Low External Input Sustainable Aquaculture for Bangladesh - An Operational Framework

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Like most developing countries, Bangladesh wants to improve the income and nutrition of its rural population most of whom live under uncertain and harsh social and environmental conditions. These rural households farm with little access to land, water or capital. Farming itself is fraught with the uncertainties of rain and floods. There are, however, many seasonal water resources in the country in which fish will grow. There is a challenge to bring aquaculture as a complement to other agricultural activities. The potential rewards in income and food are high (see *Naga* July 1990, p. 8). What approach should be taken in order to stimulate households into culturing fish? This was the question facing ICLARM's collaborative research for aquaculture development with the Bangladesh Agricultural Research Council (BARC), Fisheries Research Institute (FRI) and Department of Fisheries (DOF).

We feel conventional high input approaches - intensive aquaculture are not suitable even though high fish productions can be achieved, for the following reasons: a) adoption is rarely sustained as the rural households cannot afford high costs involved; b) credit is not easily available to rural households; and c) the households are vulnerable to risks involved such as floods, droughts, theft, etc. Moreover, credit dependent technologies increase income disparity between those who can and those who cannot get access to credit. Finally, we suspect that commercial production, when market prices are high, goes to the urban rich and not to the rural poor as intended. Given that we are driven by goals of poverty alleviation in conjunction with fish production, an alternative approach was indicated.

Any alternative must integrate fish culture through the use of existing feed, water and labor resources into the agricultural production systems of the many 'landless' households. More than this, we want to see aquaculture sustained. Thus, not only must economic needs be met but also biological and physical resources must be used efficiently and regenerated. New farming systems are needed, requiring with the above that a systems approach involving the participation of farmers be taken.

A systems approach was indicated because we want to make use of mutually supportive interactions between the new enterprise, aquaculture, and existing agricultural enterprises. The existing feed, water and labor resources must be made to produce more under the new integration.

Farmer participation was indicated because we want to adapt fish culture to fit into a range of existing household farming strategies. We know that simulating household conditions on-station or on a few model farms will not capture the range and complexity necessary for wide application of findings. Thus, we saw our work as two fold: first as identifying underused resources and designing new ways of reallocating them; second as establishing participatory research relationships with a large number of household.

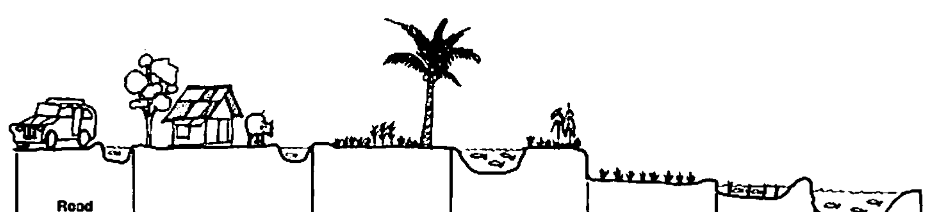
What follows is a description of how we did this.

Our research entailed four activities. First, the existing farming system was understood with particular reference to water resources; second, farmer participatory research tested techniques for integrating fish into ongoing farming systems (details of the technology are given in the center box); third, a partnership of government and nongovernment organizations supported widescale adoption; and fourth, the impact of the technology was assessed. These activities are presented along with their corresponding outcomes in the operational framework below.

Operational Framework of Research Activities and Outcomes

Activity 1:
Understanding existing household farming systems through a combination of farmer participatory appraisals to identify land and water resources through agroecosystem transects (Fig. 1), and socioeconomic surveys to understand present water use and fish culture practices.

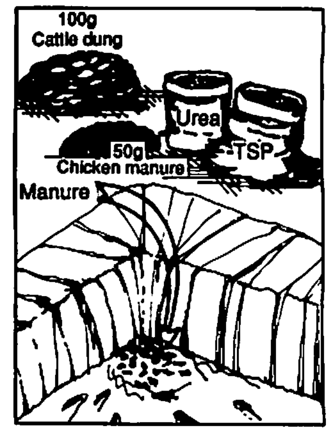
Outcome 1:
Most rural households in Bangladesh have water resources in their homestead such as seasonal ponds and ditches, or nearby roadside ditches, as can be seen in Fig. 1. Most small waterbodies result from excavation of soil for constructing houses or roads. They are rarely built for fish culture. We found that they have multiple uses, such as bathing and washing clothes, livestock washing, irrigating crops, and least of all for fish culture.
We also found that: (i) farmers were not aware that seasonal ponds and ditches can be used for fish culture; (ii) they were not aware of fish species that could reach table size within four to six months of water retention in their ponds; and (iii) they were not aware how to culture fish.



