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Review Article

Integrated Aqua-Farming in Bangladesh: SWOT Analysis

Shoaibe Hossain Talukder Shefat[1]*, Ashikur Rahman[2], Mohammed Anas Chowdhury[1] and Md. Nasir Uddin[3]

[1]Department of Fisheries Management, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

[2]Department of Biotechnology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

[3]Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

***Corresponding Author:** Shoaibe Hossain Talukder Shefat, Department of Fisheries Management, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

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Abstract

Sustainable food production is the challenge to any community and to get it need to implement appropriate strategy in case of productivity. Single crop production systems are vulnerable to different risks and uncertainties such as seasonal, irregular and uncertainty in income and employment to the farmers which have demanded the development of a suitable integrated farming systems. This review was conducted to investigate the present status of integrated aquafarming in Bangladesh with the strengths, weakness, opportunities and threats (SWOT) of integrated aquafarming. The investigation reveals that the integrated aquafarming has gained much popularity in Bangladesh as one of the most important eco-friendly and sustainable agricultural food production system due to its multidisciplinary outcomes. Different types of integrations are being practiced in Bangladesh such as Rice-Fish culture system, poultry-fish culture system, duck-fish culture system, rice-poultry-fish culture system and others. All of these integrated farming systems have some potentials, some drawbacks, and some constraints which are very important to be identified for the later steps in planning to achieve the objectives of new integration technology. SWOT analysis explores the strengths, weakness, opportunities and threats of any technology which helps the decision-makers to identify if the objectives are attainable or not. Although the Integrated aquafarming system possess great potential for using the land and water resources of Bangladesh but still its potentiality has not been fully explored in our country. This review also focuses on the socio-economic potential of Integrated Aquafarming and the factors affecting the widespread dispersion of integrated aquafarming emphasizing SWOT analysis.

Keywords: Integrated Aquafarming; Synergistic use; SWOT; Aquaponics; Rice-Fish Culture

Introduction

In Bangladesh, small farmers generally practice subsistence farming to produce a balanced food supply and cash to fill up the fundamental demands. Different types of risks, vulnerabilities and uncertainties in single crop production systems such as irregular uncertainties in income and employments have demanded the exploration and implementation of suitable integrated aquafarming systems [1]. Integrated aquafarming can be defined as the systems of producing fish in combination with other agricultural or livestock farming operations centered on the fish pond. Integrated farming system is a cross-linked farming system where farmers use high-quality organic food and renewable energy. The main principle of such system is to reduce pollution and increase income by combining different types of farming [1-5]. The term Integrated means synergistic cultivation, culture system of several plants and animals from different environment together, using water-born nutrient and energy. Each species has different functions in the ecosystem that can benefit another species. It makes better use of the site and facilities and greater diversity of production, which in turn brings higher profits from multiple products instead of one, plus more jobs [6-8]. The basic principles of integrated farming system include the utilization of inter-related farm resources such farm wastes. In integrated aquafarming, nothing is considered as waste because so called waste of any trophic level is used as valuable resource for another production system [9,17-19]. Integrated aquafarming system highlights the mutual benefits from different farming without causing damages or threats to the environment [1-4]. Farmers in Bangladesh were dependent on the conventional farming over the last decades but now they are being motivated to the integrated farming systems to face the future challenges towards sustainability as it is more profitable [11]. Integrated aquafarming aims to sustain the agricultural production, incomes, nutritional improvement and safeguard to the environment [10-11].

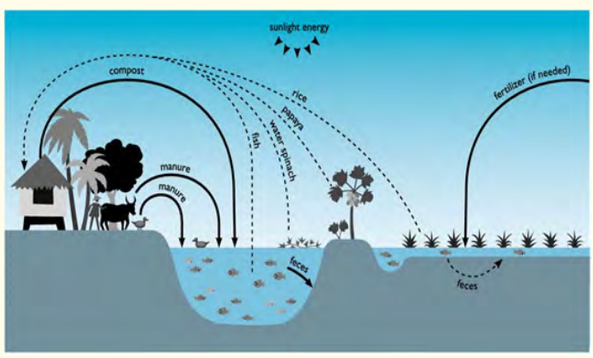

Figure 1: Conceptual flow diagram for integrated aquafarming (Livestock-fish-rice integration).

