INTEGRATED AQUACULTURE TECHNOLOGIES FOR FISH FARMERS

EXTENSION BULLETIN No. 229
Fisheries Series No. 15

Published by

National Agricultural Extension and Research Liaison Services
Ahmadu Bello University
Zaria.

Sponsored by

West Africa Agricultural Productivity Programme (WAAPP)

(2013)

Acknowledgement

We acknowledge all sources of information that have been pooled together for the production of this bulletin. The authors are indebted to the National Project Coordination Office of the West Africa Agricultural Productivity Programme (WAAPP) for sponsoring this publication in order to popularize the options for integrated aquaculture among our farmers so as to boost their productivity and increased income**.** The Management of NAERLS provided the enabling environment for the production of the bulletin and is therefore acknowledged. We hope the users of this bulletin will find the information contained useful in improving their farm productivity.

Authors

Bolorunduro, P. I., Yunusa, A., Onimisi, H.U., Umar, R., Umar, B and Idris, M

(2013)

Table of Content

1.0 Introduction

Aquaculture is the production of protein-rich foods through the controlled cultivation and harvest of aquatic (water) animals and plants. It ranges from the cultivation of the fin and non-finless fish, shell-fish (molluscs and crustaceans) to the cultivation of water plants. Using inexpensive and simple techniques, aquaculture can supply more protein than normally produced through conventional agriculture such as dairy, poultry, cattle rearing and even traditional fishing. This is more so, judging from the high cost of inputs necessary for the running of any of the arm of conventional agriculture.

Integrated aquaculture is a combination of aquatic organisms (e.g. fish) culture with other forms of agriculture such as poultry, piggery, cattle/goat-rearing and different crops in arable agriculture in such a way that some of the by-products of these forms of agriculture that are considered as wastes can still be recycled for either direct or indirect consumption by fish.

Modern farming methods with their high external inputs and economies of scale may promise food but at the risk of high production cost and environmental degradation. One option for sustainable development in farming is small-scale integrated agriculture and aquaculture with obvious benefits of stability in production, efficiency in resource use and conservation of the environment. Uncertainty in markets and climate is countered by a wide array of enterprises in integrated farming and moreover, wastes of one enterprise become inputs to another and, thus, optimize the use of resources and lessen pollution. Fish are efficient converters of low-grade feed and wastes into

high-value protein and fish products are the greatest sources of animal protein in rural Nigeria. Adoption of integrated agriculture-aquaculture will facilitate the addition of new resource flows, the integration of new enterprises, the substitution of external inputs and the rehabilitation of degraded agro-ecosystems.

The scope of practices in an integrated fish farm could be considerably wide. Apart from fish cultured in the water body, the water surface can be used for goose and duck rearing, pond dikes for fruit and mulberry cultivation or for setting up pig-sties or slopes for fodder corps. The products from an integrated fish farm are not only fish but also meat, milk, eggs, fruit, vegetables, etc. It is apparent that integrated fish farming can fully utilize the water body, the water surface, the land and the pond silt, etc to increase food supply for the people. Integrated system of fish farming involves methods in utilization of organic wastes. Animal excreta alone can be effectively utilized through employing various methods and techniques. Fresh animal manure can be applied directly to the fish ponds. Pig-sties, poultry coops and pens for ducks and geese can be constructed on the dikes or above the ponds. Fresh manure thus enters the ponds directly, avoiding energy loss due to processing of manure and transportation. The feedstuffs of livestock are not fully digested and these can be directly utilized by fish. Therefore, the number of animals should be compatible with unit water surface. Animal manure can be used indirectly through one or two tropic levels in a food chain such as growing fodder crops to feed herbivores (forage eating) fish or producing earth worms or other animals

for carnivores (flesh eating) fish directly. Poultry manure can be used to feed pigs and pig manure can in turn be used as fertilizers for fish pond. In fish-rice integrated culture, crop residues and compost are utilized in fertilizing the ponds, while the fish movement helps in aerating the pond for healthy rice growth.

