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AQUACULTURE AND THE ENVIRONMENT

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ABSTRACT
Aquaculture industry in the last five decades has grown at an unprecedented rate (Average growth of 3.2 percent per year) stimulated by the increased demand for fish and fishery products as global population awareness of fish as a health food increased and the production from capture fisheries becomes almost static. In the light of this noticeable expansion this review paper focuses on the deleterious effect of many aquacultural practices which includes; degradation of terrestrial environments, pollution from chemical as well as waste and nutrient loading, diseases to mention but a few. Measures are proffered to reduce the negative impact of Aquaculture on the environment. The efforts of the National Environmental Standards and Regulations Enforcement Agency (NESREA) as it concerns EIA should be broadened to ensure that small aquaculture ventures along the coastline and within inland water bodies be considered to avoid environmental hazards.
Keywords: *Aquaculture, Environment, Poverty, EIA, Food security.*

INTRODUCTION
Aquaculture has traditionally played a role in ensuring food security for humans and is a component of rural development programs to alleviate poverty. Aquaculture is the world's fastest-growing food-producing sector. Beginning from the 1970s, aquaculture has grown significantly due to advances in hatchery technology, pond husbandry and disease/water quality control. According to the FAO (2006), aquaculture will constitute 50% of world seafood production by 2010 – 2012, or about 90 to 100 millions tons compared to about 3,1% to 7.1% millions of tons per year between 1992 to 2004. The annual rate of aquaculture consumption has increased by 2% since 1992. The value of aquaculture to nutrition and animal protein intake in developing countries is inestimable.

Aquaculture is regarded as being uniquely placed to reverse declining supplies from capture fisheries, With sustained growth in fish production and improved distribution channels, world fish food supply has grown dramatically in the last five decades, with an average growth rate of 3.2 percent per year in the period 1961–2009, outpacing the increase of 1.7 percent per year in the world's population (FAO 2012) and the activity has notable potential for new livelihood opportunities, consequently providing the mechanism for lower priced fish, enhanced nutritional security and employment for poor communities by servicing urban markets (Jagger and Pender 2001). Aquaculture production in Nigeria and the West African sub-region has witnessed tremendous growth with the development of technical and human resources to cater for the needs of the industry. Nigeria's natural resources that can support aquaculture of various forms are vast. Ita *et al.,* (1985) revealed that Nigeria is blessed with an estimated inland water mass of 12.5 million hectares capable of producing about 512,000 metric tones

of fish annually. There is a vast expanse of inland freshwater ecosystem from the coastal region in the South to the arid zone in the North.

According to Inoni (2007), total domestic fish production fluctuated between 562,972 to 524,700 metric tonnes in 1983 to year 2003; while the output of fish farming during this period was 20,476 to 52,000 metric tonnes. Fish farming accounted for between 3.64 and 9.92% of total domestic fish production in Nigeria within this period, while the bulk of production came from artisanal fishing. Current statistics of fish production in Nigeria shows that aquaculture production has increased reasonably (Table 1). The increase is connected to increasing population and awareness of the benefits of fish as a source of protein for healthier living. Projected population as against demand for fish in Nigeria is not proportional. Currently, demand for fish in Nigeria stands at 3.11 million MT while production is crawling behind at 751,000 MT. The balance is sourced via importation which drains foreign exchange. Table 2 shows the gap between annual demand for fish and population increase.

Table 1: Fish production in Nigeria between 2005 and 2009 (Metric tons, MT)

Sector	2005	2006	2007	2008	2009
Aquaculture	56,355	84,578	85,087	143 ,207	152,796
Capture	523,182	552,323	530,420	601,368	598,210
Total	579,537	636,901	615,507	744,575	751,006

Source: FAO (2011).

According to the UNDP (2010), Nigeria ranks 142 out of 169 countries in terms of human development index with a value of 0.423 with Ghana (0.467) and Togo (0.428) being ahead of Nigeria and as at 2008 64.4% of the population live on ≤$1.25 a day and 15.7% face danger of multidimensional poverty while 63.5% already suffer multidimensional poverty with 53.7% under intense deprivation. Eight Percent of Nigerians are undernourished while there is an 11% shortfall in minimum dietary energy requirements. Population has continued to increase and it is estimated that by 2020, there will be 217.6×10^6 Nigerians (FDF 2007). The projected annual population growth rate between 2010 and 2015 is 2.1% (UNDP 2010).

