Rice–fish production strategies in the coastal floodplains of Ondo State, Nigeria

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Abstract
Rice–fish culture is an integrated approach to food production and can increase food and income. This system can be practised with little investment and can maximize the use of existing resources. It is one way to increase the economic benefits from rice fields and at the same time develops freshwater fisheries. Rice–fish culture has been practised in 28 countries on six continents. Egypt is the largest rice producer among Middle Eastern and African countries, and Egyptian rice yields are some of the highest in the world.

Nigeria has large and expansive areas of swampy landscapes and regularly flooded lowland areas that are suitable for rice–fish culture. In Nigeria, the extensive style of growing rice and raising fish simultaneously in the same field for the period of rice culture is gaining ground and attention in the swampy floodplains, and is contributing significantly to the diets and economic livelihoods of coastal (lowland) inhabitants. This paper presents the results of a study of rice–fish production in the lowland coastal floodplains of Ondo State, Nigeria. The study examined the practice, advantages and possible contributions of this system to the realization of 'food for all' in the Vision 20/20–20 of Nigeria's developmental agenda. The advantage of the system is that sophisticated engineering, facilities and supplemental feeds are not needed. On the basis of the huge economic benefits of this system, the paper recommends: (a) the estimation of carrying capacity and production capacity of each rice field; (b) determination of optimum stocking size and stocking density; (c) establishment of stocking/harvesting system according to rice crop cycle; (d) interaction between rice production and fish production (fertilizer, pesticides, soil quality, etc.); and (e) establishment of management technologies of rice culture and rice fields under fish culture. It is envisaged that a substantial amount of rice can be produced through integrated rice and fish culture in Nigeria.

Introduction

Integrated rice–fish farming has existed in China for about 2000 years (Li, 1992); China cultivates almost one million hectares and Indonesia 94 000 ha (Lightfoot *et al.*, 1992). In rice–fish culture system, fish are usually cultured within rice areas protected from excess flooding by small dikes. Fish are cultured in rice paddies either concurrently with rice or in rotation. A wide range of fish species has been tested in rice fields, including: *Oreochromis niloticus*, common carp (*Cyprinus carpio*) and major Indian carps such as catla (*Catla catla*), rnrigal (*Cirrhimis inrigala*) and rohu (*Labeo rohita*). Other fish species that have shown good results and are of high acceptability in Asia and China include Chinese carps like silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*). Over 1.5 million ha of swamp areas in the Niger Delta show good prospects for rice–fish culture, as do areas in the Niger floodplain between Yauri in Kebbi State and Lokoja in Kogi State. The potential land area that could be put under rice production in Nigeria is estimated at about 4–6 million ha, but only some 2 million ha (about 40%) are cultivated (Miller, 2003). Rice is produced in virtually all the states of the federation. However, seven states — Kaduna, Taraba, Niger, Benue, Borno, Kano and Adamawa — have half of the rice cultivation area in the country. With such potential for rice production and with the previous presidential task force on rice production and the current 7 Point Agenda of Vision 20/20–20, the country should be self-sufficient in rice production. The integration of fish production with rice production, otherwise called rice–fish culture, should be able to boost fish production in the country. This paper presents the result of a study of rice–fish production in the lowland coastal floodplains of Ondo state, Nigeria. The study examines the production strategies, i.e. the practice, advantages and possible contributions of this system to the realization of the 'food for all' program of the country.

Rice–fish culture system in Nigeria

Rice–fish farming is not practised as a culture system in Nigeria. Rather, it is primarily the capture method that is practised. Most of the rice–fish culture methods in Nigeria have been on experimental bases. The studies of Yaro (2003) and Okoye (2004) showed — through cost–benefit analysis of rice monoculture, fish monoculture and rice-cum-fish culture in 675 m^2 farm — that rice-cum-fish culture system gives an increase of 10% in rice yield and increase of 54% in revenue due to inclusion of fish in the culture system. It was also observed in these studies that farmers have always caught wild fish in lowland rice fields, but integrated rice–fish culture has never been common. Nevertheless, there is considerable potential for increased involvement of poor farming households in rice–fish culture in both rainfed and irrigated rice, as indicated by successful examples from such widely separated areas as Bangladesh, Madagascar and Thailand. Nigeria's coastal ecosystem is very complex

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yet it has numerous potentials. These include (a) swamp rice cultivation, (b) crab culture, (c) fishing and fish culture, (d) shrimp culture, (e) mangrove oyster culture, (f) wood and timber exploitation, (g) mat production, and (h) fossil oil production. Opportunities abound for the integrated approach of rice–fish culture in this ecosystem.