2.0 Advantages of Integrated Fish Farming

The advantages of integrated fish farming include the following:

1. Establishment of a man-made ecosystem without any un-utilized wastes, thereby improving fertility of the local environment. The farmer obtains free pond fertilization from animal/organic manure and also free pond water for animal husbandry purposes. It therefore constitute a continuous process of disposal and recycling of animal wastes which would otherwise be accumulated on land or washed via water courses to the river, thereby creating pollution problems
2. There is maximal and efficient utilization of space and resources. Income generated by any of the combined systems is higher than that from pure fish culture, animal husbandry or plant cultivations. Integrated farming can play an important role in national economy through the creation of more jobs and in augmenting production of animal protein and crops.
3. There is no need for sophisticated and expensive fishing gear and craft in harvesting since simple draining and harvest methods are used.

4. The system has low operating and maintenance cost, thereby saving feeding cost, which is a major component in agricultural enterprises. Money that otherwise would have been used for feeding of fish can be diverted to other projects. The system is more efficient than sole fish culture in the utilization of primary resources such as organic fertilizer and feed, water, land and labor.
5. It enables multiple uses of land that would otherwise have been useless especially for arable agriculture.
6. The farmer is enabled to make effective monitoring of the production system since both fish and other animals or plants are within the same environment.
7. Decreased dependence on production inputs from outside the farm, such as artificial fertilizers thereby increasing profit and the ecological stability of the farm.
8. Increased productivity and efficiency on the farm. However a farmer needs to understand the stocking rates and densities of the commodities cultured together to enjoy the venture.

3.0 Fish Species Choice Considerations in Integrated Culture

The following are considerations that must be anticipated and responded to in integrated aquaculture in the interest of the farmers:

1. Will local or improved fish species grow well in rice fields and adapt to shallow water, high turbidity and temperature and low dissolved oxygen conditions of the fields i.e. economically important and ecologically suitable (Catfish, Tilapia)?
2. What will be the stocking rate of the fish in the rice-poultry cum fish (under monoculture and polyculture and the stocking densities)?
3. Compatibility of cultural practices on rice- poultry to the fish?
4. Will fish be stocked to serve other grow-out ponds or to maturity within the rice field?
5. What size of fish is suitable, 5-8 or 10-12cm as practiced by some farmers?
6. Suitable water depth (10-20cm?) and duration of fish growth in the rice field (30-40 days?)
7. What will be the construction design to prevent fish escape during floods (dykes strengthening)

There are a number of factors which will determine what fish species are most suitable. The general

requirements of fish recommended for integrated aquaculture are:

● It must be available locally for the farmer's use in culture.
●It should have a short food chain i.e. it should not be feed-type specific.
●It should be hardy to withstand stress.
●It must be tolerant to adverse conditions e.g. temperature variations, low dissolved oxygen
●It must be disease resistant.
● It must be hardy and do well in water of low quality, and reproduces easily
●It must be fast growing and a good feed converter (good food conversion ratio).
●It must be the generally sought-after type for easy marketing.
●If rearing is for commercial purpose, it should have good market value.

The widely recommended species that meet almost all these requirements are Tilapia, the Mud Catfish and the Common Carp as shown in **Figures 1 to 3**

Fig 1 Tilapia: Suitable for culture with rice, chicken, duck and pig.

Fig. 2 Catfish: Suitable for all types of integrated fish culture

Fig.3 Common Carp: Suitable for fish-rice culture

4.0 Types of Integrated Aquaculture

4.1 Fish-cum-Poultry Farming

Many small-scale farmers in the tropics keep chickens which are not expensive to rear for meeting household needs for eggs (layers) as well as meat (broilers). Chicken manure contains a lot of nutrients and makes very good fish food just like turkey, duck and geese.