Table 2: Projected population and fish demand in Nigeria 2011 to 2020

Year	Population ($\times10^6$)	Fish Demand ($\times10^6$ MT)
2011	163.9	3.11
2012	169.1	3.21
2013	174.5	3.32
2014	180.1	3.42
2015	185.9	3.53
2016	191.9	3.65
2017	198.0	3.76
2018	204.3	3.88
2019	210.9	4.01
2020	217.6	4.13

Source: FDF 2007

Given the level of poverty and the need to meet animal protein demands to ensure food security, rural aquaculture as well as the urban version has increased in Nigeria. However, poverty and environmental degradation have a link. Poverty and malnourishment leads people to destroy their environment in a quest to survive. According to The Africa Society (2008), poverty leads to a greater exploitation of natural resources for survival, and this worsens the environmental problems with the degradation of agriculture and arable lands, and mismanagement of available water resources. Also, the UNDP (1990) pointed out that poverty is one of the greatest threats to the environment. Poverty could be both the cause and effect of environmental degradation. The vicious circle of poverty and environment is very complex. Income disparity can lead to unsustainable production as the poor who rely mostly on natural resources for survival tend to deplete these resources, aware of the exhaustive nature of the resources as well as the fact that they have no access to complementary resources. Poverty is also accelerated with environmental degradation since the poor depend on resources from the environment.

Living aquatic resources play a fundamental role in sustaining the livelihoods of many of the rural poor in Asia with poorer people often the most dependent on aquatic resources, particularly low-value fish and other living aquatic organisms. Such resources provide opportunities for diverse and flexible forms of income generation and contribute towards food security (Edwards 2002). Unlike in Asia where the tradition of "farming fish" dates back thousands of years, it is only in the last few years that the development of aquaculture as a source of income and food has begun to be exploited in West Africa (OECD 2007). Aquaculture is in fact a means of alleviating poverty but it will be unwise if the environmental consequences are sacrificed at the altar of poverty alleviation. The benefits of aquaculture are great and these according to Frankic and Hershner (2003) includes:

1. Increase household food supply and improve nutrition.
2. Increase household economy through diversification of income and food sources.
3. Strengthen marginal economies by increasing employment and reducing food prices.
4. Improve water resource and nutrient management at household or community levels.
5. Preserve aquatic biodiversity through re-stocking, and recovering of protected species.
6. Reduce pressure on fishery resources if done sustainably.
7. Improving/enhancing habitats.
8. Stimulates research and technology development.
9. Increase education and environmental awareness.

Deficient management or accidents in aquaculture facilities and irresponsible aquaculture are the root cause of negative effects of aquaculture on the environment (Dominguez and Martin 2004; Nugent 2009). The negative effects of aquaculture on the environment given the link between the rural aquaculturist, poverty and need for food security include:

1. Waste and nutrient loadings: Aquaculture in both urban and rural areas in Nigeria causes increased nutrient concentrations in natural waters hence an increase in plankton and microbial load (Eutrophication). Wastes from fish farms can pollute adjacent waters and harm fish and other wildlife. Un-consumed fish feed accounts for a greater percentage of this waste along with metabolic waste products

from the cultured fish. Regionalization of aquaculture development can lead to greater environmental damage as effects of individual farms become additive and detectable at the ecosystem level compared to the more localized effects caused by a single discharge (Salah and Guindy 2006; Nugent 2009). Aquaculture is practiced on a large scale in South-West Nigeria. Adedokun *et al.*, (2008) reported the seasonal variation in Nutrient Load of the River System in Ibadan Metropolis. They reported that Total suspended solid (TSS), total solids (TS) and total nitrogen were generally higher during the dry season suggesting that run-offs have only a diluting effect on these parameters while nutrient load based parameters (phosphate, sulphate, nitrate and nitrite) were generally higher during the rainy season.

2. Pollution from chemical use in Aquaculture: In modern aquaculture, to prevent diseases, eliminate harmful biota, disinfect and restrain polluted and damaged water, multiple chemicals are used. Diagnosis of aquatic diseases in the developing countries involves undeveloped instruments and weak technical power, hence inability to distinguish bacterial, viral, vermin, and nutritional diseases, which directly influence correct medication. Once the disease comes on, the abuse of medicines is imminent. Many aquaculturists use human and animal medicines which lack pertinence and have bad treatment effect. Residues of such medication are polluting the environment and reducing the quality of water products. The main environmental concerns over the use of chemical therapeutants in aquaculture result from the direct toxicity of the compounds; the development of resistance to compounds by pathogenic organisms; the prophylactic use of therapeutants and the duration of they remain active in the environments (Salah and Guindy 2006). This constitutes a risk to human health should resistance be acquired in bacteria that cause disease in humans. (Jia *et al.*, 1997).