Materials and methods

Study area

The study was carried out in the coastal wetland area of Ondo State, Nigeria. The area produces over 95% of the fish consumed in the state, 65% of the local dry gin brewed in the state and 25% of a cassava by-product (a local dish) called *pupu*. The area is largely a concentration of moist forests, mangrove and freshwater swamps. The mangrove is inundated with salt water for 2–10 months of the year. There are over 76 settlements along the coastal fringe of this area, whose major occupations include artisanal fishing, farming and hunting. The entire area is poorly drained particularly during the rainy months when the creeks and rivers overflow their banks. The estimated amount of fish produced here is over 12.5 tonnes per year. The population of the active fisherfolks across the study area has been put at 450 000. Fish revenue amounts to about NGN 945 million (US$ 7.26 million) per year (Akegbejo-Samsons, 1995). Farming is the second major occupation of the settlements; however, scarcity of farmland is the major obstacle to food production. The existing land and water is under family title-deed, communal or privately owned by individuals.

Study population, sampling procedure and sample size

The study area was divided into three strata for ease of identification and data collection. The first stratum consisted of settlements and villages situated along the 18 km coastline of the study area. The second stratum consisted of all villages and settlements within and on the creeks and lagoons. The third stratum comprised settlements located within the forested swamps, floodplains, river canals and waterways. In each stratum, 10 settlements were selected randomly. Thus, a total of 30 settlements (fishing and farming villages) was used for the study. The register of membership of the different co-operatives was used as the population size of the project (325 fishers). Only 80 respondents were used for analysis, however, because these were rice–fish farmers.

Types of data collected

Eighty rice–fish farmers, 40 in each sub-district, were interviewed at their houses and/or farm sites. The interviews, lasting about an hour, focused on rice–fish farming systems, culture practices, productivity and constraints to rice–fish farming. A participatory rural appraisal tool, focus-group discussion (FGD), was conducted with rice–fish and rice-only farmers to obtain qualitative information. Data were collected through structured questionnaires, personal interviews and direct field observations. The data collected included farm size, labor, seeds, fertilizer and output of rice–fish culture.

Data analysis

Field responses from the stakeholders formed the data that were subjected to descriptive analysis. Survey data rely on farmer responses and enumerators to capture these. Data presented were typically derived from the village survey. Along with the questionnaire, other forms of discussion and ideas were also recorded.

Results and Discussions

Socioeconomic profile of the fishers

Table 1 shows some of the socioeconomic profile of the fishers in the study area. The average age of the fishers was 43.5 years, with 55.5% in the 36–45 years age category, and 27.5% in the 16–35 years category. About 36.2% of the fishers were male, with an average of about 6 years of formal education. Each of them owned fishing locations of an average of 2.4 km^2 and traditionally inherited their water areas. Family sizes ranged between 1 and 12 persons, with an average of 8 persons. Average annual income from fishing alone, standardized at 2005 value, was about NGN 256 000 ($1652), ranging from NGN 45 000 to 458 000 ($290–2958). Studies from other coastal artisanal activities found similar earning bracket (personal observation, 2002). Fisheries activities form the exclusive preserve of the people in their active age, and they were fully aware of the interplay between the resources and the environment.

Table 1. Some socioeconomic profile of coastal fishers in Ondo state

Characteristics	Percentage (N=270)	Mean/Mode	Standard deviation	Minimum	Maximum
Age (years)					
Less than 15	3.6				
16–35	27.5				
36–45	55.5	43.5	12.78	13	72
46–60	5.1				
Above 60	8.3				
Education (years)					
None	30.6				
Less than 6	25.8	5.7	4.66	0	24
7–12	36.2				
More than 12	7.4				
Fishing access (no. areas)					
1. One	42.1				
2. Two	35.8				
3. Three	17.5	2.4 km^2	1.67	1	5
4. Four	3.2				
5. More than four	1.4				
Family size (persons)					
Up to 2	8.3				
3–5	20.7	8	7.3	1	15
6–9	34.4				
10–12	36.6				
Income per annum, 2005 (NGN)					
Less than 50 000	3.4				
50 000–100 000	10.6				
100 000–150 000	20.5				
150 000–200 000	27.8	256 000	na	45 000	458 000
200 000–250 000	28.2				
250 000–350 000	4.9				
350 000–500 000	3.8				

Rice–fish production in the study areas

Geographically, coastal wetlands of Ondo State have been identified as one of the most important and promising areas for rice–fish culture, because of favorable resources and climatic conditions, such as the availability of lowlying agricultural land, warm climate, fertile soil, and cheap and abundant labor.

