An Exposition of the Potentials and Utilization of Sustainable Culture Fisheries in Africa

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Abstract: The interactions between fish culture and existing uses of floodplain indicate the need to develop overall and integrated management strategies in order to optimize the exploitation of water resources. In a country where animal protein is an expensive commodity sustainable culture fisheries management is inevitable. This review article is an exposition of the potentials and utilization of water resources in sustainable culture fisheries in Africa particularly in Nigeria. Areas discussed include: Meaning and importance of fish culture, reasons for fish culture in natural waters, relevant physiographical and climatic features fish culture in Africa, development of fish culture in Africa, tilapia culture, cultured species of tilapia in Africa carp culture, culture of other fish species, potential fish for pond culture in Africa, brackish water fish culture in Africa, current status of fish culture in Nigeria, specific composition of managed natural stock, cropping procedures and productivity species for culture in Nigeria. These exposes the status, potentials and utilization of fisheries resources in African countries particularly Nigeria. It provides information for management decision in developing her economy through the fisheries sector.

Key words: Africa, fish culture benefits, fish species, Nigeria, water resources

INTRODUCTION

The culture fisheries industry is witnessing a faster rate of development in contrast to the slow pace witnessed in the last three decades (Eweka, 1973). The current trend is as a result of the profitably and feasibility of aquaculture projects in addition to the increased demand for fish protein (Ezeri et al., 2009). This has resulted in the establishment of many fish farms across the world, including both large commercial and small-scale fish farms. The success or viability of these aquaculture projects depends among others, regular supply of fingerlings of desired fish species to stock the ponds or tanks. However in many instances, farmers do not obtain sufficient number of fingerlings from the existing hatcheries and some times have to source for fingerlings from the wild (Anonymous, 1972).

The economy of riverside peoples in Nigeria is based not only on activities in the main river channels but also, and perhaps more importantly, on the associated rich alluvial plains or adjacent lands which are flooded regularly, and usually annually, by the river (Ezeri et al., 2009). These annually silted floodplains are locally called the “fadama” (Ezenwa, 1974). The contributions of the floodplains of the Niger-Benue river complex in crop, livestock and fish production came into sharp focus with the recent construction of a number of multipurpose dams in Nigeria (Ezenwa, 1974). Because of its location and size, the Kainji dam on the upper Niger produced the widest and most dramatically noticeable effects on agricultural and fisheries production of downstream areas from New Bussa to the upper reaches of the Niger delta (Sivalingram, 1972). As might be expected, because of the contribution of local rainfall to the annual flood, this effect of the dam is inversely proportional to the distance downstream of the dam site (FAO, 2006). It is perhaps largely correct to indicate that the aftermath of Kainji did more than anything else to direct the attention of Nigerian biologists and agriculturists to the need for studies aimed at developing management and conservation procedures for protecting and maximizing the utilization of major floodplains in the country (Hayward, 1961).

Data is scare on the actual number of farms established in the world so as to project on fingerlings requirement. However, the demand for fingerlings is over 160 billions. This demand is scarcely met and most farmers under stock their ponds. The demand for fish fingerlings far exceeds supply, due to lack of commercial hatchery production and from collection from the wild (White, 1973).
To produce one tone of fish (1000kg) under semi-intensive system, 200-2500 fingerlings are needed for a 6 months - grow out period. The current level of aquaculture production in Nigeria is put at 30,000 tones annually. To produce 30,000 tones of fish, therefore, 75 million fingerlings will be needed. To increase fish production to 100,000 tones annually 250 million fingerlings will be required. If 20% of the land and swamp suitable for aquaculture is to be cultivated, at least 3.4 billion fingerlings will be required to stock the ponds at a stocking density of 1 fish/m² (FAO, 2006).

This therefore underscores the urgency for intensive mass production of fish fingerlings of culture fish species, especially, mud cat fish through establishment of more hatcheries. Fish hatcheries range from small-scale to hyper-intensive systems. Facilities used range from small wood boxes lined with tarpaulin to intensive indoor water re-circulatory system using plastic, concrete or fibre-glass tanks. Other hatcheries use water flow-through systems. Major species produced is African mud catfish and their hybrid using hormone treatment. Notable fish hatcheries in Nigeria include NIOMR Lagos, Arac, Port Harcourt, Durante Ibadan, Chi Lagos, Barnaly Lagos, Zartect Ibadan, And Paiyco Lagos and others.

The constraints to increased fish seed production are numerous. Scarcity of gravid parent brood stock: This problem can be solved through brood stock development and management. Size variation among the fry of mud catfish leads to cannibalism and low survival. Regular sorting and removal of “Shooters” increase survival rate. Low hatching rate of fertilized eggs. Use of viable eggs and adoption of correct breeding/spawning procedures increase hatching rates of fertilized eggs. High fry/fingerling mortality due to predation in nursery ponds and tanks: Screening of ponds with mosquito mesh and control of unwanted organism will enhance fry survival. Good hatchery management technique will however solve most of the problems enumerated above thereby ensuring higher survival rate of fry.

Fish culture classification and facilities depends on the prevalent economy and soil topography. Adequate knowledge of soil topography culture facilities and classification bridges the technical language between the aquaculturist and; both surveyors and engineers. Fish breeding, seed procurement, Hatchery management, fish nutrition, handling, preservation and processing are also inevitable vital tools in culture fisheries management and practice. Aquatic ecosystem, pond and water quality management are also very essential in culture fisheries.

Culture fisheries, like every other agriculture practice encounter problems. These may be finance, land tenure system, pest and disease. An understanding of the nature, sources, fate and possible ways of controlling them is necessary for an effective culture fisheries management and practice. These are basic unavoidable issues needed in culture fisheries management. The meaning and importance of fish culture, reasons for fish culture in natural waters, relevant physiographical and climatic features fish culture in Africa, development of fish culture in Africa, tilapia culture, cultured species of tilapia in Africa carp culture, culture of other fish species, potential fish for pond culture in Africa, brackish water fish culture in Africa, current status of fish culture in Nigeria, specific composition of managed natural stock, cropping procedures and productivity species for culture in Nigeria expose the status, potentials and utilization of fisheries resources in African countries particularly Nigeria. This review is aimed at exposing the culture, and importance of fisheries resources to individuals, private companies and national economy. It can also form the basis for management decisions in the management of fisheries, particularly Nigeria and other African countries.

