Research Journal of Applied Sciences, Engineering and Technology 3(10): 1096-1107, 2011
ISSN: 2040-7467

Submitted: May 17, 2011 Accepted: June 10, 2011 Published: October 20, 2011

The Classification, Facilities and Practices of Culture Fisheries in Nigeria

[1]J.F.N. Abowei and [2]C.C. Tawari
[1]Department of Biological Sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria
[2]Department of Fisheries and Livestock Production, Faculty of Agriculture, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

Abstract: Fish culture levels range from subsistence level farming by individual farmers to small production units as part time small fishers. Fish culture can often be combined with crops and animal production. The most significant criterion in classifying fish culture practice from an economic point of view is its intensity. Types of culture cage culture, cage types, benefits, faults, and constrains in pen and other enclosures fish culture, perquisites of cage culture, design and construction of cage, materials for cage culture , qualities of fish for cage culture: biological and economic point of view, cage culture classification, cage fish stocking, cage fish feeding, cage sanitation, pond culture, fish pond types: barrage ponds, contour ponds, fish pond designs, fish pond design materials and equipment, dyke, monk and sluice gate design, designing pond layout, compartmentalization of ponds, climatic condition, water control mechanism, Home stead fish pond, homestead fish pond management technique, species selection and stocking, home stead fish pond feeding, estimation of materials, costing of fish pond fish pond construction an d materials, work plan, Mari culture: advantages and disadvantage are aspects of culture fisheries classification, facilities and practices in Africa with emphasis on Nigeria reviewed in this article to provide fish culturist more knowledge on culture fisheries.

Key words: Cage culture, homestead fishpond, mari culture, pen, pond culture, raft and raceway culture

INTRODUCTION

Fish culture practice can be classified based on an economic point of view and the kind of enclosure used (Tawari and Abowei, 2011). The most significant criterion in classifying fish culture practice from an economic point of view is its intensity. Intensity is the division into extensive, semi-intensive and intensive fish culture. This criterion is commonly employed but often misused (Ezeri *et al*., 2009). This is because it is difficult to distinguish between extensive and intensive fish culture. The quantity of fish produced per unit area is sometimes used as the measure of the intensity of fish culture. In most cases, this measure is misleading, especially when it is used as the sole criterion. The reason is that, it does not consider any effect of natural condition and other economic factors that affect the level of production. The most frequently used measure of intensity is feeding (Anonymous, 1972).

The growth rate of fishes depends on their feeding habits, which are largely determined by water temperature (Awachie, 1968). Proper feeding of culture fishes involves maintaining a suitable feeding rate based on the fish's appetite at the time and a suitable feed volume based on the rate of weight gain. When the amount of feed is insufficient you will begin to see a difference in growth rate between the individual fishes of a given culture group. In the fry stage, some fish species feeds on each other. After the fingerling stage, there is the tendency for the weaker and smaller fish to die from malnutrition. On the other hand, when the amount of feed being given is too large, pollution of the culture water with left over feed debris occurs. Also, considerable economic loss will occur (Awachie, 1969).

Fish culture with artificial feeding is treated as an intensive operation, while that without feeding as an extensive operation (FAO, 2006). Feeding does not consider the effects of fertilization, which affects the intensity of fish culture. In addition, the feeding levels and methods vary greatly and are not reflected in this measure. A more useful measure of the intensity is the quantity and cost of major supplies. Two major categories of organization can be identified: Small scale rural fish culture and large scale (vertically integrated) fish culture (Eweka, 1973).

Though many intermediate levels of organization can exist, there are some important general features, which characterize these two types of organization. It is worthy to note that, in the course of development, one type may gradually merge with the other (Awachie, 1973).

Corresponding Author: J.F.N. Abowei, Department of Biological Sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

Fish culture levels range from subsistence level farming by individual farmers to small production units as part time small fishers (Eweka, 1973). Fish culture can often be combined with crops and animal production with several advantages: Paddy rice- cum fish culture, poultry-cum-fish culture, duck-cum fish culture and pig-cum fish farming. These are established and practiced in some parts of the world. The practices have proved beneficial, yielding increased overall food production as well as enhanced economic benefits to the farmers. The bunds and embankments of fish farm provide suitable sites for intensive horticulture (Ezeri *et al*., 2009). The bunds may also be used for the cultivation of cassava, sweet potatoes, green beans, melon, bananas etc. The ponds' water may serve as reservoirs for irrigation of fields, gardens and watering live-stock. Excess silt from ponds is often used as fertilizer for crops. This small-scale fish culture is well suited for integration with other rural activities and can contribute substantially to the income of farmers (FAO, 1966).

Small-scale fish culture is generally more relevant when the main objectives are socio-economic development of rural areas. Large-scale ventures, dealing with large production capacity, will have to be involved in preservation, processing and product development. At the production end, seed production, feed manufacture etc may also have to be included as essential activities with the result that a certain degree of vertical integration is involved (FAO, 2006).

Fish culture practices can also be classified into three different kinds based on the source of fry. The first involves capturing of fry or fingerlings from natural waters for stocking production ponds (Hayward, 1961). This is largely practiced in Nigeria. The potential for developing this kind of fish culture is restricted because of the limited supply of fry, as a result of over fishing, water pollution and seasonal fluctuation in fish supply (Holden and Green, 1960). The second involves raising young fish from eggs obtained from wild parents. The eggs are kept in enclosures until they hatch and reach marketable size. The third and most sophisticated, involves breeding, hatching of eggs, rearing of young in enclosures until they reach marketable size; and maintaining the brood stock. The last method seems more reliable because the culturist can regulate the life cycle of the fish. It compared favorably with land animal husbandry and easy source of obtaining fish fry and fingerlings (Mann, 1962).

Types of culture cage culture, cage types, benefits, faults, and constrains in pen and other enclosures fish culture, perquisites of cage culture, design and construction of cage, materials for cage culture , qualities of fish for cage culture: biological and economic point of view, cage culture classification, cage fish stocking, cage fish feeding, cage sanitation, pond culture, fish pond types: barrage ponds, contour ponds, fish pond designs, fish pond design materials and equipment, dyke, monk and sluice gate design, designing pond layout, compartmentalization of ponds, climatic condition, water control mechanism, Home stead fish pond, homestead fish pond management technique, species selection and stocking, home stead fish pond feeding, estimation of materials, costing of fish pond fish pond construction an d materials, work plan, Mari culture: advantages and disadvantage are aspects of culture fisheries classification, facilities and practices in Africa with emphasis on Nigeria reviewed in this article to provide fish culturist more knowledge on culture fisheries.