SWOT analysis that addresses the strengths, weakness, opportunities and threats is a valuable tool used for analyzing internal and external factors to attain a systematic approach for decision-making. New technologies are promoted as having the potential to improve the economic, environmental, and health conditions in developing countries. However, the adoption rates of these new technologies are often disappointing and are not uniform [10-15]. SWOTs analysis is important in planning and decision-making as it explores whether the objective is attainable or not. If the objective is not attainable, decision-makers can select a different objective and repeat the process to implement new technology [1]. Meaningful information for each category (strengths, weaknesses, opportunities, and threats) to make the analysis useful are collected from local communities and farmers. Although the Integrated aquafarming system possess great potential for using the land and water resources of Bangladesh but still its potentiality have not been fully explored in our country. As no effective technological solutions have been developed for large scale integrated aquafarming production, they farmers think that monoculture offers greater profitability than integrated aquafarming [16]. The SWOT analysis is useful in showing what other countries think and what problems should be taken into account. This review analyzed all the ecological, economic and social aspects of integrated aquafarming in Bangladesh in relation to each other with the strengths, weakness, opportunities and threats for sustainable expansion on integrated aquafarming.

Materials and Methods

This review was conducted using information available in the different secondary sources such as national or international peer reviewed journals, articles, periodicals, magazines, related books, and others. Information was also collected from different websites related to fisheries, aquaculture, agriculture and integrated agri-aquafarming systems. Electronic media and leaflets were also important sources of information. Information was collected from directly from fish farmers, poultry farmers and others who have used this practice. Valuable information was collected from respected course instructor and others. All the information collected from different secondary sources was compiled systematically and arranged chronologically.

Review of findings

Integrated farming aims to sustain agricultural production, maintain farm incomes, achieve nutritional improvement and safeguard to the environment which emphasizes the strong interdependence between different agricultural products. It can directly control the land and environmental degradation that is considered as a middle course between organic and intensive farming to maintain environmentally friendly farming also improves the space utilization, recycles resources among different agricultural enterprises [1-4]. Integrated Aquafarming with crops, livestock, and aquaculture can be used for potential yield improvements and monetary advantages as well as positive implications for food security, dietary balance, and nutrition [10-12]. Integrated Aquafarming can reduce the risk of enterprise failure, offer increased protection from disease and pest damage and increase profitability. Integrated farming can extend the harvest period, helps to alleviate food shortages, enhances the household food stability and reduces the erosion risks by providing increased soil cover. The greatest threat comes from the fear that the Integrated Aquafarming concept will be wrongly communicated to the public and this concern should not be underestimated [4-8]. Negative media coverage of faulty or unsuccessful Integrated Aquafarming practices could quickly sink any prospect of further development. In a process that involves developing innovative new concepts, there has to be space to try and fail within acceptable limits.

Integrations Practiced in Bangladesh

Bangladesh is an agro-based developing country where almost all the people are directly or indirectly dependent on agriculture. Peoples engaged in agricultural activities are dependent on agriculture for livelihood and other people are dependent on farmers for their food. To supply the demand of the food requirement of the nation, farmers have been working hard in different ways from the time immemorial. Single crop production, multiple crop production in same field and integration or two or more different environments such as aquatic environment, agricultural cropland, and terrestrial animal husbandry have been practiced by the farmers of Bangladesh from a long time ago only for providing food to the nation. With the increase of population and developmental activities, the cultivable land has decreased drastically which have demanded new, updated and advanced technologies in agricultural production. Different types of integrations have been practiced in Bangladesh including Integrated Agri-Aquaculture systems such as rice-cum-fish farming, vegetable-cum-fish culture; an integrated livestock-fish farming systems such as poultry-cum-fish farming, duck-cum-fish farming, cattle-cum-fish farming, goat-cum-fish farming; integrated Horticulture-Fish farming such as embankment horticulture-cum-fish farming and integrated irrigation-fish farming system.

