

Review

Economic benefit and ecological efficiency of integrated fish farming in Nigeria

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The population of people living in Nigeria has risen tremendously in recent years with its corresponding increase in demand for food. Thus, there is the need for a suitable agricultural system to meet this increasing demand and also maximize the utilization of the available limited resources without much wastage integrated fish farming offers hope in this direction. This system of farming was introduced into the country some years back, its uniqueness, lies in the fact, that it has capability of combining fish culture with live stock and crop production. Its economic benefits in the enhancement of food production and self sufficiency are thoroughly discussed. Its significance in making various types of food available all the year round as well as making farmers self reliant and occupied most time of the year sets it apart from all other systems of farming. Its ecological importance which are often overlooked by farmers i.e. manure loading, nutrient cycling and productive capacity of ponds, are critically analyzed. This ecological consideration is of paramount importance in integrated fish farming in that it allows recycling, and maximum utilization of resources without wastage. Suggestions, therefore, have been made on how integrated fish farming can be ecologically sustained.

Key words: Integrated, fish, economic, ecological, farming Nigeria.

INTRODUCTION

Hunger and malnutrition remain amongst the most devastating problems facing the world poor and needy (FAO, 2002). About 80 to 90 million people have to be fed yearly and most of them are in the developing countries. The most reliable source of protein for many is fish, yet millions of people who depend on fish are faced daily with the fear of food shortage (World fish center, 2003). With the population of Nigeria on the rise, there is a corresponding demand for fish consumption (Table 1). Thus, there is the need for a suitable agricultural system to meet the increasing demand for food, and also maximize the utilization of the available limited resources without much wastage. In view of this, integrated fish farming fit exactly into this. Integrated fish farming is a diversified and coordinated way of farming with fish as the main target (Ayinla, 2003) along with other farm products. The

items produced are to be used either as a source of feed, fertilizer or source of additional income (Chen, 1989). Considering the relevance of integrated fish farming in the livelihood of every segment of the Nigerian population in the provision of food, employment opportunities and recirculation of waste for maximum utilization, this paper critically reviews the economic and ecological benefit of integrated fish farming.

Important socio-economic factors in integrated fish farming

In Nigeria Integrated fish farming has been reported in many states of the federation in which 50% of fish farmers integrate, poultry, piggery or livestock with fish production, while integrated fish cum crop production is on the rise also in several states (AIFP, 2005). According to Asala (1994) the essence of integrated system is productivity of fish as to meet the challenges of food shortage

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Table 1. Nigerians projected population and estimated demand for fish (1991 - 2010).

Year	Projected Population (million)	Per Caput Consumption- (kg)	Projected Fish Demand (million Tons)
1991	88.5	11.0	973500
1992	90.36	11.0	993960
1993	92.36	11.0	1014420
1994	94.08	11.0	1034880
1995	95.94	11.0	1055340
1996	97.08	11.0	1075800
1997	99.66	11.0	1096260
1998	101.52	11.0	1116720
1999	103.38	11.0	1137180
2000	105.24	13.0	1368120
2001	107.10	13.0	1392300
2002	108.96	13.0	1416180
2003	110.82	13.0	1440660
2004	112.68	13.0	1464840
2005	112.54	13.0	1489020
2006	116.40	13.0	1513200
2007	118.26	13.0	1537380
2008	120.12	13.0	1561560
2009	121.98	13.0	1585740
2010	123.84	13.0	1609920

Source: (FDF) 1994.

and reducing the unemployment rate in Nigeria. Socio-economic conditions should be considered when developing integrated fish- farming systems. The development of a diversified economy depends on the harmonious interactions between socio-economic conditions, agricultural productions and regional environmental conditions (Huazhu and Boatang, 1989)

In any part of the country the type and level of integration depends on the prevalent environmental conditions, social norms, cultural values and religious factors. For example in the northern part of the country, fish cum pig integration is not advisable because of religions factors. The agricultural enterprise to be combined and their level of intensity determine the type of integration fish culture can be extensive, semi-intensive or intensive. The semi-intensive earthen pond fish culture is the most suitable integrated aquaculture system because of the natural ecosystem that can conveniently accommodate both crop and livestock production (Ayinla, 2003). Apart from market forces, demands for agricultural products should be put into consideration before establishing any integrated farming enterprise in any area.

