

Aquaculture: Evidence from China and Nigeria

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Abstract

The results of this paper indicates that the state of Nigeria's aquaculture industry has been driven by Dependency Theory. But the state of the Chinese aquaculture industry has been driven by Modernisation Theory. Nigeria is the largest oil producer in Africa. Since independence Nigerian's only saw 10 years of elected government until the end of military rule in 1999. The military were not concerned with the needs and welfare of the country's citizens but with the needs of the US and European multinational oil companies. China started a series of ongoing economic reforms in 1978. These reforms incentivized farmers to farm fish. The reforms facilitated the development of institutions such as a legal and regulatory framework as well as centers of technological innovation. For the needs of food security it is imperative that Nigeria transforms its aquaculture industry based on the China model.

Keywords: Food Security, Aquaculture, Governance, Economic Development

1 Introduction

The aim of this paper is to assess the state of development of the aquaculture industry in China and in Nigeria; and whether this can be explained by Modernisation Theory or Dependency Theory. China is the world's largest producer of farmed fish, accounting for 36.7 million tonnes in 2010, FAO (2010). The next biggest producer of farmed fish was India with 4.6 million tonnes. The objective of the paper will be to evaluate how the lessons learnt from the development of the Chinese aquaculture industry can be applied to the development of the Nigerian aquaculture industry.

While China is the most populous country in the world, Nigeria is Africa's most populous country. But while China's population will reach a maximum by 2021 after which it is expected to decline, the population of Nigeria is expected to continue to grow. This will place increased demands for protein based food of which fish represents one type. However, the opportunities for capture fishing in Nigeria are dwindling due to overfishing and pollution of coastal waters. At the moment Nigeria's aquaculture industry cannot meet the shortfall in the domestic supply of fish and the government has to import fish for domestic consumption. This leads to a depletion of the country's foreign exchange reserves and gives rise to opportunity cost as the money could have been spent on improving the country's infrastructure, educational opportunities, employment training and aquaculture production facilities at home. A dynamic domestic aquaculture industry in Nigeria would relieve rural poverty by providing work and incomes to rural agricultural workers, enhance the country's food security and generate export expenditure for the country from the export of fish. The extent of the development of the aquaculture industry in Nigeria and in China may be explained by either Modernisation Theory or by Dependency Theory. This issue has not been addressed in the literature. By resolving this issue this paper will fill a gap in the literature and so contribute to the broadening of knowledge.

The structure of the paper is as follows. Firstly, the background of the problem which the paper evaluates will be discussed. Secondly, the economic framework, Dependency Theory and Modernisation Theory, for the analysis and evaluation of the problem of low aquaculture based fish production in Nigeria and the high levels of aquaculture based fish production in China will be explained. Thirdly, a case study of the Chinese and Nigerian aquaculture industries will then be presented. The criteria which will be analyzed for each country will include the location and type of the fish farms, government laws and regulations regarding the aquaculture industry, the nature of innovation in the aquaculture industry and the environmental impact of the fish farms. Fourthly, the results of the case study will be discussed. Finally a conclusion will bring together the elements of the paper in such a way as to provide a policy framework for the development and sustainability of the Nigerian aquaculture industry.

2. Background

This shift in the population growth of China and Nigeria will mean that the shift in dietary consumption which has been experienced by China over the last three decades will be experienced by Nigeria in the years to come, FAO (2012).

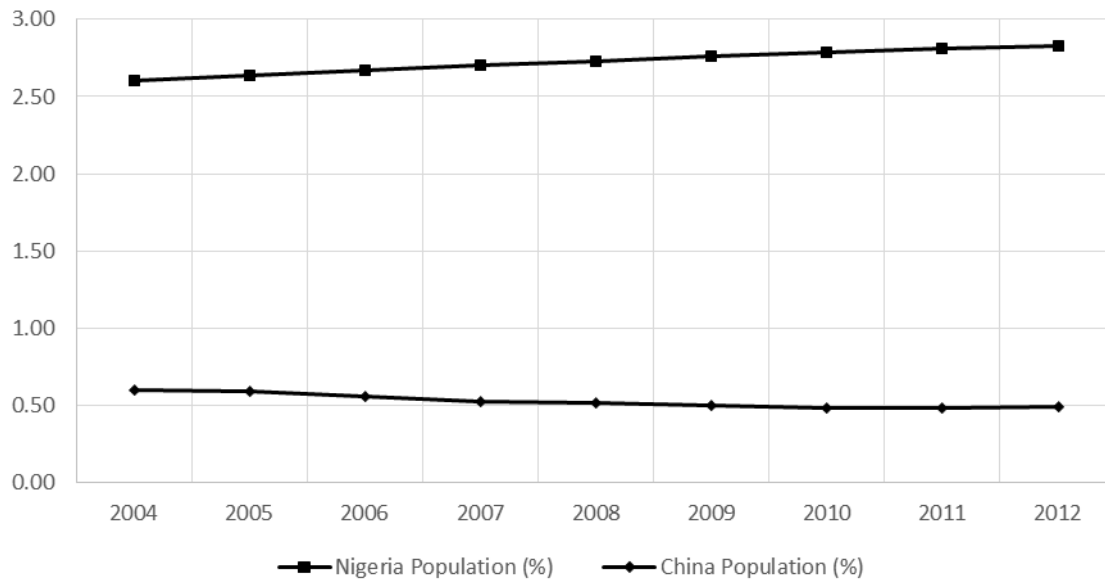


Figure 1: % Change in Total Population – Nigeria and China

Source: World Bank

It is possible to see from Figure 1 above that the trend percentage change in China’s population from 2004 to 2012 is between 2.5% and 3%. On the other hand it can also be seen from Figure 2 that the trend percentage change in Nigeria’s population from 2004 to 2012 is approximately 0.5%. China’s current total population is seven times as much as Nigeria’s.

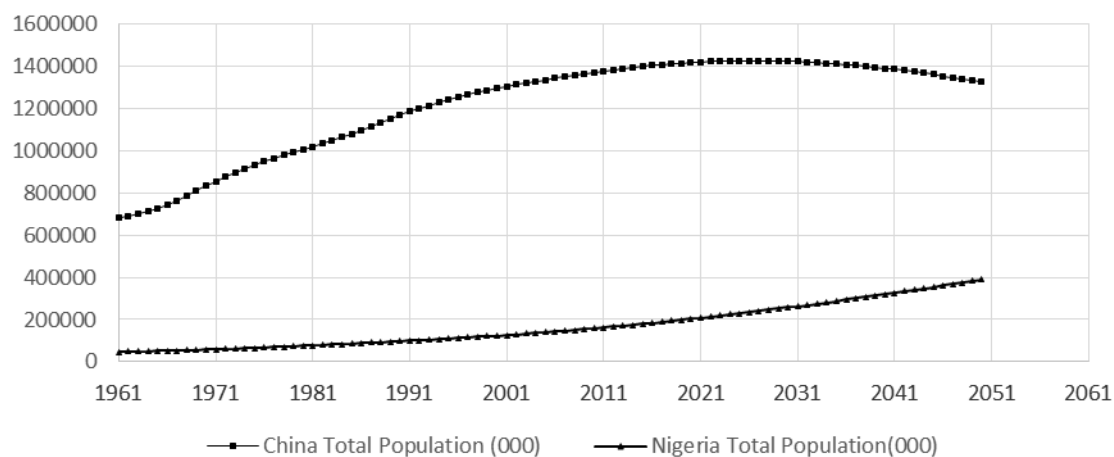


Figure 2: China and Nigeria Total Population – Projected and Estimated: 1961-2050

Source: www.fao.org

Figure 2 above shows that China’s population level will peak around 2021 before beginning to fall but Nigeria’s population level will begin to grow. China’s bigger population and rising incomes, over the reform years, as

meant that there has been a shift in the dietary consumption of China over the last three decades. This has ensured that there has been a shift from cereals to livestock as a result of an increase in Chinese incomes.

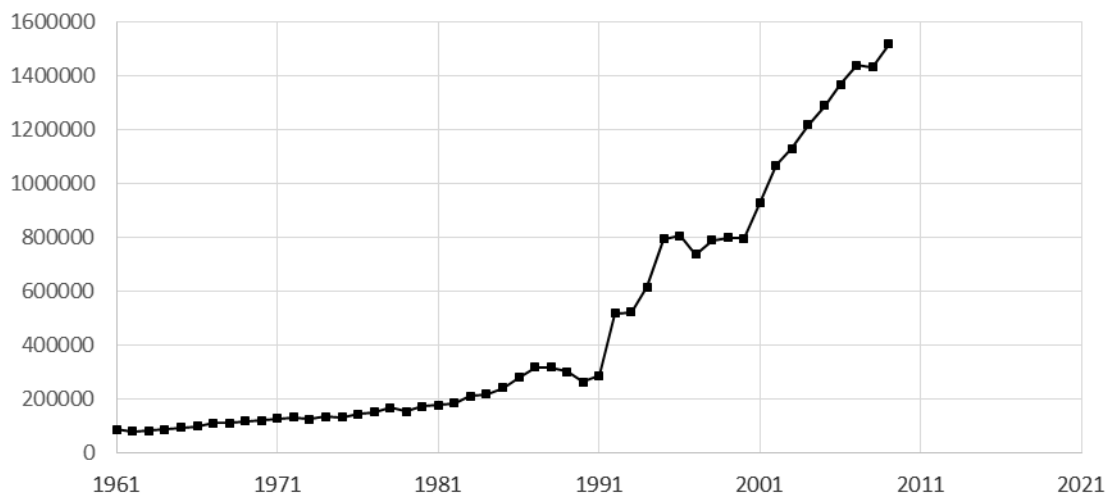


Figure 3: China Meat, Other supply quantity (tonnes): 1961 - 2009

Source: www.fao.org

The increase in livestock consumption has meant that more agricultural produce has been diverted to feeding livestock than to feeding the human population. The increased demand for meat in China for consumption is more evident after 1991 when the quantity of meat supplied begins to increase rapidly over the ensuing years. This is clearly evident from Figure 3, above.