**Meaning and importance of fish culture:** Fish culture is the raising of desirable fish species. Fish culture is practiced in ponds, cages and pens. It permits the supervision and regulation of reproduction, feeding, growth and control of fish size as well as stocking and maintenance of fishponds instead of leaving it to nature. Rearing of fish also improves the quality of fish products. Reared fish are intended for food or restocking open waters such as running and stagnant waters, natural and artificial lakes and ponds.

Fish culture for restocking is different from fish culture for food. The latter is an extension of fish farming to the production of fish for consumption. Fish culture also enhances the exploration of ponds resulting in the development of land, which, otherwise would have remained unproductive because of too much water, or marshy land.

Fish is an important component of the total human and other animal food. It is nutritionally equivalent to meat in protein with a good amino acid profile, sufficient essential minerals and low in saturated fatty acids. Catches from the wild fluctuates. Therefore, fish culture is necessary for the steady supply of fish. The fish culturist operates under specific conditions. He should be able to control water quality, ensure proper nutrition, promote breeding and protect fish from diseases and predators; and consider the economics of its venture.

The advantages of fish rearing over conventional fishing are many. Fish rearing is more efficient than hunting because, extensive search efforts are not required. Besides, harvest is proportional to effort and can be predicted. Environmental conditions can be largely controlled and genes can be manipulated to improve yield. Exclusive right to resource can be established in most cases and international agreement is not necessary.

Fish culture practices can be done on land not suited for other agricultural purposes. This means that fish can
flourish on lands whose waters are mostly saline or brackish. Fish lives in a fluid medium and are cold blooded. So, they require a minimal metabolic energy for maintenance of body temperature and normal movement compared to land animals. Therefore, they are efficient converters of food.

Fish also use space more efficiently than many land animals, because, they are three-dimensional habitants. In addition, the market demand for fish in fish culture can be expanded more easily than the demand for wild fish. Fish farmers are able to guarantee the delivery of a certain quantity and quality of fish. This is not always possible in artisan fisheries.

Fish culturist can also control production and market their stock when natural supplies are seasonally low or unavailable for other seasons. There is always the possibility of improving the species by selective breeding to meet consumer’s taste and market requirement. Fish fingerlings collected from the wild include *Tilapia* sp. (Plate 1), *Clarias gariepinus* (Plate 2), *Heterobranchus* sp. (Plate 3), *Chrysichthys nigrodigitatus* (Plate 4), *Mugil* sp. (Plate 5), *Lutjanus* sp. (Plate 6), *Tarpon atlanticus* (Plate 7), *Lates niloticus* (Plate 8), *Heterotis niloticus* (Plate 9), etc. Shellfish larvae are also sourced from the wild and these include *Penaeus notialis*, *Macrobranchium* sp., *Crassostrea gasar* and others (Mann, 1962).

Collection from the wild is seasonal and unreliable whereas hatchery propagation of fish seeds ensures all year-round supply. Fingerlings that are produced in hatcheries in Nigeria include Mud catfish (*Clarias gariepinus*, *Heterobranchus* spp., Hybrid of *Clarias gariepinus* and *Heterobranchus* sp., *Tilapia* (*Tilapia guineensis*, *Oreochromis niloticus*) Common carp (*Cyprinus carpio*) (Plate 10) and silver catfish (*Chrysichthys nigrodigitatus*) (Phelines et al., 1973)

Fish culture has become a major income-generating element in integrated development programmes. There can be a steady increase in fish culture through an improvement of existing technology, the expansion of culture areas and the development of new culture technologies. Most of the present technologies of fish culture in Nigeria are traditional. Although the yield per hectare is usually low. Experience from other countries indicated that, production levels of existing fish farming could be doubled or tripled through the application of improved techniques, if the various constraints on expansion can be solved.

It is believed that an acceleration in the transfer of technology, adequate support in credit, training, extension and other essential infrastructure and; appropriate environment and legal management polices are required to exploit the potentials of fish culture for self-sufficiency in fish production. The development of fish culture through a variety of methods and under different conditions has resulted in many different kinds of operations. Various criteria are used in classifying and defining different kinds of fish culture. Classification and definition are necessary because they ensure proper conduction of economically efficient assessment and comparative study.
Fish is cultivated for a variety of purpose. These include the production of human food for domestic consumption or export trade, improvement of natural stocks by means of recruitment and artificial transportation, production of sport ornamental fish and bait fish for both commercial and artisan fisheries; and the production of industrial products such as fish meal, fish feed, fish silage, minced fish and canned fish. Among these, the production of human food is the most important function of fish culture in any society.

Reasons for fish culture in natural waters: It is perhaps important to underline the fact that so far most fisheries biologists, both Nigerian and foreign, have tended to hold the view that fish culture in general is not recommended or feasible for most areas in the Nigerian Niger-Benue floodplain. Reasons advanced to support the above viewpoint include the high evapo-transpiration rate in the middle Niger and Nigerian Benue which raises doubts about the life span and thus availability of excavated pond.
water for continuous culture. It is also held that under the present conditions, fish culture is unlikely to be profitable and what is more, does not offer scope for significant increase in fisheries production in the area (Mutter, 1972b). Even the tainting of flavor of cultured fish is advanced as an economic consideration against culture (Mutter, 1972a). The fact that cheaper capture fisheries have not been fully exploited is also held against fish farm development.

While it is accepted that some of the factors such as the availability of water for long periods and the high inputs for artificial farm pond development are important and valid considerations, the present low level of national protein intake, the fish supply and demand situation as well as fish consumption preferences of the people of Nigeria inter alia, should receive due consideration, if not over-riding weighing, in decisions regarding the development of fish culture.