TYPES OF FISH CULTURE

Fish culture can be categorized into six culture systems based on the kinds of enclosures (Mutter, 1972a): Pond culture, cage and pen culture, raceway culture, raft culture, closed high-density culture, and ocean ranching. Pond culture is probably the most prevalent in the world today. Taking advantage of natural topography, an area of water, can be blocked off by a retainer. A water gate is made to allow the circulation of seawater. In man-made pond, fish are raised from fry to mature fish. In the early stages of saltwater fish culture, this was the most common method, but it gradually disappeared with the development of net and cage net methods. Under the pond system, fish are also confined in earthen, concrete or otherwise structured ponds whose water are fresh brackish or marine. Stocking the ponds, feeding the stock and regulating the water quality can be manipulated to some extent (Mutter, 1972b).

With advances in marine construction technology and improved materials, the more advantageous enclosing stationary net culture method appeared and began to replace pond culture methods. This new method is divided into two types, a pole type and a hanging type (Olayide, 1966). The pole type involves driving a line of concrete poles or steel piles into the sea bottom in a shallow water area to create the outer boundary for a culture area. Hen nets are hung from these poles to divide up the waters inside the area. On the other hand, the hanging type involves stretching a cable across the water and hanging netting from the cable or using floats, sinkers and strays to hang the netting vertically in the water (Mutter, 1973). With the enclosing stationary net method, nets can also be hung in a circular pattern out from the shoreline to create a culture area. This allows for the selection of better culture waters than possible with the pond culture method. Water circulation is also superior to that of the pond culture method (Phelines *et al*., 1973).

Cage culture is the confinement of fish stocks in cages in either static or flowing large bodies of water. Cages used for fish culture are made of bamboo or wood planks and less frequently with wire of nylon netting. These cages can be placed near rivers, in streams or along the edges of lakes and lagoons. In brackish water, they are placed in tidal canals or other estuarine areas (Pillay, 1962).

The cage net culture method was introduced in 1957 in Japan. This method involves building a raft framework from logs, bamboo or iron pipes and hanging nets down from its edges. The rafts are then floated out in the water on lines of floats linked together. The raft framework is usually made in a rectangular or square shape, but some steel-construction frames are also made in heptagonal or octagonal shapes. Although there are no set standards for frame size, they are usually either 6 m×6 m with 4-6 m net hanging depth or 8 m×8 m or 10 m×10 m×10 m (Reed, 1969). The main advantages of the cage net method are:

- The facilities can be built with a relatively small capital investment .
- Culture activities can begin on a small scale.
- Water circulation within the case is extremely good.
- The fish can be moved readily from one cage to another as they grow, making for efficient, high- intensity culture operation.
- The culture facility can be moved from one water area to another.

On the other hand, the cage net method has the following disadvantages:

- Damage to the net can cause fish to escape.
- Because of the density of fish, disease resulting from net abrasion can occur more easily, and parasites and fish diseases spread more quickly among the culture population once they appear.
- The feeding operation becomes more laborious.

As for the netting, in the early stages, hemp palm nets were used, but today most of the nets are made of synthetic fibers such as nylon and Cremona or wire nets coated with vinyl or galvanized. The nets are changed 5 to 6 times with a progressively increased mesh size during the culture process as the fish grow in size (Pillay, 1968).

In pen culture, nylon netting of specific mesh size wrapped around bamboo wood frame is used to enclose the culture areas. Pen culture is used primarily in lagoons or lakes. Cage and pen cultures rely on natural food present in the water. Inadequate natural food in the water demands reduced stocking density or additional supplemental feed (Sivalingam, 1972).

Raceway culture involves the confinement of fish stock in a container through which water is passed at a rapid rate. Feeding is mostly manipulated.

Raft culture is mainly used in the culture of shellfishes. The raft floats on the sea surface with strings suspended below. Seeds from natural waters or hatcheries grow on collecting shells that are tied on the strings.

In the closed high-density culture system, stocks are confined in a container through which water is continuously recycled. Stocking and water quality are completely manipulated.

Cage culture: Cage culture perhaps originated from Kampuchea in Mekong-river. The live fish were held in bamboo cages and fed with kitchen scraps to market size. Carps were reared in bamboo cages in Java. These cages were kept in small, organically enriched streams and the fish fed on plankton or benthic drifts (Tawari and Abowei, 2011).

The Japanese later experimented with floating cages made of netting materials. The species cultured were *Senola quinqueradiata* in brackish water and *Cyrinus carpio* in lakes and these proved to be excellent producers. Following these and other successes in cage culture and coupled with the development of balanced artificial feeds, there had been a worldwide spread of the culture system. The earliest record of cage culture in Africa was in 1974 in the Central African Republic and Tanzania where *Clarias gariepinus*, *Tilapia esculenta* and *Tilapia zilli* respectively, were reared on experimental basis. Research on the possibility of cage culture was carried out from 1974 in Kainji lake (Nigeria) using four Tilapia species: *Tilapia galilaea, Tilapia melanopleura, Tilapia nilotica and Tilapia Zilli.* Intensive cage culture has developed in Cote d'ivoire and Niger Republic (White, 1973).

Cage types:
Three principal types of cages include:
Floating cages: These are surface cages consisting of a rigid and floating frame with mesh bag suspended in the water column. The cages are provided with floating structures such as metal/plastic drums, Styrofoam floats etc. This is the most commonly used type of cage.

Fixed cages: These can only be used where there is little or no fluctuation in water level. Fixed cages also allow the use of shallow areas (Welcomme, 1971). Here the cage frame is supported by poles, which are struck in the substrate.

Submerged cages: These are essentially marine cages and are either floating in mid water or resting on the bottom. They are normally found in areas where severe storms occur. Such cages can be lowered to avoid damage during bad weather. Feeding is by a funnel from the surface or by divers (Welcomme, 1971).