Integrated Agri-aquaculture System

Rice-cum-fish Farming

The integrated rice-fish production system is the most traditional integration system practiced in Bangladesh which can optimize resource utilization through the synergistic use of land and water. Integration of fish with rice farming improves diversification, intensification, productivity, profitability, and sustainability [10]. Two types of rice-fish integration systems are commonly used in Bangladesh, alternate fish culture in rice fields and integrated rice-fish farming system [13]. Rice and fish are rotationally produced in the alternate rice-fish culture system on the plain and medium lowlands under rain-fed conditions and alternate farming are performed in deeply flooded lowlands. On the other hand, rice and fish are cultured in together in the integrated rice-fish farming system. In the integrated rice-fish farming system, Indian major carp, exotic carp, common carp, Nile tilapia, silver barb, and silver carps are generally stocked in the alternate farming system. Some specialists suggest avoiding common carp and grass carp because rice plants are uprooted and consumed if rice fields are stocked with common carp and grass within 2 weeks of planting seedlings [11-12].

Figure 2: Integrated rice-cum-fish farming system in shallow waterbodies practiced in Bangladesh.

Fish-Cum-Rice and Vegetable

Different types of agricultural crops (vegetables, rice, and maize), aquatic plants (water spinach, duckweed, and water hyacinth) are integrated with fish farming [38]. The most common system in fish-cum-crop production in Bangladesh is the cultivation of fish with rice, and vegetables, widely practiced in rural areas, at the subsistence level. Different vegetables such as water leaf and spinach are planted on the dikes and the rice is planted right inside the pond. The crops derive water and nutrients from the fish ponds while the crops serve as food, especially for herbivorous fish. Besides, periphytons on the crop may enhance the yield of cultured fish species [39].

Figure 3: Integrated rice-cum-fish and vegetable farming system in Bangladesh.

Aquaponics System

Aquaponics is a bio-integrated system that links recirculating aquaculture with vegetable, flower, and herb production. The waste products of one biological system serve as nutrients for a second biological system. The integration of fish and plants results in a polyculture that increases diversity and yields multiple products [40-41]. Water is re-used through biological filtration and recirculation. Local food production provides access to healthy foods and enhances the local economy. In aquaponics, nutrient-rich effluent from fish tanks is used in fertilization of the hydroponic production beds. This is good for the fish because plant roots and rhizobacteria remove nutrients from the water [42-43]. The nutrients generated from fish manure, algae, and decomposing fish feed are contaminants that would otherwise build up to toxic levels in the fish tanks, but instead serve as liquid fertilizer to hydroponically grown plants. In turn, the hydroponic beds function as a biofilter by stripping off ammonia, nitrates, nitrites, and phosphorus and recirculate back the clean water [39-45].

Figure 4: Aquaponics (integration of plants and fish) system.

Integrated Livestock-fish farming system

Poultry-cum- Fish Farming

The integrated poultry-cum-fish farming system is one of the most commonly practiced and also more profitable integrations system in Bangladesh. In this farming system, Poultry droppings are used as feed resources for fish cultured in the pond [35], which integrates the poultry (chickens, ducks, and geese) with fish farming. Generally, the poultry house is constructed over the pond or near to the pond so that the excreta from the birds can easily serve as feed. Poultry droppings can improve the primary productivity of pond by automatic fertilization, even some of the fish directly feed on the excreta [36]. Poultry manure contains both the organic and inorganic fertilizer particles for use in the fish pond without resorting to the addition of supplementary feed [37].

Figure 5: Integrated poultry-cum-fish farming system practiced in Bangladesh.

Duck-Cum-Fish Farming

Duck farming with fish culture is an economically viable and productive system for both the rural farmers and the commercial entrepreneurs in Bangladesh. Duck manure contains nutrients that enhance the growth of natural fish food organisms in ponds and thus can indirectly enhance the fish growth. Since, duck manure is less expensive than inorganic fertilizer and supplemental feed, the cost of fish production could be significantly reduced if duck farming is integrated with fish culture [39].

Figure 5: Integrated duck-cum-fish farming system practiced in Bangladesh.

