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Aquaculture Engineering: Status and Roles in the Growth of Aquaculture Industry in Nigeria

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Abstract: This study reviews the role of aquaculture engineering in Nigeria's aquaculture sub-sector. The focus was on solving site selection problems due to environmental, Climatic and hydrological factors, equipment selection and fabrication, and site specific engineering problems. The poor growth of the aquaculture industry in Nigeria in the past is attributed to the poor status of aquaculture engineering. Also emphasis was placed on the shortage of qualified manpower, aquaculture engineers, in Nigeria, and suggestions were made for the short, medium and long term solutions. It is hoped that this review article will elicit a positive shift in policy towards aquaculture engineering in Nigeria and beyond.

Key words: Engineering, fish farming, growth, manpower problems, potentials, site selection, solutions

INTRODUCTION

Aquaculture is a process of raising aquatic animals and plants in well defined, controlled pen, cage, pond, raft and other aquatic systems (Uzukwu, 2010b). It is the branch of fisheries commonly referred to as culture fisheries where one must stock, rear, and harvest when the fish stocked attains table-size. On the other hand, in capture fisheries, one harvests the fishery without having to sow. Aquaculture is also, by its nature, a multi-disciplinary field of study. Its major sub-disciplines include biology, biochemistry, aquaculture engineering, surveying, chemistry, veterinary science, extension, economics, law (SEAFDEC, 1995; Uzukwu, 2010a). Biology being the prime sub-discipline. Successful aquaculture ventures hinge on expertise of professionals from the above mentioned sub-disciplines (SEAFDEC, 1995). Of the sub-disciplines of aquaculture, aquaculture engineering is the least developed in Nigeria. Aquaculture engineering is the application of engineering principles to the production of food in aquatic environments (Uzukwu, 2010a). It is the branch of aquaculture that deals with the planning, design, construction, and management of aquaculture technical facilities (ponds, hatcheries, pumps, pumping stations, feed plants, canals, biofilters, etc.,). With the expansion of aquaculture in many countries, the relevance of aquaculture engineering is beginning to be recognised (Kovari, 1984; Hossain *et al*., 2009; Turmelle *et al*., 2009). The aquaculture industry has made remarkable progress in many countries most especially Southeast Asia (FAO, 1997), due largely to the contributions of aquaculture engineering. The aquaculture industry in Nigeria will likewise witness a boost if aquaculture engineering is fully explored. This study discusses the importance of aquaculture engineering to the growth of the aquaculture industry in Nigeria.

Potentials of aquaculture in Nigeria: Globally, aquaculture production has continued to witness expansion since the 1980s. In 1994 for instance, total production of finfish, shellfish and aquatic plants reached 29.50 million metric tons with a value of US $9.83 billion (ex-farm), representing an overall increase of 11.8 and 10.3% over 1993 production in weight and value respectively (FAO, 1997). The report further indicated that Asia expanded its dominance of world aquaculture production in 1994, accounting for about 80% of world's production. According to the report, aquaculture production continued to expand in developing countries including Nigeria, which has a potential of 0.65-1.50 million metric tons annually (Anyanwu, 1990). However, Anyanwu (1990) stated that total aquaculture production in Nigeria ranged from 0.40-0.50 million metric tons annually. Although empirical production data for 1994 and subsequent years for Nigeria are not available it can be said that Nigeria has a vast potential of aquaculture production which has not been fully tapped. One of the major factors responsible for this is the poor state of development of aquaculture engineering in Nigeria, especially in the area of manpower. At present no university in Nigeria offers aquaculture engineering course at the undergraduate level. This clearly reflects the negligence of aquaculture engineering in Nigeria.

Roles of aquaculture engineers: Engineering is concerned with improving the quality of human life by developing and maintaining complex physical

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infrastructures necessary for the functioning of the modern society. The importance of engineering to the rapidly developing coastal and inland aquaculture industry in Nigeria cannot be over stressed. Inadequate engineering of coastal and inland fish farms is one of the major causes of low aquaculture production and/or failure (dela Cruz, 1983). Such engineering inadequacies can be classified into four categories viz:

- Problems due to environmental factors
- Problems due to climatic and hydrological factors
- Problems in selection and repair of equipment and simple tools
- Site specific engineering problems

Environmental problems: Fish ponds, particularly coastal fishponds, can be affected by a number of environmental factors namely: the nature of the soil, elevation of site, topography, salinity, vegetation, water quality, and water pollution. If the site has sandy or peaty soil type bigger (wider) dikes need to be provided. In some cases it may be necessary to import clay soil for dyking and sealing porous pond bottoms at high cost. This is to be avoided as much as possible. Thick vegetated areas, with big-size trees entail higher construction cost and greater construction effort. The elevation of the site in relation to the water level determines whether partial or complete excavation of the pond will be required, while land with uneven topography will need more work in levelling (cut and fill) of the area (Pillay, 1977).

Data on the physicochemical, biological and microbial characteristics of the water source are important, even before the farm site is finally selected. These include water temperature, dissolved oxygen (DO), hydrogen ion concentration (pH), biochemical oxygen demand (BOD_5) nutrients ($N0_2$-N, $N0_2$-N, P_2O_5-P, etc.,), Chemical Oxygen Demand (COD), primary productivity, and parasites. These data, aside from being used in design process, would serve as baseline data in the event of any Environmental Impact Assessment (EIA) of the farm after a major pollution episode (Adindu, 1990; Horsfall and Spiff, 2001; Ubong and Gobo, 2001).