Rice is predominantly produced by small-holders. Hydrological conditions are also favorable for rice–fish farming, as this area is located within the tropical rainforest zone with an average annual rainfall of 2500 mm. Moreover, conditions are highly encouraging for the expansion of rice–fish farming as the quantity of fish fry produced is easily obtained from around the 76 communities. Nevertheless, a small number of farmers (about 35) are involved in rice–fish farming in Mahin, Idi-Ogba and Ita-Aiyelala. Table 2 shows the potential fish production in the various water systems in the Niger Delta of Nigeria.

Table 2. Potential fish production in various water systems in the Niger Delta

	Potential production (t/year)
Freshwater aquaculture	500 000
Brackish water aquaculture	400 000
Marine aquaculture	300 000

Source: Ezenwa (2006).

Integrated culture methods

Various types of integrated farming have been experimented with and practised in many parts of the tropics. In most cases, fish production remains the major activity, with rice, pig or poultry production associated with fish production as the minor activity.

There were two main culture methods in the study area: (1) paddy fish culture and (2) capture rice–fish production. Over 65% of the studied farmers practised capture culture method, while the other 35% were engaged in paddy fish culture. In the capture culture system, the fish are trapped in the field and allowed to grow along with the rice. The fish are then captured at the end of the growing period when the rice is to be harvested

for consumption. Fish species under this method include tilapias and the common catfishes *Clarias gariepinus* and *C. bisordalis*.

The development of paddy fish culture is of great significance in increasing both freshwater and brackish-water aquaculture and small-holder farmers' income in Nigeria. Three fish species constitute the main harvest from the paddy fields in the study area: (a) the major tilapia *Sarotherodon melanotheron*; (b) the major catfish *Clarias longifilis*; and (c) the mullet *Mugil cephalus*. Table 3 shows the various fish species that were integrated with rice culture in the study area — mullets, tilapias and catfishes. While mullets have the potential for very high yield, tilapias were observed to be stunted in growth on some farms. This was, however, not the case for all the farms studied.

Table 3. Available fish species and potential yield in rice–fish production in Ondo state

Species	Market value	Availability of fry	Feeding habits	Potential yield
Mullets *Mugil cephalus* *Mugil bananensis*	Good	All year round but inadequate	Phytophagous/detritivorous	Very high yield. Perform well in poly-culture with catfish, snappers and tarpons. Yield = 3000 kg/ha per year
Tilapia *Sarotherodon melanotheron*	Good	All year round and adequate	Phytophagous and detritivous	Handy and wide acceptance for culture. Highly prolific with stunted growth. Yield = 4800 kg/ha per year
Catfishes *Clarias gariepinis* *Chrysichthys nigrodigitatus*	Very good	Seasonal and inadequate	Omnivorous	Handy. Grow very slowly in culture medium. Require artificial fields and grow well with tilapias and mullets. Yield = 4542 kg/ha per year

Source: Anyanwu *et al.* (2007).

The study showed that culturing fish in paddy fields has some advantages, including: (i) eradication of weeds and harmful insects; (ii) loosening the soil texture; and (iii) increasing dissolved oxygen and improving the fertility of the soils. Over 78% of the farmers who practised it said that the paddy–fish system is low cost, effective and brings better economic returns to farmers in the often inundated (flooded) areas of the study area. During the rainy season when water flows into the paddy field, fish are trapped in the field. The study showed that if fish are properly managed, rice yields can be improved considerably.

Table 4 shows the integrated rice–fish production analysis for some of the farms in the study area.

