Prospects, Potentials, Practices and Benefits of Integrated Rice-Fish Farming in Bangladesh

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***Abstract*—**For centuries, traditional agricultural systems have contributed to food and livelihood security throughout the world. Recognizing the ecological legacy in the traditional agricultural systems may help us develop novel sustainable agriculture. In order to meet the rising demands for food and nutrition of the over-increasing populations, there is an urgent need nowadays to increase rice and fish production in Bangladesh. Despite there have been higher potential for rice-fish integration in Bangladesh, it has been adopted by comparatively few farmers due to various socioeconomic, environmental, technological and institutional constraints. Even though, integrated rice-fish farming is the best farming practice in terms of resource utilization, diversity, productivity, production efficiency and food supply. In spite of this, a small proportion of farmers are involved in integrated rice-fish farming. However, from their findings, it has been documented that rice-fish farming is a viable option towards an efficient farm production compared to the rice monoculture practice and that integrated performs better in terms of cost and technical efficiency, and benefits. Thus, integrated rice-fish farming can help Bangladesh keep pace with the current demand for food through the production of sufficient rice and fish by efficient resource utilization and proper management. However, the lack of technical knowledge of farmers, high production costs and risks associated with flood and drought, are inhibiting the widespread adoption of this practice throughout the country in a sustainable and significant manner.

***Keywords*—**Rice-fish farming, prospects, potentials, practices, benefits.

I. Introduction

Global food security is becoming an acute problem because of the increasing world population [1], the limitation of agricultural resources (e.g., land and water) [2], and the effects of global climate change on crop production [3, 4]. World agriculture currently faces great challenges in producing sufficient food while minimizing the negative environmental effects of crop cultivation. In the past 50 year, crop yields have substantially increased, mainly resulting from the use of chemical fertilizers and pesticides, the development of new crop varieties, and the improvement in cultivation methods. The heavy application of chemical fertilizers and pesticides for long periods, however, negatively affects the environment, induces pest resistance to pesticides, and increases agricultural costs [5, 6]. As a consequence, modern agriculture now requires "rethinking" [1, 7], and such rethinking should include reconsideration of traditional agricultural systems [8–10].

Bangladesh is mostly an agro-based country and needs appropriate research and adequate extension works in the agricultural sector aimed at developing and disseminating sustainable eco-friendly technologies, to make optimal use of water and land resources. Sustainable agriculture development is required to meet the needs of the rural population and also to provide opportunities for improved livelihoods [11]. This country is also one of the least developing and most densely populated countries in the world, covering an area of 144,000 km^2 with a total population of 164 million [12]. The peoples of Bangladesh are commonly referred to as 'Macche-Bhate Bangali' (i.e., the people made of fish and rice) [13]. Rice and fish are the staple foods in Bangladesh. Given the security of land and the need to meet the demand of the increasing population, alleviating poverty and malnutrition, there is no alternative to the rice-cum-fish culture [14]. Fish is the main source of animal protein, providing an average of 8.4 g per day, or 13.3 % of the average per capita total intake of protein (63 g) [15]. Not only the adequate supply of carbohydrate, but also the supply of animal protein is significant through rice-fish farming. Fish, particularly small fish, are rich in micronutrients and vitamins, and thus human nutrition can be greatly improved through fish consumption [16, 17]. It can optimize the utilization of resources through the complementary use of land and water [18]. Integrated rice-fish farming is also ecologically sound because fish can improve soil fertility by increasing the availability of nitrogen and phosphorus [19]. The natural aggregation of fish in rice fields inspired the combination of rice farming with fish to increase productivity [20]. It has been found from several studies that rice-cum-fish culture becomes able to enhance the net benefit by 64.4% and yield by 5% [12, 21]. Therefore, it has been evidenced that the rice-fish integration is quite attractive both in economic and environmental points of considerations.