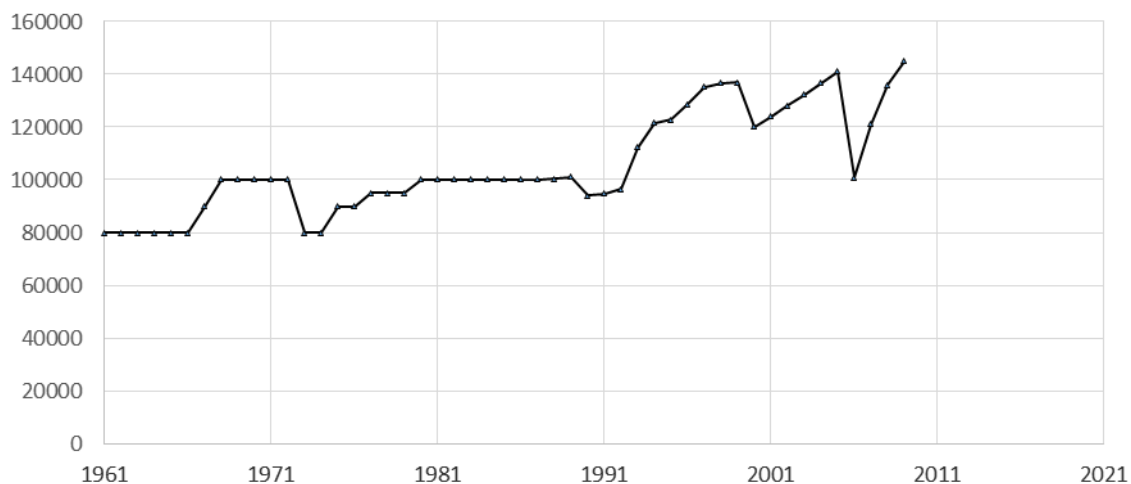


Figure 4: Nigeria: Meat, Other supply quantity (tonnes): 1961 - 2009

Source: www.fao.org

However, land based production of food seems to have limited capacity due to a lack of arable land, water and other resource inputs, Diana et al (2013). In the case of China, the country has 10% of the total arable land in the world in order to support 20% of the total global human population, Tao et al (2013). Increasing urbanization, increased desertification, increased loss of arable land due to pollution and increased meat consumption has caused loss of arable land and placed greater demands on agricultural production. Chinese government economic

and development policy has facilitated the development and the growth of the Chinese aquaculture industry. In a wider context aquaculture is a global industry with Asia being the biggest producing region representing 92% of the global total by production and over 79% by value, Asche (2010).

The supply of meat in Nigeria has remained relatively static from 1961 to 1991 after which it did rise dramatically. This is clear from Figure 4. But comparing Figure 3 to Figure 4 shows that shift in Nigerian dietary consumption to meat has not taken place. This is because the change in meat supply does not increase consistently in the Nigerian case has compared to the Chinese case.

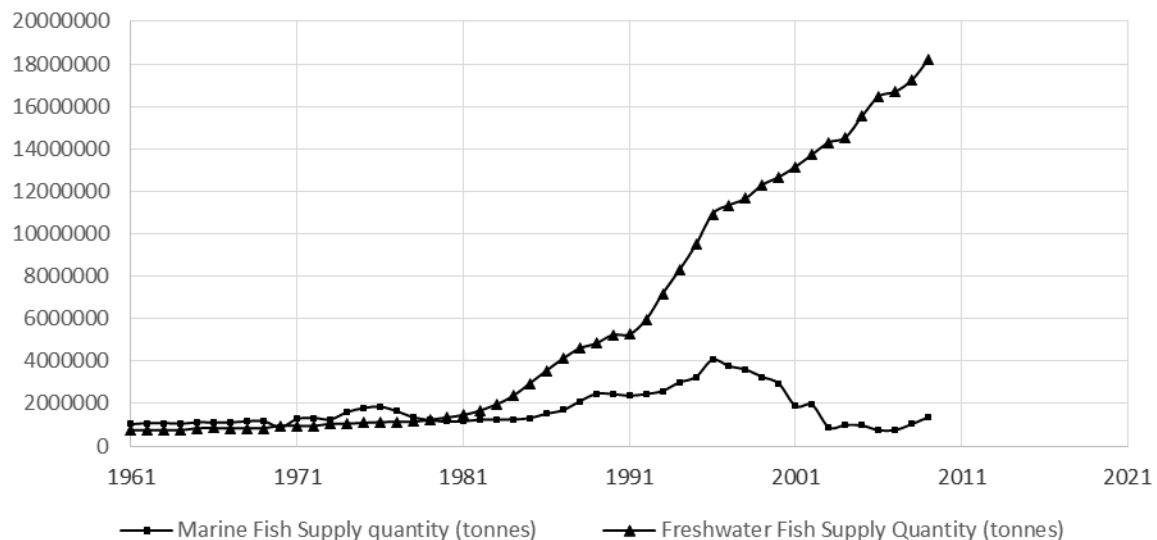


Figure 5: China: Marine Fish and Freshwater Fish Supply: 1961 - 2009

Source: www.fao.org

However, this hides the fact that in terms of value share of total aquaculture production China has 50%. And by volume share China has a 70% share of the total. Aquaculture based production of nutrient rich fish is a means by which the nutritional requirement of a growing population can be met. The growth of the aquaculture industry also favors employment generation and a reduction in a country's fish import expenditure, Grema et al (2011). It is estimated that at a global level there are around 54 million people working in the production of farmed fish with 26% of these workers being accounted for by China alone, FAO (2012b). More interestingly apart from employment in the primary sector, the production of farmed fish as a positive externality on the global employment sector, creating further employment opportunities for an estimated 660-820 million people in supporting activities ranging from the processing of fish to research and administration, FAO (2012b). Employment generation facilitates the reduction of rural poverty while the reduction in import expenditure on fish allows a country to reallocate its national expenditure to projects which would better stimulate sustainable economic development. Figure 5, above shows the quantity supplied of Marine and Freshwater fish in China from 1961 to 2009. It is easy to see that after 1978 the quantity of Freshwater fish supplied increased dramatically in contrast to the supply of Marine fish. This was entirely due to the post-1978 economic reforms which favored and facilitated the development of the Chinese aquaculture industry, Zhou et al (2013).

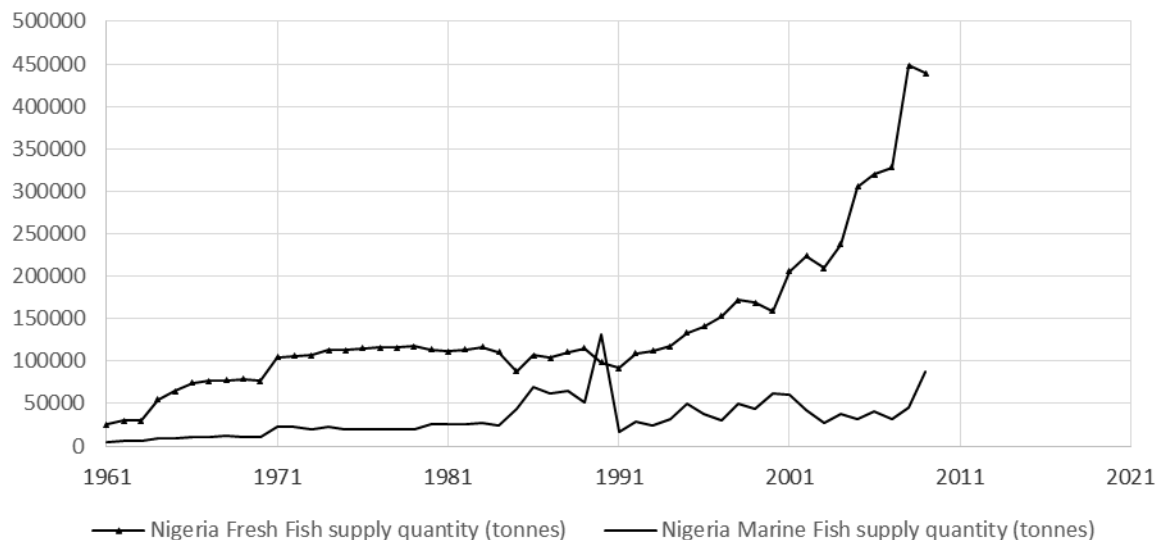


Figure 6: Nigeria: Marine Fish and Freshwater Fish Supply: 1961 – 2009

Source: www.fao.org

Figure 6 above shows the relative infancy of the Nigerian aquaculture industry compared to that of the Chinese aquaculture industry because the supply of Freshwater fish in Nigeria showed an upward trend after 1991 and a short spurt in growth between 2000 and 2001. On the other hand the supply of Nigerian Marine fish has remained relatively low since 1961. While China's aquaculture industry is much more mature than the Nigerian aquaculture industry it still needs to address issues of sustainability. The more intensive the cultivation of fish then the more unsustainable the aquaculture industry will become, Cao et al (2013). In China the intense cultivation of fish in lakes as resulted in dwindling fish populations, less aquatic diversity, intrusion into the lake ecosystem by foreign species and eutrophication, Jia et al (2013). Eutrophication is the process by which the aquatic ecosystem receives excess nutrients leading to the excess growth of aquatic plants. In China as in Nigeria there is also a big problem associated with water pollution. Despite water pollution and questions of sustainability the experience of the Chinese aquaculture industry can bring benefits to the Nigerian aquaculture industry as Nigeria seeks to contend with the issue of food security in the face of an inevitable and consistent increase in its population.

