Environmental and Natural Resource Degradation in Intensive Agriculture in Bangladesh

Substantial intensification of agriculture in Bangladesh has led to foodgrain self-sufficiency being achieved in good years. As currently practiced, however, intensive agriculture is degrading the soil resource base, posing a threat to its sustainability. These problems result primarily from the difficulties of learning how to manage complex new agricultural production systems, not from distortions or market failures inducing inappropriate behavior. Environmentally, intensive agriculture appears to pose less of a threat than is sometimes feared, with the important exception of pesticide use on vegetables.

Bangladesh has made substantial progress towards achieving its goal of foodgrain self-sufficiency. This achievement has been based on a substantial intensification of agriculture: modern rice varieties now account for almost half of the rice area; an increasing proportion of land is double- or triple-cropped; and use of chemical fertilizers has doubled since the early 1980s. Continued and accelerated agricultural growth will require intensification to continue. There has been rising concern, however, that intensive agriculture may not be sustainable and that it may be damaging to the environment or to other productive sectors—such as fisheries—particularly through water pollution.

Sustainability of intensive agriculture

Evidence of declining productivity

The overall picture of rising average yields and rising production in Bangladesh has tended to camouflage evidence of declining productivity. Farmers often claim that yields have been declining and that higher fertilizer applications are necessary to maintain yields. Analysis of data on yield trends at the district level shows that, despite rising input levels, yields have been declining or stagnant on about two-thirds of the area planted to modern varieties in the boro season in the last decade, and stagnant throughout the country in the aman season. Yield declines are strongly associated with the length of time that intensive production practices have been employed in each district. The results of long-term trials by the Bangladesh Rice Research Institute (BRRI) also indicate that intensive rice cultivation can result in declining yields, even under good management and with full recommended doses of all nutrients being applied. Stagnant or declining yields in the context of rising inputs indicate that land degradation is reducing productivity; if increases in input use had not counteracted the effects of degradation, yields might have fallen even further. This evidence is consistent with patterns of yield change in other Green Revolution countries, many of which have also experienced a slowdown in the rate of growth of production and yield.

Causes of declining productivity

There is considerable debate over the exact causes of declining productivity. In Bangladesh, the most likely cause is nutrient imbal-
ances. High-yielding modern varieties are far more demanding of soil nutrients than local varieties had been, a problem worsened by the increasing prevalence of multiple cropping. Chemical fertilizer use has increased, but not sufficiently to compensate for the higher rates of offtake and has been offset by reductions in applications of farmyard manure, which is in increasing demand for use as fuel. In general, applications of nitrogen are adequate but those of other nutrients often are not. Changes in soil physical and chemical properties, such as changing quality and quantity of organic matter and formation of a plowpan, also play a role in declining yields.

Because of its particular characteristics, Bangladesh has not experienced the irrigation-related problems, such as declining availability of water, salinization, and waterlogging, which have been an important reason for decreasing productivity in areas such as the Pakistani Punjab. There is some evidence of a build-up of insects and diseases, but this problem does not appear to be a major factor in current yield declines.

Consequences of declining productivity

The switch from traditional to modern varieties is essentially complete in the dry season and well underway in the wet season. While further expansion of irrigation is possible, it will become progressively more difficult. If current trends continue, the scope for production growth arising from intensification alone will be exhausted in about the year 2000. Further growth will then depend on improvements in productivity. Since the yield gap between farmer yields and potential yields remains high, even in districts which have not experienced yield declines (farmer rice yields in the dry season, for example, range from about 3 to 4 mt/ha while experiment station yields are generally in the 6 to 7 mt/ha range), the potential for such growth remains substantial.

Farmer responses

Because yield declines affect them directly, farmers have incentives to respond to them and are in fact doing so. Farmers are using higher and more balanced fertilizer applications. In particular, many have recently begun using fertilizers supplying micronutrients such as sulphur and zinc. They are also undertaking other activities, such as fuelwood planting, which will in the long run help to relax some of causes of declining productivity by allowing manure to be applied to agricultural fields rather than being burnt as fuel.

Need for intervention

There is considerable scope for the research and extension service to assist farmers in developing appropriate responses. This will require a re-orientation of research efforts towards an increased focus on site-specific conditions, on long-term research, and on cropping systems and practices used by farmers. The days of "blanket" messages which are equally applicable to all farmers are over; what farmers need is assistance in fine-tuning their cropping practices to improve yields and avoid degradation, not fundamental qualitative changes. This effort will also require a much improved extension system, which must not only deliver infor-
mation to farmers but also convey information back to the research system on farmers' needs and constraints. Efforts are already underway to achieve these aims, but much remains to be done.

Farmers will also need reliable and timely access to inputs, including irrigation, fertilizers, and credit. The liberalization of irrigation in the late 1980s was largely responsible for the sharp increase in growth in that period, and liberalization of the fertilizer distribution system during the 1980s has resulted in substantial improvements in fertilizer availability at the farm level. Problems persist, however, in the supply of urea, which need to be addressed.

**Environmental problems**

In addition to sustainability problems, concern has also been expressed that intensive agriculture harms the environment more generally. In particular, the rapid increase in the use of pesticides is thought to (i) adversely affect the health of farm workers and others exposed to pesticides; and (ii) contaminate ground- and surface water, harming downstream users of that water and damaging inland fisheries. Pesticide use fell in the late 1970s, when subsidies were removed, but has since increased again; sales of pesticides doubled in the second half of the 1980s.