Cage culture benefits: Several benefits can be derived from cage culture. Among these are:

- There is the possibility of making use of all available water resources.
- There is an important economy of water.

- It helps in reducing the pressure on land resources.
- There is always the possibility of combining several fish species within one water body.
- The culture can easily be displaced if necessary.
- There is room for the intensification of fish production in terms ofhigh densities, optimum feeding and growth.
- It has a reduced length of rearing period.
- There is optimum utilization of artificial feed for growth in minimizing its conversion rate to fish flesh.
- The fish population can be easily observed daily.
- Competitors and predators can be controlled easily.
- Mortality and fish handling is reduced
- Parasites and disease control are easier and more economical
- The initial investment is relatively small.
- The harvest is flexible and easy.

Faults in cage culture: There are also several disadvantages in cage culture (Sivalingam, 1972). These include the following:

- It is difficult to apply when the water surface is very rough.
- There is the need for adequate water renewal in the cages for elimination of metabolites and maintenance of high dissolved oxygen level. Sometimes repeated contamination of the cage walls requires frequent cleaning.
- It depends absolutely on artificial feeding. High quality balanced food rich in particulate proteins, vitamins and minerals. Feed losses are possible through cage walls.
- Sometimes, natural fish populations interfere with the cages.
- There is an increased susceptibility of fish to dissolved oxygen deficit.
- There is an increased labor cost for handling feeding and cage maintenance.

Constraints in cage, pen and enclosure fish culture: Even though cage, pen and enclosure fish culture systems have very unique advantages and greater potentials than commonly known and practiced fishpond system, the following constraints have militated against their practices (Reed, 1969).

Ignorance: These fish culture systems are unknown to many people. However, the extensive "brush park" method of fish culture being practiced especially in the southern part of Nigeria is a pointer to some knowledge of cage, pen and enclosure fish culture by some local fishers. The extensive fish culture using fishing installation made of brushes, tree branches or other soft vegetation collectively termed "brush parks" are common in Bangladesh, Kampudea, China Srilanka and many parts of West African Countries such as Benin Republic, Ghana, Cote d'ivore and Nigeria (Sivalingam, 1972).

In Benin Republic, there were a complex variety of brush parks, which have evolved over the last two centuries. It is worth noting that an equivalent of 30 to 40 tones dry weight of wood per hectare can be used in the fishing installation. The yields from mature parks in Benin Republic have reached 20 tons/ha.

Invariably, the fish harvested was multi-sized and multi-species resulting in mass harvest of under-sized fish on an annual basis. Some of the fish species caught can be spawning for the first time in life. These brush parks were normally "stocked" naturally with fish "by attraction" from the wild.

Incidentally, in recent times, a steady increase in the number of such fishing installations have been observed in some parts of the lagoon system of Lagos state (Nigeria). This scenario portends danger to sustainability of the aquatic flora and fauna of that part of the ecosystem.

People lack the training on practical cage culture. This form of training would have afforded the participants an in site into the potential profitability of cage, fish culture. The trained manpower is hoped on an improved and increased cage, pen and enclosure culture system (Ezeri *et al*., 2009).

Lack of capital: The reluctance of financial institutions in granting loans to fish farmers may not be unconnected with their skepticism about the profitability/viability of the enterprise. The skepticism about the enterprise will however be blown off as related constraints like those discussed above, are ameliorated (Tawari and Abowei, 2011).

Lack of concerted efforts: This constraint can be blamed on lack of government policy on fish culture as it relates to the utilization or exploitation of the existing water bodies in cage, pen and enclosure systems. However, the three tiers of government may not be totally capable, if the policy makers at different departments of fisheries do not appropriately advise the government of the center.

Prerequisites for cage culture: One major prerequisite for the success of a cage culture lies in the selection of a suitable site. An extensive knowledge of the site considered for cage culture is vital, prior to its establishment (Sivalingam, 1972). The criteria for the site selection are:

Physical factors:

The physical factors considered in the site selection include:

Shelter: Records of wind and wave actions should be studied carefully before choosing a site for cage culture. The records can be obtained from a local meteorological office. Areas with waves greater than 0.5 m in height should be avoided as this will increase cost of anchorage and construction of storage rafts and cages (Ezeri *et al*., 2009).

Land base: This is required to provide operational base, accommodation for working staff and storage of gear and equipment.

Bottom condition: It is difficult to set up anchorage on rocky bottom, whereas soft muddy bottom indicates low water exchange rate and this is not suitable for high-density culture. A firm substrate consisting of fine gravel, sand, mud or a combination of these provides optimal condition for cage culture (Tawari and Abowei, 2011).

Hydrological factors: These factors involve the condition of the water body for the cage culture. These include:

Tidal current: Tidal movement produces currents, which brings about water circulation through the cultured fish. This introduces oxygenated water into the cage as well as removing the waste materials from it. The speed of the current will dictate the strength and resistance needed in the construction, placement and size of cages. Very high current velocity as is found in fast flowing tidal rivers is not suitable for cage culture as the caged fish expends much energy swimming against water current. Therefore, growth is retarded, as there would be loss of feed.

Water level fluctuation: This is vital particularly in rivers and dams with tidal influence. The high and low water level would influence materials and techniques used for construction. Seasonal variations experienced in water levels of rivers and wide tidal range in coastal waters are points to consider before choosing a site. If there is a big difference in water level, there is need for floating cages; otherwise fixed cages are preferred in shallow areas (Ezeri *et al*., 2009).

Water quality: Fluctuation in temperature, salinity, $_{p}$h, dissolved oxygen and quantity of plankton need to be assessed. Water quality helps to determine the suitability of a site and the management techniques to be employed. Water bodies close to pollution sources need be avoided. Pollutants often come from industries, agricultural runoff, toxic algae and petroleum effluents (Tawari and Abowei, 2011).

Biological factors: These are living organisms (Biotic factors) and include:

Diseases and predators: Water bodies with heavy occurrence of natural diseases and predators of fish should be avoided.

Other factors:

Navigation interference: Cages should not be placed in waterways so as not to create obstruction to navigation.

Proximity to market: Localities of difficult transportation of inputs and products are not economical for cage culture.

Local Labor: Availability of labor within the locality is advantageous.