3 Dependency Theory and Modernisation Theory

According to Modernisation Theory economic development occurs through technological change, Andersen et al (2006). This technological evolution can only be led by changes in the nature of institutions within the country as well as 'traditional attitudes and values', Andersen et al (2006). While Modernisation Theory may be considered to be whole by itself it can also be viewed as a composite of theories, So (1990). These theories could include, for example, Functionalist Theory and Evolutionary Theory. Evolutionary Theory examines how societies transit from traditional to modern. On the other hand Functionalist Theory considers society as a biological organism in which the well-being of the whole system is dependent on the effectiveness of the interaction of different institutions or organs which have separate functions, So (1990). Functional Theory would suggest that the effectiveness of four functions is critical for the survival of society. Firstly, the economy must facilitate the adaptation of the country to the environment. Secondly, goals need to be set by the government and achieved. Thirdly, institutions should be linked together. This can be achieved through the legal system and by government. Finally, there needs to be latency. This means that values need to be passed from one generation to the next. It is easy to see that without effective Functional Theory, Evolutionary Theory would not lead to a progressive change in economic development. For example, if a state is not strong enough to allow institutions to develop over time, as China as done over the last 30 years, and neither follows progressive reform policies then economic development may regress. It is, therefore, easy to see that Evolutionary Theory is dependent on a working Functional Theory. So Modernisation Theory attempted to explain why a country was underdeveloped on the basis that institutions were not formed which facilitated effective governance; and that any existing

institutions did not or could not function together to foster economic development. Modernisation Theory can not only be used to explain why an economy may be underdeveloped. It can also be used to explain why specific sectors within the economy may remain underdeveloped.

Dependency Theory on the other hand contrasts with Modernisation Theory in the way in which economic development can be explained, Ethridge et al (2011). Dependency Theory supports the view that developed countries with advanced economic and military power maintain a political system such that developing countries find it difficult if not impossible to be able to achieve economic development. Another way about thinking about Dependency Theory and economic development is that economic development is prevented because developed economies demand for the natural resources of a developing country. This is accomplished through foreign investment and trade, ensuring that the developing country is unable to diversify its economy in to other sectors and so promote sustained economic development, Wong (2005). From the perspective of Dependency Theory, the development of Nigeria's oil sector has been at the expense of the other sectors of the economy. The high value of the country's oil exports has meant that wealth has been concentrated in the hands of a few with the rest of the population, particularly those in the agricultural sector, remaining poor. While Modernisation Theory may suggest that a country's economic development may be constrained due to internal factors, Dependency Theory allows for external factors such as trade and investment in one sector of the economy to be a constraining force on economic development, Wong (2005).

4 Case Study

4.1 Aquaculture Fisheries Management in China

The Chinese economy can be characterized as being centrally planned from 1949 to 1978. However, fearing that the economic and social needs of a vast population could not be met by such an economic system led Deng Xiaoping to start implementing free market economic reforms in 1978. The roots of these economic reforms lay in the agricultural sector in which peasants were allowed to use land to produce crops and sell some of it for profit, Wong (2005). However, the sale of land on a private basis was still not allowed. The partial reintroduction of the pricing mechanism back into the agricultural sector allowed farmers to accumulate wealth and thus boosted their productivity, Wong (2005). While the Chinese government instigated further free market oriented reforms to the economy over the next thirty years, an important fact which should be remembered is that the country's currency was managed. The artificially managed value of the currency meant that as a result of the country's free market economic reforms exports boomed.

Although aquaculture has existed in China for thousands of years, the roots of its modern rise lie in the post economic reforms of 1978, Zhou et al (2013). This has been primarily for two reasons. Firstly, the economic reforms reintroduced the price mechanism back into the Chinese economy. This would not only allow the scarcity and abundance of goods to be valued but also for profit to be determined. Secondly, in the 1980's Chinese government policy favored the development of the Chinese aquaculture industry for the nutritional value of seafood, the economic benefits for rural economic development and the reduction in pressure on traditional land based agriculture, Zhou et al (2013). Aquaculture in China can be either freshwater or marine based. In terms of area freshwater aquaculture in China is much bigger at 4.9 million hectares than marine aquaculture at 1.5 million hectares, Zhou et al (2013). However, in terms of production per hectare, marine aquaculture is much bigger at 8489 kg/hectare than freshwater aquaculture at 3916 k/hectare.

China's total population will continue to increase in the foreseeable future but will peak between 2021 and 2031 before falling back below 1.4 billion by 2031. However, this masks the fact that the urban population has increased significantly at the expense of the rural population which will decline. The increase in China's urban population has been most notable after the economic reforms of 1978. But the fall in the rural population was much more significant after 2001. In 2051, China's total rural population is estimated to be 250 million, while in 1978 it was about 800 million. China's increasing urbanization and urban incomes will increase protein consumption. This increase can be met by terrestrial production with the use of genetically modified crops. However, this poses several disadvantages. Firstly, crop production will have to meet the competing requirements of humans and livestock. Secondly, terrestrial crop production has a high carbon footprint. And, thirdly currently there is no way of knowing what the impact of genetically modified crops will be on either the ecosystem or on human and livestock health. Other limitations of increased terrestrial crop and livestock production in China, to meet the increasing protein consumption of the rising urban population, includes limited and dwindling arable land and water resources. Due to these issues it is easy to see that a sustainably managed

aquaculture industry will not only relieve the pressure on terrestrial agriculture production but also contribute towards sustainable development by reducing the carbon footprint associated with production. Furthermore, while arable land is limited and dwindling, the seas are abundant. Approximately 72% of the world's surface is covered in sea water which is divided into several oceans. China is surrounded by several seas including the South China Sea, the Yellow Sea, the East China Sea and the Sea of Japan. It also has easy access to the Pacific Ocean and the Bay of Bengal. The country also has more than 1500 rivers within its borders as well as a number of freshwater and saltwater lakes. The Yangtze is the largest river with the Grand Canal connecting five rivers, the Haihe, Yellow, Huaihe, Yangtze and the Qiantang rivers. China's freshwater lakes includes the Poyang, Dangting, Taihu and the Hongze while its saltwater lakes includes the Qinghai, Nam Co, Siling Co and the Poyang Lakes. Fujian province has its coastline on the Taiwan Strait with several rivers flowing into it from the province. These rivers includes the Min, Long, and Jiulong rivers with the Luo and Jin rivers to be found in Quazhou Bay.

Declining offshore fish stocks and declining offshore fishing grounds due to the formation of PMZ's and TZ's due to agreements with Japan and Korea has led to a reduction in China's offshore fishing capacity. This led to the Chinese government favoring the development of inshore aquaculture at the expense of offshore capture fishing, China Daily (2005). As a result the Chinese government placed a quota on offshore fish catches and national and local governments budgeted for taking up to 14000 fishing boats out of service, China Daily (2005). The surplus fishing labour would then be transferred to the inland aquaculture industry, Xue (2005). The 11th Five Year Plan of 2006 to 2010 had specific objectives related to the development of China's aquaculture industry, Fang (2007). These included increasing the quality and quantity of the country's aquatic products, increasing employment opportunities for farmers as well as promoting the aquaculture industry's sustainable development by developing resource conserving fisheries, Fang (2007).