This article describes the rice-fish farming system and its opportunities and constraints to increase farm productivity and food supply in Bangladesh. It further assesses the production efficiency of rice-fish farming as an alternative option to rice monoculture that can make better use of available inputs and that it can provide higher socioeconomic and nutritional benefits to the households of poor farmers and, more broadly, overall food security in Bangladesh to a greater extent.

II. Emerging Prospects And Potentials

We are very fortunate that our Bangladesh is an agro-climatic and favorable resource based highly productive country. It is

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also suitable for small-scale freshwater rural aquaculture [22]. The contribution from agriculture to GDP is estimated to be 16.33% (including fisheries) in 2013-14. There are around 29 million families and 15 million farm holdings in Bangladesh. The total area of rice fields in Bangladesh is about 10.14 million ha with a further 2.83 million ha of seasonal rice fields where water remains for about 5-7 months [23]. Rice-based fish farming is the main source of earning in many parts of Bangladesh. The carrying capacities of these lands and waters are not fully utilized; however there exists tremendous scopes for increasing fish production by integrating aquaculture with agriculture [24]. Thus, integration of fish with rice farming improves diversification, intensification and productivity [25, 26]. This practice began to receive attention in the 1980s. The new technology was perceived to have potential for multiple environmental benefits in Asia. Integrated rice-fish farming is also being regarded as an important element of integrated pest management (IPM) in rice crops [27, 28]. Moreover, fish plays a significant role in controlling aquatic weeds, algae and snails, and hence reduces the need for chemical spray leading to better farm economics within ecologically-sound low-cost, low-risk option for poor rice farmers in Bangladesh and elsewhere [12]. The multiple benefits of the integration between rice and fish have been globally documented and could be summarized in enhancing farm productivity either in biomass or in economics. Fish in rice field improves soil fertility through their organic waste. Many reports suggest that integrated rice-fish farming is ecologically sound because fish improve soil fertility by generating nitrogen and phosphorus [29]. More importantly, the integrated rice-fish leads to the production of a more balanced diet (rice) as a main source of carbohydrate and fish which is an important animal protein source required for the health and well-being of rural households. The integration of aquaculture can increase rice yields by 8 to 15% with an additional average fish production of 260 kg/ha [30]. Based on field surveys and studies, it has been observed that farmers households usually inclined to eat small fish than sell them in the market and hence, fish consumption contributes significantly in the nutrition of children and lactating mothers to avoid child blindness as well as to reduce infant mortality.

Rice and fish have been equally essential parts of the life of Bangladeshi people from the prehistoric time. Rice is the main agricultural crop in Bangladesh with an annual production of 29 million tons per year [13], while annual fish production is 2.7 million tons [31]. The demand for rice and fish is constantly rising in Bangladesh with nearly three million people being added each year to its population [32]. Nevertheless, integrated rice-fish farming offers a solution to this problem by contributing to food and income. Although rice-fish technology has been demonstrated successfully and a considerable number of farmers have been trained through various projects, rice-fish farming has yet to be widely practiced. Traditionally wild fish have been harvested from rice fields, but the introduction of high yielding varieties (HYV) of rice and accompanying pesticides have reduced fish yields [33]. However, important changes have taken place through IPM that has reduced the use of pesticides in rice fields [26, 34]. In this technology, as a "do not spray" strategy could be changed to a more attractive strategy "grow fish" [35].

III. Protocols and Practices of Rice-Fish Farming

In general, integrated fish farming is a technique of fish culture with other organisms i.e. plants or animals to get maximum output through minimum input supply in a minimum time frame. Rice-fish culture is quite old and first started in ancient China about 2000 years ago. Meanwhile, this practice became introduced in Indonesia, Vietnam, Thailand, India, Bangladesh and many other countries of the world. Lastly, Azola is cultured with rice-fish in China. [36]. In traditional culture system, several small ditches were prepared in the rice fields and tree branches or bushes were placed for creating suitable artificial habitat to attract wild fishes. Sometimes fry of common carp (*Cyprinus carpio*) was stocked but production was much lower (50 kg/h) than the expectation [12].

