Bangladesh Needs a “Blue–Green Revolution” to Achieve a Green Economy

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INTRODUCTION

Bangladesh is the 7th most populous country in the world, covering an area of 144 000 km² with a population of 164 million. population is constantly increasing in Bangladesh with 2.26 million more people being added each year (United Nations 2009). Bangladesh is also the most densely populated country (1142 per km²) in the world, ranking 11th in population density when small island countries and city-states are included. Despite sustained efforts by donors since independence (1971), Bangladesh remains one of the world's least developed countries with 58% of its population classified as poor (Alkire and Santos 2010). Although per capita income has more than tripled from US\$203 in 1975 to US\$641 in 2010, it is still extremely low compared to the world average of US\$8 985 (IMF 2010).

The effects of climate change are a further threat to food security in Bangladesh as the country ranks first in terms of vulnerability to climate change (Harmeling 2010). Already one in four households, or 27% of the population (44 million), are undernourished (FAO 2010a). Despite progress in reducing child malnutrition in Bangladesh, it is still one of the highest in the world (Faruque et al. 2008; Bland 2009). Moreover, up to 77 million people in Bangladesh are being exposed to water contaminated by arsenic (Argos et al. 2010).

We suggest that a “blue–green revolution” of fish farming in rice fields can offer a solution to these problems. Because of its fertile soil and available water resources,

Bangladesh is ranked 4th and 6th in global rice and fish (aquaculture) production, respectively (FAO 2010b, c). Rice is the most important agricultural crop in Bangladesh with an annual production of 29 million tonnes a year (BRKB 2010), while annual fish production is 2.7 million tonnes (DOF 2010). The total area of rice fields in Bangladesh is about 10.14 million ha with an additional 2.83 million ha of inundated seasonal rice fields where water remains for about 4–6 months (BRKB 2010). The carrying capacities of these lands and waters are not fully utilized, but there exists tremendous scope for increasing food production and economic growth through a blue–green revolution.

BLUE–GREEN REVOLUTION

The agricultural sector in Bangladesh has grown at an amazing rate since the original “green revolution” in the 1970s (Hossain 1988; Alauddin and Tisdell 1991). Most lands suitable for agriculture have been transformed to cultivation of high yielding varieties of rice. However, the green revolution had not been able to solve food insecurity for Bangladesh because of the huge gap between population growth and food production. Moreover, the green revolution is not “green” because the rice monoculture requires excessive use of pesticide and fertilizer resulting negative impacts on soil fertility, biodiversity, and ecosystems (Berg 2002; Jewitt and Baker 2007).

More recently, the rapid development of small-scale aquaculture, including export-oriented prawn (*Macrobrachium rosenbergii*) farming in Bangladesh, has been likened to a blue revolution (Ahmed et al. 2010). The blue revolution has significantly increased the socioeconomic

conditions of farming households. However, considerable debate has occurred on the impacts of the blue revolution on the environment, biodiversity, and society (Neori et al. 2007).

The increased adoption of prawn and fish farming within rice fields suggests that blue is joining with green in Bangladesh. Fish farming in rice fields is a combination of blue revolution (aquaculture) and green revolution (agriculture) referred to as a “blue–green revolution” (Rahman et al. 2010). The blue–green revolution can optimize resource utilization through the complementary use of land and water, suitable for a country like Bangladesh, where land is scarce and the population is growing rapidly. The blue–green revolution is a form of sustainable intensification, i.e., producing more food from the same area of land without environmental impacts (The Royal Society 2009; Godfray et al. 2010).

GREEN ECONOMY

A green economy is one in which the vital links between economy, society, and environment are taken into consideration. A green economy is one that results in improved human well-being and social equity, and at the same time significantly reducing environmental risks and ecological scarcities (Green Economy Initiative 2010). Green economy is an effort to solve the current environmental crisis

and economic crisis. The thematic focus of the green economy is sustainable development and poverty eradication. The green economy is growth-positive, employment-positive, and poverty-negative. It is hypothesized that the blue–green revolution in Bangladesh can provide such benefits (Fig. 1).

Economic Growth

One of the positive impacts of the blue–green revolution is livelihood opportunities for poor households. The blue–green revolution is providing three broad elements of livelihoods, including farm-based rural livelihoods, market-based livelihoods, and multi-location nonfarm livelihoods. The connection between farming and marketing systems are the key forces for diversifying livelihoods. A secure livelihood is able to cope with shocks and stress, and reduces vulnerability (Lindenberg 2002; Marschke and Berkes 2006). Enabling farmers to adopt prawn–fish–rice farming is important to improving their opportunities for better livelihoods and alleviating poverty.

The blue–green revolution of prawn farming in rice fields is already making significant contribution to economic growth. Prawns are highly valued by international markets and therefore export to the USA and Europe. During 2008–2009 fiscal year, Bangladesh exported 50,368 tonnes of prawn and shrimp valued at US\$404 million (DOF 2010). If prawn farming expanded to a quarter of the

Fig. 1 Potential benefits from the blue–green revolution

2.83 million ha of seasonally inundated rice fields, the country would earn an additional US\$2 353 million annually. Similarly, the country would get an additional US\$9 413 million annually, if prawn farming expanded to the entire 2.83 million ha of rice fields (Table 1).