4.1.1 Location and Type of Fish Farms

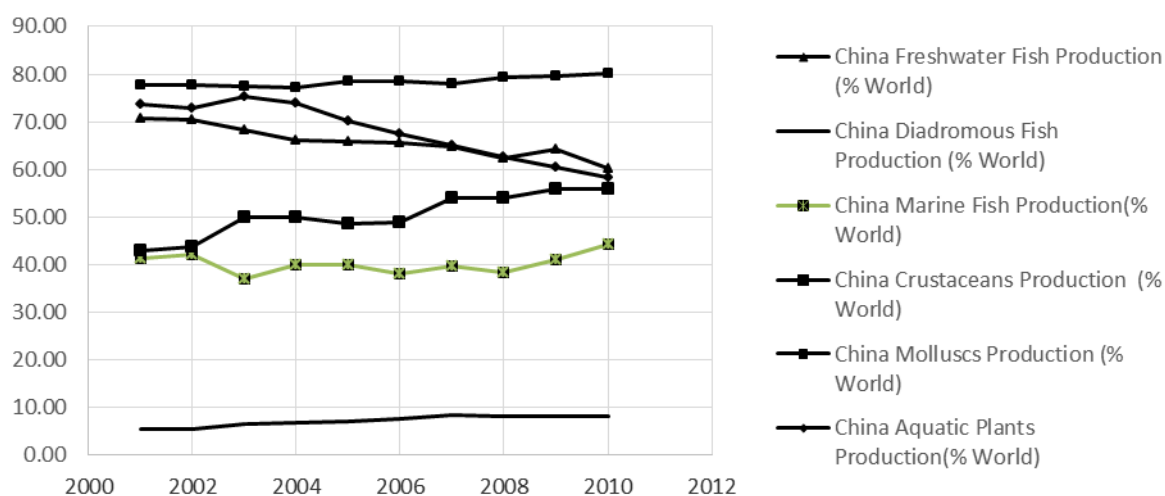


Figure 7: Aquaculture Production in China as Percentage of Total World Production (2010)

Source: Data compiled by author from FAO

Figure 7 above shows that China leads the world in terms of aquaculture production in terms of freshwater fish production, marine fish production, crustacean production, mollusc production and in the production of aquatic plants. In 2010 for mollusc production China produced 80% of the worlds output. China's production of aquatic plants and freshwater fish amounted to 60% of total world output in 2010. However, in 2010 China only produced approximately 58% of the worlds output of crustaceans. But in the same year marine fish production was only around 44% of the world total. Nevertheless, in the case of diadromous fish, those which migrate between freshwater and salt water, China only produced approximately 8% of the world total in 2010. It is easy to see from these figures that in five out of six categories of aquaculture production, China was the world leader.

Figure 8 below shows the total aquatic production by province in China in 2010. From Figure 8 it can be seen that the Coastal provinces (Guangdong, Shandong, Zhejiang and Jiangsu) of China predominate other provinces in the production of total aquatic output. The Coastal provinces are followed by Central provinces such as Anhui, Henan, Hubei and Hunan in the production of total aquatic output. The only outlier amongst these provinces is Hebei, a Coastal province. The provinces of China which are furthest from the Coastal region, in the Western region such as Guizhou, Yunnan, Shaanxi, Qinghai, Ningxia and Xinjiang produce the least amount of total aquatic products amongst China's provinces. It would be easy to assume that China's Western provinces produce low levels of the country's total aquatic products because they are further from the coast. However, the Western region possesses over half of the country's water resources, although these water resources are distributed unevenly amongst the Western region provinces, Yeung et al (2004).

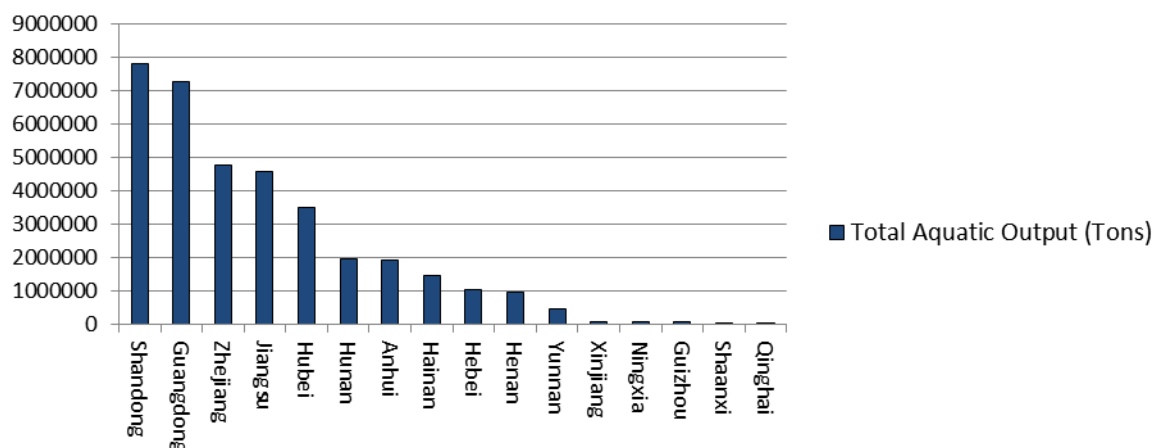


Figure 8: China: Total Aquatic Output by Province (2010)

Source: Provincial Yearbooks, Chinese National Bureau of Statistics

It would also appear that some regions of China are specialized in the production of certain types of aquatic product. This can be seen from Table 1, below.

Region	Provinces	Aquatic Products
Eastern and Southern Coastal	Zhejiang, Fujian, Guangdong, Hainan, Guangxi	Eels, Prawns, Tilapia, Large Yellow Croaker
Yellow and Bohai Sea	Shandong, Hebei, Liaoning	Prawns and Shellfish
Middle to Lower Yangtze	Anhui, Jiangxi	Fresh Crabs

Table 1: Type of Aquatic Production by Chinese Province/Region

Source: Agrifood (2013)

From Table 1 above it can be seen that there is a tendency amongst China's Coastal provinces in comparison to its other provinces to produce a more diverse range of aquatic products. In total in China by the end of 2009 there were 1500 aquaculture institutions registered in Certification and Accreditation Administration with 400 of these enterprises with annual exports of over US\$ 10 million, MoA (2010).

4.1.2 Government Laws and Regulations Regarding the Aquaculture Industry

1979	Regulation on Breeding and Protection of Aquatic Resources ⁴
1984	Water Pollution Prevention Law of the People's Republic of China – amended 1996 ⁴
1986	The Fisheries Law of the People's Republic of China, revised in 2000 ^{1,2}
1989	Environmental Protection Law of the People's Republic of China (Water Standard for Fishery Sector) ⁴
1991	National Committee on High Quality Original Seed, based on The Fisheries Law ³
1992	Administrative Rules on Aquatic Seed ³
1993	Implementation Regulation on Protection of Aquatic Wild Animals ¹
1993	Product Quality Law ⁵
1994	Consumer Rights Protection Law ⁵
1995	Food Hygiene Law - Article 9
1999	Zero growth on fishing policy, fishing ban ¹
1999	Administrative Rules on High Quality Original Aquatic Seed ³
1999	List and Usage of Pharmaceuticals that can be used for Aquaculture ³
1999	List and Usage of Pharmaceuticals that cannot be used for Aquaculture ³
1999	Regulation on Healthy and Safe Aquaculture Production ⁵
2002	Agriculture Law of the People's Republic of China ²
2006	Agricultural Product Quality Safety Law ⁵
2007	Special State Council Rules on Strengthening Supervision and Management of Food Safety
2009	Food Safety Law ⁵

Table 2: China's Food and Aquaculture Laws and Regulations

Source: Compiled by Author from Broughton et al (2010), King and Wood (2009) and Hishamunda et al (2003).

¹Laws, regulations and policies to protect fisheries resources

²Laws relating to water areas and management

³Laws, policies and rules relating to the control of aquaculture method and production

⁴Laws relating to the protection of the environment.

⁵Laws relating to aquatic food safety.

Table 2 above shows the evolution of the laws and regulations relating to not only food safety but also to sustainable aquaculture. These laws, regulations and policies represents the framework for the regulation and control of the aquaculture industry in China which are interlinked and can be broken down into five distinct categories, Hishamunda et al (2003). These categories relates to the protection of fisheries resources, the use and the management of water areas, the control of aquaculture method and production, the protection of the environment and the safety of aquatic food. The imposition of a comprehensive legal and regulatory framework on the Chinese aquaculture and maritime fisheries industry has seen a shift from maritime fishing to aquaculture production. This has meant that traditional fishermen, faced with declining catches at sea, quotas and seasonal fishing restrictions, have reallocated to fish production based on aquaculture.

4.1.3 Innovation

As of 2010 there was around 130 marine research related institutions in China with more than 13000 technical and scientific staff, Xiang (2010). This scientific staffs was mainly distributed amongst the Chinese Academy of Sciences, the State Oceanic Administration, the Ministry of Agriculture; and the Ministry of Education. Institutions which are affiliated with the Chinese Academy of Sciences includes the Institute of Oceanology, the South Sea Institute of Oceanography, Yantai Coastal Zone Institute for Sustainable Development, Institute of Acoustics, Institute for Atmospheric Physics, the Ecological Environment Research Center, Shenyang Institute of Innovation, Institute of Geology and Geography, Xiang (2010). The State Oceanic Administration also has a number of research institutions associated with it. These include the Institute of Marine Research, the Institute of

Oceanography, the Marine Technology Research Center and the Polar Research Centre, Xiang (2010). The Ministry of Agriculture also has a number of research institutions affiliated with it. These include the Yellow Seas Fisheries Institute, the East Sea China Fisheries Institute, Xiang (2010). Similarly, the Ministry of Agriculture also has a number of research institutions allied with it. However, these are always university institutions which include the Ocean University of Research, Xiamen University, Tongji University, Sun Yat-Sen University, Shanghai Ocean University and the East China Normal University. There are also a number of enterprises which undertakes maritime related research, Xiang (2010). It was due to the abundance of maritime and ocean science research personnel in China that the country was fourth in the world for the publishing of maritime science research papers in the period 2001 – 2008 in the world, Xiang (2010). All research activity in China whatever the institution ultimately falls under the orbit of the Chinese Academy of Fishery Sciences (CAFS), Zhang et al (2003). The main areas of research for CAFS includes the identification and the sustainable utilization of marine resources, to ensure the sustainability of the marine ecosystem, the identification, recording and preservation of the genetic material of aquatic organisms, the development of aquaculture technology, the control of aquatic diseases, and the improvement in the quality of aquaculture fish stocks by the use of suitable breeding techniques, Zhang et al (2003). Other areas of potential innovation by CAFS includes information technology, the processing of fish and its safety, deep water fishing and fishery policy, Zhang et al (2003). Specific programmes which emerged included the National Science and Technology Supporting Plan, the 973 Program, the 863 Program and the National Natural Science Foundation Projects, Xiang (2010). The 863 Program focused on developing breeding techniques for high density aquaculture, mechanisms, techniques and vaccinations for disease control, and large scale artificial breeding, Zhang et al (2003). On the other hand the 973 Program focused on the ecological dynamics and the sustainable use of biological resources in the Yellow Sea and in the East China Sea, Zhang et al (2003). The National Science and Technology Supporting Plan focuses on the development of technology the production of high value fish feed, the production of healthy marine aquaculture, ecological inland aquaculture and the facilitation of deep sea net aquaculture, Zhang et al (2003). CAFS not only works with the institutes which fall under its umbrella but also with other institutes in China which does not fall within its orbit such as the State Oceanic Administration.