Systems of integrated fish farming

In Nigeria integrated fish farming is carried out mainly at subsistence level (Nnaji et al., 2003). Ibiwoye et al.(1996)

found out that out of 254 fish farmers sampled in the country only 46% did any form of integrated fish farming. Integrated fish farming can be practiced under different systems depending on the production function which largely depends on finance, and the level of integration to be engaged in. The common types of integration that are being practiced in Nigeria are as follows:

Fish cum poultry farming

Poultry- fish farming is the integration of poultry animals like chicken, duck and geese with fish farming (Tokrisna, 1995.) The most common practice in Nigeria is fish cum chicken, which is widely practiced because of its profitability. Birds raised for egg (layers) or the one that are raised for meat (broilers) can be integrated with fish farming. This will reduce the cost of inputs, such as fertilizer and feed, so as to maximize profits (Asala, 1994). The poultry house can be constructed inside and raised over the pond or beside the pond as the case may be. The excreta from the birds serve as manure, which fertilizes the pond or the fish can feed on them directly. It will be more ideal and better if the poultry house is raised over the ponds that is, vertical integration, allows easy transportation of manure to ponds thereby maximizing the usage of the land. The poultry house will be cleaner, as the excreta falls directly to the ponds.

Fish cum pig farming

Pig farming is widely practiced across the southern and middle belt of Nigeria, offers the farmer a husbandry which is easier than chicken farming. It has good returns. (AIFP, 2005) The pig is a highly prolific animal and its combination with fish not only increase economic efficiency, but also increase its ecological efficacy as wastes, residues, and left over from kitchen, aquatic plants are often used as pig food. The excreta in turn are used as organic manure in fish ponds. Farmers practicing pig cum fish farming may benefit from up to 28% - 30% economic advantage over normal pig farming (AIFP, 2005), Ansa and Jiya (2002) recorded an impressive performance in the culture of *Oreochromis niloticus* using pig manure not only as source of fertilizer but as source of feed.

Fish cum crop production

This is the cultivation of agricultural crops (e.g. vegetables and arable like maize, rice etc) and aquatic plants (like water spinach, water chestnut, aquatic weeds like *Pistia*, duckweed, water hyacinth, *Azolla* etc) with fish farming (Nnaji et al., 2003). The common practice in fish cum crop production in the country is in cultivation of fish with rice, and vegetables. This is widely practiced among the farmer in the rural areas, at subsistence level. The vegetables, like water leaf and spinach among others are

Table 2. Doses of manures required for maximum growth of cultured fish.

Animals	Animals/ha of fish pond	Fresh manure (Kg/adult/day)	Maximum manure loading (Kg/ha/day)
Pigs	30-3000	5 for 100kg pig	150
Chickens	1000-4000	0.15 for 1.5 kg bird	150-600
Ducks	750-3000	0.2 for 2 kg bird	150-600

Source: STOAS 1993.

planted on the dykes, while in the case of rice; it is planted right inside the pond. The crops derive water and nutrients from the fish ponds while the crops serves as food, especially for herbivorous fish. Besides, periphytons on the crop may enhance yield of cultured fish species (Miarana et al., 1995; Nnanji et al., 2003) Table 2.

Economic benefit of integrated fish farming

The economic benefit of integrated fish farming cannot be over-emphasized since the integration is varied and diversified in nature. It is one of the most viable, reliable and profitable of any farming enterprise. It contributes immensely to the economic empowerment of many families especially in the rural communities. It enables the farmer to be productive all the year round and fully maximize its production. Its contribution in the enhancement of food security and self sufficiency is highlighted below:

Food security

Nigeria is one of the developing countries affected by hunger, deprivation and abject poverty by its citizenry inspite of its enormous natural and human resources (Alamu et al., 2004). With the prevalent economic situation in the country, there is the need for farmers to engage in a result oriented farming system that will guarantee and sustain adequate food security. The supply of proteinous food in Nigeria is very expensive, a problem that needs to be tackled very seriously, considering the limited available resources. Integrated fish farming offers hope in this direction as it serves as food-production base that combines cultivation of crops, rearing of livestock and fish farming. The scope of integrated fish farming can be considerably wide. The fish farm supplies not only enough fertilizer to produce a large quantity of fish, but also produces meat, milk, eggs, vegetable, etc as it fully utilizes the water body, the water surface, the land and the pond silt to increase the food available for human consumption.