Design and construction of cage: In the design and construction of cages, certain terminologies are being used. These include:

Frame: This is the structure, which gives the mesh material the desired shape. The simplest or most common shape of cages is rectangular or square. More complex structures are also constructed. The materials for the frame range from the inexpensive bamboo poles to aluminum or steel. The mahogany wood is commonly used for cages with much longevity in water. Two frame types are common depending on the mesh material used (Tawari and Abowei, 2011).

Rigid frame: These are used when plastic or metal meshes are utilized for construction. This type is ideal in strong water current.

Flexible frame: These are surface structures used for the required configuration to the net bag. The submerged net bag is attached to the surface frame. The materials used for the construction of the frame determine the duration of the cage in water. Bamboo and wood are more susceptible to contaminating organisms. However, they are locally available; and are relatively inexpensive. Treatment with paints or cero sole increase (Ezeri *et al.*, 2009).

Materials: In traditional cage culture, bamboo splints are used in making the mesh. These are mounted on the bamboo poles. In modern and intensive cage culture, synthetic netting or rigid mesh materials are used. The metal mesh requires more floatation because of its rigid support, which increases its weight. However, this kind of mesh requires less cleaning than other materials especially in brackish water; and is resistant to corrosion. The net material (nylon) is less expensive. It does not require rigid frames to handle. The plastic mesh is light and lasts longer in water and less expensive than metal mesh.

In West Africa, the most commonly used mesh material in cages is the nylon net of 14 mm mesh size of 210/48 types. This is strong and heavy, but expensive.

Treat nets with tar to facilitate their resistance to contamination. Dark colored nets are also obtainable.

The mesh size is determined by the stocked fish size. Smaller mesh sizes are used for smaller fish. However, large mesh sizes are required for effective water renewal. Aquatic organisms clog the small openings. Therefore, the water quality can be reduced to critical levels. Knotless and square meshes are preferred to knot and diamond shaped meshes. This is because the latter may cause injuries to fish.

Floatation: The design of the floatation system of a cage is important to consider because it will add to the cost of the cage. It is estimated that the volume of a liter supports a kilogramme weight. This value is multiplied by a safe factor of 2 or 3. The materials used in the floatation system include metal or plastic drums and Styrofoam blocks. The cost can be minimized, using lightweight materials. Local materials such as logs or bamboos can be tied into bundles and used as float (Ezeri *et al*., 2009).

Anchorage: An anchor is used to keep the cage in place in case of strong currents and wind. It is designed to resist movement of the cage. Anchors can be made with rocks attached to the bottom edges of the net cage or iron.

Qualities of fish for cage culture: The following qualities are recommended for a fish to be selected for cage culture:

- Biological Quality:

The biological qualities of a fish species selected for cage culture are:

- A rapid growth
- Acceptability for food
- Effective conversion efficiency of dispensed food
- Tolerance to high population densities
- Tolerance to existing water conditions
- High resistance to parasites and diseases
- Availability of the fish/fingerlings

Economic point of view:
The qualities of a fish selected for cage culture based on economic point of view are:

- A high market value
- An existing market
- Easy commercialization

In Africa, the most commonly cultured species in cage culture is *Oreochromis niloticus.* Others are *Paraophicephalus* sp., *Tilapia zilli*, *Tilapia esculenta Sarotherodon melanotheron*, *Tilapia guineensis*, *Clarias gariepinus*, *Chrysichthys walkeri* and *Chrysichthys nigrodigitatus* (Tawari and Abowei, 2011).

Cage culture classification: Cage culture like other culture systems can be classified based on the feeding level.

Extensive: The fish rely on naturally available food such as plankton. No supplementary feed is given. This practice is only for plankton eating fish species such as *O. niloticus, O. mossambicus*, *O. aureus* and juveniles of most fishes. This kind of fish culture is feasible in lakes and other eutrophic water bodies (Ezeri *et al*., 2009).

Semi-intensive: This involves the addition of low protein (10% protein) feed, which are compounded from locally available plants or agricultural by-products to supplement natural food in water. Omnivorous species such as carps and catfishes are suited for this culture.

Intensive: The fish rely almost exclusively on artificial diet of high protein (20% protein) based on fishmeal.

Cage fish stocking: In the intensive culture, the stocking rate varies with species, fish size, and cage size. The stocking rate can also be affected by the culture method adopted, quality of feed and species used. The optimum stocking rate corresponds to the maximum holding capacity of the cage. Hence, it is necessary to study the maximum holding capacity of cages for each species. This determines the optimum stocking density. The initial biomass of the fish can be estimated from the holding capacity and the culture period. An additional 10% is added to the initial biomass to compensate mortality during culture (Tawari and Abowei, 2011).

Cage fish feeding: This constitutes the highest expenditure in intensive culture. It is as much as 70% of the annual budget. The artificial diet dispensed is compounded from local ingredients such as rice bran, maize, brewers' waste, fishmeal etc. The feed is sometimes pelleted (floating or sinking) and given to the fish 2 to 3 times daily. Pellets of at least 25% protein are adequate for Tilapia fingerlings and a feeding rate of 3 to 6% biomass is recommended. This depends on the fish size (Tawari and Abowei, 2011).

Cage sanitation:
Fouling: Fouling organisms such as algae, sponges, barnacles and oysters accumulating on the cage should be periodically removed. These organisms restrict water flow and could also tear the net. Nets treated with tars and copper have low incidence of fouling organisms.

Water quality: This should be monitored at regular intervals. Dissolved oxygen is particularly important both inside and outside the cage. Toxic substance such as sulphide, ammonia, nitrogen and all forms of pollution should be monitored. At critical levels, the cage should be removed from the area to prevent fish kills.

Harvesting: Harvest fish by lifting the net or by mechanical device in the case of large production.

Pond culture:

Fish pond types:

Fishponds can be classified into two main types:

***Barrage Ponds*:** These are established in the lower side of a valley by constructing a wall across the stream or river. Water supply comes from one or several springs from underground the pond bottom, a stream in close proximity. The cost of construction is generally low. Natural productivity is directly related to the quality of water.

However, a well-designed spill way is needed. A heavy flood may break the barrage. It is not possible to control the water flow. Application of fertilizer is difficult due to variations in water flow levels and subsequent washing out.