There are several different ways in which research and development and innovation have changed the face of the aquaculture industry in China, Hishamunda et al (2003). These innovations arose mainly in the 1980's. Firstly, the genetic composition of 14 different fish species have been identified and the data stored. Secondly, twenty-six fish banks stocked with both domesticated and wild fish have been established around the country. Thirdly, multiploid breeding techniques have been used to propagate the seeds of commercially important fish such as the carp, oyster, abalone and the scallop, Hishamunda et al (2003). Fourthly, artificially formulated feed was abundantly produced and this allowed the aquaculture industry to expand rapidly. Fifthly, the productivity of paddy field cultured fish production and that of cultivated marine fish increased due to the adoption of improved production facilities and culture techniques. Finally, over forty shrimp and one hundred fish diseases were identified and appropriate vaccines developed. The adoption of innovative production techniques resulted in the increased productivity of Japanese Kelp, Purple Laver while the use of artificially produced feed increased the output and the production of Chinese Shrimp, Hishamunda et al (2003).

4.1.4 Environmental Impact of Fish Farms

In order to assess the environmental impact of fish farms it is necessary to consider the effects on water quality of non-aquaculture based industries as well as the effect on water quality of the aquaculture industry itself. China's rapid urbanization over the last thirty years combined with adequate water infrastructure has contributed towards significant water pollution in the country, Wu et al (2009). The maximum possible levels of human and animal excreta in water is significantly greater in rural areas than it is in urban areas. However, the industrial pollution of water in China can also occur by two means. These include the deliberate dumping of industrial waste into lakes, rivers and ponds or an accidental spillage. Water pollution from rural industries is significant with up to 50% of all pollution monitored river sections being considered to be unsuitable for human contact, Wang et al (2008). Mining, smelting and metal treatment has contributed to heavy metal pollution of lakes and rivers in China, Cheng (2003). Pollution by air emission, polluted waste water and the disposal of waste solids represent the main sources of pollution to water bodies in China. The use of fertilizer in farming may also mean that heavy metals alongside phosphates and nitrates end up in lakes, rivers and ponds as a result of draining from the land into the water table. China has access to 3 million km² of sea with an exclusion economic zone of 200 nautical miles from its coast, Liu et al (2005). In 2004 the State Oceanic Administration recorded polluting

discharges into the sea by 867 outlets. Just twenty of these outlets discharged 1.3 million tonnes of pollutants into the sea, Liu et al (2005). In conjunction with the overfishing of the coastal seas, increased pollution of China's coastal waters as seen a decline in fish catches whilst that of aquaculture production has increased, Liu et al (2005). However, water pollution arising from the aquaculture industry itself is dependent on a number of factors, Cao et al (2007). These factors includes the characteristics of the culture system, the species being farmed and the quality of the feed being used. It is widely accepted that a polyculture based aquatic farm is much more sustainable than is a monoculture based farm, Chopin et al (2001). The combination of fed aquaculture (shrimp and finfish) with extractive aquaculture (seaweed and shellfish) results in the waste of fed aquaculture becoming the food for the extractive aquaculture, Chopin et al (2001).

4.2 Aquaculture Fisheries Management in Nigeria

Before the 1970's the Nigerian economy was based on agriculture, Okonjo-Iweala (2012). The country exported a substantial proportion of the world's agricultural commodities such as cocoa, palm oil, rubber and coffee as well as commodities such as tin, coal and minerals, Okonjo-Iweala (2012). However, commercially viable quantities of oil were discovered in the Niger Delta in 1956. In 2010, Nigeria was exporting 2.3 million barrels of oil per day and had substantial oil reserves of 37.2 billion barrels of oil, Okonjo-Iweala (2012). The discovery of oil catapulted Nigeria into an economy which specialized in the production and export of a single commodity at the expense of all other commodities and products. This was in stark contrast to the pre-1970's during which the Nigerian economy was diversifying into the production of both agricultural and resource commodities. The increasing effects of the Nigerian economy's dependence on the export of oil were that there was a large amount of capital inflows, an increase in monetary liquidity in the economy and rising inflation. As a result the country's currency appreciated making exports expensive and imports cheaper. In these circumstances it was much easier for Nigeria to depend on its oil revenues and to import agricultural produce. There was no need for the Nigerian government to redress any imbalances between domestic demand and domestic supply. It could merely rely upon imports to meet any shortfalls in domestic supply of a good. It has been found empirically that between 1970 and 2011 that the economic growth of Nigeria was not significantly affected by the production of fish, Oyakhilomen et al (2013). Nigeria is a country in West Africa which is composed of thirty-six provinces. The country can also be sub-divided into six zones, South South, South West, South East, North East, North West and North Central, Ovie et al (2006). The provinces making the biggest contribution to the country's aquaculture industry being Kaduna, Niger, Taraba and Benue, Miller et al (2007). The most commonly farmed fish in Nigeria are Nile Tilapia and the sharp tooth Catfish, Brummett et al (2008). So in contrast to China's aquaculture industry, Nigeria's aquaculture industry is much more mono-culture based. The advantage of these two types of fish is that they are low trophic in nature, requiring either plant or animal matter as food. While Nigerians are big consumers of fish, the country's aquaculture industry has never taken off sufficiently to satisfy domestic demand. According to Akinsuyi (2011):

'Nigeria spent over N100 billion on the importation of frozen fish in 2010. The estimated annual fish demand in the country was about 2.66 million as against the annual domestic production of about 0.78 million, giving a demand-supply gap of about 1.8 million metric tonnes.' Dr Akinwumi Adesina, Minister of Agriculture and Rural Development.

The farming of fish does nothing to contribute towards reducing the costs associated with importing fish. And sea piracy reduces the maritime capture production because fishing companies withdrew their fishing fleets, TheFishSite (2008). The level of fish consumption in Africa in 2009 was only 9.1 million tonnes out of a global total of 126 million tonnes of fish available for human consumption, FAO (2012b). In contrast Asia's fish consumption in 2009 was two-thirds of the global total for that year. This represented total fish consumption for Asia of 85.4 million tonnes, with 50% of this being consumed outside China, FAO (2012b).

Colonial governments saw the benefits of expanding aquaculture in Africa in the pre-independence years of the 1940's and the 1950's as an additional source of food security, Brummett et al (2008). This was especially true in Nigeria where national, state and local governments supported the development of a domestic aquaculture industry by investing in fifty fish farms, some with feed mills, Miller et al (2007). However, the post-independence governments of African countries did not take the same view of aquaculture with other sectors of the economy being viewed as needing more urgent attention. A substantial number of these fish farms lie abandoned and Nigeria's private sector fish farms still face constraints attributable to the lack of fish feed as well as fish seed. In a wider African context, the aquaculture sector faces additional constraints such as poor infrastructure and ineffective policies, Brummett et al (2008). However, according to Otubusin (1986) other

constraints to the development of the aquaculture industry in Nigeria also includes lack of national developmental planning, insufficient reliable data on aquaculture production; and no indication as to the profitability of the aquaculture industry. There was also a tendency for more emphasis by governments on central planning rather than on free market forces and private sector participation in the aquaculture sector. This was often associated with money from donor countries, institutions or agencies, Brummett et al (2008).

The need for a strong domestic aquaculture industry in Nigeria is underlined by the fact that 70% of Nigerians live in rural areas while 65% of the labour force is involved in the agricultural sector, Miller et al (2007). Despite the need for regulation and guidance by the national government for the development and support of a national Nigerian aquaculture industry there are no specific laws or regulations aimed at the aquaculture industry in Nigeria, FAO (2013). Only the Inland Fisheries Law (1992) gives the Minister in charge of Fisheries the right to charge a license fee for cages and pens used to house fish nurseries. However, recent reports suggest that the Federal Government may soon place a total ban on the importation of fish and other aquatic products into the country, Aquaculture Directory (2013). Foluke Areola, the Federal Director of Fisheries suggested that a country with the natural resources of Nigeria should not be in a position to import fish. But a total ban on the importation of fish and other aquaculture products could only take place if the Federal government proposed Special Growth Enhancement Support Scheme for Fisheries and Aquaculture Value Chain programme worked. The main objective of this programme is to increase the production of fish through farming and aquaculture by 1 million tonnes over the next four years through the Aquaculture Value Chain, AVC, Aquaculture Directory (2013). The government's goal is to achieve the Agricultural Transformation Agenda (ATA) by which the Agricultural Value Chain will enable the environment to be able to sustainably generate increased production in the aquaculture industry. The government hopes that through the Special Growth Enhancement Support Scheme an additional 1.25 billion tonnes of Fingerlings, 400,000 tonnes of Fish Feed, 250,000 tonnes of Table Fish and an additional 100,000 tonnes of value added fish products will be produced, Aquaculture Directory (2013).

