



Rice - fish integration increases production and income

# Ecologising rice-based systems in Bangladesh

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The Green Revolution in Bangladesh altered highly diversified agroecosystems that were strongly dependent on natural processes. A wide variety of vegetables such as lentil (*Lens esculenta*), eggplant (*Solanum melongena*), amaranth (*Amaranthus tricolor*), chilli (*Capsicum annuum*) and okra (*Abelmoschus esculentus*) were grown as field crops in the middle elevation areas between the homestead and the rice fields. Climbing vines such as bottle gourd (*Lagenaria siceraria*), bitter melon (*Momordica charantia*) and country bean (*Dolichos lablab*) were grown in the highest elevations, using trees and houses as support. A wide variety of trees usually surrounded the homestead areas. Oxen, goats, and chickens were abundant. Irrigation networks covered only 15% of the country's cultivated land. A single annual crop of rain-fed rice was grown during the monsoon and rice fields were mainly confined to low-lying areas. Native wild fish and other aquatic organisms entered rice fields freely. The fish actively migrated and settled in the fields to breed.

Rice farmers exploited this source of protein and made sure to open their dikes at the beginning of the monsoon. They also placed branches in their flooded fields to create a habitat more attractive to gravid brood fish. The use of composted cow-dung and legumes such as *Sesbania rostrata* along with regular silt-laden floods maintained soil fertility. The absence of pesticides favored a balance between pests and natural enemies. These traditional systems provided a sustainable supply of fruit, vegetable, grain, meat, eggs, fish, fodder, fuelwood, construction material and animal power.

## Green Revolution changes

Today, irrigation networks extend over 40% of Bangladesh's cultivable land. Rice areas have been gradually extended, two crops of rice per year is now the norm. Increased production is nearly meeting the needs of 130 million people. There have been, however, serious unforeseen agro-ecological consequences. Vegetable production for household consumption, now confined to the homestead, no longer

meets the requirements of the rural population. The number and diversity of trees has reached catastrophically low levels generating a fuel crisis and a scarcity of fruit. With a scarcity of fodder, oxen are difficult to maintain and are increasingly replaced by mechanical tillers. The small quantity of dung still available is used almost entirely as cooking fuel, leaving little for organic fertilizer. Elevated roads, flood control, pesticide residues and eutrophication from fertilizers stopped the migration of fish from rivers to rice fields. Populations of native fish species (*Channa spp.*, *Heteropneustes clarias*, *Anabas testudineus*) are now endangered and the traditional rice-fish systems have disappeared.

The system is already showing signs of unsustainability. Most rice farmers are dependent on insecticides for pest control. A 1995 CARE survey of rice farmers in Comilla district—a high-input use area—showed that 96% used insecticides during the dry season. But despite—or due to—the prevalence of insecticide use, old farmers report that insect pests are now more difficult to control than in their youth. They also report increasing fertilizer dosages for the same yields and are nearly unanimous in saying that their soils “are tired”.

The decrease in the ability of rural households to produce vegetable, fruit, and high-protein food has contributed to an unbalanced diet, over-reliant on rice. The increased rice yields, on the other hand, have not translated into either improved nutrition or income.

CARE's Agriculture and Natural Resource sector realized that some of the elements of diversity and natural pest control from traditional systems could be restored to the intensive rice monoculture systems. The “ecologised” rice-based systems would help to increase the availability of diversified food while making the systems more sustainable. Using the Farmer Field School approach, the New Options for Pest Management (NOPEST) project introduced farmers to the ideas of integrating vegetables, fish and trees in their rice systems using a natural pest control approach. The “new-old” techniques have been widely adopted by more than 40,000 farmers without negatively affecting rice yields.

## Reverting to natural pest control

Starting in 1995, the project promoted non-chemical means of pest control in rice. As a result, 85% of participating rice farmers completely left out the use of synthetic insecticides within a single season, and continued to practice natural pest control 5 years later. They rely on natural enemies and on the ability of the rice plant to compensate for insect damage, with no negative effects on their yields. The yields of project participants using no insecticide

Table 1. Rice yield differences between users and non-users of insecticides.

	Dry season 1998 Mean rice yield (t/ha)	Monsoon 1998 Mean rice yield (t/ha)	Dry season 1999 Mean rice yield(t/ha)
Project participants using no insecticides	4.66 (n=134)	3.28 (n=172)	5.11 (n=114)
Non-participants using insecticides	4.18 (n=155)	2.73 (n=172)	4.71 (n=152)

Table 2. Rice yield differences between rice-vegetable and rice-only systems.