Contour Ponds: These are constructed along the side of a valley and supplied with diverted water from a spring or a main stream. Water flow inside the pond compartment is controlled by properly constructed structures. Contour ponds are easy to manage because water flow can be easily controlled. Application of fertilizers and artificial foods is easy because water supply can be controlled. However, the cost of construction is relatively high. Natural productivity is also relatively low especially when the ponds are dug in a poor soil.

Ponds can also be named after the source of water supply or area of construction. For instance, sky ponds depend on rain for water supply. Contour ponds are built on the contour of high lands. Spring ponds depend on spring for its water supply.

In valley or diversion ponds, water is diverted from streams or rivers through channels into the ponds. They are constructed in flat areas of the valley. It is one of the best types of ponds because water supply is constant and can be controlled.

There are also large-scale commercial fishponds. These range from five to five hundred hectares. The establishment of such ponds demands a feasibility study.

Fishpond designs: In practice, various designs of fishponds exist. There is no restriction to the shape of the pond. It can be circular, square, triangular, rectangular, pentagonal etc. This depends on the shape and topography of the land available.Other considerable factors in fishpond design are**:**

- Flood heights, based on prolong observation because it determines dyke height. Soil type because dyke size and slope relates directly with soil type.
- Breeding habit of the desired species. The number and size of various ponds: nursery, transition and production ponds are determined by it. Type of equipment and machinery used in the farm. If inadequate provision is made for equipment and machinery, during designing, dyke crowns will be affected.
- Desired size of fish produced. For instance, fry, fingerlings or table size fish. Farm facilities and lay out depend on this factor. For example, if only table size fish is desired, then the hatchery is not necessary. Rather, nursery, transition, rearing and production ponds are necessary. These ponds can be linked to each other for easy transfer of water from one pond to another. A good pond design adds beauty to the farm and plays a very important role economically and materially in farming activities.

Fishpond design materials and equipment: The most important material used in the design of fishponds is the topography map drawn from the surveyed site. Other materials include drawing desk and papers, graph papers, tracing papers, graduated and parallel rules compasses, set squares, dividers, tree-square, calculator, spring bows, slide rule, stencil, HH pencil, eraser and drawing inks.

Dyke, monk and sluice gate designs: The parts of a dyke are crown (crest or pop) base, core, loe and sides (with slopes). Generally, a depth with water ranging from 1 to 1.5 m is ideal for fish culture. For effective penetration of sunlight to the bottom, adequate shallow areas should be provided to encourage the growth of microscopic organisms. Dykes should have freeboard of length ranging from 60 to 100 cm to check excess water in the pond.

Earthen dykes should have slopes ratio 1:2 on both sides for dyke perimeter and 1:15 for secondary dykes. The best size for dyke top width range from 1 to 2.0 m, so that it can be used as roadway. The gradient of the pond bottom should be 1 in 200 and slope to drainage. Place water inlet at the shallowest end of the fishpond. For two or more ponds, an independent water supply and drainage be constructed for each pond. However, a common embankment can be allowed to cut down costs.

Designing of pond layout: Physical features of a site are clearly shown on its topographic map. In planning the ponds layout, the shape of the pond can take the shape of available land and the topography. The layout should be properly defined to contain different sizes of fishponds, dykes, canals, sluice gates or monks, carrying out relevant functions. Ponds can be for nursery, transition, raring and production. Similarly, there are main dykes, secondary dykes and tertiary dykes. There are also main sluice gate, subsidiary sluice gates and multiple sluice gates.

Compartmentalization of pond: For an effective management of fishponds, the principle of pond compartmentalization can be adopted in the layout. For instance, the respective percentages for dykes, nursery ponds, transition ponds and; rearing and production ponds are 10, 5, 15 and 70, respectively. In the layout, construction of access roads, farm buildings and other pond assets should be considered.

Climatic conditions: This should be taken into account, since adverse weather conditions such as, heavy rain; wild wind action, floods and wave action militate against proper farm management practices.

Water control mechanism: One of the most important characteristics of modern fishpond is that, it should be drainable. Ponds are usually provided with water control mechanisms. The structures are inlets for filling and outlets for draining. These constitute monk, sluice gate (inlet) culvert (outlet) and spill way (anti-flowing device). Most brackish water fishponds are filled and drained by tidal system. They are fitted with simple structures, which serve the dual purposes of inlet and outlets.

Estimation of materials: Dam and dyke: Earth excavation for the construction of dam and dykes are estimated by calculating the volume of the space to be filled with soil. The volume of soil required to fill the dyke can be obtained by multiplying a cross section of the dyke by the length of the dyke.

Monk and sluice gate: Monks are vertical concrete or wooden structures. The construction of the monk is similar to that of the sluice gate. Both are operated in the same manner, using sluice board or screens. The difference is that, monk has a drainage, pipes or culvert constructed under the dyke. Monks and sluice gates are identical in function.

Spillway: The spillway acts likes a safety valve, which takes care of excess water in reservoirs or some ponds. The excess water can result from flood when the reservoir or pond is supplied with water from rivers or streams. The materials for the construction of spill way are similar to those of sluice gate, but estimates of quantities required depend on the spill way size.

Costing of fish pond: In order to estimate the total cost of constructing a fishpond, it is necessary to calculate the cost of all activities involved in the construction exercise. The costs include:

- Land acquisition and surveying
- Clearing and removal of vegetation
- Excavation of top soil and stumping
- Excavation of core trench and refills
- Excavation and dyke construction
- Excavation of canal and channels
- Construction of water control mechanisms such as sluice gate, monk tower and spill way

In large projects, it is advisable to prepare proper "Bill of Quantities". It is important to note that the cost of soil excavation varies from locality to locality. This also depends on the method used (manual labor or Machinery).

Fish pond construction: The features described below are applicable to earthen dykes not more than three meters high. Larger dykes or dams demand the services of a pond engineer.

Pond construction material: For manual labor, simple agricultural and building tools such as spades, shovels, machetes, hoes, head pans, diggers, hammers, land chains and measuring tapes are used. The machinery employed in the mechanical works include bulldozer, excavator, pay-loader, rollers, tippers, tractors, chain saws, amphibian dozers, caterpillars, graders, scrapers and land chains. The surveyor level is indispensable for checking heights and gradients.

