



Integrated Rice-Cum-Fish Farming in Nigeria: Prospects, Status and Challenges

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ABSTRACT

Nigeria has over time become a consumer nation where the majority of the rice and fish consumed is imported from other nations to balance the demand and supply. Due to Nigeria's rising population and strong demand for fish and rice, the pressure to increase production has been consistent. There is a decrease in the consumption of a healthy diet, and many people are developing diseases related to nutritional deficiencies. Around the world, traditional agricultural practices have helped ensure the security of food and livelihoods but the increase in population is making it difficult to achieve the same again. We might be able to create new sustainable farming practices if we recognize the ecological heritage of old agricultural systems. There is a pressing need now for Nigeria to improve its rice and fish output in order to meet the growing population's demands for food and nutrition. Nigeria has a larger potential for rice-fish integration, but due to different socioeconomic, environmental, technological, and institutional barriers, very few farmers have adopted it. Integrated rice-fish farming is one of the best farming systems in terms of resource usage, diversity, productivity, production efficiency, and food supply. Nevertheless, only a small percentage of farmers engage in integrated rice-fish farming. Integrated rice-fish farming can help Nigeria meet up with the current food demand by producing enough rice and fish through effective resource use and good management. The country's ability to adopt this method is being limited by the farmers' lack of technical expertise, insufficient finances, and limited awareness. Therefore, this paper reviewed the prospects, status and challenges of integrated rice-cum fish in Nigeria.

Keywords: Environment; Fish; Food security; Integrated farming; Rice

INTRODUCTION

When all individuals at all times, have economic, social and physical access to sufficient, healthy and nutritious food to meet their dietary needs and food choices for an active and proper state of health, they are said to be food-secured [1]. Ample food production is the fundamental prerequisite for social and economic justice. In order to hold a position of pride in the international world, a nation must be able to feed its people. Nigeria is a nation that has been generously gifted with a wealth of natural and human resources that, if properly utilized, can both feed its citizens and export to other nations to increase revenue. However, the nation continues to face food crisis in

both quantity and quality [2].

Fish consumption can significantly improve human nutrition since it is high in minerals and vitamins, especially for small fish [3,4]. For most demographic groups, fish has a special ability to enhance and diversify dietary intakes and promote nutritional wellness. Fish has been noted to be a fantastic source of high-quality animal protein that is easy to digest and has a very desirable nutritional profile [5].

Rice is the principal diet for roughly half the world's population, as it accounts for 20% of all calories consumed worldwide. Consumption of rice rises along with population expansion. The population is expected to increase significantly in the twenty-

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first century. In Nigeria, rice is a significant annual crop. It is one of the most significant staple foods that can give the nation's citizens the required 2,400 Calories per person per day needed for food security [6].

The simultaneous blending of rice and fish farming as a component of a larger farming system is known as integrated rice-cum fish farming. Over 50% of the world's population, particularly poor rural households, rely on rice and fish as their primary sources of carbohydrates and protein, making them essential to global food security [7]. Integrated rice and fish farming is a solution that tackles these issues given the dangers of rice farming in Nigeria and the requirement to boost rice and fish production in light of a constantly expanding population [8]. Researchers have previously reported that integrated rice-cum-fish is ecologically important because fish increases the availability of essential nutrients such as nitrogen and phosphorus in the soil, which consequentially increases soil fertility [9]. Therefore, the goal of this review is to discuss the potential, status and challenges of integrated rice-fish culture in Nigeria.

LITERATURE REVIEW

The concept: Integrated rice-cum fish culture

Integrated farming is a part of the whole farming system that combines two or more separate farming systems concurrently or alternately [7,10,11]. Rice-fish farming is an example of an integrated agricultural system which combines the culture of fish and the production of rice to maximize the use of available resources [10]. The goal of integrated rice-fish farming is to cultivate fish and rice together while using the least amount of resources and time possible to produce the greatest amount of product. The history of rice-fish culture dated back to more than 2000 years in ancient China. In the meantime, this practice spread to many other nations, including Bangladesh, India, Vietnam, Thailand, and Indonesia. According to previous reports, rice monoculture is not environmentally viable over the long run and is depleting the natural resource base [12,13]. The primary characteristic of an integrated system is the recycling of waste materials so that the output of one system becomes the input of another. With the right management techniques and monitoring systems, integrated rice and fish farming has a lot of potential and has achieved excellent productivity in terms of protein and carbohydrates in some food-secured countries [14].