Although the laws and regulations aimed at the aquaculture industry in Nigeria, excluding schemes in the pipeline, seem to be superficial there is a hierarchy of responsibility for the support and the regulation of the aquaculture industry between national, state and local government in Nigeria. At the national level the Federal Department of Fisheries (FDF) of the Federal Ministry of Agriculture and Natural Resources issues regulations and provides support to each states State Department of Fisheries (SDF) which then is able to support Local Government Authorities (LGA), FAO (2013).

4.2.1 Location and Type of Fish Farms

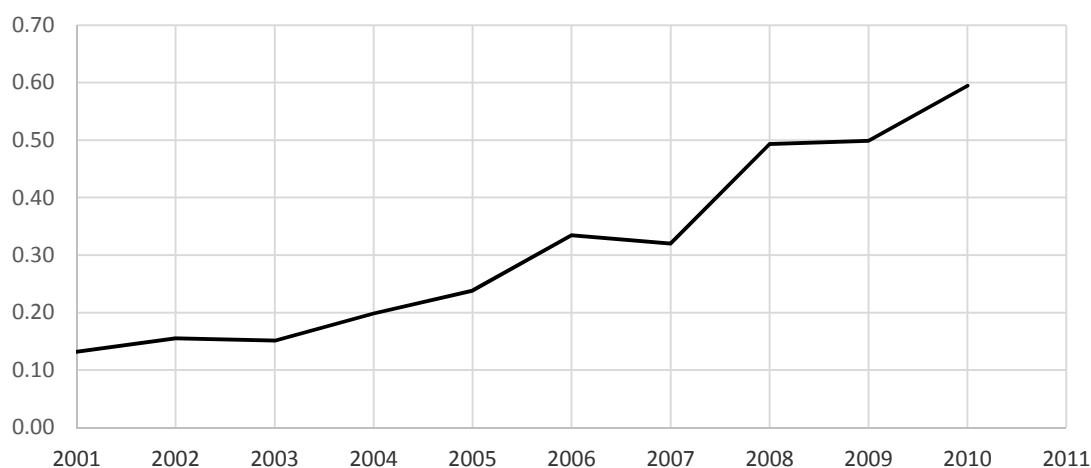


Figure 9: Nigerian Freshwater Fish Production (% World)

Source: Compiled by Author from FAO

Aquaculture started in Nigeria in the 1940's with the establishment of brackish water ponds and a small aquaculture school at Onikan by the colonial authorities, Otubusin (1986). The main purpose for this was to adequately train staff so that they could effectively take on the responsibilities of running a fish farm. In post independent Nigeria, external organizations such as the FAO also assisted in the establishment of an African

Regional Aquaculture Centre (ARRC) at Aluu in River State, Otubusin (1986). The main purpose of the ARRC was to train personnel so that they could effectively manage an Aquacultural establishment. Federal and State governments in Nigeria also established demonstration fish farms at Panyam, Odeda, Oyo, Agodi, Ibadan, Maska, Bagauda, Wuya, Akure, Okigwe and Oluponna, Otubusin (1986). The data available from the FAO for aquaculture based fish production in Nigeria suggests that such production is only freshwater based. Fishermen using small boats and traditional methods produce fish from rivers, lakes and coastal waters, Graham (2004). Figure 9 above shows the total Nigerian Freshwater fish production as a percentage of total world Freshwater fish production. While Figure 9 illustrates that the trend in Nigerian freshwater fish production as a proportion of total world freshwater fish production is upwards since 2001, the percentage of Nigerian freshwater fish production as a fraction of total world freshwater fish production is insignificant at 0.6% in 2010. Moreover, the contribution of farmed fish to the total catch of fish, shrimps and eels is only 0.1%, Graham (2004). The types of fish cultured in Nigeria include the Catfish, the Carp and the Tilapia, Grema et al (2011).

Fish farms can be of various types. These include earthen ponds, integrated fish culture, rice paddy associated cultivation, running water culture, recirculating water systems, cage culture, fish pen culture and mollusc culture, Otubusin (1986). The most commonly practiced method of aquaculture production in Nigeria is the use of earthen ponds, Grema et al (2011). There are also three different types of fisheries management systems in practice in Nigeria, Vincent- Akpu (2013). These include Type 1, Type II and Type III. Type 1 management is followed by traditional authorities, such as the village headman, to control fishing by placing bans on fishing during certain periods when fish may be breeding for example. Type III management occurs in which central government administrations enforce fisheries regulations using fisheries department officials, Vincent-Akpu (2013). The Type II management system is a combination of both Type I and Type III systems and is the most commonly found in Nigeria. Type I management systems are the most effective while the effectiveness of a Type II management system depends on sound logistics and the availability of suitable manpower, Vincent-Akpu (2013).

4.2.2 Government Laws and Regulations Regarding the Aquaculture Industry

Year	Reform
1941	Inputs at subsidized rates, Technology Transfer, Revolving Loan Schemes
1971	Sea Fisheries Decree, Sea Licensing Regulation
1972	Sea Fisheries (Fishing) Regulations
1972	National Accelerated Food Production Programme ¹
1974	Agricultural Developments Projects ¹
1976	Operation Feed the Nation ¹
1976	River Basin and Rural Development Authorities ¹
1978	Exclusive Economic Zone Decree
1978	Land Use Act
1980	Green Revolution Programme ¹
1988	FMAWRRD
1989	National Policy on the Environment
1992	Inland Fisheries Decree
1992	Federal Environmental Protection Decree
2000	Draft National Fisheries Policy
2002	Nigerian Special Programme for Food Security (NSPFS)
2012	National Fadoma Development Project (NFD ¹)
2013	Special Growth Enhancement Support (GES) Scheme for Fisheries and Aquaculture Value Chain

Table 3: Nigerian Fisheries Programmes and Policies

Source: Compiled by author from Vincent-Akpu, I (2013) and Aquaculture Directory (2013)

Nigeria has no specific interlinking regulatory framework for its aquaculture industry, Percy et al (2001). However, Table 3 above shows the various reforms associated with the aquaculture industry. This is in sharp contrast to the multidimensional integrated network representing China's aquaculture industry which is shown in Table 2.

Most if not all the laws and regulations in Nigeria were more procedural than ones which would foster the growth and sustainability of the aquaculture industry. The 1971 and 1972 Sea Fisheries Decree and Regulations were mainly associated with the registration and licensing of fishing trawlers, the size of trawl nets to be used, the size of fish to be caught and the distance from the coast fishing could be carried out within, Vincent-Akpu (2013). The Inland Fisheries Decree of 1992 does not refer to the aquaculture industry in Nigeria. It merely stipulates the requirements for the granting of a license for fishing and catching shrimps. However, the regulation of inland fisheries was left to the discretion to the governments of the individual 36 states of Nigeria. Out of these 36 states only 15 had laws and regulations in place to manage inland fisheries, Vincent-Akpu (2013). Other programs¹ as shown in Table 3 above had an effect on the fisheries industry. The first nationally comprehensive agricultural policy to affect the fisheries sector in Nigeria was FMAWRRD in 1988. The main objectives of this policy was to increase domestic fish production, increase revenues from fish exports; and increase employment opportunities for Nigerians in the rural sector by increasing the mechanization of processes. A national Fisheries Policy was drafted in 2000 but it was never enacted and did not differ from the national Agricultural Policy of 1988, Vincent-Akpu (2013). It would seem that the emphasis of these policies was to increase the productivity of the fisheries sector mostly through increased mechanization. But it would seem that feeds, the environment and sustainability issues were not comprehensively addressed as they were in China's aquaculture regulatory framework. Nevertheless, the Federal Environmental Protection Decree of 1992 only requires an Environmental Impact Assessment of areas designated for aquaculture in conjunction with the clearing of 20 hectares of mangrove forest, Percy et al (2001). The National Policy on the Environment 1989 requires that environmental monitoring and assessment should provide data to specific sectors of which aquaculture is one. Despite the lack of an adequate regulatory and growth promoting framework for the Nigerian aquaculture industry, the most significant reform takes place in 2013 with the implementation of the Special Growth Enhancement Support (GES) Scheme for Fisheries and Aquaculture Value Chain. The purpose of the GES is three fold, Cross River State (2013). First to provide cheap seeds and fertilizer to small holder farmers. Secondly, to target fertilizer subsidies at small holder farmers. And thirdly to improve productivity in the fertilizer value chain. Allied with the GES, the Federal Government of Nigeria also favors a ban on all fish imports into the country. The implication is that the Federal Government wants to follow an import substitution policy in order to facilitate the growth of the Nigerian aquaculture industry. This type of developmental policy failed in other countries which sought growth in its industries. Most notably China, India and Brazil, countries which then had to abandon such policies and embrace liberalization/free market policies.