	Monsoon 1998 Mean rice yield (t/ha)	Dry season 1999 Mean rice yield (t/ha)
Participants' rice-vegetable	3.61 (n=13)	5.82 (n=10)
Participants' rice-only	3.66 (n=17)	5.16 (n=14)

**Table 3. Rice yield differences between rice-fish and rice-only systems.**

	Monsoon 1998 Mean rice yield (t/ha)	Dry season 1999 Mean rice yield (t/ha)
Participants' rice-fish	3.04 (n=35)	5.25 (n=35)
Participants' rice-only	3.66 (n=17)	5.16 (n=14)

**Table 4. Rice yield differences between rice-fish-vegetable and rice-only systems.**

	Monsoon 1998 Mean rice yield (t/ha)	Dry season 1999 Mean rice yield (t/ha)
Participants' rice-fish-vegetable	3.30 (n=3)	5.59 (n=10)
Participants' rice-only	3.66 (n=17)	5.16 (n=14)

are consistently higher than those of non-participant insecticide users (see Table 1). Since the project participants also modify other practices, besides foregoing insecticides, it cannot be said that the yield increase is due entirely to the absence of insecticides. It does show, however, that insecticides are not needed to obtain yield increases. Project participants have higher net returns than insecticide users. In 1998, the average net return from the rice crop of participants, if they sold the entire crop, was Tk.5,373 (=US\$107) per farmer per season, as opposed to Tk.3,443 (=US\$69) per farmer per season of insecticide users.

project began exposing men and women farmers to such cropping systems using the Farmer Field School approach. Since then, at least 40% of participating farmers are growing vegetables on the dikes of their rice fields, by elevating and widening their dikes. The most successful crops have been country bean, yard-long bean, bottle gourd and okra, all of which, except for yard-long bean, are traditional crops.

Data of 1998 and 1999 show either no difference or a slight increase in the rice-vegetable systems, in spite of the area lost to dike crops, i.e., the entire rice-vegetable field—the check plus the wider dikes—is producing at least the same total quantity of rice (see Table 2). The net returns from the vegetable crop that farmers would obtain if they were to sell the entire crop—they usually sell 1/4 of the crop—is Tk.733 (= US\$15) per farmer per season, an added value of 14% to the rice crop. Rice-vegetable growers eat vegetables more frequently and share the surplus with neighbours, friends and relatives.

#### Trees-on-dikes

The project also introduced the idea of growing trees on the dikes without affecting the rice crop, using cultural practices, such as periodical pruning of roots and branches. This type of pruning is perfectly appropriate to trees producing timber, cooking fuel and fodder. Now, 35% of project farmers are growing bokain (*Melia azidirach*), shishoo (*Dalbergia sissoco*), mahogany (*Swietenia macrophylla*) and acacia (*Acacia auriculiformis*), and continue to tend them long-term. Although it is too early to formally evaluate the benefits of this technique, the number of farmers planting trees on their dikes is growing and many have initiated small-scale tree nurseries to supply their community with planting material.

#### Integrating fish in rice-based systems

ICLARM and the Bangladeshi Government's Fisheries Research Institute were among the first to experiment with integrating fish in flooded rice systems in Bangladesh, but their ideas were not extended to farmers. In the 1992 dry

season, CARE conducted pilot activities in which 180 farmers experimented with rice-fish using non-native fish species as common carp (*Cyprinus carpio*), tilapia (*Tilapia spp.*) and sharputi (*Puntius gonionotus*). These early trials showed that rice yields were increased by 16% with rice-fish relative to the previous dry season with rice-only, 6% of which was attributed to presence of fish in the rice field.

In 1998 and 1999, yield data of project participants practicing rice-fish compared to those practicing rice-only shows that rice-fish causes no significant decline in rice yields, and in some cases even an increase. The rice yields presented here are under-estimated by about 5% because the ditch area in the rice-fish field was not taken into account when calculating rice yields (see Table 3).

The net returns from selling all the fish average Tk.7,354 (= US\$147) per farmer per season. This is more than the returns from rice and it is perfectly compatible with rice production. Although not all rice fields are feasible for rice-fish systems, 30% of project farmers are practicing it and their numbers are constantly increasing. As with vegetables, rice-fish farmers eat fish more frequently and donate much of it to their social networks.

#### Integrating both vegetables and fish

Of course, both vegetables and fish can be integrated into the rice monoculture and we estimate that 18% of project farmers have done so. As expected, their rice yields are not inferior to those of farmers practicing rice-only (see Table 4).

#### In conclusion

Cereal crops are frequently considered to be obligate monocrops. Our experience, however, shows that there are many ways in which rice can become part of a more diversified agroecosystem. The "ecologised" monocrop becomes more productive, it offers more services to the farmer household, and the multiple ecological interactions within the system increase its sustainability. The successes we obtained in diversifying rice monocultural systems still represent the initial stages in making small-scale agriculture more sustainable. Areas that require future attention include use of native fish species, integration of livestock, interactions between the home garden and the rice field, and scarcity of organic inputs for soil fertility management in rice. In other words, there are probably still many possible beneficial options that could further diversify and "ecologise" these systems. ■

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Planting vegetables on rice bunds to improve nutrition and income

#### Integrating vegetables

In 1991, a group of agronomists from CARE visited Sitakondo (Chittagong District), in the southeast of Bangladesh. They found what appears to be an indigenous dike crop system. Covering several kilometers, dikes between and surrounding rice fields are occupied by rows of country bean grown on simple supports. Local growers did not know the origin of the method and believed it to be ancient, attested to by the large number of country bean varieties in the area.

This system, along with experimental dike cropping systems from Indonesia prompted CARE staff to initiate a pilot project involving this technique. In 1995, the