This system of integration involves the building of poultry house over a pond (**Figure 4)**. If the farm is on large-scale, the chicken coop (building for small animals, especially chicken) can be built on the embankment of the pond as in **Figure 5**. The poultry are fed in this enclosure and their droppings are allowed to fall directly into the fish pond or on to a platform from where the droppings could be quantified before releasing it into the pond or stored.

Fig 4: Example of a chicken coop above a fish pond

Fig. 5: Large scale poultry Coop beside Fish Pond

The advantage of poultry manure is that it has nitrogen, phosphorus and organic compounds that are suitable for primary production in the ponds just like fertilizers in farmlands. Proceeds from the sale of chicken manure may exceed profit from sale of chicken and eggs. Research has established that a chicken produces 40g of excreta daily (14-15kg/yr) and therefore it is recommended that 10-30 chicken be stocked per $100m^2$ pond area and this could yield 35-50kg/yr/$100m^2$ of *Oreochromis niloticus* and *Clarias gariepinus* when reared for 4-5 months.

However, the size of the pond should always be put into consideration before erecting a poultry house. That is, a very big poultry house built on a small pond should be discouraged since the droppings from the birds will be too much and may thus contaminate or pollute the pond. A poultry housing about 25-35 birds should be ideal for a pond of 15m x 10m x 1.5m i.e. $225m^3$ for stocking catfish.

In a situation where the fish pond is secondary in consideration to the poultry, it is better to construct the pond separately and then feed the fish manually with the poultry droppings (10-15 kg dry weight/week for same size of pond). However in a situation where the poultry is secondary, in which case there is a large fish farm to a small poultry attachment, then supplementary feeding from other sources should be considered since the droppings alone from the poultry may not be sufficient for the fish to utilize.

If the size or the poultry is proportional to the pond, additional feeding of the fish may not be necessary. In all circumstances, a close study of the pond and fish should always be made, especially if the birds are infected with diseases since this would affect their feeding habits and consequently less droppings. It should be noted that some poultry diseases may also cause infections to the flesh and skins of the fish. The poultry house floor should be made in such a way that the dropping should fall directly inside the pond.

Poultry Requirements

1. Birds should come from fast growing, well feathering, strain-bred and cross-bred parents to convert feed into meat efficiently in shorter time.
2. Birds should also have resistance to diseases.

Factors to Consider Before Using Poultry Wastes

1. Are wastes available already on-farm? If so, are the wastes already used? Should they be divided for use in fish culture? Poultry wastes are often important as crop fertilizers and fuel. Consider the opportunity costs. Is it

worth raising poultry, especially to generate wastes for aquaculture?

2. Costs/difficulties of doing so (e.g. feed availability and cost; marketing difficulties; technical abilities and interest of farmers).
3. The bulkiness of poultry manure and the environmental nuisance of smelling.
4. Are all wastes to be used in fish culture? If some wastes are to be used elsewhere, the wastes should be collectible prior to entering the pond (e.g., use a sump). Also, wastes should be available in larger quantities at certain periods when their use should be reduced for fish culture (e.g., during cold season). Pens should be close to the pond to reduce labor cost of loading waste.
5. In the layout/design aspect, consideration must be given to size and number of poultry, space availability/land cost; and relative cost of materials.
6. Can all the wastes be collected? In deep liter or cage systems poultry rearing are kept confined at all times so all the wastes can be collected and used. Small-scale poultry farmers often allow birds to be free range during daylight hours and only confined at night. This reduces feed costs considerably, often allowing only on-farm or low-cost supplementary feeds to be given. But collectible wastes will be less.
7. Ponds may be multi-functional (diverse usages) increasing the risk of water transmitted diseases

4.2 Fish-cum-Duck/Geese Culture

Ducks and geese are attractive poultry for small-scale farmers. Duck (a very common water bird with short legs and a wide beak) and geese manure also contains a lot of nutrients and are suitable for feeding fish. Ducks and geese swim in the fish pond, thus spreading their own manure. The amount of manure produced over a two month period is approximately 6 to 9kg per bird.