A wide range of aquatic flora and fauna are preserved in rice-based environments through reduced fertilizer and pesticide use [15]. A crucial component of Integrated Pest Management (IPM) for rice crops is integrated rice-fish farming [16,17]. Increased fertilizer and pesticide use in rice monoculture have resulted in the release of additional radionuclides and residues, which is hazardous to the soil [18]. Integration of fish and rice helps to reduce production costs because insects and pests are consumed by the fish. On the other hand, rice fields provide fish with planktonic, periphytic and benthic food [19]. Shading by rice plants also maintains the water temperature favourable to fish during the summer [20]. As a result, if farmers can reap the

environmental advantages of the integrated rice-fish farming system, it can offer a sustainable alternative to rice monoculture.

Types of integrated rice-cum-fish aquaculture

There are three major types generally practiced as documented by Unnithan et al, which are [14,21]:

- (i) Combined or simultaneous farming.
- (ii) Sequential or Alternate farming or paddy-fish rotation.
- (iii) Relay farming.

Combined or simultaneous farming: In this type, fish and rice are both produced in the same field at the same time. In addition to killing weeds, tillering, enriching the soil with nutrients, and allowing the crop plant to utilize leftover aquatic feed, this method is significant since it provides protein at no additional expense. This results in a 5%–15% increase in rice output over traditional approaches.

Sequential rice-cum-fish farming: This is a straightforward agricultural technique in which fish species are planted in flooded fields following the harvest of rice without the rice stubbles being removed. In the case of rice, the water levels were shallow, but for aquatic species, the water depth is increased.

Relay farming: Relay farming, which combines these two techniques, is a prolonged and more complex system than synchronous and alternate rice-aquaculture farming. In this farming, rice and fish species are planted simultaneously, but the rice is harvested before the fish. This indicates that aquaculture relay farming takes a longer time frame. The growing aquatic species are moved into specific ditches/ponds that are connected to the channels/pools of the rice field during rice harvesting, and subsequently restocked in the rice field once the water was filled up for future growth.

Prospects of integrated rice cum fish

The supply of rice and fish has been linked to prosperity and food security in Asia where the capture and culture of aquatic species from rice fields has a long history and tradition. Rice and fish have over time been associated with wealth and stability, the depictions of rice fields and fish on ancient Chinese pottery is a worthy evidence of such farmers in resource-poor areas need alternate sources of additional income because the country's economic recession has made this condition worse [22,23]. Diversification of rural livelihood activities within and outside the farm sector is one of the available options to smallholder farmers in developing countries to address income and food security gaps [24]. Ellis noted that income diversification is the process by which rural households build an ever-diversifying portfolio of ventures and possessions in order to thrive and raise their standard of living [25]. In essence, rice and fish are essential elements for ensuring global food security and the primary source of carbohydrates and protein for more than 50% of the world's population, particularly rural poor households [7]. According to trends seen in China, fish production on rice fields has expanded thirteen fold over the past 20 years, and rice-fish culture is now one of

the country's most significant aquaculture systems, significantly enhancing rural incomes and ensuring food security [22]. The major issues affecting rice production are the availability of fertilizer, drought, pests and diseases, soil salinity, availability of land, sufficient mechanization and support from government, NGOs and relevant international organizations [26]. By diversifying agricultural operations and raising both the yields of the rice and fish crops, rice-fish farming produces more food and cash. The integrated rice-fish system has been noted to use 68% less pesticide than rice monoculture despite having similar rice yields. Fish consume rice pests, hence, lowering pest pressure. In addition to the fact that the majority of broad-spectrum insecticides pose a direct threat to healthy fish culture and aquatic life, experienced farmers are far less inclined to apply pesticides. In light of this, it has been proposed that integrated pest management and fish farming are complementary activities [27].

According to the forecast of the International Rice Research Institute (IRRI) on the food issue and global population, 800 million tons of rice will be needed by the year 2025 [28]. Recent international meetings of the International Rice Commission, the Convention of Biological Diversity, and the Ramsar convention have recommended to rice-producing countries support the further development of integrated rice and fish systems as a means of improving food security and sustainable rural development.

The studies of Okoye and Yaro revealed that the rice-fish culture system led to a 10% increase in rice yield and a 54% increase in revenue due to the inclusion of fish in the system [29,30]. It was also noted in these studies that farmers have a history of catching wild fish in lowland rice fields, but integrated rice-fish farming is not well embraced. Nevertheless, there is considerable potential for increased involvement of resource-limited farming households in rice-fish integrated systems both in rain-fed and irrigated rice farming systems.