Land type	Road side ditch	Homestead	Vegetable crops Upland	Medium land	Lowland	Flood-land	River
Soil		Sandy loam	Sandy loam	Loam	Silty clay loam	Clay loam	
Crops	Jute retting		Rice, Gram, Wheat, Potato, Mustard, Cabbage, Lady finger, Pulse, Pea, Beans, Tomato, Garlic, Onion	Rice, Wheat, Gram, Sugarcane	Rice, Wheat	Rice	
Trees		Mango, litchi, guava, date palm, papaya, coconut	Coconut				
Livestock		goat, cattle buffalo, poultry		Grazing (Dry season)	Seasonal		
Fish (BEFORE)	Wild fish			wild fish		Wild fish	Wild fish
Fish (AFTER)	Tilapia Silver barb	Silver barb Tilapia		Carps, tilapia silver barb,		Wild fish	Wild fish

Fig. 1. ***Agroecosystem transect of Mymensigh flooodplain.***

A



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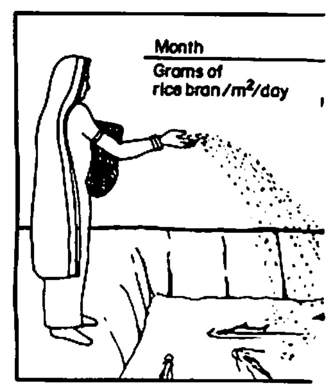
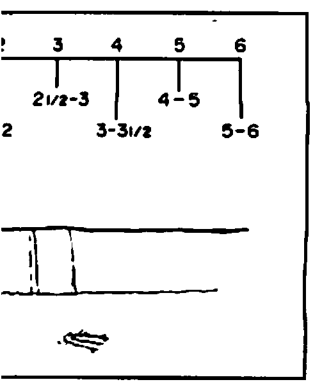


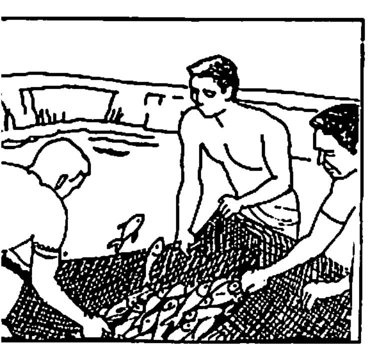
D

3. **Stocking:** Gently release healthy fingerlings of 3-5 g size at a rate of $2/m^2$ for Nile tilapia and $1.5/m^2$ for silver barb in the pond (Fig. C).
4. **Feeding:** Feed the fish once or twice a day using the rates shown for rice bran in a $500\text{-}m^2$ pond. Apply kitchen wastes, weeds and other inputs to reduce the requirement for rice bran (Fig. D).
5. **Harvesting:** Harvest fish as they reach table size or when the water level goes shallower than 50 cm. A combination of line fishing and netting is used (Fig. E).

1. Pond preparation: Trim branches and remove shrubs and tall grasses from pond embankment. Clear submerged and floating weeds. Apply 25 g/m² of lime or kitchen ash to pond bottom (Fig. A).
2. Fertilization: Apply 100 g/m² of cattle manure or 50 g/m² of chicken manure once every two weeks to the corner of the pond. Organic manures can be substituted with 2 g/m² of urea and 5 g/m² of triple superphosphate (Fig. B).

C





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Activity 2:

Farmer participatory research. This builds on households' resource flow models (Fig. 2) to stimulate farmers and researchers into designing technologies for integrating fish into existing farm systems. Through repeated visits to farms and research stations, the culture of short-cycle species such as Nile tilapia (*Oreochromis niloticus*) and silver barb (*Puntius gonionotus*) largely fed with on-farm wastes in underused seasonal ponds and ditches was designed and tested by farmers. See box for a fuller description of the technology.