Ducks and geese grow quickly, are strong and easy to keep. They eat waste products as well as weeds, frogs, insect larvae and snails from the pond. It is especially good to keep ducks and geese if the farmer has a large amount of tender green grass or water weeds. Chopped (to cut something into smaller pieces) up *Amaranthus sp* makes good feed for ducks. These food sources can form a large proportion of the feed for ducks and geese, supplemented with less bulky feed such as grain. Ducks stir up the bottom of the pond when looking for food. This reduces algae growth as sunlight cannot penetrate so deep into the water. By keeping the ducks in one half of the pond only, algae can grow in the other half, which also provides food for the fish. Geese spend less time in the water than ducks, and more time on the banks resting and looking for food. The banks of the pond have to be fenced off so that they are not destroyed by the geese. Ducks raised in water grow more quickly than those raise on land, and are cleaner and healthier. One advantage of geese is that they are good guard animals.

A minimum area of 0.5m per duck or goose is required. Ducks and geese can be housed in a variety of ways. A pen can be

built which floats on the water, or resting on stilts above the water or on the bank of the pond. Ducks and geese only need shelter for resting which can be built above the pond or by the side of the pond. (**Figure 6**)

Fig. 6: Duck shelter construction on the dyke

A shelter built above the water must have a floor of slats or mesh which will let the manure through. Ideally all the manure should fall into the water. By fencing off the banks with wire or netting, and not building a shelter on the banks, one can ensure that all manure is deposited in the water, and that the dykes (a wall or bank build to keep back water and prevent flooding.) remain undamaged. In this type of integration you can obtain yields of 30 to 55kg per $100m^2$ per year. The yield will depend on the number of ducks per square meter and the fish species cultured. A combination of Tilapia (*Oreochromis niloticus)* and African catfish (*Clarias gariepinus*) will yield 35 to 40kg of fish per $100m^2$ per year. When a high density of Nile tilapia (*Oreochromis niloticus)* (400 fish per $100m^2$) is used up

to 70kg per $100m^2$ can be harvested. The maximum number of laying ducks or geese is 75 per $100m^2$ when carp species are raised (200 fish per $100m^2$). Where Tilapia are raised, which are less sensitive to oxygen content, then 350 ducks or geese (plural of goose) for meat, or 400 laying ducks or geese can be kept $100m^2$. Where catfish are reared (400 fish per $100m^2$) the number of ducks or geese for meat rises to 700 per $100m^2$, or 800 egg laying geese per $100m^2$. Catfish can breathe in oxygen from the air as well as from the water. This means that more animals can be kept per square meter, and production levels of 150kg per $100m^2$ can be obtained.

Ducks can be reared in the vicinity of the fish pond by leaving the birds to move on the water bodies. The pond open to ducks can be stocked at the rate of 45 fingerlings (10g)/m^3. The droppings continually manure the pond and a huge quantity of phytoplankton (minute-fish food of plant origin) will be readily available. The ducks also clear the ponds by rooting up water plants and eating some of the fish predators such reptiles, amphibians and water snails.

Apart from the direct manuring of the pond, ducks further produce additional droppings during their rest periods when they converge in their house. The duck house must be constructed low enough to allow birds always go out to swim and come back to the house without any hindrance whatsoever. The materials to be used for the pillar of the house should be hard wood that will last several years. Concrete cement or iron rods are better materials. Feeding of the ducks should be done inside their house. Regular

supplementary feeding of the ducks should be ensured to avoid the hungry ducks searching for food. However, supplementary feeding for fish may not be necessary unless feeding is for a purpose, such as feeding the fish to attain the required size at a targeted time.

4.3 Fish-cum-Pig Culture

The combination is less obvious than the earlier mentioned ones but gives much larger yield of fish and appears to be an easier technique. Though pigs are not water animals, they like taking baths and every time they have access to a pool or pond they usually lay there and all their excreta, manures the water directly.