The current demand for fish is about twice the level of local production from all sources. In many parts of the country especially the southern areas, fish may constitute over 40 percent of human protein intake. Indeed, fish forms the dominant source of available animal protein in riverside areas and most parts of the hinterland of the lower half of Nigeria. In the latter area also, the demand for freshwater fish is very high and people are prepared to pay more for this commodity (which also serves for seasoning foods) in preference to cheaper saltwater fish. From longstanding orders for cultured carp and tilapias at Government fish culture demonstration farms in both Western and East Central States, there is no doubt that the flavor factor is unlikely to be a practical consideration in Western and East Central States, there is no doubt that the flavor factor is unlikely to be a practical consideration in

The indicated wide deficits in fish supply and the persistence of protein deficiency diseases in the country call for immediate mobilization of all available inland waters for maximal production. It seems obvious that one of the readily available paths through which the projected maximum sustainable yield can be further increased is by fish culture. While the coordination and other problems of artificial fish farming, as suggested by FAO (1966), are being sorted out by the Federal Department of Fisheries, the cheap facilities for culturing fish offered by the extensive natural residual lagoons, lakes, ponds and pools of the Niger-Benue fadamas should be put to immediate use to increase fish production by culture. It is pertinent to note that this line of action is already being pursued in a few of the adjacent river systems in the country. For instance, even in the drier and hotter far northern areas, culture trials in fadama lakes is a component of the integrated development of river floodplains as in the Hadejia River Project in Kano State.

Relevant physiographical and climatic features:

Considerable data on the present features of physiography and climate of the Niger-Benue floodplains are given by Mutter (1972a, b, 1973). Since the culture media under consideration are natural lentic bodies of water which are already in existence, details of such pondfarm limiting factors as soils, topography, water supply etc. do not require extensive discussion here. Therefore, only the salient features to show the extent and quality of the resource are briefly outlined below.

Niger floodplain: The lower Niger floodplain stretches from the extensive coastal brackishwater areas to the confluence of the Niger with the Benue at Lokoja. South of Onitsha, the fadama, 30-40 km wide, is intersected by many channels with numerous perennial and seasonal ponds. From Onitsha to Ida (Fig. 1) the floodplain gradually widens to about 40 km, almost all of this lying between the Niger and the Anambra River to the East. The last stretch of the floodplain from Ida to Lokoja is narrow with very few perennial ponds. At flow peak, the freshwater sector from the apex of the delta to Lokoja has an area of about 6 350 km² (Mutter, 1973).

Fluviosols are dominant in the floodplain of the Niger and its tributaries but its complex pattern in the alluvial areas where heavy texture with poor drainage is interspersed with more sandy and well drained patches is very important in considering schemes for increasing the size of natural fadama ponds. Characteristic climatic features include high humidity (60-80%) with mean annual temperature ranging from 26-28°C. The rainy season lasts from April to September and causes the heavily silted single annual flood, the “white flood”, experienced in the area. Annual average rainfall varies from 2500 mm at the apex of the delta to 1200 at Lokoja (Mutter, 1973).
Vegetation cover commences with mangrove swamps of the coastal and deltaic brackish waters, through freshwater swamp forests, to riparian forest and savanna mosaic at the northern limit. The fadama area of the remaining upper portion of the Niger is generally narrow with fewer perennial lakes and ponds compared to the lower Niger. It is estimated that up to 5% of the floodplain may be covered by seasonal and perennial lentic waters. Because of the Kainji dam, the future of these lakes and ponds is uncertain.

The area is drier and hotter with average annual rainfall of 1125 mm and annual temperature range of 21-38°C. The rainy season is from April to October and results, as in the Lower Niger, in a single “white flood” which peaks usually about September/October. The pre-Kainji siltless “black flood” which used to peak about January/February in this area and derived from a prior six months monsoon rains outside Nigeria, has been obliterated by the Kainji dam.

Guinea savanna dotted with trees and shrubs forms the dominant vegetation over the entire area and therefore provides little cover for natural lakes and pools. These consequently lose more water by evaporation during the dry season than their counterparts in the lower Niger floodplain.

Benue floodplain: With the exception of the sector at the Cameroon border, the floodplain of the Nigerian Benue with an area of about 2415 km² and stretching for about 905 km from the frontier to Lokoja, is generally narrow and has fewer perennial lakes and ponds than the Niger system (Fig. 2 and 3). Heavy clay soils with occasional vertisols in the back swamps predominate. These are seasonally inundated with floods of up to 6 m from July to December.

Vegetation and climatic features closely approximate those of the middle Niger. The climate is warm and humid with mean monthly temperature and average rainfall of 25-30°C and 1125 mm, respectively. The rainy season lasts from March to November with most of the rain falling from June to October. Scant vegetation cover is provided by savanna woodland.

Water quality: Very little published information is available on the physical and chemical characteristics of the Niger-Benue floodplain lentic waters and associated main river channels. From Welcomme's (1974) review of what is known of these factors in other African systems, it seems likely that these parameters for the Niger-Benue system would approximate the more general African conditions.

Such important factors as pH, dissolved oxygen, conductivity and current characteristics of the floodplains are known to be closely related to the flood cycle. Dissolved oxygen is generally higher in both the floodplain lentic waters and river channels during the floods. Conductivity, usually an index of total ionic concentration, on the other hand, tends to be higher in the dry season than in the wet. Holden and Green (1960) are of the view that the total salt concentration remains the same but that the lower figures during the flood may be due to dilution.

The most variable factor between different African systems is pH. This variability is thought to be related to soil factors. However, Holden and Green (1960) observed that in the lagoons of Sokoto River, a tributary of the Upper Niger, pH tended to alkalinity due to the concentration of calcium by evaporation.

The existence of water currents on the floodplain, except perhaps during late dry season when the fadama lakes and pools are completely isolated, is a feature which no doubt contributes immensely to the maintenance of the physico-chemical qualities of fadama lentic waters and consequently, their capacity to support the characteristic fish fauna/fisheries of the area.