3. Diseases: Intensive aquaculture utilizes a dense stocking rate hence overcrowding which may induce stress problems and increase susceptibility to diseases. Overcrowding leads to poor water quality due to decreased oxygen level, high levels of accumulated metabolic products and excrement, rapid growth and transmission of noxious parasites, micro-organisms and pathogens. However, the relationship between intensity of aquaculture production and environmental degradation is not straightforward; intensification can have both positive and negative environmental impacts (NACA/FAO 2001).

4. Weak environment protection consciousness: In aquaculture, some enterprises or individuals only give attention to their immediate interests. Environment protection consciousness in aquaculture is still deficient, and the random discharge of aquaculture waste waters without any treatment has deteriorated most aquaculture environment (Guangjun *et al*,. 2010).

5. Degradation of terrestrial environments: Poor construction and management of ponds leads to problems of erosion, dyke failure and leakages. These cause flooding of adjoining land and also the aquaculture site. In coastal areas, it is caused by salinization of soils, affecting adjacent agricultural practices, coastal fingers, excessive clearance of mangroves and protective cover (Salah and Guindy 2006).

6. Exotics/Escaped stocks: Aquaculture is one of the largest causes in which foreign species are introduced into new areas, creating invasive species under the right conditions. Farmed fish can escape from their pens, damaging both the environment and threatening native fish populations.

Invasives can compete for food and habitat, displace indigenous species, and interfere with the life of wild species. They can also carry diseases or parasites that might kill native species.

Exotic fish and local domesticated fish may escape from damaged systems, or through flooding, damaged or ineffective discharge screens. Farmed stocks tend to adapt poorly to the wild environment and when they escape they inter-breed with the wild stock resulting in wild types diminished due to introgression of domestic stocks, loss of genetic adaptation to local conditions as well as potential susceptibility to diseases. Introduction of exotic species (accidental or deliberate), has high adverse impacts. They may alter or impoverish the existing communities and populations of the receiving ecosystems through inter-breeding, predation and competition for food, space, habitats, etc. Genetic pollution of indigenous stocks is possible (Naylor *et al.*, 2000).

7. Fish feed production: Small wild fish, like anchovies, are caught to produce fishmeal and fish oil—the primary ingredients in fish feed for omnivorous and other carnivorous species. Fish caught to make fish feed now represent a third of the global fish harvest. As aquaculture grows, so does the pressure on these wild fisheries (WWF 2005).

ENVIRONMENTAL IMPACT ASSESSMENT IN AQUACULTURE

An Environmental Impact Assessment (EIA) is defined as a systematic process of identifying, assessing and reporting environmental impacts associated with an activity. It can also be defined as a systematic process of examining the possible or potential environmental effects of a development (Department of Environmental Affairs 2011). EIA is vital to the development of the aquaculture sector given the need for intensification and food security. Nugent (2009) stressed that it is a process that is proving useful for aquaculture, a sector which has been seen to have created some significant environmental problems in the course of its recent rapid global development.

The National Environmental Standards and Regulations Enforcement Agency (NESREA), as established by the NESREA Act (2007), gives the agency responsibility for control over our environment and for the development of processes and policies to achieve this.

The EIA component of the act makes it mandatory for any project or activity which might significantly affect the environment to be subjected to an environmental impact assessment with applications sent to NESREA. According to the NESREA act, an EIA comprises:

i. a description of the proposed activities;

ii. a description of the potential affected environment including specific information necessary to identify and assess the environmental effects of the proposed activities;

iii. a description of the practical activities, as appropriate;

iv. an assessment of the likely or potential environmental impacts on the proposed activity and the alternatives, including the direct or indirect cumulative, short-term and tong-term effects:

v. an identification and description of measures available to mitigate adverse environmental impacts of proposed activity and assessment of those measures;

vi. an indication of gaps in knowledge and uncertainly which may be encountered in computing the required information:

vii. an indication of whether the environment of any other State, Local Government Area or areas outside Nigeria is likely to be affected by the proposed activity or its alternatives;

viii. a brief and non technical summary of all the above information.