In this kind of combination, three arrangements of the piggery can be adopted either directly by the side of the pond or on a sloping shore or on pilings above the pond. The main point is to let the garbage pour continually into the water. It is recommended that 45-50 pigs be stocked per hectare of fish pond or 0.6-0.8 tons of pig droppings per hectare per week.

Pig dung contains more than 70% digestible feed for fish. It is reported that the feed while passing through the alimentary canal of pig, gets mixed with certain enzymes which continue to act even after defecation. The undigested solids present in the pig dung also serve as direct food source of Tilapia and common carp. A density of 60-100 pigs has been found to be enough to fertilize a fish pond of one hectare area. The optimum dose of pig manure per ha has been estimated may be obtained from 50 pigs. If the manure is to be obtained from a

dosage of 400kg/ha/day for 12 times in a year will be required. Fish like grass carp, silver carp and common carp (1:2:1) are suitable for integration with pigs. Pigs generally need a minimum floor area of 1 to 1.5m^2 per pig. There are two ways of housing pigs combined with fish. The most common is to build the sty on the banks of the pond (**Figure 7**). Dig the drainage channels so that the pig manure can be rinsed with water into the pond through a channel (**Figure 8**) It is a good idea to make a sty(a place where pigs are kept) with hard floor, so that less manure is lost. Lay the floor so that it slopes down towards the pond, as that makes it easier to wash the manure into the pond. Surplus manure can always be carried to another pond if necessary.

Fig 7: Pig Sty construction for integration with fish

In some cases pig sties are built above the pond. These are made of wood, built on stilts with a slatted floor so the manure falls into the pond. Where the sty is above a small pond it must be built on the windward side, so that the wind spreads the

manure over the pond. If the pond is large it is worth building the sties in different places above the pond. There are a number of disadvantages of building sties above a pond. It is often damp and draughty above a pond which can cause respiratory problems in pigs. You cannot use any cleaning materials to clean the sty as they will pollute the pond.

Fig. 8: Pig Sty with Hard Floor

Best results are obtained when the fish species cultured are hardy and can withstand low dissolved oxygen. The mud catfish and Tilapia meet these requirements.

It is good to take note that some pig diseases such as tape worms (*Diphyllobathrium spp*) are transferable to fish and in some cases to man, so keep a good hygiene and de-worm your pigs regularly.

4.4 Fish-cum-Cattle/Goat/Sheep/Rabbit Culture

This type of culture combination involves the construction of a fish pond near cattle ranch or pasture land and collecting the cow, sheep, or goat droppings and feed the required quantity into the pond. This dung thus manures the pond or are taken directly as food by the fish

In this culture combination fish pond can only 'be considered secondary in an already established ranch where the dung are considered as wastes. 400 goat/sheep or 30 cattle can be stocked for 1 hectare fish pond.

Cattle

Fish rearing is not often integrated with ruminants as these often graze in pastures, which makes collecting manure difficult and time consuming. Cattle produce large amounts of manure each day, but it is of poor nutritional quality. However, large numbers of cattle are raised in the tropics, and during the time that they are kept tied up it is easier to collect the dung. (Solid waste from animals especially cow) Cows can be fed Napier grass for example cow dung is commonly used to fertilize fish ponds in India, but fish yields are rarely higher than 20kg per $100m^2$. On a farm with a biogas converter the fish harvest can be doubled by first processing the cow dung in the biogas (organic gas used as fuel) converter before using it to fertilize the fish pond.