Outcome 2:

The model in Fig. 2 shows flows before and after integration of fish. Integration resulted in water and pond mud irrigating and fertilizing the vegetable gardens. Moreover, agricultural wastes and by-products such as animal manures, vegetable wastes and rice bran were used for fertilizing the pond and feeding the fish. Compared to a catch of 100 to 200 kg/ha of wild fish, farmers were able to culture silver barb (*Puntius gonionotus*) and Nile tilapia (*Oreochromis niloticus*) and obtain fish yields between 1 and 2 tonnes/ha.

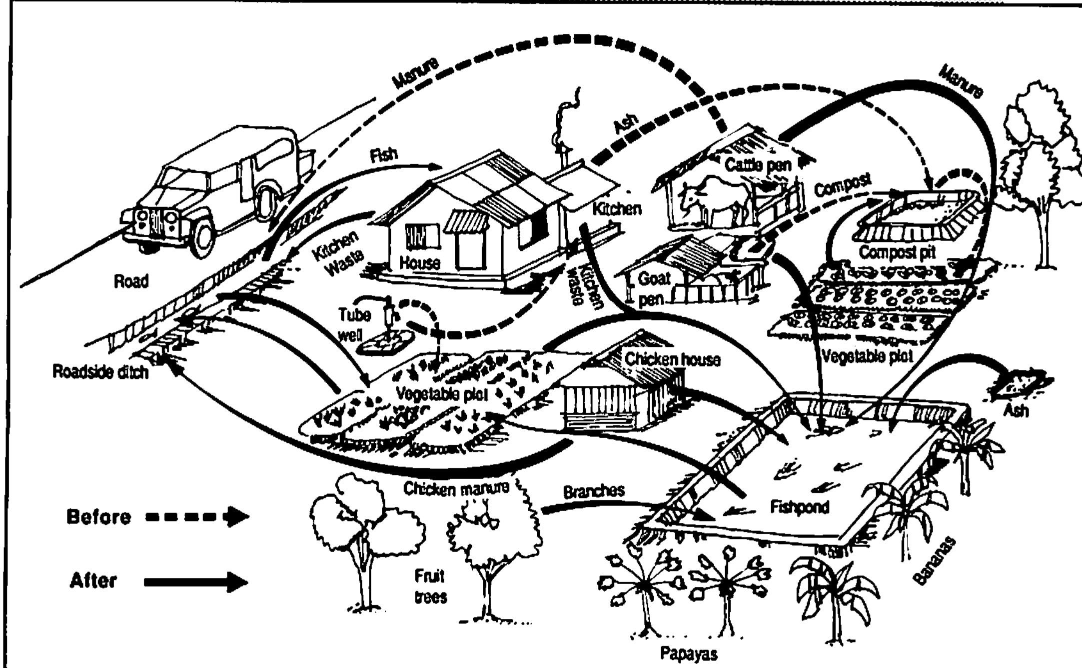

Fig. 2. ***Bioresource flow model before and after aquaculture irrigation.***

Activity 3:

Encouragement of farmers (by a partnership of government researchers and extensionists - government and nongovernment) to try the technology in seasonal ponds and ditches. This was done through a sequence of NGO-initiated awareness rallies, government facilitated farmer-to-farmer technology training, and provision of input support by NGOs where needed.

Outcome 3:

At FRI and Bangladesh Rural Advancement Committee (BRAC) organized farmer rallies, researchers gained knowledge of farmer's resources and integration needs, to optimize the use of these resources and farmers gained knowledge about optimizing benefits from integration of seasonal ponds and ditches into their various agricultural enterprises. Also through these rallies, contacts were established within the community enabling successful farmers to pass their knowledge to new entrants. This initiative was supported by training facilitated by FRI and provision of input support by BRAC to farmers where necessary. Through this sequence, some 300 farmers, one-third of whom were women, have adopted aquaculture and thereby contributed to family income and nutrition.

Activity 4:
Assessing the biological and socioeconomic impact on farming systems and households through a combination of farmer participatory appraisals of the flow models and socioeconomic impact surveys.