Work plan: Proper supervision of pond construction is very important for an effective work. Work plan must be carefully prepared to save time, energy and cost.

Clearing of pond area: The principle of site clearing remains the same, be it manual or machinery. All trees and shrubs within the dyke site should be cut and removed. Felling of huge trees and stumping along dyke lines should be properly done, and all roots dug out to a depth of one meter. All wooden materials on the dyke-site should be cleared because they might decay and cause leakage or seepage in the dykes. Such materials within the roadside may not be removed but can be pilled and burnt off when dry. Stumps should be cut close to the ground level (White, 1973).

Removal of topsoil: The topsoil of the site should be dug to a depth of 15 to 30 cm for freshwater ponds and 45 to 60 cm for brackish water ponds. However, this depends on the percentage of fibrous and other organic matter content of the soil. This can be done to provide a good bind between the soil and pond bottom, and the use of dykes.

Putting of profiles: Profiles are put to aid construction. They indicate guidelines for piling up soil to required heights and slopes, as construction progresses. The profiles are put up after preparation of the dyke or dam line. The materials for profiles are straight small size bamboo poles, sticks or stakes of 20 to 25mm size and small size rope (twine). To put up profiles, two equal bamboo poles, cut to the height of a point in the dyke line are placed opposite each other across the base of the dyke. A piece of rope can be tied across the poles. Two pieces of ropes are tied to the top of the ponds and pulled to the toe stakes on the outline of the dyke.

Core trench excavation and refill: This depends on the quality of the soil. Clay core can be obtained by digging the centre portion or heart of dyke or dam. In the case of core trench refilled with puddle clay that bind the ground portion of the dyke to the sub-soil of the pond bottom. This can be done to prevent excessive seepage of water through the porous soil. It is therefore essential that the core be built with best materials containing much clay.

Building up the dyke: The elimination of seepage through dykes is affected by removal of the top layer of soil from the base of dyke length. The sub-soil is piled by the layers in stages and rammed down. The soil can be compacted by matching on it. As the dyke "rises" perpendicularly from the base toward the crest or crown to a convenient height above flood level in the locality. The first heaps of topsoil (when suitable) can be used with the sub soil for completion of the dyke to required height (White, 1973).

***The sluice gate*:** There are two types of sluice gate for brackish and fresh water fishponds. These are the concrete and wooden sluice gates. The basic principles of constructing them are the same. Concrete sluice gates are preferred to the wooden sluice gate for strength and durability of the pond. However, the wooden sluice gate is cheaper to construct. Both sluice gate and monk are located within the dyke base, such that the gradient is in the ratio of 1 in 200. The components of sluice gate are the floor, two walls with grooves for sluice boards. Some prominent features in the construction of concrete sluice gate include (Reed, 1969):

- Strong reinforced foundation for the base against weight of walls
- Adequately reinforced walls
- Apron walls against side pressures
- Appropriate concrete mixture of cement; sand and gravels
- Adequate precaution against water undercuts

Poured concrete is preferred to concrete blocks because of the strength of the structure. For the floor and base, the mixture of cement, sand and gravels are in the ratio 1:2:4; while the wall mixture ratio is 1:2½: 5. The latter mixture is best. The mixture of cement plaster should be 1:3 and the thickness should be 12.5 mm. Reinforcement of the floor and walls are affected by iron rods of two sizes as follows (White, 1973):

Walls: 12.7 mm for vertical and 6.35 mm horizontal
Floor: 12.7 mm for length and 6.35 mm width

These sizes can be increased for larger size gates of more than two-hectare ponds.

Monk: Monks are vertical concrete or wooden structures with identical functions as the sluice gate. In fact, the materials and methods of construction are similar. Both are operated in the same manner using sluice boards and screens.

Spillway: The spillway is located at the end of dyke. The component parts of the spillway are two walls and the floor. The method and material used in constructing spillway resembles the concrete sluice gate. The quantity of materials used depends on the size of the spillway. During construction, 30 cm width of spillway is needed for every three meters length of dyke.

Homestead fishpond: A homestead fishpond is any unit of a reception in concrete, earthen, metallic or plastic, sited within the vicinity of a household. It is not more than 232.5 m^2 surface area and established primarily for fish culture. The size of homestead fishpond depends on three main variables (Reed, 1969):

- Land space
- Water supply
- Fund availability

Homestead fishpond can be of any size and shape within the specified limits when the main variables are available. Four locations modifying the size of homestead fishpond include:

- Households in high-density urban areas with very little extra land space but with enough water supply
- Households in medium density urban areas with reasonable land space and sufficient water supply
- Households in low-density urban areas with very large land space and copious water supply
- Households in very low-density rural areas with abundant "unlimited" land space but very little or no regular water supply

In case of "a" above, the limiting factor is more than fund because only small homestead fishponds can be sited. The situation is different in "b" and "c". Small to medium fishpond are possible for "b", while medium to large homestead fishponds are expected in "c". This is because; it is likely that occupants of such low-density areas have enough money to set up fishponds of large dimensions. Only small to medium ponds are encouraged in "d", because water supply is limiting. The recommended minimum economic size of a homestead fishpond for an average family of six is, 4.92 m × 3.05 m (Reed, 1969).

Ten Clarias fingerlings size of 0.65 kg can be stocked in the pond. Mortality allowance of 10% can be provided in such ponds. The estimated yield is 87.75 kg. This means that for a family of six, each member can consume 14.6 kg of fish produced in pond. This figure is more than the 12.7 kg per year recommended by the United Nations Food and Agricultural Organization (White, 1973).

If a pond is sited within a household, it should be located close to a building. This enables run-off water from the building diverted into it. However, if the pond is far from a building, water should be supplied using water tankers or borehole. As soon as the location and size of the pond are known, mark out outline on the ground and provide labor to dig out the earth. The following guidelines are necessary for the construction of homestead fishponds (White, 1973).