Year	Law / Regulation
1915	Water Works Act
1917	Public Health Act
1937	Forest Ordinance
1958	Public Health Act
1968	Oil in Navigable Waters Act
1969	Petroleum Drilling and Production Regulation
1969	Ministry Act
1979	Associate Gas Re-Injection Act
1988	Federal Environmental Protection Agency Act (FEPA)
1988	National Resources Conservation Council
1998	National Policy on the Environment

Table 4: Nigeria's Environmental Protection Laws

Source: Oyefara (2013)

Prior to 1988 the implementation and formulation of environmental protection law was left uncoordinated, focusing on specific areas such as public health, forest, water works and oil. However in 1988 the Federal Environmental Protection Agency Act set up the Federal Environmental Protection Agency, FEPA, Campbell (2008). The objectives set by the Nigerian government for the FEPA was to protect the Nigerian environment and develop appropriate technology and standards in order to do so, Campbell (2008). The environment was defined as being composed of the land, water and the air. The FEPA was given responsibility for removing hazardous waste and materials from the Nigerian environment and ensuring the quality of the atmosphere. As can be seen from Table 4 above much of the environmental protection legislation between 1968 and 1979 relates to the oil industry. It was not until 1988 with the establishment of FEPA that the Federal government adopted a national environmental strategy. Under the 1998 'National Policy on the Environment' it was envisaged by the Federal government that the Federal Ministry of the Environment would take over the powers of FEPA, Campbell (2008). Despite Nigeria's Environmental protection laws the only industry with waste treatment facilities is the oil industry, Kotze et al (2009). The major environmental problems in Nigeria are caused by industries which discharge harmful substances into the atmosphere causing air pollution or those industries which discharge effluents into the water causing water pollution. The states of Nigeria were also allowed to formulate their own environmental protection laws.

4.2.3 Innovation

Two institutes provide research on fisheries and aquaculture. These include the Nigerian Institute for Oceanography and Marine Research (NIOMR) and the National Institute for Freshwater Fisheries Research (NIFFR), FAO (2013). The training for workers in the aquaculture industry in Nigeria is provided by the African Regional Aquaculture Centre. At a regional level NEPAD and ECCAS have signed a memorandum of understanding in order to enhance the implementation of fisheries policy in Central Africa, Nigerian Guardian (2011). NIOMR was established in 1975 and its research has facilitated three main changes in the Nigerian fisheries industry. Firstly, procedural changes have been facilitated through government legislation on access to and management of the country's fisheries resources. Secondly, the geographical identification and cataloguing of the country's aquatic resources has been addressed. And the mechanization of and improvement in fisheries tools has been facilitated. For example, through the work of NIOMR papyrus boats have been replaced with motorised and non-motorised canoes; and nets made from natural fibers have been replaced by synthetic ones, Tobor (1991). The research implications of NIOMR contrasts with that of CAFS and other allied research institutes in China where the research has facilitated productivity increases in the aquaculture industry not on the basis of production mechanization but on the basis of developing new breeding techniques, the production of abundant and quality fish feed, sustainable production of a diverse range of aquatic products, the development of new methods of production as well as the intensive cultivation of fish.

4.2.4 Environmental Impact of Fish Farms

Nigeria has experienced increased population growth and urbanization since it became an independent country. Increasing urbanization has brought with it increased consumption and production. The result has been an increased demand for the means of waste disposal. These have included water borne disposal, land spreads, dumpsites, incineration and land filling, Adeyemo (2003). The last four ways of waste disposal may seem to be safe. However, Nigeria experiences heavy rain and the sites where waste is dumped is not lined. This means that the waste can interact with the rain water and feed through into groundwater and freshwater aquatic systems. All fish farming in Nigeria is fresh water based. An added disadvantage to the country sustainably managing its waste disposal is that it lacks both the technical knowhow as well as the manpower resources in order to do so, Adeyemo (2003). Furthermore, while Nigeria has 12.5 million hectares of freshwater resources a combination of industrial, human, agricultural and aquaculture based practices contributes to polluting the aquatic environment and degrading it, Adeyemo (2003). The Niger Delta and Lagos are also prone to oil pollution while Kaduna state is susceptible to pollution from the textile industry, Adeyemo (2003). But pollution regardless of its source is not the only factor which causes damage to Nigeria's aquatic habitat. The other factor which degrades Nigeria's aquatic habitat is over fishing and harmful fishing practices which although outlawed by the Federal government may still go ahead unnoticed, Adeyemo (2003). These harmful practices may include the deposition of poisonous substances in the water to kill fish but which inadvertently has a negative impact not only on the targeted fish but also on the whole aquatic ecosystem. The laws and regulations relating to the Nigerian aquaculture industry were listed in Table 2 above. But the quality of water resources in Nigeria can be improved by better educating

communities with regards to effective waste disposal; and the implementation and enforcement of existing water quality standards, Adeyemo (2003).

5 Results and Discussion

The preceding analysis suggests that there are different forces which have driven and are driving the development of the aquaculture industry in China and in Nigeria. In China there is a diversity in the production of aquatic products which can be regionally delineated. At the regional level while each region of the country may focus on producing different types of aquatic products, the Coastal regions of the country in general leads the way in the production of aquatic foods. However, in Nigeria aquaculture tends to be more monoculture based with a focus on the production of Catfish, Tilapia and Carp.

Aquaculture at some scale of production has had a traditional history in China. However, perhaps this has not been the case with the Nigerian aquaculture industry which did not emerge until the 1940's. Over the last thirty years the trend in China has been for aquaculture based fish production to increasingly replace sea capture fish production. This has largely been due to government imposed quotas, seasonal bans on maritime fishing and a zero growth policy on fishing fleets and sea based fishing. Fishing boats have also been taken out of service. These measures have been primarily aimed at protecting the coastal aquatic ecosystem whose fish species have dwindled due to over fishing and water pollution. Chinese fishermen have been reallocated by these measures to stop fish production by capture and to become employed in producing fish through aquacultural farming methods. However, in Nigeria the Federal government has articulated laws and regulations on the licensing of fishing but there has been no zero growth policy on sea based fishing. Nevertheless, recently the government has implemented a program which would provide cheap seeds and fertilizers to small hold farmers. In order to incentivize the increased domestic production of fish in Nigeria, the government is also considering a ban on fish imports into the country. But the factors which incentivized farmers and fishermen to switch to the aquaculture based production of fish included not only the flexibility of the usage of land; and the zero growth rate of sea based fishing but also the ability to sell surplus produce at free market prices. In this way farmers were able to make profits and to accumulate wealth through their endeavours.

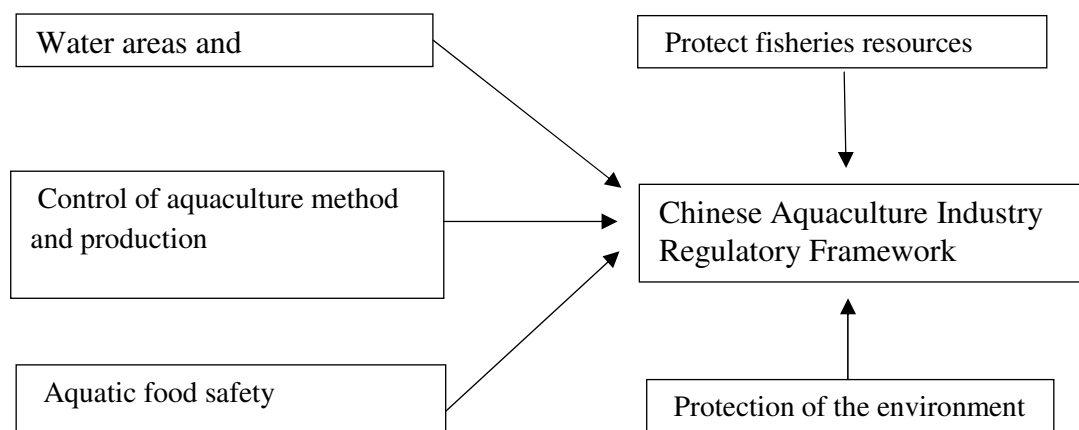


Figure 10: Interlinking Aquaculture Regulatory and Legislative Framework in China

Source: Author

In China has opposed to Nigeria the legislative and regulatory framework for the aquaculture industry is both interlinked and multifaceted. It is multifaceted because it simultaneously deals with issues such as the protection of fisheries resources, the management of water areas, the control of aquaculture method and production, the protection of the environment as well as aquatic food safety. The way in which these issues are interrelated in the aquaculture regulatory and legislative framework of China is shown in Figure 10 above.