Fish culture in Africa: The introduction of warm water fish culture in Africa, with Tilapia, took place between 1953-1960. But until that time, fish culture is Africa was carried out mainly at the subsistence level as a part time engagement of agriculturalist. The practice of fish farming had not been done on any appreciable scientific level. In most cases breeding and rearing were done simultaneously in the same pond. Large fish were cropped while the total stock was harvested by draining. Many
Tilapia remained the most widely cultured fish in Africa. A total of eighteen species have been tried, but only a few have stood the test of time. Other widely cultured fish include various species of carp, *Heterotis niloticus* and catfish. Predators have been introduced to control overcrowding in Tilapia ponds. The most commonly used predators include *Lates niloticus*, *Micropterus salmoides* and *Hemichromis fasciatus*.

**Development of fish culture in Africa:** Trout hatcheries appeared to be the earliest practice of fish culture in Africa, mainly for stocking of spot fishing waters. They were established in 1924 at the higher altitudes of Morocco, South Africa, and Basutoland. Pike hatcheries for River and Lake stocking started before World War II in 1939 in Morocco, while the first and only modern carp farm was built in 1954 in Panyam, Northern Nigeria. It was initially cultured with Tilapia but later changed to carp production in 1959.

**Tilapia culture:**

*Several methods are widely practiced:*
- The mixed method: This involves culturing of mixed age classes in which, the same pond is used for both
Table 1: Yield of Tilapia species with variation in altitude and species utilized in Madagascar

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Altitude</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T. mossam + T. nilotica</td>
<td>Coastal zone near sea level</td>
<td>5 to 6 tons/ha/yr</td>
</tr>
<tr>
<td>2.</td>
<td>T. macrocheir + T. zilli</td>
<td>In middle latitude</td>
<td>3.5 to 4.5 tons/ha/yr</td>
</tr>
<tr>
<td>3.</td>
<td>All species</td>
<td>Plateau above 1,000m</td>
<td>3 to 3.5 tons/ha/yr</td>
</tr>
<tr>
<td>4.</td>
<td>Only T. melanopleura</td>
<td>Above 1,500</td>
<td>2 tons/ha/yr</td>
</tr>
</tbody>
</table>

FAO (1966)

Table 2: Tilapia species cultured and countries where they are grown in Africa

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tilapia macrocheir</td>
<td>Cameroon, central Africa, Republic, Brazzaville, Zaire, Gabon, Ivory Coast, Madagascar, Tanzania, Togo, Zambia</td>
</tr>
<tr>
<td>2.</td>
<td>Tilapia melanopleura</td>
<td>Cameroon, Brazzaville Zaire, Gabon, Madagascar, Nigeria, Tanzania, Togo, Uganda, Zambia</td>
</tr>
<tr>
<td>3.</td>
<td>Tilapia mozambicans</td>
<td>Brazzaville, Zaire, Mozambique, Rhodesia, Uganda Zambia</td>
</tr>
<tr>
<td>4.</td>
<td>Tilapia nigra</td>
<td>Zaire, Kenya, Mozambique and Uganda</td>
</tr>
<tr>
<td>5.</td>
<td>Tilapia niloticus and T. zilli</td>
<td>Most East, Central, and West African Countries</td>
</tr>
<tr>
<td>6.</td>
<td>Tilapia galilea</td>
<td>Central Africa Republic, Cameroon, Brazzaville, Zaire Morocco, Togo, Ghana, Ivory Coast and Congo</td>
</tr>
<tr>
<td></td>
<td>Tillapia hendelottis</td>
<td>Nigeria and Tanzania (Brackish waters)</td>
</tr>
<tr>
<td></td>
<td>Tillapia aurea</td>
<td>Experimental stage in Uganda</td>
</tr>
</tbody>
</table>

FAO (1966)

production and propagation. The pond is stocked with different sexes, species and age groups of Tilapia. The population propagates and grows rapidly to a size near carrying capacity of the pond.

- Rearing in age group: The pond is stocked with one age group. After one reproduction, the pond is emptied, the larger fish are removed and the younger fish restocked. This method is not very popular because production is less than in the mixed method, due to underutilization of the available food.
- Rearing with reproduction control: This method makes it possible to avoid the danger of over population using three reproduction checks.

Predators: The commonly used predators include Hemichromis fasciatus, Lates niloticus, Clarias batrachus and Micropterus salmoides (Largemouth black bass). This method is not very successful, as predation can either be insufficient or total.

Sexing: This involves sexing and stocking only male Tilapia, which grow two or three times the size of the female.

Hybridization: If Tilapia honorum is crossed with female Tilapia nilotica or Tilapia mossambica, a 100% male hybrid results.

Cultured species of tilapia in Africa: Tilapia belongs to the family Cichlidae and comprises of several species. It is the most cultured fish in the tropical warm waters in Africa. Tilapia galilea and Tilapia zilli are indigenous to the lowlands of Morocco, while T. hendelottis is indigenous to the mangrove areas of Nigeria. FAO (1966), reported that the production of Tilapia per hectare decrease with increase a altitude and varies with species utilized in Madagascar as presented in Table 1.

Tilapia mossambica and Tilapia nilotica are most adequate for brackish water culture. The most widely cultured Tilapia species and the countries where they are grown in Africa are presented in Table 2.

Fertilization feeding: Experiments at various culture stations have shown that fertilization with commercial fertilizer (N.P.K) can increase yield considerably. The increase is attributed mostly to the phosphate component. According to Anonymous (1972), Tilapia ponds do not respond to fertilization and cow dung as carp ponds. Yield of Tilapia mossambica, has reportedly been doubled by liming only, but liming before manure application and mineral fertilization in Africa is not recommended.

Intensive feeding with leaves, grass and folder has proved very satisfactory. For better utilization of available natural food such as plankton, mixed culture with herbivorous and microphagous species is recommended. Food conversion ratio of the leaves = 20:1. For aquatic food and herbivorous species, soft submerged and semi-submerged water-flora is recommended.