Sheep and Goats

Sheep and goats are important animals for many small-scale farmers in Africa, Asia and Latin America. Sheep and goat manure can be used as fertilizer in a fish pond. It is possible to house the animals in a pen above the pond or in the pond dyke as shown in (**Figure 9**)

Fig. 9: Cattle in the Pond Dyke

Rabbit

Rabbit rearing is very simple. They could be raised in the open or in cages as discussed for poultry. They don't gnaw (to keep biting something hard) into the dykes as musk's, rats or ducks. Harvested aquatic plants and vegetables could be fed to them. Their droppings increase food for fish their meat is of special interest to some consumers and their fur (thick soft hair that covers the bodies of some animals like rabbit, cat etc. animals could be used for leather wears and souvenirs(an object that you keep or buy to remind yourself of a special occasion or place you have visited)

4.5 General Hints on Animal Manures in Integrated Culture

Animal wastes (droppings) are organic manures. Manures from Chickens, Goats, Sheep, Ducks, Pigs, Rabbits, Cattle and Horses are excellent fertilizers for fish ponds. Other examples of organic fertilizers good for ponds are molasses from sugar cane factories, composted vegetation, table scraps and wastewater from animal slaughterhouses. Manures release nutrients for phytoplankton through decomposition.

4.5.1 How Animal Manure Work

1. They decompose and release nitrogen, phosphorus and potassium, which are used by plankton for growth and reproduction, thereby producing more natural food organisms for fish to eat.
2. Animal manures provide nutrient attachment sites for bacteria and other microscopic organisms. These organisms provide nourishment for fish even though in some cases the manure itself may have no direct food value when eaten.
3. Undigested food in animal manure is easily digestible and provides direct nutrition when eaten by fish.

4.5.2 Advantages/Disadvantages of Integrating Fish Culture with Animal

Advantages are:

i. Manure will be readily available to fertilize pond and cheaper to obtain.
ii. The pond environment cools the animal especially during hot weather
iii. Undigested foods in them are good sources of food for fish. Certain fish can digest specific components of manure or the bacteria, fungi and other organisms.
iv. Their usages at the correct rate increases pond fertilization, thereby making natural foods (phytoplankton, zooplanktons, worms, insects etc) available and less supplementary feeds will be used.
v. Animal can utilize the pond water directly or the drainage water flowing from the pen to pond site. e.g. Duck, Pigs, etc
vi. Birds like Duck increases Oxygen content (DO) of pond water through swimming.
vii. Population of fish can be controlled e.g. ducks can control Tilapia through predation.
viii. Farmers will have meat and fish to eat and increase income through sales.

ix. Integration makes maximum utilization of available land space.

x. Encouraging integration of fish and livestock in farming is a way of promoting farmers interest in fish culture.

The disadvantages are:

a. Large quantities of manure are needed to fertilize the pond
b. Tendency of over application can lead to dissolved oxygen depletion in pond
c. If not well managed, diseases can be transmitted to man.

4.5.3 Recommended Application Rates of Animal Manure in Integrated Culture

Manure	Application Rate		Number of Animals	
	Kg/100 m^2/wk	Kg/ Hectare	Per 100m^3	Per Hectare
Cattle	10	1000	a) 0.3 (all day)	30
			b) 0.6 (night only)	60
Chicken	6-8	600-800	10-15	1000-1500
Duck	6-8	600-800	10-15	1000-1500
Goat/Sheep	10	1000	a) 4 (all day)	400
			b) 8 (night only)	800
Horse/ Donkey	10	1000	0.5	50
Pig	6-8	600-800	0.5-1	50-100

Note - *Parenthesis indicate estimates per hectare.*

4.5.4 Important notes about the use of Animal Manures.

1. Manure vary in nutrient quality depending on the quality of food eaten by the animals, for example animals like Pigs and Chickens which are given high quality commercial rations will have manure higher in nutrient quality than animals like horses and cattle which feed on grasses.

2. Manure of higher nutrient quality will be required in lesser quantity than manure of lower nutrient quality to achieve equivalent result in the same pond.
3. Moisture content of manure affects its quality. Dry manure will have more of some chemical nutrient than an equal weight of wet manure because it is more concentrated, but the food value may be lower since bacteria and other organisms may have already removed much digestible materials. However dry manures are easier to manage than wet manure, and they are less dangerous.
4. Divide the weekly dose into daily application. With this, low oxygen problems will be less likely to occur and fish will more effectively utilize food in the manure.
5. Chickens, Pigs and Ducks may be confined. Chickens may be raised over Pigpens, which are built over fish ponds or raised directly above the pond.
6. Cattle, Sheep and Goats may be difficult to confine. If reared near the pond their droppings can be easily collected or flushed into ponds.
7. Restrict the access of large animals to pond site, else their hooves can break down pond dikes causing shallow weedy areas to develop. Protect pond with fence and limit access of large animals to small area of pond shoreline.

