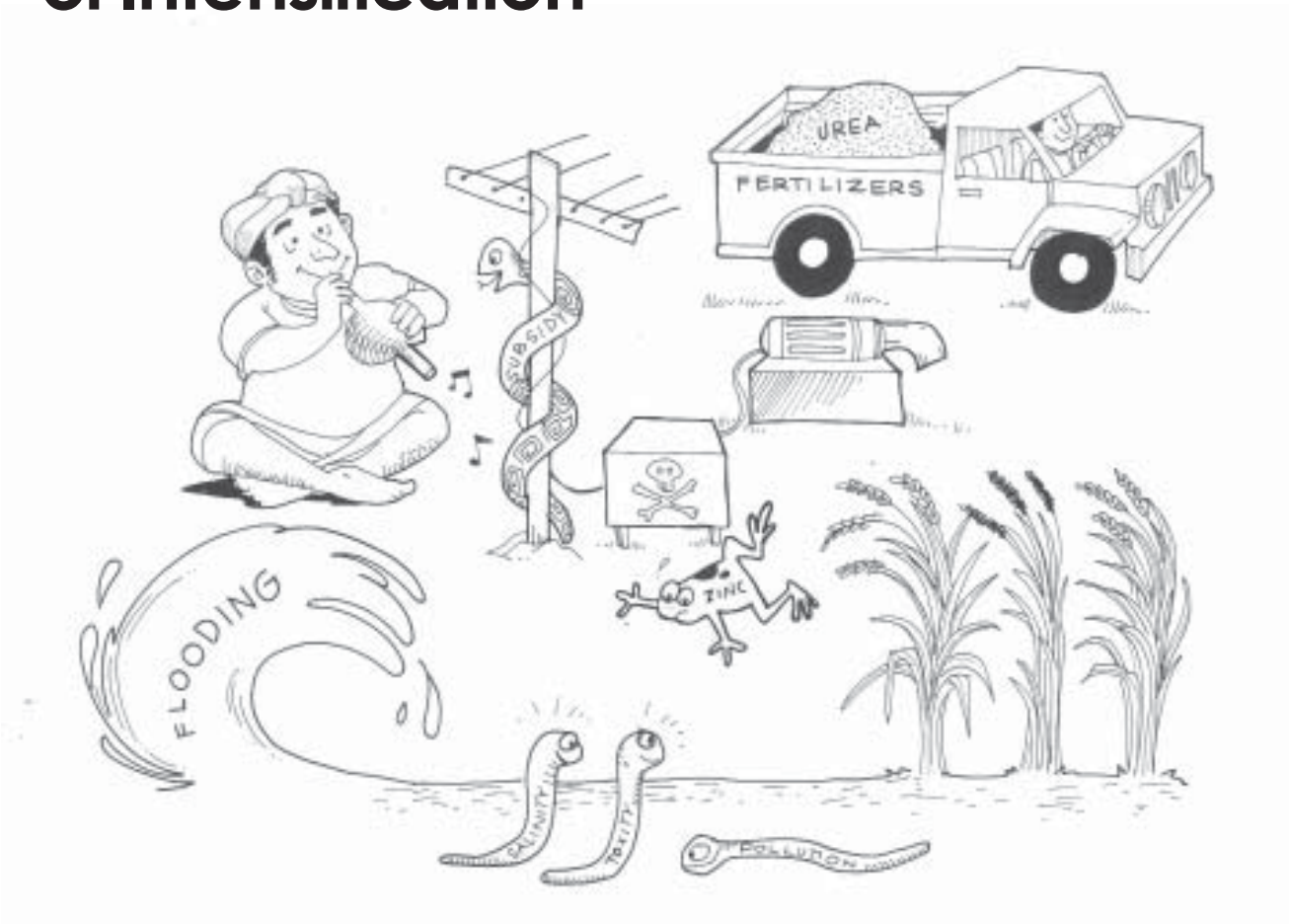
Ecological Consequences of Intensification



Intensive rice-wheat crop rotation is an obvious outcome of an assured irrigation facility and short-duration varieties becoming available in the Indo-Gangetic Plains of South Asia. This crop rotation results in the following changes:

- seasonal wet and dry crop cycles over a long term;
- increased use of, and reliance on inorganic fertilizers;
- asymmetry of planting schedules; and
- greater uniformity in crop varieties cultivated and hence their susceptibility to the same pests.

The most common environmental consequences of crop intensification in lowland areas are:

- waterlogging and salinity buildup;
- depletion/pollution of (ground) water resources;
- hardpan formation (or subsoil compaction);
- toxicities or deficiencies of nutrients in the soil; and
- pest buildup and pest-related yield losses.

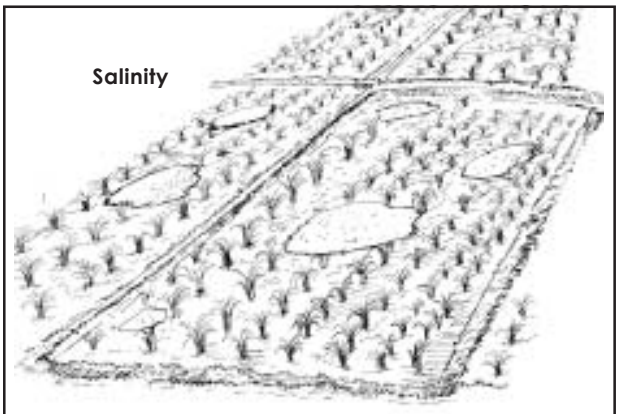
ALERT!
W-a-r-n-i-n-g S-i-g-n-s

At the farm level, long-term changes in the biophysical environment are manifested in terms of declining total factor productivity, input efficiencies and profitability.