The cost-benefit analysis that compared rice-cum-fish culture, monoculture of rice and monoculture of fish revealed that rice-cum-fish culture system is of better advantage as it led to an increase in rice yield and total revenue as a result of fish inclusion in the culture system, and this has been a major justification for the system [20]. According to Akegbejo more than 1.5 million hectares of swamp areas in the Niger Delta as well as a massive expanse of land in the Niger flood plain between Yauri in Kebbi State and Lokoja in Kogi State show good prospects for rice-fish culture [31]. Miller had earlier noted that Nigeria has about 4-6 million hectares of land area with good potential for rice production [32]. However, less than 40% of such land is being put to use for rice production. Rice is produced in virtually all the states of the Federation, however, seven states; Niger, Benue, Kaduna, Borno, Kano, Adamawa and Taraba make up half the area used for rice cultivation in the country [29]. Considering the potential for rice production and some initiatives of the government on the transformation of the agricultural sector against the low oil prices in the world market, the country should be self-sufficient in rice and fish production. A boost in fish production is expected with the integration of fish and rice otherwise called rice-fish culture [31].

Advantages and benefits

The production of fish between rice fields provides the farmer with an off-season job and makes more income available without necessarily increasing expenses. It also ensures a reduction of labor in terms of weeding and subsequently increases the yield of paddy between 5% to 15% [33].

Some other benefits include:

- Source of employment to the populace especially youth and women.
- Investment opportunity in production, land development, marketing and processing.
- Increased source of income for farmers and other actors along the rice and fish value chains.
- Source of food supply to the nation, hence, ensuring food security.
- Provision of raw materials to processors, food manufacturing and related companies.
- Provision of the market to agro-allied and non-agro-based products.
- Rice by-products such as straw, husk, and bran are used for livestock feed production.

Several factors have been attributed to the increased rice yield in the integrated rice-fish culture system, some of which were listed below as documented by Rahman et al. and Rahman and Dasic [7,33].

- Activities of the fish lead to improved tilling of the rice seedlings.
- Increased aeration of the soil and mineralization of the organic matter due to the puddling of mud by benthic feeders.
- Control of weeds and algae which compete with rice for nutrients and light.
- Lowering the number of harmful insects, especially, the likes of paddy stem borers, whose larvae are eaten by fish.
- Reduction in the number of rodents including rats due to an increase in the water level.
- Excreta of fish and uneaten artificial feed are available as organic fertilization to improve rice production.
- Suitable fish species and rice varieties for integrated rice cum fish
- Because paddy fields offer unique biological circumstances, not all fish are ideal for this sort of farming. The following characteristics are typically used to choose fish for the rice-fish farming system as documented by Bidika and Manita [34].
- Fishes with shallow water adaptation.
- Fishes that can withstand extreme temperatures.
- Fishes that can survive in environments with low levels of dissolved oxygen, which are typical of rice fields, particularly in tropical regions.
- Fishes with a somewhat high turbidity tolerance.
- Because the period of culture is quite little, it is important to choose fish with rapid growth rates so they can develop to a size that is suitable for sale within a few months.
- Fishes that can live in captivity and don't frequently swim outside the farmed area.

Some of the fish species successfully cultured in integrated rice-cum-fish culture are listed in Table 1. The rice identified as

suitable is lowland rice varieties which are long grains of grade A, high-yielding, and resistant to some economic abiotic stresses. Some of the new varieties are distinctively uniform and stable across the tested locations [35-37]. They also possess good agronomic traits including; resistance to lodging, early and medium maturity period and acceptable heights, making them easy to integrate into the Nigerian farming system [38]. They also meet the cooking quality preferred by consumers in Nigeria, has some of the successfully experimented varieties (Table 1).

Table 1: Some suitable fish species and rice varieties for integrated rice-cum-fish culture systems.

S/N	Fish species	Rice Varieties
1	Nile tilapia (<i>Oreochromis niloticus</i>) [20,29,35,36]	FARO 52 [37]
2	Common carp (<i>Cyprinus carpio</i>) [20,35,36]	FARO 8 [29]
3	African catfish (<i>Clarias gariepinus</i>) [29, 36,37].	FARO 44, UPIA1, UPIA2, and UPIA3 [38]
4	Heterobranchus species [29,37].	FARO 27 [36]