Terrestrial food: For herbivorous and omnivorous species, all kinds of soft vegetation, household and rural waste could be fed. Others are maize, cassava, rice bran, potatoes, rubber seed and groundnut (Peanuts).

Carp culture: Carp were cultured in Africa before 1895 and used in the Cape province of South Africa in 1896 to stock natural waters. But it was not until the early 1960’s that carp culture gained acceptance in Africa. Carp culture started in Panyam fish farm in Northern Nigeria in 1959 with carp of Yugoslavian and Israeli origin. Some European strains were introduced in Rhodesian and South Africa in 1958 and 1959, respectively. Carp were introduced in Ghana in 1962 from the Panyam fish farm for experimental purposes, while Uganda started to culture Israeli carp in 1961.
In the temperature countries, carp mature in the 3rd and 4th years, but in the warm waters of the tropical region, they mature in the first year. In the plateau highlands of Nigeria, carp have a distinct spawning season, but in the lower altitude, it spawns and matures at any time.

The most widely cultured species is the common carp, *Cyprinus carpio*, which has gained prominence in Zaire, Ghana, Nigeria, Morocco, Uganda and Rhodesia. In Nigeria, an average production of 3,000 kg/ha for carp, *Tilapia* or catfish plus 500-600 mullet in poly culture experiments (with fertilization and supplemental feeding) have been recorded. The principal feed used for common carp was groundnut cake and fishmeal at 10% of body weight per day. Carp can grow at the rate of almost 0.5 kg per month in warm waters of the tropics.

**Culture of other fish species:**

**Heterotis niloticus**: This species has received great attention in Africa because of its rapid growth rate of 2 to 3 kg/year. It does not easily spawn in small ponds. Therefore, more than two hectares of pond are recommended. Breeding occurs all through the year in the low altitude. Supplemental feeding with rice bran, groundnut cake, and cotton seed cake has produced good results. Heterotis has been introduced in Nigeria, Cameroon, Ivory Coast and Madagascar, but was accepted with reluctance by consumers, because of its taste and numerous sharp lancette-sharp bones. It could be raised in home - stead fishponds together with *Tilapia*.

Largemouth (*Micropterus salmoides*): The production of the American largemouth black bass has been tried in Zaire, Gambia and Rhodesia in combination with the blue gill (*Lepomis macrochirus*), but has gained no economic importance. The fish has reportedly not done so well, especially as regards propagation in the lower altitude region of tropical Africa. In the Atlas mountain of Morocco, propagation in rivers and reservoirs has not produced satisfactory results.

**Lates niloticus**: This is produced mainly in fish culture centers for the control of *Tilapia* overpopulation. Propagation in ponds has proved difficult, but the fish has been made to reproduce by changing the water level of the ponds according to the rhythm of the flood in the rivers. Lates need larger water bodies for spawning.

For combined culture, a poly culture of carp and *Tilapia* is recommended, but experiments at the Payam fish farm in Nigeria has shown that over population by *Tilapia* can suppress the growth of carp. Heterotis is normally raised together with *Tilapia* satisfactorily. Also, Citharinoides can be grown together with *Tilapia*. A mixture of carp, *Tilapia nilotica* and *Tilapia melanopleura* or carp, *Tilapia macrocheir* and *Haplochromis mellandi* are often recommended.

**Potential fish for pond culture in Africa**: These include: Chinese carp, Indian carp, Israeli carp, mullet, *Tilapia*, *Anabantiidae*, Nile perch, *Protoperus*, *Heterotis*, *Chanos* chanos, *Stolothrisa*, *Clupeids*, *Characid*, *Catfishes*, *Cichlids* other than *Tilapia*, *Symbrahus*, *Lepidosiren* and other air breathers, trout; and large mouth bass.

The grass carp (*Ctenopharyngedon idellus*) has extraordinary ability to ingest great quantities of grass and other vegetation. The by products of ingestion may be utilized directly by other fishes or by consumption of plankton which arises from faecal decay. The grass carp plays a vital role in pond ecosystem and therefore, has great potential in Africa.

*Tilapia zillii* eats plants and plankton; and therefore clears waters. The turnover rate of nutrients with in the pond is accelerated when this plant eater is introduced. This results in higher productivity by decreasing the energy exchange time. High rates of fish production can exist in tropical waters even though nutrients appear to be limited, because there are many plant eating fishes in the tropics (Phelins et al., 1973).

Fishes, which feed on phytoplankton, are by far the most commonly occurring herbivores. *Tilapia esculenta* has a feeding mechanism, which adhere plankton by normal breathing motion with mucous secretion, and the gill rakes prevent the escape of the entangled algae (Olayide, 1966).

*Tilapia esculenta* and *Tilapia variabilis* consume diatoms, green and blue-green algae. *Tilapia nilotica* is capable of digesting blue-green algae and is quite capable of obtaining large sizes on such a diet. *Tilapia mossambica* is also capable of good growth but cannot utilized blue-green algae. Epiphytic bacteria or protozoa on the algae were thought to have an effect. *Chanos chanos* is capable of digesting blue-green algae with well-noted growth rates. *Pangasius satchi*, which may grow to a length of one meter, feed exclusively on the blue green algae, *micorcsydis* (Mann, 1962).

Epiphytic algae eaters are quite common in the Lakes of Northern Africa. Nineteen species of fish have this feeding method. *Pangasidon gigas*, which reaches a length of two meters, has no teeth and feeds exclusively on algae growing on the bottom of Rivers and Lakes. *Cirrhinus auratus* and *Cirrhinus jullieni* have been caught in large quantities and they are all epiphytic algae. *Thynnichthys thynnchthys* has identical feeding habits and represented 15-20% of the total tonnage caught in some Lakes. *Castlacarpio sjamensis* feeds on diatom and can obtain lengths up to 2.5 m (Hayward, 1961).