The secret for putting up a good concrete fishpond lies in ensuring that the concrete receptacle is completely leak-proof. The pond walls can either be the literati surface of the dug-in-pond or erected with solid blocks or concrete slab casts with iron bar reinforcements (Welcomme, 1971). The durability and cost increases in that order. The pond, no matter the size can be dug to 1.22 m and built up to 0.61 m with an effective pond depth of 1.83 m. This depth is necessary to combat pressure and temperature effects. Alternatively, the pond can be built up and the sides compacted with earth to provide cool environment and ensure easy drain ability. The corners of the pond walls should be reinforced in order to avoid the development of leaks. The floor of the pond should be well concreted to a depth of 0.08 m and the walls plastered to 0.05 m thicknesses with rich cement and sand mixture. The use of six tub of river sand to one bag of cement in plastering gives excellent results (Tawari and Abowei, 2011).

As a rule, an emergency spillway that is well protected with fine wire gauge should be installed 0.61 m below the pond top. The spillway can be of an overflow pipe. The gauge screen allows water to escape from the pond in the event of a heavy rainfall without allowing the fish escaping from inside the pond. If electricity is available, a point of light should be extended to each pond. The bulb should be protected from rain by a lampshade. The light traps, insects at night. It is necessary to fence off the pond to avoid children and domestic animals from drowning (Reed, 1969).

Homestead fishpond management technique: When the pond is constructed, the pond bottom is prepared before flooding. Clean river sand is evenly spread on the pond bottom to 0.025 m high. The sand beds purify the pond water, ensures good ionic exchange between the bottom sediment and the pond water column, which forms a receptacle for algal growth. The sand bed prevents direct contact of the fish with the rough cement floor that would have resulted in abrasion on the fish skin. Abrasion on the fish skin results in diseases and mortality (Sivalingam, 1972).

During flooding the pond, it is advisable to maintain the pond water at levels between 0.91 and 1.22 m. The catfishes such as *Clarias* spp. and *Heterobranchus* spp. have the tendency to jump out of the pond at free boards less than 0.61 m. This can be easily noticed during heavy rains (Reed, 1969).

Liming is necessary for the management of fresh concrete fishponds. The pond water can be fertilized with inorganic or organic fertilizers. If an organic fertilizer such as N:P:K is used, good results will be obtained when 1kg of the fertilizer per 10 m^2 pond water surface area is applied. The fertilizer enhances phytoplankton growth in the water. The pond water turns green within the first ten days of application. However, fish culturists are advised to use organic manures that are free and efficient. Pillay, (1968) obtained excellent results by applying a mixture of cow and poultry dung in the ratio of 1:1 by weight within 5 days.

He tried the mixture in jute bags before lowering the pond water. Twenty kilogrammes of this mixture will be enough to fertilize a pond of 15 m^2 water surface area. The jute bags containing the organic mixture were withdrawn from the pond when the green color was disappearing. Pond fertilization encourages the production of fish food organisms such as plankton and benthos (Pillay, 1962).

Species selection and stocking: High yield results, when, species are properly recruited and stocked. Fish culturist should be able to identify the appropriate fish species for homestead concrete fishponds. The appropriate combination is inevitable for a successful poly culture homestead fishpond (Phelines *et al*., 1973). Most homestead fishpond owners overstock their ponds. A homestead fishpond with, a stocking density of 200 fish fingerlings, are overstocked with 2,000 fingerlings. High rates of stocking without adequate feeding leads to stunted fish growth and poor yields. Hence, the need to contact a fisheries extension worker. The recommended fish species for culture in concrete homestead fishponds are *Clarias gariepinus*, *Heterobranchus spp*, *Heterotis niloticus, Tilapia spp* and *Cyprinus carpio.* A minimum and maximum economic stocking density of 5 and 10 fish/m^2 respectively, can be maintained for *Clarias* spp., *Heterobranchus* sp., *Heterotis niloticus* and *Cyprinus carpio*. The stocking density for tilapia is 2-3 fish/m^2 because of their prolific nature. In tropical regions, tilapia can be stocked in October and harvested in May (Olayide, 1966).

Homestead fishpond feeds: Most agricultural by-products can be easily sourced locally for compounding quality protein feed. Animal based protein feed ingredients such as blood meal; fishmeal and fish dust/waste can be included while compounding cake, cotton seed cake and soya bean meal. Feeding at regular intervals is necessary during feeding. This can be done two or three times daily for *Clarias* spp. Feeding should be carried out at specific points in the pond. These points are called feeding points. Homestead pond fish should be fed daily at full ration during the dry season. This reduces the degree of contamination (Mutter, 1973).

When the culture fish reaches table size, they can be cropped. Cropping can be total or partial. If the homestead fishpond is for household alone, partial cropping can be adopted to ensure steady fresh fish supply to the family for a long period. Materials such as scoop-nets, baskets, small dragnets, hook and line are recommended for homestead fishpond harvesting. A small water pump is necessary to dewater the pond (Mutter, 1972b).

Mari culture: Mari culture, which is marine aquaculture, is the husbanding of motile fish species in enclosures and structures erected within lagoons, creeks, estuaries or flood plains within the coastal environment (Mutter, 1972a).

In Nigeria, besides the Niger Delta flood plains that encompasses Warri in the west and Port Harcourt in the east, the Lagos/Lekki lagoon, the Mahin lagoon and Badagry creek have been known to have a remarkable display of barrier beach-lagoon complexes suitable for Mari culture (Mann, 1962; Holden and Green, 1960). For example, about 60.839 ha of Lagos State surface area of 357,700 ha is made up of lagoons, creeks and river estuaries. The Mahin lagoon (east and west) covers over 967 ha, most of which are fishing grounds (Hayward, 1961). All these are suitable for Mari culture.

Systems of Mari culture: Two specific systems of Mari culture are practiced all over the world (FAO, 2006). These include:

Intensive Mari culture: Large numbers of marine organisms are, raised in small, confined area such as net-pen, sealed off canals, floating barges etc. The barges and cages are lowered into the open lagoon or at the seaward entrance of water into estuaries. The desired fish species are reared into table size or sold at desired stages.

Extensive Mari culture: This is the system whereby large areas are used for the culture of marine organisms. The culture organism must be prevented from leaving the area by using levees, weirs or structures that restrict their movements. The structures, which are water control devices, could be passive or active e.g. plugs fixed-crest weirs, rock-weirs, or gated devices.

Each of the system mentioned above, has its own advantages and disadvantages, though; they can be practiced singly or in conjunction with each other (FAO, 1966).