SWOT analysis

SWOT analysis is a widely used framework due to its simplicity and practicality which stands for the Strengths, Weaknesses, Opportunities and Threats which is used to analyze the internal and external factors to attain a systematic approach for decision-making [1]. It is an important tool in addressing the weaknesses of quantitative analyses. The aim of SWOT analysis is to maximize the future position of an enterprise like rice-fish farming system in Bangladesh [15]. SWOT analysis is a strategic planning tool which consists of two parts:

I. Analysis of the internal situation: This only discusses actual strengths and weaknesses rather than speculative, future strengths and weaknesses.

II. Analysis of the external situation: This includes the ac tual situation, i.e., existing threats, as well as unexploited opportunities and probable trends.

SWOT analysis is used to identify and analyze the constraints in adoption and diffusion of integrated farming system in Bangladesh among the indigenous communities [18-19]. When the ecological and economic status of the aquaculture industry is communicated to the general public, the focus tends to be more on the negative than the positive. It was therefore surprising to see the generally low score for social impacts in the SWOT analysis. As an example, conflicts over space were given a low score under weaknesses in the social impacts section. This score might perhaps have been higher under Norwegian conditions, where use of space for aquaculture continues to come into conflict with other users of the coastal waters. [19-24]. The greatest threat comes from the fear that the Integrated Aquafarming concept will be wrongly communicated to the public, and this concern should not be underestimated. Negative media coverage of faulty or unsuccessful Integrated Aquafarming practices could quickly sink any prospect of further development. In a process that involves developing innovative new concepts, there has to be space to try and fail within acceptable limits. The fact that Integrated Aquafarming could bring a whole new insight into aquaculture practices, with improved environmental consideration through the recycling of nutrients, was seen as the greatest strength [25-29]. Another strength was the financial benefit of products that could be sold in new market areas and new niches. A sustainable image could have a major positive effect on the economics of the industry. The SWOT analysis may be useful in showing what other countries think and what problems should be taken into account. It is, however, essential to analyze all aspects of the ecological, economic and social effects in relation to each other and to place this in a more explanatory context instead of individual analyses in these areas, as was done here [30-34].

Strengths	Weaknesses
• Nutrient recycling . • Reduced demand for feed from pelagic marine fisheries and terrestrial crops. • Increased farm productivity. • Increased farm crop diversity. • Greater emphasis on quantifying ecological effects. • Can be used in many applications, e.g. freshwater, saltwater, closed and open systems.	• Lack of thorough understanding of environmental impacts. • Currently emphasize only high value products and thus less likely to contribute to world food needs (except seaweeds). • Converts more resilient food webs to more vulnerable food chains. • Shifts nutrient flows in the environment to reduce natural production.
Opportunities	**Threats**
• Remediation of anthropogenic eutrophication. • Increases domestic production, decreased environmental costs (e.g. transportation) of imported sea-foods. • Produce products (such as seaweed-based biofuels) that would reduce environmental impacts of fossil fuels. • Greater scope for decision-making for the aquaculture industry • Potentially greater profitability compared to existing aquaculture systems. • Strengthens collaborative opportunities between different players. • Aquaculture research platform, Specialized markets for products.	• Potentially lower profitability in the short term compared with existing aquaculture systems. • Not enough public funding (i.e. political will) for developing a network of demonstration and research sites to examine feasibility of Integrated aquafarming. • Larger scale applications may have greater environmental impact and thus less social license.

Table 1: SWOT Analysis of ecological impacts of integrated aquafarming in Bangladesh [1-8,10-12,18-34].

