1.9 million metric tonnes per annum [8]. Various administrations have tried to boost local production by formulating several policies but none have been successful as the situation still persists.

According to FAO sub-committee on aquaculture in 2010, aquaculture should move further offshore if the world is to meet its growing demand for seafood [9]. With the way human population keeps increasing, will humans have the ability to feed the world’s growing population with nutritious food in the centuries to come? The answer might be in how effectively we use the oceans. This paper thus aims to discuss the potentials of offshore aquaculture as a means of bridging the shortfall of fish supply in Nigeria.

2. STATE OF AQUACULTURE IN NIGERIA

Aquaculture has been in existence for more than 2,000 years [10, 11]. Asia and America are the World leading aquaculture producers. The United States of America (USA) aquaculture production is increasing rapidly. It rose more than 400 % between 1980 and 2000 [12].

Nigeria is still lagging behind in aquaculture production. She has not been able to meet domestic production demand for the populace despite its history dating back to about 50 years ago [13]. In Africa, Nigeria is the leading aquaculture producer. The production output is over 15,000 tonnes per annum [14]. Zambia, Madagascar, Togo, Kenya and Sudan trail from behind with a production slightly above 1,000 tonnes each [15]. This is an indication that Africa is generally far behind in aquaculture production. The projected population and fish demand/supply up to 2025 is presented in table 1. Up till recent year, Nigeria still fall short of fish supply up to the tune of 0.20 million tonnes of fish despite being the leading producer of fish from aquaculture in Africa (table 1).
Table 1
Projected population and fish demand/supply from 2000 to 2025 in Nigeria.

| Year | Population (million) | Fish demand (million tonnes) | Fish supply (million tonnes) | Shortfall (million tonnes) |
|------|----------------------|------------------------------|------------------------------|---------------------------|
| 2000 | 114.40               | 0.87                         | 0.53                         | 0.34                      |
| 2001 | 117.60               | 0.89                         | 0.57                         | 0.32                      |
| 2002 | 121.00               | 0.92                         | 0.61                         | 0.31                      |
| 2003 | 124.40               | 0.95                         | 0.65                         | 0.30                      |
| 2004 | 127.90               | 0.97                         | 0.69                         | 0.28                      |
| 2005 | 131.50               | 1.00                         | 0.73                         | 0.27                      |
| 2006 | 135.20               | 1.03                         | 0.77                         | 0.26                      |
| 2007 | 139.10               | 1.06                         | 0.81                         | 0.25                      |
| 2008 | 143.00               | 1.09                         | 0.85                         | 0.24                      |
| 2009 | 147.10               | 1.12                         | 0.89                         | 0.23                      |
| 2010 | 151.20               | 1.15                         | 0.93                         | 0.22                      |
| 2011 | 155.50               | 1.18                         | 0.96                         | 0.21                      |
| 2012 | 159.90               | 1.22                         | 1.00                         | 0.22                      |
| 2013 | 164.40               | 1.25                         | 1.04                         | 0.21                      |
| 2014 | 169.10               | 1.29                         | 1.08                         | 0.21                      |
| 2015 | 173.90               | 1.32                         | 1.12                         | 0.20                      |
| 2016 | 178.80               | 1.36                         | 1.16                         | 0.20                      |
| 2017 | 183.30               | 1.39                         | 1.20                         | 0.19                      |
| 2018 | 189.00               | 1.44                         | 1.24                         | 0.20                      |
| 2019 | 194.40               | 1.48                         | 1.28                         | 0.20                      |
| 2020 | 199.90               | 1.52                         | 1.32                         | 0.20                      |
| 2021 | 205.60               | 1.56                         | 1.36                         | 0.20                      |
| 2022 | 211.40               | 1.61                         | 1.40                         | 0.21                      |
| 2023 | 217.40               | 1.65                         | 1.44                         | 0.21                      |
| 2024 | 223.50               | 1.70                         | 1.48                         | 0.22                      |
| 2025 | 229.80               | 1.75                         | 1.52                         | 0.23                      |

Source: [16 cited in 14]

3. RECENT TRENDS IN OFFSHORE AQUACULTURE
Aquaculture is the fastest-growing animal food industry in the world. In 2010, more than 25 % of the global aquaculture production came from offshore aquaculture [17]. In the early 1990s, global offshore aquaculture production increased as the harvest from fisheries leveled off [18]. Although most of the developing nations practice aquaculture traditionally in freshwater, offshore aquaculture is currently increasing, and there is a strong interest in its expansion in those nations.

About 70 % of the earth’s surface is covered by water. [19, 20, 21]. However, little food is derived from the oceans. One could then wonder why these vast coastal areas have not effectively been exploited and the possibility of exploitation that will help feed humanity in the future [1]. To ascertain how far Nigeria has gone in offshore aquaculture, a look at what other countries have done will be of help as we can learn from progress or improve on their shortfalls.