Self sufficiency

Integration is suitable for poor farmers with remarkably low expenditure pattern and continuous low spending for food and other dietary requirement (Ayinla, 2003). The

varied nature of an integrated fish farm make more jobs available than in unitary system of fish farming (Huazhu and Baotony, 1989). The system is all encompassing as the time is well utilized in other farming activities depending on the type of integration involved. In fish cum crop production, crops like the vegetables are harvested continuously even in dry season as water from the pond is used to water the farms adequately. The farmers are engaged in one farming activity or the other throughout the year thus, making them self reliant and productive all year round.

Regular source of income

Integrated fish farming provides the farmer with a steady source of income all year round; this comes from various farm products. For example, in poultry-cum fish farming before the harvesting of the fish, which may take some months, the farmer can sell the eggs which will generate money for some time. Apart from this, money can also be generated from the vegetables or the crops that may be combined in the integrated fish farming. This corroborated the submission of Nnaji et al. (2003) that integrated fish farming is more profitable than unitary system of farming.

Ecological importance of integrated fish farming

Sustainable agriculture depends upon eco-friendly culture system for its survival (Dhawen and Kaur, 2002). One of the appealing features of integrated farming is that it leads us to view farms in terms of interdependent components (Dalsgaard, 1995). Integrated farms are comprised of different ecosystems (Conway, 1985) that can be described, modeled, analyzed and compared; they are guided by principles, and the parts that make them up and the way these parts are related (Altieri, 1987). In any integrated system, the interrelationships are many; crop by-products are fed to animals, while fish and animal manures are returned to the crops and fish in the ponds. The fish may feed on insects and weed in the rice field planted inside the pond and this in turn can increase the available nutrients to the crop (Dalsgaard, 1995).

The ecological efficiency of an integrated fish farm is very paramount to the success of the entire farming enterprise, this is discussed below.

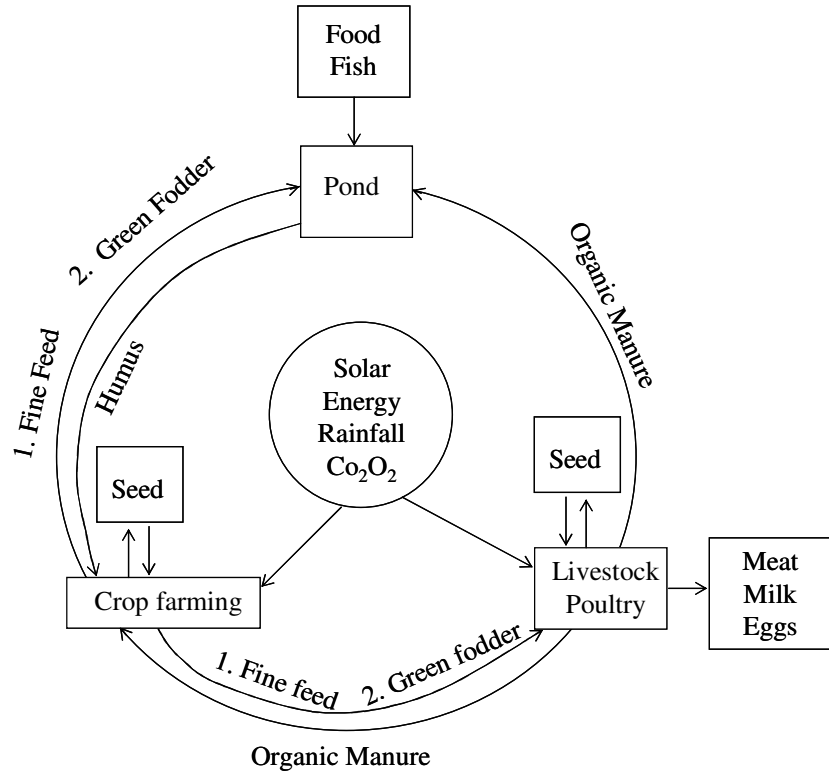


Figure 1. Recycling of material in a well managed integrated fish farm Source: NACA Technical Manual 7 (1989).