Africa has several air-breathing fishes as native species. The lung fishes, *Protoperus* and *Polypterus* and the barbel *Clarias*. (a relative of *Clarias batrachus* are among the few native species of fish capable of living in many Africa’s swamps. The development of the species: Snakehead, Gouramis, *Clarias batrachus*, the Eel...
(symbranchus), the *lungfish* (Lepidopterus), *Erythrinus unitaeniatus*, *Hypopomus brevirostris*, *Haplosterum Litoreale*, the Locricarrid fish (*Ancistrus anisisteis*) from other parts of the world as cultured fishes might lead to very high yields in extremely poor quality water (Ezenwa, 1974).

The potential of aquaculture activities in Africa seems promising. The abundance of water and the great number of herbivores and several air-breathers allow experimentation with many mixed fish communities (Eweka, 1973).

**Brackish water fish culture in Africa:** In most African countries, the importance of fish culture has not been fully recognized and its development has not been pursued, mainly, because of a lack of fisheries organization and a shortage of professional and trained staff. Another hindrance is the small amount of educational material and instruction booklets related to local conditions. The fish species of greatest value in fish culture, in central East Africa are all members of the cichlid family. The most important, belong to the genus Tilapia. For the following reasons Tilapia are highly desirable for use in intensive culture.

- They are efficient consumers of waste food stuffs
- They have a short food chain
- They can readily adapt to crowded conditions
- They can easily breed
- They are generally free from parasites

Five species of Tilapia are of importance: *T. melanopleura*, *T. sparramanni*, *T. andersonic*, *T. mossambica* and *T. macratha*.

In Nigeria, Mullet culture in brackish water ponds is necessary because:

- Mullet fry tend to congregate in shallow tidal pools at low tide, where they are caught with very little effort.
- They are available throughout the year in these pools, though in greater numbers from March to July than during the rest of the year. Two and half million fry (22-50 m) can be collected annually, with 50% mortality during handling.

Attempts are still experimental on how to acclimatize the fry to pond situation. Poly culture attempts have already started for mullet, which feed on bottom detritus and the catfish *Chrysichthys nigrodigitatus*, a freshwater species that feeds on mollusks (Anonymous, 1972).

The first attempt consisted of four ponds having a combined area of 0.82 ha. Salinity varied from 0.5% at the end of the rainy season in September-October to 20% during the end of the dry season in March-April. The tidal ranges in ponds were narrow with a maximum of 40 cm during the latter part of the rainy season. In new ponds, the pH was 4. A year later the pH was 7. For unfertilized ponds the pH was 6.25 and 6.75. *Tilapia, C.nigrdigitatus* and Mullet have been attempted in poly culture. Yields of 957 to 1,159 kg/ha/yr were reported when the fish harvested came in as fish eggs and larvae through the screen at the gates of the pond. These yields were attained without any form of stocking, feeding or fertilization, and in the absence of predatory species. With feeding and fertilization a yield of 2,200 kg/ha/yr was reported (White, 1973).

Poly culture trials in brackish water ponds in Lagos indicated that natural entry of mullet fry with tide could result in production of mullet up to 239 kg/ha/yr in addition to that of other species which entered along with the mullet, without supplementary feed or fertilizer. Stocking of mullet fry increased the mullet yield. Experiment indicated that supplementary feed also increased both yield and average size. Predators like *Barracluda* reduced *Mullet* populations in fishponds and also their yield Sivalingam, 1972).

**Current status of fish culture in Nigeria:** In the traditional riverside fishing community in Nigeria, the development of culture fisheries has lagged behind capture fisheries. However, fulltime fishermen in practically all sectors of the Niger-Benue floodplain have for long realized that the seasonal as well as perennial pools, swamps, lakes and lagoons of the fadama form a rich and surer source of fish than river fisheries during the dry season. This had led over the years to local and uncoordinated attempts to convert some of these floodplain ponds and swamps into what can be rightly described as extensively managed and largely unfed “culture ponds”. The level of management depends on whether such ponds are communally or privately owned also their distance from settlements or villages (Pillay, 1968).

Privately owned ponds near villages or temporary farm settlements are usually partially fed and fertilized with agricultural wastes and household sweepings. On the other hand, communal lakes and ponds, whether seasonal or perennial, are unfed.

**Niger floodplain:** The lower Niger has the best known cases of partially managed and fed natural fish ponds. The rich triangular floodplain between the Niger and Anambra rivers has over 52 large perennial lakes and ponds, largely under private ownership with a total dry season surface area of about 1650 ha (Awachie, 1973). The practice of dumping rice husk and maize wastes from local mills on the edges of perennial lakes and ponds and even the river channels is widespread here. Local farmers, who are also part-time fishermen, are aware that this practice helps to
fertilize the ponds as well as provide fodder for herbivorous fish such as the “river cow” Distichodus spp. and some omnivorous. It is noteworthy that about 70% of the fish sold at Otuocha, Onitsha, and Ogrugu during the dry season consist of Clarias, Heterobranchus, Gymnarchus, Distichodus, Ophiocephalus and Citharinus species “cultured” in these semi-fed and unfed ponds (Pillay, 1962).

At Atani and Odekpe, south east of Onitsha, supplementary feeds are provided, as indicated above, by household wastes such as dry cassava peels which find their way into smaller and continuously cropped family ponds. Here also the construction of temporary dwarf earth dams across outlet channels, not so much to retain water as to prevent fish from migrating back into the main river channel with receding floodwater, is common (Phelines et al., 1973).

Similar semi-culture but more rudimentary practices exist all over the Niger delta including brackish water areas. Unlike in the upstream freshwater areas, the saltwater zone has mainly perennial lakes and ponds which are replenished daily by tidal flow. To retain fish, therefore, various combinations of barriers involving sticks of mangrove and raffia palm as well as wire mesh are built round the ponds/pools as necessary. The arrangement ensures free flow of water with minimal loss of fish (Olayide, 1966).

Benue floodplain: Most of the perennial fadama lakes and lagoons are communally owned and unfed. Indeed, it is perhaps correct to indicate that, traditionally, very little if any attempts are made to manage these bodies of water to improve their productivity (Mann, 1962).