3.1 OFFSHORE AQUACULTURE IN IRELAND
Ireland is the world largest producer of fish from the open ocean [21, 22]. Most of Ireland’s sheltered inshore waters are too shallow for finfish cage farming and nearly all of the farming companies operate a
mixture of inshore and offshore sites. This is because of its gentle slope of the continental shelf. Therefore, Irish farmers are very familiar with how unsuitable inshore technologies are for offshore use. They were among the earliest to test cages specifically designed for use in exposed sites.

3.2 OFFSHORE AQUACULTURE IN THE UNITED STATES OF AMERICA
According to [23], there is no offshore finfish aquaculture in the United States of America, with the exception of Blue Ocean Mariculture, which is located in Hawaii state waters and relatively close to shore but considered “offshore” by NOAA. Blue Ocean produces kanpachi (Hawaiian yellowtail) in InnovaSea Sea Stations. Established in 2009, Blue Ocean Mariculture is a small, growing company that hopes growth will bring costs down over time, once economies of scale are reached. Two prospective offshore farms are:
- The Rose Canyon project off the coast of San Diego
- Manna Fish Farms off the south shore of Long Island, NY. Both businesses have put considerable time and effort into the design, development, and communication of their operations but have not yet started production as they lack necessary permits. It is therefore impossible to judge the viability of their operations directly.

3.3 OFFSHORE AQUACULTURE IN THE UNITED KINGDOM
The English industry is predominantly re-laid in intertidal bays but considerable expansion of suspended mussel production in England is proposed (e.g. Offshore Shellfish Ltd, n.d.). There are no marine finfish farms in England and Wales but other marine farms do exist on land. Emerging offshore technology from Norway and Scotland, together with investment from a suitable industrial partner, may make offshore fish farming in England and Wales feasible in the future. A very useful and practical Toolbox has recently been released by [24], which provides a detailed and comprehensive inventory of the regulatory requirements with respect to the whole range of aquaculture types in England. Seaweed culture is at the experimental stage in the UK. There are very little volumes of several species produced for experimental use and for specialty food ingredients [25].

4. POTENTIALS OF OFFSHORE AQUACULTURE IN NIGERIA
Nigeria has what it takes in term of resources to compete with the world leading aquaculture nations. Some of these potentials include:
- More than 260 medium and large dams. These dams have a combined storage capacity above 30 billion cubic meters of water [26]. The dams can be used for cage and pen aquaculture.
- More than 850 km coastline and a maritime water of 210,900 km² including the Exclusive Economic Zone [27, 28, 29].
- A narrow continental shelf extending, for only about 15km in the western area and ranges from 60–80km in the eastern tip. This condition limits the trawl-able grounds to 3200nm² of the 1147nm² continental shelf area. The inshore waters (0–50m) are characterized by a variety of small fish species varying from 25 to 50cm in total length [30].

All these potentials have not been fully utilized to cover the gap in the short fall between total domestic fish production and the total domestic demand. Generally, the growth in agricultural sector in Nigeria has fallen short of expectations [31].
5. SYSTEMS OF COMMERCIAL AQUACULTURE IN NIGERIA

5.1 Freshwater Aquaculture
Some cultivable fish species cultured in Nigeria, which are capable of thriving well in the fresh water environment, include: *Clarias gariepinus*, *Clarias lazera*, *Heterobranchus bidorsalis*, *Heteroclarias*, *Tilapia sp.*, *Tilapia mariae*, *Oreochromis niloticus*, *Oreochromis mossambicus*, *Sarotherodon galilaeus*, *Sarotherodon melanotheron*, *Tilapia zilli*, *Tilapia guinensis*, *Hereterotis niloticus*, *Chrysichthys nigrodigitatus* and *Cyprinus carpio*, and so on. However, there has been three major freshwater fish genus farmed in Nigeria, namely, *Clarias*, *Tilapia* and *Heterotis* [32]. Apart from the earthen ponds, tank cultivation is characterized by high yield, with its efficiency dependent on aeration, water quality and flow rate [33]. Tanks are usually made from treated wood, concrete or PVC plastic and fibre glass, with capacities ranging from a few hundred litres to several thousand cubic metres [32]. Even though this cultivation technique is a capital intensive venture, the input is usually relatively quickly recovered if the system is well managed. The Nigeria freshwater aquaculture technology is developing, still undergoing research and has gained steady recognition, due to the increasing demand for cheap source of protein and livelihood that has seen the need for sustainable production [34].