Currently, several NGOs (Non-Government Organization) have been working on rice-fish culture, and both nursery and table fish are producing through their improved techniques. For example, freshwater prawn (*Macrobrachium rosenbergii*) is now also stocked for more profit and diversified product [21]. Major fish species used are: *Labeo rohita* (Rui), *Catla catla* (Catla), *Cirrhinus mrigala* (Mrigal), *Cyprinus carpio* (Common carp and Mirror carp), *Hypophthalmichthys molitrix* (Silver carp), *Tilapia* sp. (Tilapia), Thai barb (*Puntius goniontus*) and giant freshwater prawn (*M. rosenbergii*). Production of fish is much higher than traditional system, which is on average 200kg/ha (per crop) [12].

Fish culture with rice can be practiced in two ways- a) concurrent system and b) alternative system. In Bangladesh, these methods are generally practiced during dry (Boro) and rainy (Amon) seasons.

a) **Concurrent system:** Generally practiced during the Amon season in moderate to low paddy fields where water logging exists naturally for 4-5 months. Major carps and Thai barb are highly suitable for this practice but tilapia or giant freshwater prawn can also be stocked with rice. These practices are recommended for rice-fish farming. The use of pest and disease resistant rice varieties is encouraged to minimize pesticide application.
b) **Alternative System:** Fishes are stocked in the paddy fields after harvesting rice from the land. Rearing of fishes up to 6-8 months (until plantation for the next crop season) is possible in this system. Carp and barb species are suitable but grass carp (*Ctenopharyngodon idella*) can also be stocked as a candidate in this composite culture system. In case of grass carp stocking, precaution should be taken so that the fish cannot eat the young paddy.

IV. Advantages and Benefits

The advantages and benefits of rice-fish integration in terms of resource utilization, productivity and economics are diverged and well-documented. The socio-economic importance of fish culture in rice fields were pointed out the deficit of animal protein in densely populated rice growing areas [37]. The fish grown in the paddy fields will be ideal use of land and would also be an easy source of cheap and fresh animal proteins. Thus

fish culture can greatly contribute to the socio-economic welfare, especially for rural populations of developing countries. An added advantage also is that unlike sea fish or other animal proteins, the fish from local paddy fields would cause no transport problems and would be most fresh and healthy.

The production of a fish crop between the two rice crops provides the farmer with an off-season job [38]. This can increase the income without increasing expenses [39]. Apart from the additional income available from rizi-pisciculture (rotational culture of fish and rice), the combined culture leads to a reduction of labor in weeding and an increase in the yield of paddy by 5 to 15%. The increasing rice production in the rice-fish integration is attributed to various factors [12, 37], namely:

a) Reduction in the number of harmful insects, such as paddy stem borers, whose larvae are eaten by fish.
b) Reduction in rat population due to increase in the water level.
c) Increase in organic fertilization by fish excreta and remains of artificial feed.
d) Better tilling of the rice seedlings due to the activity of the fish.
e) Increased mineralization of the organic matter and increased aeration of the soil resulting from the puddling of mud by benthic feeders.
f) Control of algae and weeds (by phytophagous fish) which compete with rice for light and nutrients.
g) Fish stir up soil nutrients making them more available for rice. This increases rice production.

V. Conclusion

To meet the increasing demand of food for the over-increasing populations, there should be needed to more increased rice and fish productions. This document accomplishes that rice-fish integration could be a practical opportunity for farm diversification. Such divergence will enhance food security. Rice-fish integration makes the rice field ecosystem with an efficiently and environmentally comprehensive production system for rice and fish. Rice monoculture cannot alone provide a sustainable food supply, while integrated rice-fish farming will be the best in terms of resource utilization, productivity and food supply. It should therefore be recommended that integrated rice-fish farming could be a sustainable alternative to rice monoculture as more production and benefits can be achieved in rice-fish culture compared to the rice farming alone.

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