The liability of aquaculture projects to EIA is determined by the priorities given to different categories of development activity by the Nigerian government. The Act defines three categories – High Risk, Low Risk and No Significant Impact (Nugent, 2009). Aquaculture was not vividly classified under these categories hence it could fall under high risk or low risk. In addition, only "land based aquaculture projects accompanied by clearing of mangrove swamp forests covering an area of 50 hectares or more" are subject to the full process. This exempts cage and pen aquaculture which cause a lot of fouling and interfere with navigation as well as other uses of water bodies and can cause conflicts in terms of user rights. An aggregation of fish farms or ponds in an area is not covered by this legislation hence clustered ponds that tend to cover 50ha are ignored. Also, the discharge of effluents from individual farms will accumulate in the receiving water body causing eutrophication and excessive nutrient loading. Furthermore, according to Nugent (2009), this rules out almost all the existing farms, which would not be liable to mandatory EIA, unless they are sited in one of the defined environmentally sensitive areas. This type of trigger point is not fully relevant to the type of intensive production unit now being created, which have significant production volumes on areas much less than 50 ha. It may be reasonable to assume that the more intensive methods carry a higher level of environmental risk than a more extensive pond-based system.

The link between poverty and the exploitation of the environment is vividly displayed in the area of aquaculture. The Nigerian aquaculture industry is expanding rapidly and individual farmers are not concerned about the environmental impacts of their activities. Nugent (2009) pointed out that this relatively light handed approach to aquaculture may be quite rational in the circumstances, while contributing in the short term to the forces favourable to the continuing growth of the aquaculture sector in Nigeria.

Mitigating the impacts of aquaculture on the environment requires proactive measures. A checklist of rules to govern development of aquaculture sites as provided by the Department of Environmental Affairs (2011) and GESAMPP (1991) include:

1. The selection of aquaculture sites that are less environmentally sensitive and with as little conflict as possible with natural processes or ecosystem functionality.
2. The selection of aquaculture sites that do not pose land and resource use conflicts with other users.
3. The incorporation of all stakeholders in the environmental authorisation process to ensure that all users of land, water and natural resources in and around a proposed project site can provide inputs into spatial matters.
4. The use of unobtrusive structures in the design and construction of aquaculture facilities (including the use of unobtrusive colours).

5. The positioning of aquaculture facilities so that they fall outside of the line of general sight where they can cause aesthetic impacts.
6. Assess the capacity of the ecosystem to sustain aquaculture development with minimal ecological change
7. Establish guidelines for the use of bioactive compounds in aquaculture
8. Assess and evaluate the true consequences of transfers and introductions of exotic organisms
9. Regulate discharges from land based aquaculture through the enforcement of effluent standards

CONCLUSIONS AND RECOMMENDATIONS

Humanity has the ability to make development sustainable and to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987). Any aquaculture that takes place needs to be sustainable and fair. For aquaculture systems to be sustainable, they must not lead to natural systems being subject to degradation caused by an increase in concentrations of naturally occurring substances, an increase in concentrations of substances produced by society, such as persistent chemicals and carbon dioxide or physical disturbance, In practical terms the following recommendations are made;

1. Because most aquatic wastes come from feeds, to reduce these wastes, the nutrimental components and feeding mode should be changed to those that limit the percentage of un-consumed feed in the culture facility. Adding digestible carbohydrate in feeds can enhance the utilization of proteins. Selecting the optimal proportion of the energy content and the protein content in feeds can reduce the excretion of nitrogen in feed, and the excreted energy in a unit biology quantity will also be reduced.
2. In feeding of fishes, the proper feed quantity should be confirmed, this will reduce the amount of feeds scattered and loss during feeding, so it is very important to control the feed inception (Funge-smith, 1998). To reduce nutrient wastes also Aquaculture effluents should be monitored and managed, to avoid and reduce any negative environmental impacts (Manoochehri *et al*,. 2010).
3. To overcome these problems it has been suggested that enclosed bag nets or closed wall sea pens should be used to prevent fish from escaping or those land-based tanks should be used (Naylor and Burke 2005). Ultimately, land-based tanks are the only option if the goal is to eliminate any risk of escapes which might otherwise occur as a result of hurricanes or other extreme weather events at sea. It is crucial to use native rather than exotic species (Pérez *et al*,. 2003) in stocking of salmon. Only species which are native should be cultivated in open water systems, and then only in bag nets, closed wall sea pens or equivalent closed systems.
4. Cultivation of non-native species should be restricted to land-based tanks. Experts advised the use of sterile fishes such as triploid fishes and gynogenesis fishes this will prevent the problem of genetic variability when escape of cultured fishes occurs (Gowen, 1992.)
5. The chemical dosage must the strictly controlled, and the performance and method of fishery chemical administration must be correctly known. The researches about the pharmaco-dynamics, pharmacology, and the toxicology should be further strengthened, and the fishery chemicals with high efficiency, low

poisons and without pollution and residuals deposits in water should be studied to prevent the fishery diseases (Wang, 2004).

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