Sources of freshwater such as tidal rivers, streams, or groundwater are always important for staff use and for diluting high salinity water for cultured species. Brackish water often times is a better culture medium (dela Cruz, 1983). When this is not possible, rainwater from roofs of farm buildings can be harvested for use (UNEP, 1983). The sources of brackish water and freshwater mentioned above will require engineering structures including pumps, pumping stations, canals or pipelines to harness them (Veroli, 1985; Coche and Muir, 1992; Kepenyes, 1984; Uzukwu, 2010a).

The occurrence of pollution is a nagging problem in coastal aquaculture. According to Boyd (1990) fish ponds are usually constructed where industrial pollution is not a factor. It is usually advisably to avoid polluted areas and this is one of the reasons for conducting site selection studies prior to the establishment of any fish farm. However, if pollution occurs after the farm has been established additional engineering facilities such as oil containment booms or silt traps may be mounted to minimize the effect of the pollutant(s). The aquaculture engineer is best suited to know the best available facility to be mounted from the standpoint of economics and functionality (Uzukwu, 1996).

Climatic and hydrological problems: Important climatological data for proper fish farm design should be obtained from a meteorological station nearest to the farm site. This include mean monthly rainfall, mean monthly temperature, mean monthly evaporation, mean monthly humidity, mean monthly sunshine, and mean monthly wind speed and direction (Kovacs and Szollosi-Nagy, 1984).

The intensity and duration of rainfall, the height, duration and return period of astronomical floods, as well as incidence of droughts all influence the nature of fishponds to be constructed in a given area. Where floods are strong or tidal range exceeds 3 m, the water control structures to be put in place are bigger and sturdier. In areas where there is less flooding incidence or small tidal range (about 1 m) the dikes and sluice gates can be smaller. Small dikes and gates can also be built in areas with tidal range of 3 m but with land elevation of 1.5-2.0 m above ordinance datum. These details become clearer after detailed engineering survey by an aquaculture engineer.

Problems of selection of aquaculture equipment: The factors which determine the type of equipment, for example water pumps, to be selected for a given duty are:

- Discharge capacity
- Power requirements
- Lifting (head) capacity,
- Efficiencies of pump and prime mover, and
- Functionality

Often problems arise when replacing faulty parts or the whole unit. The above mentioned factors need to be considered when affecting such repairs.

Often it becomes important to fabricate simple tools and implements like crab hook, secchi disc, wooden mud rake, staff gauge, and so on, for the operation of the farm. Engineering are better placed to decide on the design and materials to be used in construction that will yield efficient performance.

Site specific engineering problems: These are location - specific problems that may be encountered during the construction or after the construction of the farm. For

example the nature of the soil may demand importation of clay soils for dike building and sealing porous pond bottom, or it may well be that there is excess soil from pond construction that need to be disposed off properly to avoid blockage of drainage systems. Moreover, sediments from the excess soil may lower in-stream water quality parameters which interfere with the spawning of fish like covering gravel beds, limiting light penetration, and direct damage to fish gill structures (Boyd, 1990).

Many engineering problems occur in aquaculture with regard to the water control structures such as sluice gates, monks, culverts, canals, and so on. These need to be properly engineered and located in relation to cost effective management. Research into least cost designs and materials are desirable in this regard particularly in relation to choice of construction materials such as fibre glass, wood, metal, plastic and ferro-cement.

Water leakage and seepage in completed fish ponds often present difficult problems. The approach to solving such problems involves drilling the pond bottom sub-soil to find out the nature of underlying formation (Kovacs and Szollosi-Nagy, 1984; Uzukwu, 2010a). The frequency with which this problem occurs shows that in the past we have been treating the issue of soil surveying during site selection with levity.

Manpower development: The shortage of qualified and experienced aquaculture engineers is felt all over the world. This is because institutionalized training in aquaculture engineering is scarce. This problem is particularly serious in developing countries like Nigeria. For example, there is no university in Nigeria in which aquaculture engineering course is offered. It is against this background that the Aquaculture Development and Coordinating Programme (ADCP) organized in 1983, a series of ad-hoc inter-regional courses to impart specialized instruction in the subject to qualified civil, irrigation, agricultural and environmental engineers. Fadayomi (1995) revealed that there was no qualified aquaculture engineer in Nigeria. ADCP's policy of evolving aquaculture engineers by training qualified engineers in related disciplines could only provide interim palliative solution. It is therefore, reasonable to adopt ADCP initiative and organize specialized instructions in the subject to qualified civil, irrigation, agricultural, water resources, and environmental engineers in Nigeria as short and medium term measures. As a long term solution, aquaculture engineering should be offered, as a matter of deliberate policy, in selected universities in Nigeria. A lot needed to be done in the area of manpower development in aquaculture engineering in Nigeria, and it is reasonable to begin now to address these problems for the growth and sustainable development of the aquaculture industry in Nigeria.

Summary: The important role of engineering expertise in the rapid development of aquaculture industry in Nigeria has been presented. This is to be seen as part of a larger effort at the development of the proven potentials of the aquaculture industry in Nigeria. In summary:

- Aquaculture is a multidisciplinary field of study with input from biology, biochemistry, aquaculture engineering and others, aquaculture engineering being the least developed in Nigeria.
- Manpower development in Nigeria in the area of aquaculture engineering is poor; with no University in Nigeria offering the course. Specialized instruction, in the subject to qualified civil, environmental, agricultural, irrigation, and water resources engineers seems to be the starting point, in the short and medium term, of solving the problem of manpower paucity in aquaculture engineering. In the long run universities in Nigeria should be encouraged to offer aquaculture engineering course.

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