Salinity, Waterlogging and Groundwater Degradation

Intensive use of irrigation water in areas with poor drainage leads to buildup of salinity in arid and semi-arid zones, and waterlogging in the humid zone. In canal irrigated fields, the watertable may rise due to the continuous recharge of groundwater. On the other hand, it can also lead to falling water tables and groundwater depletion in tubewell irrigated areas where the pumping rates exceed the rate of natural recharge of the aquifer.

Salinity



The groundwater itself need not be saline for salinity to build-up; it can occur due to the long-term evaporation from a soil surface continuously recharged with water of low salt content.
(Moorman and Van Breeman, 1978)

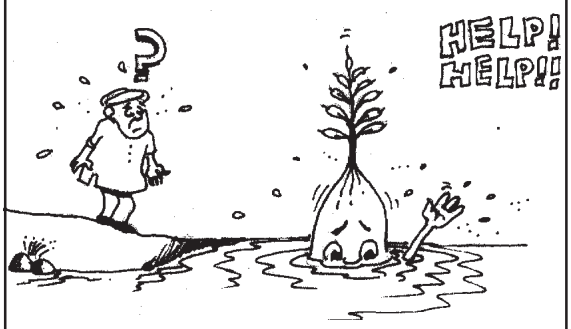
Salinity

Poor irrigation system design and management are the primary factors leading to salinity problems. Salinity in semi-arid zones is induced by an excess of evapotranspiration over rainfall causing a net upward movement of water through capillary action bringing with it salts that are then concentrated on the soil surface. Salinity problems are aggravated by seepage from unlined irrigation canals.

Waterlogging

Excessive water use and poor drainage in high rainfall areas cause problems of waterlogging resulting in low productivity levels due to poor aeration and lower rates of organic matter decomposition and mineralization, lower nitrogen availability and accumulation of soil toxins. Waterlogging early in the growing season can also lead to lower plant population and yield in wheat.

Waterlogging



Waterlogging is reported to have reduced wheat yields by half a ton per hectare in Nepal's Terai region.
(Hobbs, *et al.*, 1996)

Groundwater

Overdrafting of groundwater through power operated tubewells is a universal phenomenon. The resultant falling water tables have negative environmental and productivity consequences. Laws to regulate silting and use of tubewells are either absent, inefficient or their enforcement is abysmal.

Soil Characteristics

Soil physical characteristics and nutrient status over a long-term are adversely affected by seasonal cycles of tillage, flooding and drying due to intensive crop rotation.

Hardpan

Due to wet tillage or puddling operations for rice, the subsoil at a depth of 10-40 cm from the soil surface gets compacted. This 5-10 cm thick layer of sub soil, or hardpan, has less number of medium to large-sized pores and hence a higher bulk density. Water cannot move through this layer to the deeper soil and the water holding capacity of the overlying topsoil layer is increased. While this is ideal for rice, it has an adverse effect on the plant population and productivity of wheat. However, if the hardpan is broken by deep tillage, it has a negative effect on the yields. Flexibility is lost due to crop rotation.

Toxicity

Toxicities are not inherent to most irrigated lowlands but may build up in some soils due to continuous flooding, increased reliance on poor quality irrigation water and impeded drainage, especially on soils with hardpan. Iron toxicity is the most common. Farm level diagnosis of toxicity is complicated and corrective actions are not straightforward.

Nutrient Status

The most commonly observed effect of intensive rice-wheat system is the decline in partial factor productivity of nitrogen fertilizer. Fertilized rice and wheat obtain 50%-80% of their nitrogen requirement from the soil, mainly through mineralization of organic matter (De Datta, 1981). Continuous flooding for rice cultivation reduces the soil's capacity to provide nitrogen to the crop. Using long-term experimental data, Cassman and Pingali estimate the decline in yields in rice-sequence to be around 30% over a 20-year period at all nitrogen levels. Deficiencies of two other macronutrients, phosphorus and potassium are becoming widespread in areas not previously considered to be deficient.

Pest Incidence

Weeds, insects and disease-causing microorganisms like fungi and bacteria reduce crop productivity and quality of yield. The situation is aggravated by inappropriate crop management and pesticide use practices. Intensive crop rotation and susceptible crop varieties continuously provide sustenance to the pests. Prophylactic or preventive pesticide application has actually resulted in the contrary due to the disruption of pest-predator balance and a resurgence of the pest populations later in the crop season (Heong *et al.,* 1992). Relatively, minor pests of rice like caseworm, army worm and cutworm have started to cause noticeable losses.

Some diseases like Spot blotch of wheat are on the rise while others like Karnal bunt, for which the flooded conditions of rice are unfavorable, are on the decline. Insect and disease resistant varieties of rice and wheat have now been developed to reduce the need for pesticides.

Deficiency A-L-E-R-T

The deficiencies of macronutrients like nitrogen, phosphorus and potassium are directly related to the increase in cropping intensity and the predominance of year-round irrigated production systems. Two thirds of the agricultural land in China and nearly one-half of the districts in India are now classified as low or deficient in phosphorus (Stone, 1986; Tandon, 1987)

The micronutrient zinc has also become deficient in the tropics and is the limiting factor for rice in 2 million hectares in Asia alone. Drainage increases zinc availability (Lopes, 1980). Quite often, micronutrient deficiencies are misdiagnosed as pest-related damage.

Adapted from:

Pingali, P.L. and M. Shah. 1999. Rice-Wheat Cropping Systems in the Indo-Gangetic Plains: Policy Re-Directions for Sustainable Resource Use. pages 1-12. *In:* Pingali, P.L. (ed). 1999. Sustaining Rice-Wheat Production Systems: Socioeconomic and Policy Issues. Rice-Wheat Consortium Paper Series 5, Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

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