In contrast to the Chinese aquaculture industry which has a national regulatory and legislative framework in place, the Nigerian aquaculture industry does not. Instead while the national aquaculture regulatory framework

in Nigeria is patchy, not effectively interlinked with no specific focus on the aquaculture industry, 15 of the 36 states of Nigeria formulate their own legislation and regulations for the aquaculture industry in their states. Furthermore, the legislation and regulations in the Nigerian aquaculture industry focus more on licensing requirements and the apportionment of land for aquaculture purposes. Nevertheless, the FMAWRRD in 1988 was the first agricultural policy in Nigeria with some emphasis on the fisheries sector. While the FMAWRRD had a series of objectives for the fisheries sector it did not do much to stimulate the productivity or the growth of the aquaculture sector in Nigeria. This is easy to see because the country to this day has relied upon the importation of fish in order to meet the shortfall in domestic supply. On the environmental protection front the Federal Environmental Protection Decree of 1992 and the National Policy on the Environment 1989 only calls for the environmental impact assessment of areas designated for aquaculture and the collection and dissemination of environmental data to sectors including aquaculture. Whilst in China the aquaculture regulatory framework interlinks the protection of the environment with other factors such as the protection of fisheries resources, water areas and management, control of aquaculture method and production and aquatic food safety. This clearly is not true of the Nigerian aquaculture regulatory framework.

In China all research with regards to the fisheries/aquaculture sector falls under the remit of the Chinese Academy of Fishery Sciences, (CAFS). A number of research organizations falls under the umbrella of CAFS which has a number of research responsibilities. These responsibilities includes conducting research into the sustainability of marine resources, the marine ecosystem, developing aquaculture technology, breeding techniques, the control of fish diseases and the identification and recording of aquatic genetic material. On the hand in Nigeria fisheries/aquatic research falls under the remit of the National Institute for Freshwater Fisheries Research (NIFFR) and the Nigerian Institute for Oceanography and Marine Research (NIOMR). While these institutes have research remits the main impacts of their research is on the fisheries industry in Nigeria rather than on the aquaculture industry. Moreover, the innovations developed to increase productivity are more mechanical in nature (motorized canoes, nets made with synthetic fibers) rather than technological innovations which relate to the quantity and quality of feed, breeding techniques, control of fish diseases, improving the quality of fish stocks; and maintaining the sustainability of marine resources and the marine ecosystem. It can be seen that the innovations in fisheries and aquaculture in Nigeria will face productivity constraints because mechanization will lead to dwindling catches in the future. On the other hand in China the innovations in fisheries and aquaculture go beyond the pure mechanization of practices by ensuring the sustained productivity of the aquaculture industry.

In both Nigeria and China the major challenge to the aquaculture industry is represented by water pollution due to increasing urbanization and industrialization. In the case of Nigeria the Niger Delta is particularly prone to oil pollution. China has a more comprehensive environmental pollution prevention laws, policies and regulations in force dealing with just not water pollution. The central plank of this legislation is the Environmental Protection Law of the People's Republic of China. The main problem for China is the implementation and the policing of the legislation. This will determine its effectiveness in the long run. However, there are also a number of factors which have contributed to the ineffectiveness of Nigeria's environmental protection laws. Firstly, the environmental protection laws are focused primarily on the oil sector. Secondly, the laws are not linked into the development policies associated with any other sectors. Thirdly, the penalties associated with the violation of the laws are not high enough. Finally, there is a lack of enforcement of the laws. In contrast to Nigeria's environmental protection regulatory framework, China's environmental protection laws are more diverse and interconnected because they have a common root in the Environmental Protection Law of 1979 as amended in 1989. The other fundamental difference between the Nigerian environmental framework and the Chinese one is the role of the state. While in Nigeria the role of the state is associated with merely formulating standards and the enforcement of those standards, in China the state has the additional role of protecting the environment through innovation and education, Oyefara (2013). This is based on two strands. Firstly, to protect the environment by developing the education associated with the science and the technology of environmental protection. Secondly, by encouraging and facilitating innovation to produce technology to reduce environmental protection.

6 Conclusion

The aim of this paper has been to assess the state of development of the aquaculture industry in China and in Nigeria; and whether this can be explained by Modernisation Theory or Dependency Theory. The objective of the paper has been to evaluate how the lessons learnt from the development of the Chinese aquaculture industry

can be applied to the development of the Nigerian aquaculture industry. China is the world's most populous country. But its population is expected to peak and fall by 2021. However, Nigeria is Africa's most populous country and its population is expected to continue to grow after 2021. A combination of a rising population and rising incomes in China following the post economic reforms of 1978 have ensured an increase in demand for protein based agricultural produce such as meat. This placed an increased strain on crop products which were now needed in larger amounts in order to feed livestock. At the same time China's capture production of fish was beginning to fall due to a combination of overfishing and coastal sea pollution leading to dwindling fish stocks. In order to conserve maritime fish stocks, the Chinese government facilitated the growth of the country's domestic aquaculture industry. The production of fish by aquaculture based methods was facilitated in a number of ways. As a part of its post economic reforms of 1978 China marketised its agricultural sector in two ways. Firstly by giving farmers the flexibility to use land to produce whatever they seemed deemed fit to produce. The only caveat was that land should not be sold. Secondly, farmers were allowed to sell part of their produce at free market prices and so to make a profit. This incentivized farmers to increase agricultural output. In addition to the marketisation of agriculture, a regulatory legal framework for the management of the aquaculture industry evolved in China over the post economic reform years. This was a comprehensive regulatory legal framework which interlinked a number of functions as illustrated in Figure 10. These functions included the protection of the environment, protection of fisheries resources, the safety of aquatically produced food, the control of aquaculture method and production as well as water areas and management. The benefits of interlinking these functions was that protection of the environment could be associated with the control of water pollution. Clean water improves the medium in which aquatic products can breed. The main difference between the aquaculture regulatory framework in China and Nigeria is that the Chinese one is not only comprehensive but also national. It can be supplemented by provincial laws and regulations but these are usually based on national laws. In Nigeria the aquaculture regulatory framework virtually non-existent at a national level. Moreover, in Nigeria the protection of the environment is often associated with the oil industry.

In China the central government also followed a policy whose primary objective was the zero growth rate of the capture fish industry. This policy is consolidated by seasonal bans on capture fishing, fishing quotas and the decommissioning of fishing boats. Fishermen who become unemployed as a consequence were redeployed to the aquaculture industry. In Nigeria the Federal government has only just instigated a policy of targeting feed subsidies to small holder fish farmers in order to lower their costs. This policy is to be coupled with a possible ban on all fish imports. The adoption of an import substitution policy by the Nigerian government in order to expand the country's fishery industry may lead to domestic shortages of fish. One of the major constraints associated with expanding the domestic aquaculture industry in Nigeria is the availability of fish feed. The costs of domestic aquaculture producers in Nigeria are therefore dependent on the value of the country's currency, the naira. A high value of the naira would mean that imports are cheap, although indicating high domestic inflation. But, a low value of the naira would mean that imports would be expensive.

In China aquaculture related research falls to the institutions under the umbrella of the Chinese Academy of Fisheries as well as institutions such as the State Oceanic Administration which does not fall under its remit. But all aquaculture research based institutions collaborate with each other and carry out a diverse range of research activities which aims to increase aquaculture production by improvements in technology. This technology may be associated with the production of feed, breeding techniques; and issues relating to aquatic management as well as the genetic identification and cataloguing of aquatic species. On the other hand in Nigeria there are only two major federal research institutes, NIOMR and NIFFR. The main innovations associated with the aquatic industry relate to mechanization of fishing; and the regulation and management of the industry by licensing. These innovations include the replacement of papyrus fishing boats with mechanized canoes or the replacement of fishing nets made from traditional materials with fishing nets made from synthetic fibers.

Both Nigeria and China are emerging countries with increasing urbanization, although this is much more significant in China than it is in Nigeria. This has led to increased water pollution. While China has a comprehensive environmental framework, despite high levels of pollution, Nigeria does not. Moreover, because Nigeria has a significant oil industry waste control is only available for this industry and is non-existent for other Nigerian industries.

Since 1978 the Chinese economy has transitioned from a completely centrally planned economy to a mixed market economy and the second largest economic power in the world. This gradualist economic transition has been facilitated by a number of economic reforms the main essence of which has been to reintroduce the price mechanism into the Chinese economy. As a result of these economic reforms the evolving economy has been

able to facilitate the adoption of the country to a changing global economic environment. China has been able to take advantage of its low cost labour and to experience economic growth by the manufacture and export of light technology goods. The Chinese government has been able to formulate goals for the economy through a series of 5-year plans. Unachieved goals could be accounted for in successive 5-year plans. Laws, regulations and institutions have been linked together in order to ensure the good governance of specific sectors and consistent innovation and technological change. Furthermore, the values associated with China's economic reforms have been passed from one leader to another in the last thirty-five years. These facts would indicate that China's aquaculture industry has transitioned from a traditional industry into a modern one on the basis of Modernisation Theory.

Nigeria is the fifth largest member of OPEC and the largest oil producer in Africa, Ngomba-Roth (2007). Oil is extracted and produced in Nigeria by US and European oil companies. Oil wealth is concentrated in the hands of the few. Since the country gained independence from the United Kingdom in 1960, Nigerian's only saw 10 years of elected government until the end of military rule in 1999. The rest of the time the country was either under military rule or its favored candidates for power. The military were not concerned with the needs and welfare of the country's citizens but with the needs of the US and European multinational oil companies who were paying for the privilege of extracting, producing and exporting Nigerian oil, Falola et al (2008). It is easy to see therefore that in contrast to China's aquaculture industry, the state of development of the Nigerian aquaculture industry was driven by Dependency Theory. Nigerian oil revenues could have been used to fund the development and implementation of a comprehensive national aquaculture and environmental framework as well as to fund Federal aquaculture research institutes linked to state ones to technologically transform the aquaculture industry as China did to its aquaculture industry.

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