Specific composition of managed natural stock: Field interviews with fishermen do not seem to indicate that stocking of fadama lakes and ponds is a long standing practice. The stocking of backyard natural ponds with fingerlings of various fish, especially clarid species, taken along temporary barriers across receding flood waters and observed during 1965-1974 in the Atani/Odekpe and Oguta areas of the lower Niger, would appear to be a relatively recent development dating back to about only six to seven generations (Hayward, 1961).

The species managed and/or semi-cultured are, from the above indications, those which (as traditional fishermen are fully aware) are hardy to handle and are naturally adapted to surviving in such bodies of water. These species include those which seasonally undertake lateral migrations to the inundated fadama pools and swamps which serve as breeding and nursery grounds. The dominant elements are catfishes such as Heterobranchus, Clarias, Synodontis, Chrysichthys, Malapterurus, as well as others such as Polypterus, Protopterus, Gymnarchus, Heterotis, Xenomystus etc. which are known to possess suitable adaptive features for living under low oxygen conditions of floodplain lentic waters during the hot dry season. Common but minor elements in such ponds include some cichlids especially Sarotherodon (=Tilapia) and Hemichromis, cyprinids, mormyrids, characids (Ezenwa, 1974).

Cropping procedures and productivity: Large lakes and ponds whether private or communal, are harvested annually, usually at the dry season when catches from the main river channel are very poor. It is often the practice of migrant fishermen to purchase fishing rights of privately owned ponds and then crop them under agreed terms. Dry season communal fisheries activities in both unfed and semi-fed fadama lakes and pools have led to the development of annual “fishing festivals” which are fast becoming a tourist attraction. Indeed, the Argungu fishing festival on the floodplain of Sokoto River is today an event of some international significance (Eweka, 1973).

Smaller semi-fed family ponds are subjected to continuous cropping to meet household requirements. The mode of cropping is related to the topography, as well as the nature, size and depth of the “pond” and shows local variations.

In the few completely harvested ponds, which are usually purchased ponds, water is either evacuated by means of hired pumps or by cutting shallow canals as is more normally done in the lower Niger. In swamps and pools, the canals are usually very long and often blind. Stranded fish as well as those that move into the canals are easily picked up. Welcomme (1971) has described a very similar procedure for the Oeine River floodplain in Dahomey.

Larger fadama lakes and lagoons are cropped with all available gear ranging from local traps, weirs and scooping gear to gill and cast nets as well as long lines. As might be expected, these larger perennial bodies of water are never completely fished out. From the foregoing, it can be readily appreciated that although these natural ponds are rich, their mode of exploitation has made any reliable assessment of their yield almost impossible. It is hoped that data from experimental natural lakes and ponds in the Atani/Odekpe area and Do-Annamba floodplain will provide some useful indication of their productivity (Eweka, 1973).

Species for culture in Nigeria: Both local and acclimatized exotic species which have proved successful so far in the country will be utilized. These species are the main stay of tropical fish culture, viz.: tilapia and carp. Their fry and fingerling supply problems are well known and a number of farms now produce their fry for sale (Ezenwa, 1974).

Particular effort will be made to use those local species which naturally inhabit the media to be employed for culture and which were listed above. It is also
noteworthy that a number of these species are currently being developed for culture. Those which have shown great promise and may be described as even popular in freshwater ponds include Clarias spp., Heterobranchus spp., Heterotis niloticus, Chrysichthys nigrodigitatus, Lates niloticus, Gymnarchus, and to a lesser extent Citharinus spp., (Hayward, 1961).

The culture drawbacks of tilapias via liability to precocious breeding and consequent rutting can be turned into a cultural advantage by cropping tilapia farms continuously as is the practice in intensively managed farms in Western Nigeria. Also, fast breeding tilapias can be reared as trash fish either in mixed or poly specific culture with highly-priced carnivorous fish such as Lates niloticus or Gymnarchus niloticus; alternatively, they can be reared in mono specific culture and then used to feed the latter species (Mann, 1962).

In the brackish water areas of the Niger delta, readily available euryhaline species, apart from tilapias, are C. nigrodigitatus and the mullets especially Mugil falcipinnis. At the moment the fry/fingerlings of these species are collected from natural sources - the fadama and brackish waters (Olayide, 1966).

**DISCUSSION**

It could be inferred from the foregoing discussion that although fish culture in Africa has not progressed as would be expected, there exists a great potential for its development with more intensive research, improved management practices, better extension service programmes and better infrastructure for large scale commercial fish culture. Fish farming in Africa is sure to assume greater importance in the economy of the African nations. With production increment beyond the present subsistence level, more people would be attracted into commercial fish culture business. Above all, there are presently large hectares of swamps, lagoon, and natural bodies of water, which have not alternative uses. These could be utilized for large scale, commercial fish cultures operation. Such would not only contribute considerably to the economy of the region, but would improve appreciably the protein consumption level of the presently undernourished masses of the continent (FAO, 1966).

As can be readily surmised from the foregoing, the main bodies of water to be involved are suitable floodplain lagoons, lakes, ponds and pools already existing in natural depressions as well as swamps fringing the main river channels. To be included also are swamp rice fields with a suitable level of water for a desired period. The above will provide the mainstay of fish culture in natural waters.

As an important supplement to the above, natural as well as artificial human water supply reservoirs and even the flood control reservoirs projected for the Niger-Benue system, will be harnessed for fish culture in the present context. Depending on their life span and the length of time they are available for fish culture during the flood cycle, the above media may be utilized as seasonal or perennial farms (Phelines et al., 1973).