Manure loading

Manure loading in integrated fish farming basically comes from poultry and other farm animals, which contain considerable quantities of nutrients for fish production. Protein content from manure ranges between 10 – 30%, energy between 110 - 1400 kcal per kg manure with synthesized soluble vitamins in high concentration (Praff, 1975; Tul-eun, 1992). It also contains non digested feed. Metabolic excretory products and residues resulting in microbial synthesis which can be utilized to replace reasonable parts of feed stuff used in conventional fish production cost (Falayi, 1998; Fashakin et al., 2000). According to Yingzue et al. (1986) the effect of manure produced in integrated fish farming depends on the species of the animal involved. It is observed that the manure added to fish ponds as feed give better result than fertilizing the pond and also vary in their efficiency to produce fish biomass (Ansa and Jiya, 2002). According to Otubusin (1983) the number of farm animals should be directly related to the manure loading that the fish would require. The quantity and composition of the resulting organic manure varies with feed, age and total live weight of the farm animal. Smitherman and William (1977) reported on the benefit of manure in the production of benthic organisms, and indicated also, that *tilapia* hybrid ingests manure directly. However the indiscriminate use of these manure in fish ponds instead of improving the pond productivity, may

also lead to pollution (Asala, 1994; Otubusin, 1986; Arbolada, 1992). Therefore, it is necessary to know the standard doses of these wastes which would keep the physicochemical parameters of pond water in a favorable range required for the survival and growth of fish.

Nutrient cycling

The re-cycling of organic wastes for fish culture serves the dual purpose of cleaning the environment (by avoiding the problem of waste disposal) and providing economic benefits (Nash et al., 1980; Oladosu et al., 1990). This is important to sustainable aquaculture, and also reduces expenses on feed and fertilizer to a large extent. The calculation of bioresource flows diversity is the first step in determining the approximation of cycled biomaterials within the agroecosystem (Dalsgaard, 1995). Bioresource flows here refers to the by products which are available to the farmer for re-use within the farm. The important thing in bioresources flows is their direction and closing of mineral regardless of the volume and their number. In the extreme case, all flows may be unidirectional into one particular field or pond (Schroeder, 1980). In such a case, the extent to which resources are efficiently recycled cannot be adequately expressed (Fin, 1980). For effective cycling of nutrients in an integrated fish farm, the farm must be well managed, (Figure 1) tak-

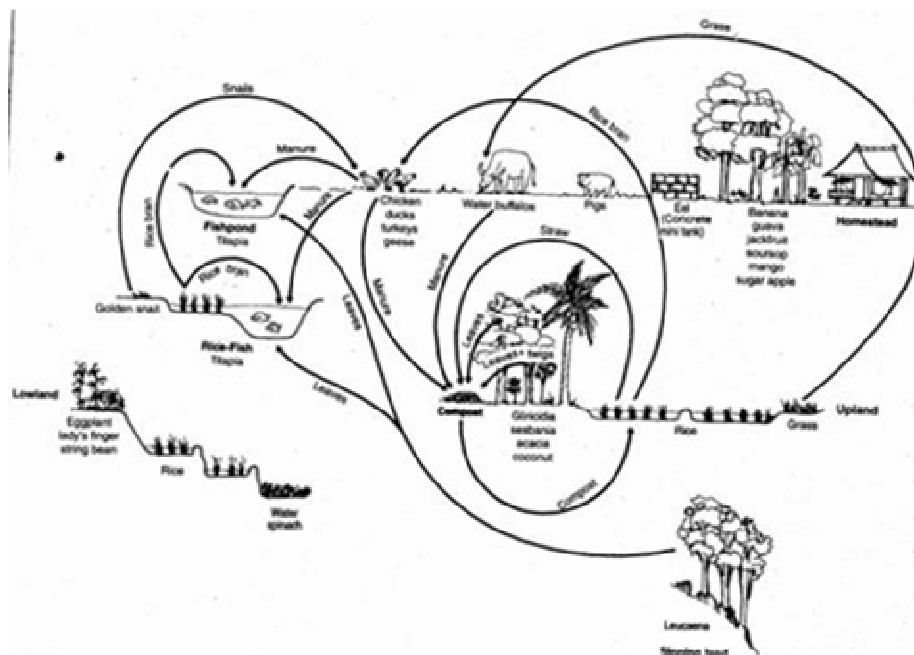


Figure 2. Bioresource flow model of an integrated aquaculture farm. Source: Dalsgaard et al. (1995).

ing into cognizance the type and level of integration involved.