8. Guide against over application of manure to fish pond. They can use all the oxygen in water and endanger fish lives.
9. If pond water is dark greenish or deep green that indicates high fertility; allow a break of 2-4 weeks before resuming manure application. Ideal pond color is bright green.

4.5.5 Application Methods.

1. For ponds just constructed, spread the manure evenly on pond bottom before flooding the pond.
2. For ponds already flooded, break the manure into smaller fragments and broadcast on pond water i.e. avoid lump application
3. Alternatively manures can be tied in jute bags and allowed to seep into the water
4. With proper construction of animal cages, manure can drop directly into the pond from animal
5. Animal droppings can also collect in a platform and the farmer later flush or sweeps them into the ponds.

4.6 Fish-cum- Rice Culture

Fish culture in rice fields is a complementary practice of the rice culture in wet land since rice is the main harvest. Wet land is defined, as land subject to excessive wetness, to the extent that the wet conditions influence the possible land uses. They range in Nigeria from river and lake flood plains in the north to

the south. Areas of swampy rice cultivation can be stocked with Mud catfish (Clarias) and bony fish (Tilapia).
This practice involves the construction of a pond which is about 0.5-1 meter deep in a low lying area of the rice field, this act as a deeper water "refuge"(deeper water that provides shelter or protection for fish from danger and water level reduction, especially during the dry season);

Fig. 10: "Refuge" constructed in rice farm

The presence of fish in a rice field generally increases the rice yield by 10 to 15%. By cultivating two products the farmer can reduce the risk of loss if one crop fails. Fish is a source of protein, and by integrating its production with rice, food security can be enhanced. Fish also sometimes eat the insects like mosquitoes which transfer diseases to people, so raising them can improve public health. Some fish species, such as common carp eat mosquito larvae and snails which spread disease. Raising fish in a rice field is a biological way of reducing weeds, insects, snails and some rice diseases. This is a

safe and cheap alternative to using chemical pesticides to control insects and algae. The water in the rice field must be at least 20cm deep as seen in (**Figure 11**) in order for the fish to be able to survive and move freely.

Fig. 11: Rice in Fish Pond

Fish that are used for these systems could withstand low water level e.g. Carp and Clarias. The advantage of this system is that fish recycle waste materials so that they can be used again as nutrients through feeding and depositing their feaces in the submerged soil and this act as fertilizer. Up-take of important nutrients like phosphorus and nitrogen by rice plants is significantly improved in comparison with rice monoculture.
The rain-fed low land rice growing areas can also be inter-cropped with fish. Experience has shown that this combination has a chance of big success only in the area where the technique of flood rice culture is already established and where the rice farmer gets the water completely under control. In so doing, wild fish can be prevented from coming into the paddies and also control loss of production which could occur in the case of over-flooding. Good fish for combination should be

able to tolerate high temperature and low dissolved oxygen content of the water. It should be the fast growing type to reach table size after a short time (not more than 3 months). The type of rice to be cultivated too, must be the lowland water-logged type. The International Institute for Tropical Agriculture (IIT A) has different varieties of this type.