Field trials at Atani on the lower Niger floodplain during 1968-70, when other fish culture farms in the former Eastern Nigeria were unavailable because of the civil disturbances showed that by skilful management of the fadama floodwater it is possible to culture fry/fingerlings to the harvest stage under almost purely natural conditions (Awachie, 1968, 1969, 1973). Fry and fingerlings collected with the aid of a task force of experienced local fishermen from receding floodwater were used in stocking the main types of natural waters chosen for the trials viz.: floodplain ponds at Atani, a cut-out lake in the hinterland, and kraals or fish-pens at the periphery of Oguta lake, Njaba and Idamili Rivers (Pillay, 1962).

To collect sufficient fry/fingerlings quickly and safely, earth-backed palm frond barriers were erected across minor receding channels and along the edge of shallow flooded pools or selected areas of the floodplain. Fingerlings and fry were then readily scooped into all available containers. Large calabashes and open tins were most commonly used in delivering fish to desired locations. About 50% of cultured specimens came from traditional “fry fisheries” which involve large locally made lift devices as well as lift nets installed at the riversides as floods recede, and used to lever out large numbers of mixed fry/fingerlings from grassy river or pool edges. The main sources of fingerlings after flood recession were the smaller floodplain pools which were surrounded with small earthwork during late flood phase (Pillay, 1968).

Two ponds, 0.6 and 1.5 ha, respectively, conveniently located near the task force fishermen's homes and almost encircled by dwarf earthwork as the flood receded, were left unfed for five months and then harvested. The average yield was 250 kg/ha with clarids, mochocids and gymnarchids being the dominant fish. On stocking the same ponds, each with 1 000 Clarias fingerlings and 1 000 cichlid fry and fingerlings from nearby ponds, the yield after six months with very little feeding was 657 kg/ha. The harvest included Synodontis spp., Hydrocyon spp. and Notopterid spp., (Anonymous, 1972).

Because of extensive poaching activities caused by wartime conditions, it was not possible to quantify with reasonable accuracy the yields from the partially-fed hinterland lake and two kraals stocked with Clarias spp. and Tilapia spp. tilapia and carp; and Parophiocephalus spp. respectively. However, the estimated yield from the lake varied from 900 to 2 060 kg/ha/yr. It may also be pointed out that because of widespread acute shortage of protein during the period, the then Head of the Fisheries
Operations (the present author) was inevitably more interested in getting the harvests out to the people than in the accuracy of production records. (White, 1973) described a similar experiment on the Niger floodplains near Lokoja. By constructing earth weirs across exit streams from a swamp/lagoon system to increase the volume of water, he recorded a harvest of 188 kg/ha from unfed ponds. This figure was estimated to be double the normal yield in previous years.

From the above review of available information on the practice and prospects of floodplain pisc culture on the Niger-Benue system, it should be clear that both seasonal and perennial culture practices can be undertaken. Despite the fact that ponds are readily available and water delivered naturally, there are attendant constraints in their utilization. It is not possible to exercise effective control over the fish species which will pass into the culture media during the flood. Even with pre-culture cropping involving local pool-fishery methods which spare neither adult nor fry, undesirable species especially ubiquitous tilapias and *Hepsetus odoe*, cannot be eliminated as experience in artificial pond farms have shown (Sivalingam, 1972).

Other constraints such as ownership/tenement problems as well as institutional and allocative conflicts in the use of the fadama lakes may be easier to contain by not only demonstrating the profitability of the proposals but also getting the local floodplain farmers and fishermen involved.

Because of the water supply characteristics, perennial culture can only be meaningfully undertaken in lakes, lagoons etc. Which meet most of the following requirements:

- Location on the outer limit of the floodplain
- Maintenance of a desired minimal water level all the year round
- In the drier areas, a considerable proportion of the water supply (ca. 50%) should be derived from the catchment area (as distinct from the river channel) in order to ensure the maintenance of reasonably good water level through most of the year
- Channels connecting them to the main river should be narrow and reasonably shallow. Those which become functional only at the flood peaks because of higher location of the ponds are the best since they can easily be cut off with earth dams

Similarly, swamps in shallow depressions with minimally suitable level at dry season can be put under semi-culture to increase their yield. As for lakes and ponds, the volume of water in them could be increased as desired by constructing earth dams across connecting channels. This procedure will no doubt improve the value of traditional swamp fisheries on the floodplains. To minimize the problem of eutrophication in adjacent fadama ponds found unsuitable for culture, fertilization of culture ponds should be carefully controlled.

**CONCLUSION**

The interactions between the proposed fish culture and existing uses of floodplain indicate the need to develop overall and integrated management strategies in order to optimize the exploitation of water resources. In a country where animal protein is an expensive commodity sustainable culture fisheries management is inevitable. It is suggested that these management measures should include:

- The siting of agro-industrial complexes in such a way that most of their water requirements can be met from the river.
- Pollution and eutrophication problems emanating from industrial effluents, application of fertilizers and insecticides in crop husbandry, are to be minimized by the provision of a suitable drainage system for the farms and industrial establishments. This may result, in some cases, in the loss of water from the catchment to the natural pond farms. On the long run, however, the latter would be better off, provided that they can be refilled partly from the remaining catchment and partly from the river floodwater.
- Filling of natural culture ponds: provision should be made against the shortening of the life of culture ponds resulting from erosion from arable crop fields. Appropriate ridge orientation procedures and the provision of additional cheap drainage channels, where necessary, would help to solve the problem to a large extent.
- Reduction of effects on capture fisheries: this can be achieved by excluding from culture purposes the larger lagoons in which traditional dry season “pool fishery” is developing into a major annual event in the life of the local people. Also, as shown above, emphasis on the utilization of larger culture ponds on seasonal basis would facilitate pre-culture pool fishery harvest from most of them, even if earlier than normal, before fry/fingerlings are stocked.
- Since multipurpose dams are currently a sine qua non in the maximal integrated exploitation of floodplain resources, management procedures to offset their effects on all sectors of fisheries activities should be applied. The provision of fish ladders in dams, strategically timed release of reservoir water and/or canalization of the latter to desiccated floodplain lakes and ponds are some of the measures to meet this exigency.
- To ensure the successful implementation, Government and voluntary organizations should
sponsor research on fish culture in floodplain natural waters.

REFERENCES