Status of integrated rice-cum-fish in Nigeria

Nigeria is the continent's highest producer and consumer of rice, and interestingly, one of the highest importers of rice in the world. In 2021, the country produced 8.3 million metric tons to lead the continent in rice production, followed by Egypt with 4.8 million metric tons [39]. Rice is an essential cash crop and it is very important for food security. The majority of the producer in Nigeria are small-scale producers who commonly sell 80% of total production and consume only 20%. In the past decade, about a 4.7% increase in consumption is experienced in the country and this is about four times higher than the global consumption growth. The total consumption attained about 6.4 million tons in 2017, representing 20% of Africa's consumption. Rice is an important staple food in Nigeria and it has been receiving a lot of attention from the government in the last 8 years in order to boost its production. The production of milled rice in Nigeria as of 2021 stood at about five million metric tons [40]. Various NGOs and international organizations have contributed immensely to the development of rice farming in collaboration with agricultural development programmes in Nigeria and this has led to an increase in rice production even though the increase has yet to be enough to make the country self-sufficient [26].

Fisheries is an important economic sector in the country employing over 8.6 million people directly and another 19.6 million people indirectly [41]. It contributed about 2% to the country's GDP in 2019 with a little over a million tons of local production [42]. Nigeria is the world's fourth-largest importer of

fish products, with about 940,000 metric tons imported in 2018. Odioko and Becer reported that about \$876 million worth of frozen fish was imported to the country in 2020 [43]. Available data from relevant government agencies including the Nigerian Bureau of Statistics (NBS), and Federal Department of Fisheries (FDF) among others indicated that the value of fish imports keeps increasing and this has been attributed to the increasing growth of the Nigerian population, hence, increased demand [44]. The fisheries sub-sector of Nigeria is faced with many challenges including overfishing, the incidence of sea piracy, poor post-harvest technology, and inefficient fishing technology. However, aside from the talk about challenges poor level of communications, public relations and restricted access to extension services are also major challenges, especially to the artisanal fisher folks and small-scale fish farmers and they contribute to the increasing shortfall between demand and supply of fish in Nigeria [45].

Status of integrated rice-cum-fish in Nigeria

Despite all the advantages of this technology, rice-fish farming is not actively practiced in Nigeria as a culture system, instead, the catch method is primarily used. Most of the rice-fish culture methods in Nigeria have been on experimental bases [30,31,37]. Rice-cum-fish farming is said to have begun in Nigeria at New Bussa on a farmer's plot at Karabande, New Bussa, Niger State, where a farmer used run-off from water running through the power generation turbines at Kainji dam to cultivate rice and fish twice a year. This endeavor paved the way for several studies with the National Cereals Research Institute (NCRI) at their rice experimental farm in Badeggi (Niger State), at the Iddo and Gwagwalada farms in Abuja in the Federal Capital Territory (FCT), Dadin-Kowa (Gombe State), Yandev (Benue State), sub-station of the institution, and their results were encouraging [29,36,37]. In April 2023, a Farm Diversification activity of the Feed the Future Innovation Lab for Fish aimed to promote a system of diversification in rice-growing communities. The research team worked with farmers in Kebbi and Ebonyi States, Nigeria, to teach through a series of pilot promotional trials how to create integrated rice-fish farming based on prevailing local conditions [46]. The project involves farmers who previously grew rice as a monoculture or single-crop system, either for local consumption or for sale in regional markets [47]. These pieces of training were spearheaded by research team members from the University of Ibadan and driven by the priorities of the local communities. The practice of farming rice and fish simultaneously aims to improve productivity, resilience and biological diversity. In order to ensure long-term support for communities to sustain and improve the farm diversification process, pilot demonstration sites were established in universities nearby and with close working relationships with the communities like Usmanu Danfodiyo University, Sokoto State and the University of Ibadan, Oyo State [46].

Challenges of integrated rice-cum fish

Potential constraints to farmer's adoption of the technology as identified by Gloria and Ikoyo are [48]:

Limited knowledge about the integrated farming system. This is suspected to be responsible for only a small portion of land under cultivation and it affects the potential production of rice and fish enterprise.

- Inadequate fingerlings supply.
- Inadequate finance.
- The perceived difficulty associated with the practice and limited land.
- Limited awareness of rice-cum-fish technology.

CONCLUSION

Integrated rice-cum-fish has the potential to boost the nation's production of fish and rice. To close the imbalance between supply and demand, Nigeria could produce its own rice and fish and cease importing them. The review revealed the ongoing effort to boost rice and fish production in the country and some of the potentials, benefits and challenges towards increasing integrated rice-cum-fish production. It is, therefore, important to intensify efforts on the extension services to provide regular training and monitoring of the implementation of the training by the farmers.

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