In aquaculture animal waste has been recycled as fertilizer for centuries with the aim of promoting pond productivity of phyto- and zooplankton (Velasquez, 1980). Due to the short digestive tract of poultry, 80% of chicken manure represents undigested feed stuffs with as high as 20-30% been total protein ((Chen, 1989). In targeted poultry cum fish farming, the protein rich chicken dropping is made available to the fish either directly or indirectly via the primary producers in the aquatic food web (Oladosu et al., 1990), which in most cases reflects the productive capacity of the ponds (Figure 2).

Productive capacity of ponds

The biological productivity of any aquatic body is generally judged through the qualitative and quantitative estimation of planktons, which form the natural food of fish (Ahmed and Singh, 1989). Animal wastes lead to increased biological productivity of ponds through various pathways, which result in increase in fish production (Orhibabor and Ansa, 2006). Productive capacity refers to the biomass produced in kg/ha, thereby measuring "net community production" of the system (Dalsgaard, 1995). This capacity reflects the quality of the underlying soil and the quality of the pond water; it also depends on the nature of the manure involved. According to Singh (1996), the nature of manure affects the community structure of plankton. In a given ecosystem the ratio of biomass supported per unit of energy flow (B/E ratio) determines how mature the system is (Odum, 1989) this refl-

ects the ability of the system to convert available energy into something useful.

Ecological sustainability of integrated fish farming

The sustainability of ecological parameters in any agro ecosystem is very important in determining the success of the farming venture. The Brundtland Commission (WCED, 1987) defined sustainable development as the ability to meet the needs of the present without compromising the ability of the future generation to meet their own needs. Some forms of integrated aquaculture development have caused severe social and environmental impacts (Pullin et al., 1995; Black, 2000). The degraded state of most aquatic ecosystems combined with public concerns about adding "new" sources of aquatic pollution to the already overburdened ecosystems will require aquaculture to develop new ecosystem approach and sustainable operating procedures (Akpan and Okafor, 1997). Poorly managed integrated systems usually have high nutrient loading leading to deleterious effect of cyanobacterial bloom (Pearl and Turker, 1995). Cyanobacterial bloom is undesirable in aquatic ponds because they are relatively poor aquatic food base. They are poor oxygenators of pond waters with undesirable growth habits, some species produce odorous metabolites and impact undesirable flavour to the cultured fish species while others produce compounds that are toxic to aquatic animals (Osuji et al., 2003). These and other reasons call for serious attention to the ecological sustainability of integrated fish farming.

However, ecologically sustainable aquaculture is the

development of aquatic farming systems that preserve and enhance the forms and functions of the natural and social environments in which they are situated (Pierce, 2002). It involves realistic ecological approaches that will develop aquaculture production techniques for various integration systems, by using local resources effective recycling of wastes and materials that can degrade natural ecosystems and proper planning for job creation and marketing strategies that will be widely accepted as meeting both economic and ecological considerations (Costa Pierce, 1992).

Conclusion

Integrated fish farming varies from one area to another in terms of production combination, rates and sizes. It is more profitable than unitary system of farming as it ensures a spread of financial risk for its varied and diversified nature in rearing of fish, animals and crops; it has a capacity of making more food available thus enhancing food security and creating more jobs for the teeming unemployed masses in the country. Before this potential can be fully realized, its ecological importance must be taken into consideration, as this will dictate the pace for effective management that will lead to its maximum yield. Clear and explicit linkages between aquaculture and the environment must be defined and the complementary role of aquaculture in contributing to environmental suitability must be developed and made known to all stakeholders in aquaculture industry for effective and efficient ecological management which will in no time facilitate optimum yield.

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