Food Security and Nutrition

The blue–green revolution is not merely a change in cropping system, it also allows a shift to a balanced diet (rice, fish). Fish, particularly small fish, are rich in micronutrients, vitamins, and minerals, and thus human nutrition can be greatly improved through fish consumption (Kawarazuka and Bene 2010). The blue–green revolution can also improve food security as integrated rice–fish farming is better than rice monoculture in terms of food supply. If integrated rice–fish farming expanded to the entire 2.83 million ha of seasonally inundated rice fields, an additional 0.73 and 1.58 million tonnes of fish and rice would be produced annually (Table 1). However, increased food production may not be enough to feed the population of Bangladesh as it increases from 164 million now to 222 million in 2050 (United Nations 2009). Productivity would, therefore, have to be increased through sustainable intensification. If integrated rice–fish farming extended across the 10.14 million ha of Bangladesh rice fields, food security might be achieved.

It has been reported that the cultivation of fish in rice fields increases rice yields by 8–15% (Mishra and Mohanty 2004). Increased rice yield will increase the availability of paddy straw, used for building houses, as cooking fuel, and as fodder for cattle. As a result of fodder availability, milk availability will increase which is suitable food for children. Cow dung will also be available to use as fertilizer for agriculture, and thus crop production will be further increased. Egg and meat production will also increase through duck rearing on harvested rice fields, a recent phenomenon in rural Bangladesh. Production of crops on the dikes may also increase by using fertile water from rice–fish farms.

Environmental Benefits

The blue–green revolution of prawn–fish–rice farming is ecologically sound because prawn and fish improve soil fertility by increasing the availability of nitrogen and phosphorus (Frei and Becker 2005). Rice fields provide fish with planktonic and benthic food, and shade (Mustow 2002). The feeding behavior of prawn and fish in rice fields causes aeration of water and recycling nutrients, improving rice growth. Prawn–fish–rice farming is also being regarded as an important element of integrated pest management in rice crops (Halwart and Gupta 2004). As a result of

Table 1 Potential for food production and export earnings from inundated seasonal rice fields

Seasonal rice field (million ha)	Converted to prawn–fish–rice farming (%)	Prawn–fish–rice farming area (ha)	Fish yield ^a (kg ha ^{−1} year ^{−1})	Total fish yield (t year ^{−1})	Increased rice yield ^b (kg ha ^{−1} year ^{−1})	Total increased rice yield (t year ^{−1})	Prawn yield ^c (kg ha ^{−1} year ^{−1})	Total prawn yield (t year ^{−1})	Export price of prawn ^d (US\$ kg ^{−1})	Export earning (million US\$ year ^{−1})
2.83	25	707 500		183 243		395 493		305 640		2 353
	50	1 415 000	259	366 485	559	790 985	432	611 280	7.7	4 706
	75	2 122 500		549 728		1 186 478		916 920		7 060
	100	2 830 000		732 970		1 581 970		1 222 560		9 413

^a Average fish production in rice fields is from Ahmed and Garnett (2011)

^b Rice yield in integrated farming (5,261 kg ha^{−1} year^{−1}) is higher than the rice monoculture (4,702 kg ha^{−1} year^{−1}), because of the presence of fish (Ahmed and Garnett 2011)

^c Average prawn production in rice fields is from Ahmed et al. (2008)

^d Export price is from processing plants

reduced pesticide use, the rice field conserves a greater variety of aquatic biodiversity for maintaining ecosystems (Halwart 2008). Fish also play a significant role in controlling aquatic weeds and algae that carry diseases, act as hosts for pests and compete with rice for nutrients. Moreover, fish eat flies and insects, and can help to control malaria mosquitoes and water-borne diseases (Matteson 2000). Integrated rice–fish farming is also capable of reducing the emission of the greenhouse gas methane by 30% compared with rice monoculture (Lu and Li 2006).

Prawn–fish–rice farming can also help people adapt to climate change, including heavy rains and floods. Bangladesh is a flood-prone country and each year about 26,000 km² (18% of the country) is normally flooded (Banglapedia 2011). When floods occur, prawn and fish can be cultured in rice fields. Farmers can strengthen the dikes of rice fields to prevent the escape of prawn and fish. Because higher dikes are constructed around rice fields, flood risks may be reduced. Prawn–fish–rice farming could also reduce the contamination of soils and crops with arsenic, if arsenic-contaminated soil has been used to build higher dikes. Using rain and flood water for prawn–fish–rice farming may reduce the need to pump water for irrigation which in turn avoids using groundwater, resulting in drinking water with lower arsenic concentrations.

VISION 2020

Bangladesh should consider promulgating the blue–green revolution to achieve a green economy for the next decade. If the benefits of a blue–green revolution are to reach the millions of rural poor, government policy must encourage the adoption of prawn–fish–rice farming. Community-based approaches supplemented with technical and financial support are likely to be the best route to adoption. The role of government and nongovernmental organizations (NGOs) like Bangladesh Rural Advancement Committee (BRAC) and Grameen Bank will play a vital role. BRAC, the largest NGO in the world (Ahmed and French 2006), can play a key role in promoting prawn–fish–rice culture technology across the country. The Grameen Bank, a specialized rural bank providing microcredits that was awarded the Nobel Peace Prize for 2006, could actively promote the blue–green revolution. It is possible that Bangladesh could become a food-secure and poverty-free country within a decade if we can accelerate economic growth and food production through a blue–green revolution.

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