Table 4. Integrated rice–fish production analysis of five farms

Item	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Cultivated area (ha)	0.43	0.34	0.36	0.38	0.35
Fish yield (kg/ha)	2500	2410	2435	2320	2215
Rice yield (kg/ha)	1800	1610	1620	1710	1540
Cost of cultivation (US$/ha)	363.6	376.5	359.4	371.1	362.5
Planting of rice (US$)	18.2	18.4	18.3	18.3	18.5
Stocking of fish (various) (US$)	Free	Free	Free	Free	Free
Labor (US$)	156.8	156.4	156.5	156.7	156.5
Fertilizer (lime)	100.5	110.6	109.6	108.4	109.6
Returns from fish (US$/ha)	1015.2	1025.4	1016.4	1026.8	1026.1
Returns from rice (US$/ha)	821.3	755.6	768.8	803.3	798.0
Net returns (US$/ha)	1197.4 (NGN 197 771.00)	1191.1 (NGN 184 651.50)	1141.4 (NGN 188 331.00)	1184.0 (NGN 195 360)	1177.0 (NGN 194 205.00)

Source: Calculated from field data given by the farmers, based on 1 year (US$1 = NGN 165.00).

Socioeconomic considerations for rice–fish production

Socioeconomic considerations are important when developing brackish-water fish farming systems (Ranadhir, 1978). The development of a brackish-water farm in any area depends on the harmonious interactions among

socioeconomic conditions, cultural values, agricultural production and environmental conditions prevalent in the area. In most parts of the coastal areas of the Niger Delta seriously considered for rice–fish culture there are variations in species abundance and market values as described by Akinrotimi *et al*. (2005). The technical factor of importance in brackish-water fish farming is a basic understanding of the physical chemical and biological components of the soil and the water body in relation to the fish species (Anyanwu *et al*., 1987). The general observation is that brackish-water fish farming should be constructed on a lowlying tidal mudflat, to ensure steady exchange of tidal waters between the farm and adjoining creek, estuary and/or lagoon (Sengupta, 1978). Table 5 shows the production problems associated with the rice–fish production system on some of the farms in the study area. While mechanization cost was an acute problem, weed control and occurrence of pests and diseases were not problems. Farmers had access to seed cost and fish fingerlings, and thus could start integration with minimum effort. There were no flooding problems, hence year-round production was possible.

Table 5. Production problems associated with rice–fish production system

Problem category	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Funds	NRA	NRA	OA	PS	NRA
Mechanization cost	Acute	Acute	Acute	Acute	Acute
Weed control	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem
Pests and diseases	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem
Access to costs of inputs	Very limited	Very limited	Not scarce	Very limited	Very limited
Weather problems	None	None	None	None	None
Access to seed cost	Available	Available	Available	Available	Available
Access to fish fingerlings	Readily available	Readily available	Readily available	Readily available	Readily available
Access to labor	Yes	Yes	Yes	Yes	Yes
Flooding problems	Very frequent	Very frequent	Very frequent	Very frequent	Very frequent
Soil problems	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem

NRA, not readily available; OA, often available; PS, personal savings.

Concluding remarks

The culture of rice and fish in coastal wetlands of Ondo State could positively influence the rural livelihoods of the communities in many ways, including: (a) additional fertilizer from fish feces and any dead fish in the flooded field; (b) fish perturbation of the soil surface makes the soil porous so nutrients are readily absorbed by the roots of the rice; (c) nutrient recycling is enhanced by fish grazing on the photosynthetic aquatic biomass; (d) amelioration of nitrogen utilization within the ecosystem, which implies higher N transfer efficiencies in all trophic levels of systems with fish.

Earlier research work (in 2002, unpublished) identified several advantages of crop–fish integration, including (i) the presence of fish in a rice field generally increases the rice yield by 10–15%, probably due to better aeration and tillering; (ii) fish cultivation 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; (iii) the water plants raised can be used as animal feed, human food or fertilizer. In addition, the water plants provide shelter for fish and natural habitat for the other useful macro- and micro-organisms in the ecosystem.

Aquaculture is essentially an agricultural activity that competes with other farming production systems for basic inputs (land, water, labor and nutrients). Integration of fish farming with crops and animals is one of the surest ways to raise the level of production and at the same time maintain equitable use of the available land and human resources to meet human food demands in rural areas.

On the basis of the results obtained from this study, integration is thought to be one of the best sustainable production models for the coastal wetlands of Nigeria and Africa. However, there is a strong need for a defined role of government and consequent improvement of government intervention in rice–fish culture in the country. Consequently this paper recommends: (a) the estimation of carrying capacity and production capacity of each rice field; (b) determination of optimum stocking size and stocking density; (c) establishment of stocking/harvesting system according to rice crop cycle; (d) interaction between rice production and fish production (fertilizer, pesticides, soil quality, etc.); and (e) establishment of management technologies of rice culture and rice field under fish culture. It is envisaged that a substantial amount of rice can be produced through integrated rice and fish culture system in Nigeria.

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