About 70 percent of pesticides are used on rice. Usage is heaviest on boro, which received over 50 percent of pesticide applications on rice, by value, in 1989-90. Nevertheless, the amounts used per unit area and the total area affected are both relatively small. In 1989-90, only about 10 to 20 percent of the area planted to modern variety rice was treated. Pesticide use on rice is mainly reactive rather than prophylactic—applications are only made upon detecting insect infestations in the fields.

Use of insecticides on vegetables follows a pattern almost diametrically opposed to that found in rice. It is common to spray vegetables such as eggplant and country beans several times a week. There are indications that resistance to pesticides is well established among several vegetable pests.

**Health problems**

The toxicity of pesticides threatens the health of users. A study of rice farmers in the Philippines, for example, found health costs associated with pesticide use to be so high as to completely outweigh any benefits arising from pesticide use. The level and nature of pesticide use in Bangladesh, however, differs significantly from those in the Philippine study area, except in the case of vegetable farmers.

In rice production, pesticide use is widely dispersed and doses are low, so exposure is low. In vegetables, doses are high and applications frequent. Vegetable production is concentrated in a few areas and among a subset of farmers, so the population exposed is small but at high risk. Vegetables are often grown close to the household (because of their management intensity) and next to ponds or waterways (to facilitate irrigation) thus creating the potential for exposure of women and children and for water contamination. Consumption patterns also create a very significant potential for pesticide residues on vegetables affecting the health of consumers.

**Water pollution**

Use of agrochemicals can also result in health problems through pollution of drinking water by residues. The flushing effect of annual floods and monsoon, however, limits the danger that residues will accumulate. Recent tests of groundwater taken from village handpumps found traces of pesticides in only ten of 78 samples, despite the samples having been drawn from areas considered most at risk of contamination. All the pesticides detected were longer-lived organochlorines, whose use is now banned; no traces of the moderately persistent organophosphates which account for the bulk of current pesticide use were found. Greater evidence was found of nitrate contamination, but even the highest concentrations found were below WHO safe drinking water guidelines.

The degradation of inland capture fisheries has been attributed to a variety of factors, including overfishing, modifications to water flows resulting from water control programs, draining of beels for use in agriculture, and the effects of agricultural and industrial pollution. The relative importance of these factors is
impossible to determine from currently-available data, however. Given the low overall level of use, however, water quality problems caused by pesticide use appear unlikely to have been a major cause of the decline.

Need for intervention

Except for use on vegetables, the available evidence does not suggest the existence of significant current problems resulting from pesticide use in agriculture. It is feared that the extent of problems might increase as intensification continues. However, more recent modern rice varieties have been bred for increased pest resistance, thus reducing the need for pesticide. Newer pesticides also tend to have lower concentrations of active ingredients and to be less persistent.

By lifting the subsidies that it paid towards the use of pesticides, Bangladesh has already adopted policies which help reduce the risk of substantial environmental problems arising from pesticide use. Nevertheless, a number of relatively simple policies and reforms could reduce pesticide use even further and make it safer.

Reform of the regulatory framework, which is primarily concerned with pesticide effectiveness rather than safety, would help ensure that the pesticides that are used are safe both for their users and for the environment. In several instances, older, more toxic pesticides such as heptachlor (an organochlorine) continue to be used even though safer pesticides are available and in widespread use worldwide.

Increased use of Integrated Pest Management (IPM) practices would allow the low current levels of pesticide use to be reduced substantially without adverse consequences for agriculture. An FAO pilot project has led to 85 percent reductions in pesticide use among trained farmers and slight yield increases. However, the complexity of the knowledge required for successful use of IPM practices has limited diffusion beyond the trained group. Given the cost of this extension, the relatively low rate of pesticide use in rice, and the general weakness of the extension service, it may prove beneficial to look for subsets of IPM which could be extended more simply, with more complete IPM training being concentrated on areas with the highest pesticide use. There is also an urgent need for research on IPM techniques for vegetables.

Conclusions

Given the scarcity of land and the continued growth of population, there is no alternative but to continue intensifying agricultural production in Bangladesh. As currently practiced, however, intensive agriculture is degrading the soil resource base, posing a threat to its sustainability. These sustainability problems result primarily from the difficulties of learning how to manage complex new agricultural production systems, not from distortions or market failures inducing inappropriate behavior. They are not, therefore, amenable to traditional forms of intervention through manipulation of the price structure or by rules and regulations on land use.

Farmers have amply demonstrated that they have both the incentive and the will to respond to degradation problems. What they need is a supporting infrastructure that will aid them in doing so. There is considerable scope for the research and extension service to assist farmers in developing appropriate responses to degradation problems. This will require a re-orientation of research and extension efforts towards an increased focus on site-specific conditions, on long-term research, and on cropping systems and practices used by farmers.

Environmentally, intensive agricultural practices appear to pose much less of a threat than is sometimes feared, with the important exception of pesticide use on vegetables. Here too, what problems there are generally do not result from the impact of distorted policies. Several relatively simple interventions can help ensure that they do not grow and may reduce them further. The most pressing need for action is in vegetables, where numerous factors indicate a high risk of damage to the health of farmers and consumers and to the environment more generally. Research is urgently needed to determine the magnitude and exact nature of problems—including threats to the health of farmers and their families, of pollution of waterbodies, and of pesticide residues on food—and to develop appropriate solutions.