5.2 Brackish-Water Aquaculture
“Naturally, brackish water environment is characterized with the salinity of the water fluctuating widely from negligible to 30‰, depending on the phase or phases of the tide and volume of fresh water discharged through the river into the sea” [35]. Brackish water fish farming produces fin and shell fish that are found in the creeks, lagoons and estuaries through rational rearing [36]. According to [37], there are about 729,000 ha of saline mangrove swamp suitable for development of commercial fish farming. Brackish water fish farming mainly works by letting the tidal wave to bring water into the already prepared ponds and fill it to the desired depth, and also allowing the outflow of the water during low-tide to a minimum tolerable depth [38]. Many fin and shell fish species are found in brackish water area, which can be cultured with in many coastal areas at low cost. According to [39], most of the shell fish production is yet to be developed in commercial scales in Nigeria. Hence, there is the need to focus more on these areas, in order to enhance food security and employment opportunities for people living in the region.

5.3 Marine-Water Aquaculture
In marine-water aquaculture, the water chemistry requirement for salinity based on dissolved salts is 0.30-50 ppt. The teeming population of engineers of various disciplines, fisheries researchers (biologists and ecologists), seasoned aquaculturists, technologists, technicians and thousands of kilometers of low lying coastline containing billion cubic metres of marine water are offshore aquaculture great potentials [34]. The culture of marine fish species can be a possibility in Nigeria, if all the available potentials can be harnessed.

5.4 Marine-Water Aquaculture
In marine-water aquaculture, the water chemistry requirement for salinity based on dissolved salts is 0.30-50 ppt. Fish farming in this zone will have some major constraints because of the choppy conditions and heavy rainfall which occur in the coastal belt. The teeming population of engineers of various disciplines, fisheries researchers (biologists and ecologists), seasoned aquaculturists, technologists, technicians and thousands of kilometers of low lying coastline containing billion cubic metres of marine water are offshore aquaculture great potentials [34]. The continental shelf is narrow, extending for only about 15 km in the western area and ranges from 60 km to 80 km in the eastern province. The culture of marine fish species can be a possibility in Nigeria, if all the available potentials can be harnessed.
6. FRAME WORK ON OPERATION OF OFFSHORE AQUACULTURE

Offshore environments are characterized by high energy. In order for it to stand, facilities must be built to be stronger than their inshore counterparts [40, 41, 42]. The new technologies of offshore aquaculture should aim at reducing cost and maintenance of facilities. Offshore facilities can made more efficient and safer if they are automated [43] as being practiced in some developed countries. However, this will not come cheap. It will take time and money.

7. Major constraints of offshore aquaculture in Nigeria
1. Nigeria coastal areas, like other developed coastal towns in the world, are densely populated with heavy commercial and industrial activities, which results in pollution;
2. Inshore and offshore oil exploration usually leads to oil spill with a resultant effect on water chemistry and fish kill;
3. The Nigeria coastal water from Lagos to Calabar region is very shallow (what depth), while coastal offshore aquaculture (earthen) will require about 200 m depth above;
4. Under-develop technology for sustainable aquaculture production in land base industrial offshore aquaculture;
5. Lack of political-will on the part of government to have preferred crude oil to offshore aquaculture in the coastal area due to the dependent nature of the Nigeria mono-economy.

8. Environmental issues concerning offshore aquaculture

There are several environmental issues in coastal and offshore farming. Benthic impacts are of major concern in offshore aquaculture. There could be loss of secondary production due to eutrophication [44]. Another risk is disease spread between farmed fish and wild ones and vice versa. Various chemicals are used in offshore aquaculture. The use of these chemicals for treatment of cultured fish poses threats to the environment [45]. The impact of offshore aquaculture on water quality depends on the methods of culture that are used [46].

9. Potential biological benefits of offshore Aquaculture

There is greater water exchange through the culturing facilities in offshore aquaculture. This is brought about by a combination of wind and wave action, and tidal currents. The water tends to have greater dissolved oxygen with very low amount of ammonia. In term of temperature, the offshore zone experience balance temperature mixture. This cannot affect the fish at inshore farms negatively [48]. This ensures a better environment for the fish. Fish grown on offshore farms are favoured to have firmer flesh and are lower in fat levels compared to the inshore fish.

10. Conclusion and Recommendation

Nigeria is a good site for fish offshore aquaculture. It is a coastal state surrounded in the South by the Atlantic Ocean. First, potential Nigerian offshore aquaculture is very diverse. Nigeria has a very large exclusive economic zone with a good portion of the Atlantic Ocean. There are many different species which could be farmed in the Nigerian EEZ, using many different types of technologies which in a long run would bridge the gap in the shortfall being experienced in fish production from aquaculture. For effective offshore aquaculture practices, suitable areas for offshore aquaculture need to be identified and properly mapped out. This should be an exclusive duty of Federal Department of Fisheries (FDF). Proper policies to provide an overall plan for the development, management, and conservation of the Nigeria Exclusive Economic Zone need to be developed. Finally, proper monitoring should be ensured in order to keep the environment and the people safe.
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