Specific Benefits and Potentials of Fish- Rice Culture Integration

1. Compared to many technologies, rice-fish culture is low risk. It demands little money, is not particularly "new" or revolutionary for most rice farmers and involves few-conflicts with other farm activities. No major changes in normal farm practices; modifications to improve yields are adapted to the traditional practices by farmers if affordable.
2. Fish cultured in rice fields provide farmer with a continuous, predictable, convenient supply of food. Farmers accustomed to depending on uncertain, declining stocks of wild fish appreciate this.
3. Rice-fish culture saves farmers' time and conserves water. This allows many farmers to begin other income-earning activities or to improve on existing ones.
2. No additional expenses, except when system is modified, such as building trenches, strengthening dikes, etc. The small amounts of money needed mean that farmers need not take out loans. They, therefore, have many options as to how to use their fish: They can eat them, sell them, keep them alive (nature permitting), preserve them or give them away. They do not have to make quick sales to reduce debts.
3. Provision of additional food and income since income from sales can provide useful money at various times. Some farmers can sell brood fish or seed fish, as well as table fish. Fish can contribute to increased rice yield by 10-15%, through:
4. Optimizes underutilized (existing) resources and maintains gene pool for locally valuable species
5. The increased size of dikes in the system offers opportunity to plant other crops such as cowpea, garden egg and other vegetables.

4.7 Fish-cum-Crops and Vegetables Culture

Some plants particularly the vegetables that are economically and nutritionally important, and are in demand throughout the year in Nigeria can be produced with fish. These plants can be grown on the ponds or dyke or slopes and or in the pond itself during the dry season.

Plants with short growing period, short fibrous root system, short bulb or tubers are most suitable for such venture. Examples of such plants include spinach, lettuce, cabbage, tomatoes etc. Other trees include palm kernel, coconut, mango, guava etc (**Figure 12**)

Fig 12 Palm Kernel grown in the Pond Dyke

5.0 Conclusion

Integrated fish farming is a low energy consuming but high efficient aquaculture system. Its cost is very low and has also been proven to be an efficient means of waste disposal and recycling which allow for savings on the use of inorganic fertilizers, supplemental feeds and labour. The integrated system is more efficient than monoculture system in the maximum utilization of organic manure, feeds, water, land and labour. The need to combine expertise of the fisheries scientists, animal scientists, veterinarians and agriculturists in this respect is very important because the animal (or plant) may be detrimental (causing harm or damage) to the other. It must be kept in mind that supervision, skilled and technical manpower is very essential in aquaculture venture and management. Capability is the rule of success of any aquaculture enterprise. Integrated fish farming holds a great

potential for augmenting production of some farmed plants and animal protein, improving the economy and providing employment in rural Nigeria. There is no doubt that this system should be considered as cheap and lucrative alternative in agriculture and fisheries development.

It is advisable that a fish farmer going into which ever type of the integrated system for the first time should start initially on small-scale for effective monitoring and control. The farmer can there after expand his activities after mastering all the techniques. Keep your pond free from enemies of your fish such as predators, reptiles, toads etc which may not only keenly compete for food with the fish but may eat the fish.

Bibliography

1. Bolorunduro P. I. and Awelewa Joseph (1992). Integrated Aquaculture Technology for Small-Scale Fish Farmers. NAERLS Extension Guide No.154, Fisheries Series No.1.10p

2. Bolorunduro, P.I (2004)**.** Fish pond fertilization techniques. *NAERLS Extension Bulletin No. 153, Fisheries Series No. 9,* 22p. *Revised 2013*

3. Fagi. A (1991) Fishing for rice. In Report, an IDRC Publication Vol.19,No.1. 8p

4. Huat, K. K. and Tan, E. S. P.(1980) Review of rice-fish culture in S. E. Asia. In: Proceedings of ICLARM-SEARCA Conference on Integrated Aquaculture Farming System Pp-14.

5. Oniye, S. J. and Awelewa, J.(1991) Prospect of Integrating Fish Culture into some Agricultural Production. A Paper Presented at the National Livestock and Veterinary Conference held at the NAERLS Conference Hall, ABU Zaria 6-8 August. 10p

6. Woynarovich, E (1979) Raising ducks on Fish Ponds In: Proceedings of the ICLARM-SEARCA Conference on Integrated aquaculture Farming System Pp.129-134.