Advantages of Mari culture: Either practiced intensively or extensively, Mari culture has a major advantage of putting the hitherto wild fish species under the controlled influence of the culturist. Of course this major influence has many advantages, which are known to exist in aquaculture practices.

Disadvantages of Mari culture: Aside from related literature and works carried out in the United States, Canada and Norway to both the environment and the fish species (Eweka, 1973; Ezeri *et al*., 2009), Awachie (1973) expressed the problems and prospects of marine coastal protected areas in Nigeria. Most importantly, two groups of fish species exist in Nigeria's coastal Marsh, thus making Mari culture environmentally unfriendly. There are: The resident species such as catfish; and The marine-transient organism such as the shrimp, prawn, mullet and bonga.

The disadvantages of Mari culture. These include: Structure and materials used prevent public access to culture areas and even prevent wild fish species from using the ecosystem, thus interfering with their migratory movements. Public rights of free access will be in jeopardy if grants and leases are given to fish farmers within an open water area. Hydrological pattern of the natural food chain is altered due to land and levees disturbances associated with the construction (Awachie, 1969).

The marsh environment is permanently put in danger since the Mari culturist will attempt to maintain water levels, favorable to high production not caring for the environmental effects. Materials, barges and other construction costs are very high compared to those used in capture fisheries. Installation will likely be very prohibitive in Nigeria (Awachie, 1968).

In Nigeria, since not much is known about the environmental effects of intensive Mari culture, a multi-disciplinary research is therefore advocated. There is no doubt that increase in the fish production will result from Mari culture but we may end up killing the goose (environment) that lays the golden eggs (fish resources) (Anonymous, 1972).

CONCLUSION

Types of culture cage culture, cage types, benefits, faults, and constrains in pen and other enclosures fish culture, perquisites of cage culture, design and construction of cage, materials for cage culture , qualities of fish for cage culture: biological and economic point of view, cage culture classification, cage fish stocking, cage fish feeding, cage sanitation, pond culture, fish pond types: barrage ponds, contour ponds, fish pond designs, fish pond design materials and equipment, dyke, monk and sluice gate design, designing pond layout, compartmentalization of ponds, climatic condition, water control mechanism, Home stead fish pond, homestead fish pond management technique, species selection and stocking, home stead fish pond feeding, estimation of materials, costing of fish pond fish pond construction an d materials, work plan, Mari culture: advantages and disadvantage are important aspects of culture fisheries classification, facilities and practice fish culturist need to know before venturing in to fish culture.

REFERENCES

Anon., 1972: Fisheries Report to the National Agricultural Development Seminar, 1971 (Revised).

Awachie, J. B.E., 1968: Fish culture trials with natural stock and ponds on the low Niger floodplain near Atani. Umudike: Report of the Fisheries Investigation Unit (unpublished).

Awachie, J.B.E., 1969: A report on fish production trials in kraals in selected river and lakes of Eastern Nigeria. Umudike: Report of the Fisheries Investigation Unit.

Awachie, J.B.E., 1973: On conservation and management of inland water resources of Nigeria. I. Natural lakes and ponds with special reference to their utilisation for fisheries development. 1st Symposium on environmental resource management in Nigeria. University of Ife Press, Ile-Ife.

Eweka, J.A. (Ed.), 1973: Proceedings of the National agricultural development seminar, 1971. Ibadan: Caxton Press.

Ezeri, G.N., O.J. Olaoye and A.O. Agbon, 2009. Fish fingerlings Production and management. Aquacultural Media Resources and extension Center, University of Abeokuta, pp: 36.

FAO, 1966. Agricultural development in Nigeria 1965-1980. Rome, FAO.

Food and Agricultural Organisation (FAO), 2006. Year book of Fishery statistics-Summary Table. Retrieved from: www,fao.org/fi/statist.asp.

Hayward, L.A.W., 1961. Observation on the quality and losses of dried fish from Lake Chad. Lagos: West African Stored Products Research Unit.

Holden, M.J. and J. Green, 1960. The hydrology and plankton of the River Sokoto. J. Anim. Ecol., 29: 65-84.

Mann, M.J., 1962. Fish production and marketing from the Nigerian shores of Lake Chad, 1960-1961. Federal Fisheries Service, Lagos.

Mutter, N.E.S. 1972a. Report of the Benue valley appraisal mission. Overseas Development Administration, U.K., PROP/7/72.

Mutter, N.E.S., 1972b. Niger Valley survey appraisal mission September-December, 1971: Final report. Overseas Development Administration, U.K., PROP/6/72.

Mutter, N.E.S., 1973. Report of the Lower Niger Survey appraisal mission. Overseas Development Administration, U.K., PROP/14/73.

Olayide, S.O., 1966. A quantitative analysis of food requirements, supplies and demands in Nigeria. Federal Department of Agriculture, Lagos.

Phelines, R.F., M. Coke and S.M. Nicol, 1973. Some biological consequences of the damming of the Pongola River. Proc. 11th Congress on Large Dams - International Commission on Large Dams, pp: 75-90.

Pillay, T.V.R., 1962: Possibilities of fish culture in lagoons. Report to the Government of Ghana. Rome Amer. Assn. Adv. Sci., FAO, Report No. 1581.

Pillay, T.V.R., 1968. Estuarine fisheries of West Africa. Special Publication Estuaries, pp: 639-646.

Reed, W., 1969. Fishing technology relating to river and swamp fisheries of Northern Nigeria. FAO/UNDP Report No. TA 2711.

Sivalingam, S., 1972. Fish culture possibilities around Lagos lagoon and results of recent trials. Federal Fisheries Occasional Paper, No. 13. Federal Department of Fisheries, Lagos.

Tawari, C.C and J.F.N. Abowei., 2011. An exposition of the potentials and utilization of sustainable culture fisheries in Africa. Res. J. Appl. Sci. Eng. Technol., 3(4): 304-317.

Welcomme, R.L., 1971. A description of certain indigenous fishing methods from Southern Dahomey. Afr. J. Trop. Hydrobiol. Fish., 1: 129-140.

White, E., 1973. Zambia's Kafue Hydroelectric Scheme and its biological problems. Geophys. Monog. Ser., 17: 620-628.