Outcome 4:
The impact of aquaculture on the farming system is shown in the before and after illustration of Figs. 1 and 2. Note the increased diversity of enterprises, increased recycling of nutrients, regeneration of upland vegetable plots through nutrient supply, and regeneration of water resources through nutrient supply and clearing vegetation. These biological indicators showed that integration not only improved the households' ability to manage natural resources, but also provided a more sustainable farming system.

Within six months, households with a seasonal pond of average size of 170 m² harvested 24 kg of fish worth $15, which is significant, where 24 kg is equivalent to the national annual fish consumption of low-income rural households with six members. Moreover, even though 70% of the harvest was consumed by the family, enough cash was generated through sale to finance the next season's activity, thus sustaining the enterprise. Fully 90% of the hundred or so farmers interviewed expressed satisfaction with their integration of aquaculture. The many and diverse technical, social and economic reasons given in Fig. 3 suggest multiple benefits from adopting such integrated agriculture-aquaculture farming systems.

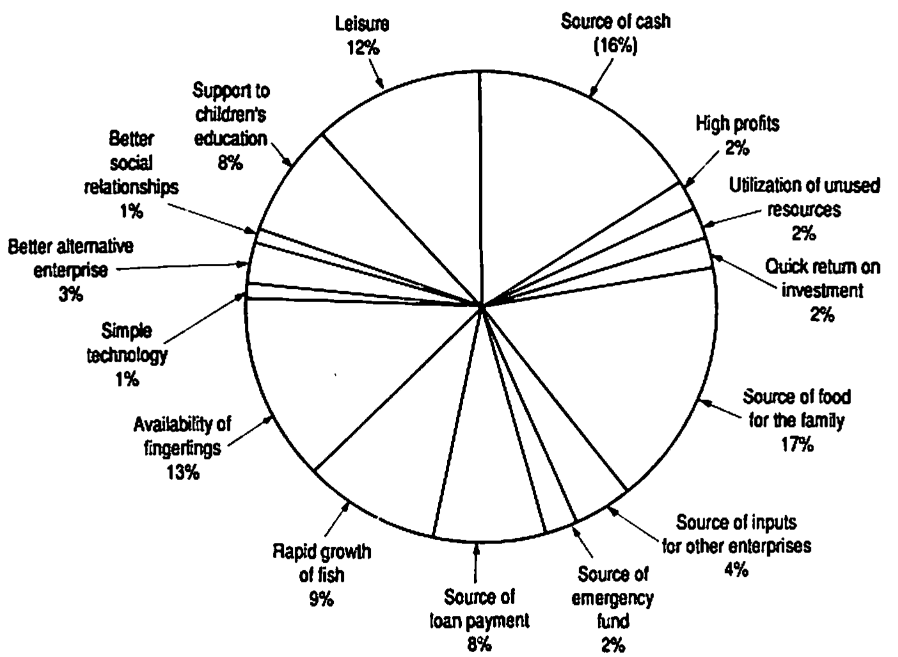

Fig. 3. ***Farmers' assessment of integrated aquaculture.***

Conclusion

Today, in and around the project area of Mymensingh, some two thousand families have taken up the new technology, while elsewhere in the country, the technology is being transferred to over 20,000 farmers, most of whom are women. There are many factors that contributed to this success. Three factors need highlighting because of their general application. First, interaction between farmers and researchers to identify resources ensured that the technology improved resource management and fitted properly with the farmers' ongoing production systems. The efficiencies gained from the use of underused feed, labor and water resources were vital as was the consequent limited need for cash and external inputs. Second, interaction between social and biological scientists ensured that the technology escaped biophysical problems of floods and drought - the short cycle species were timed to miss them, and escaped sociocultural problems of access to water resources - the farmer groups empowered participants, particularly the women, to secure water resources. Third, interaction between researchers and extensionists in government and nongovernment organizations ensured that relevant technologies would be developed, appropriate training would be conducted and farmer problems fed back to research stations.

This institutional partnership using the framework described, enabled many poor households, many of them headed by women, to count fish among their regular produce. The rural poor not only benefitted economically and nutritionally, but also their resource base was regenerated. Such impacts coupled with improved household skills in natural resource management, led to a more sustainable farming system. In this manner, a low external input sustainable aquaculture for Bangladesh emerged.

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