Among the above mentioned integrated aquafarming systems practiced in Bangladesh, rice-fish culture system is more traditional and common system. Vegetable on the pond embankment is another important integration system in Bangladesh. Duck cum fish culture, livestock cum fish culture systems are other type of integrated systems used in Bangladesh. Recently, another type of integration system has been implemented in Bangladesh that is called Integrated Multi-Trophic Aquaculture (IMTA) which integrates fish, vegetables, and snails in the same pond. Different fish occupy-

ing different trophic level of a water body are cultured in combination with snails growing on the vertical bamboo pools which can be used as feed ingredients for culture fish. All of these integration systems have some specific positive sides, some drawbacks, future

Strengths	Weaknesses
• New image: differentiated coastal aquaculture. • Operational efficiencies: labor, operational rates, leasing. • Marketing advantages. • Effective use of nutrients and coastal space. • Ecosystem services increase revenue opportunities. • Diversified products = risk production.	• Complexity: marketing, operations, juveniles, business planning. • Regulatory complexity. • Site-specific criteria (due to multiple species): salinity, current, temperature. • Greater capital start-up costs. • Risks: structural conditions, disease, operations.
Opportunities	**Threats**
• Sustainable" image. • Market: pricing, high value products, packaging, niche opportunities. • Use IA as launching platform for national aquaculture vision. • Development platform: new products, innovation, feed, macro-algae, research. • Ecosystem services, potential revenue. • Accelerated innovation potential. • Adaptability (e.g. climate change). • New partners.	• Social acceptance, public perception. • Natural threats: disease, parasites, storms • Greater regulatory requirements. • Disappointment of expectations: failures could reflect badly on entire effort. • Market threats: overproduction, price cycles. • Competition from monoculture. • Cheap compared with IMTA. • New competing users.

Table 2: SWOT Analysis of economic impacts of integrated aquafarming in Bangladesh [1-8,10-12,18-34].

Strengths	Weaknesses
• Strong brand/green business. • Organic farming sounds positive. • Young industry – new model. • Commerce / jobs / wages. • Scalable operation. • Healthy food. • Improve environmental condition. • Year-round production, multiple species. • Educational opportunities. • Greater species diversification. • Opportunities for business development. • Preserve working waterfront. • Provide ecosystem services. • Good management. • Visual perception of aquaculture operations. • Scientific discovery. • Lease revenues.	• Complexity. • Visual perception of aquaculture operations. • Fear of the unknown. • Capital intensity scale. • Economic viability. • Greater wildlife impacts and public perception thereof. • Potential to downgrade monoculture. • Poor examples and failures could color overall perception. • Lack of critical mass. • Conflict of use (e.g. water, space). • Young industry. • Maybe greater privatization of public resources.
Opportunities	**Threats**
• Opportunity to culture new ecologically responsible species. • Jobs, local buying. • Social awareness. • Eco-food tourism. • Optimize nutrient loads. • Increase healthy food supply. • Control environment (marketability). • Education pathway. • Initiate partnerships. • Improve technology, regulatory designss.	• Misinformation. • Financing. • Uncontrolled messages (e.g. on the internet). • Shoreline development. • Lack of marine spatial planning. • User conflicts over space. • Competition in the market. • Environmental degradation.

Table 3: SWOT Analysis for social impacts of integrated aquafarming in Bangladesh [1-8,10-12,18-34].

Conclusion

Through Sustainable food production, ensures food production year after year which secure the food security. To ensure sustainability, food production must be continued to fulfil the demand of deficiency. It can be maintained by rotational culture, seasonal culture or through integrated farming. Integrated Aquafarming offers huge potential. Different stakeholders possess different competencies. It is crucial to bring these competencies into a system that can work effectively. Effective collaboration between industry, business, research and politicians is necessary in order to ensure effective development of sustainable aquaculture. Such a partnership should be established simultaneously for both pilot projects and industrialization. Most of those who farm fish know nothing about growing algae or mussels. There remains some way to go before it is possible to establish large-scale production and achieve substantial profitability. However, it could all happen quickly given sufficient resources. The technology needs to be developed, and here there is no other option but trial and error. The focus should be on the overall potential. Bellona believes the future of fish farming lies in Integrated Multi-Trophic Aquaculture, and it is entirely possible to increase both area and production through such practices.

Good innovation concepts must be created. We should think about what we want for our valuable coastal areas. Whatever we humans do will leave some traces. The important thing is to find solutions that keep those traces to a minimum. We should develop a holistic understanding and come up with holistic solutions that work with the ecosystem rather than against it.

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Conflicts of Interest

The authors declare that there is no economic interest or other conflicts of interest regarding the publication of this article.

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