

# Prospects for the Environment

## Agriculture and the environment

Previous sections of this report have already discussed the environmental aspects of agriculture as they relate to each sector. This section discusses the overarching or cross-sectoral environmental issues and provides an overview of the major trends in agriculture that can be expected to affect the environment over the next 30 years.

Over the next 30 years, many agriculture-related environmental problems will remain serious. However, some problems may deepen more slowly than in the past and some may even be reversed.

### Agriculture has a vast impact on the earth

Agriculture accounts for the major share of human use of land. Pasture and crops alone took up 37 percent of the earth's land area in 1999. Over two-thirds of human water use is for agriculture. In Asia the share is four-fifths.

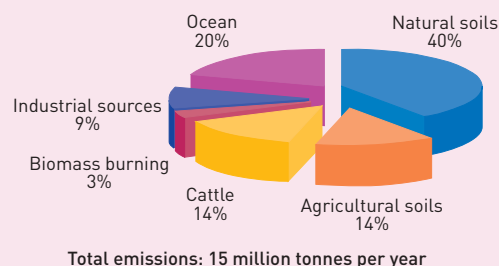
Crop and livestock production have a profound effect on the wider environment. They are the main source of water pollution by nitrates, phosphates and pesticides. They are also the major anthropogenic source of the greenhouse gases methane and nitrous oxide, and contribute on a massive scale to other types of air and water pollution. The extent and

methods of agriculture, forestry and fishing are the leading causes of loss of the world's biodiversity. The overall external costs of all three sectors can be considerable.

Agriculture also affects the basis for its own future through land degradation, salinization, the overextraction of water and the reduction of genetic diversity in crops and livestock. However, the long-term consequences of these processes are difficult to quantify.

If more sustainable production methods are used, the negative impacts of agriculture on the environment can be attenuated. Indeed, in some cases agriculture can play an important role in reversing them, for example by storing carbon in soils, enhancing the infiltration of water and preserving rural landscapes and biodiversity.

Percentage of annual nitrogen emissions from different sources



Source: Adapted from Mosier and Kroeze (1998)



### **Fertilizers, manure and pesticides are major causes of water pollution**

Pollution of groundwater by agricultural chemicals and wastes is a major issue in almost all developed countries and, increasingly, in many developing countries.

Pollution from fertilizers occurs when these are applied more heavily than crops can absorb or when they are washed or blown off the soil surface before they can be incorporated. Excess nitrogen and phosphates can leach into groundwater or run off into waterways. This nutrient overload causes eutrophication of lakes, reservoirs and ponds, leading to an explosion of algae which suppress other aquatic plants and animals.

The crop projections to 2030 imply a slower growth of nitrogen fertilizer use than in the past. If efficiency can be improved, the increase in total fertilizer use between 1997-99 and 2030 could be as low as 37 percent. However, current use in many developing countries is very inefficient. In China, the world's largest consumer of nitrogen fertilizer, up to half the nitrogen applied is lost by volatilization and another 5 to 10 percent by leaching.

Insecticides, herbicides and fungicides are also applied heavily in many developed and developing countries, polluting fresh water with carcinogens and other poisons that affect humans and many forms of wildlife. Pesticides also reduce biodiversity by destroying weeds and insects and hence the food species of birds and other animals.

Pesticide use has increased considerably over the past 35 years, with recent growth rates of 4 to 5.4 percent in some regions. The 1990s showed signs of declining use of insecticides, both in developed countries such as France, Germany and the United Kingdom and in a few developing countries, such as India. In contrast, herbicide use continued to rise in most countries.

As concern about pollution and the loss of biodiversity grows, future use of pesticides may grow more slowly than in the past. In developed countries, use is increasingly restrained by regulations and taxes. In addition, use will be curbed by the growing demand for organic

crops, produced without chemical inputs. The future is likely to see increasing use of "smart" pesticides, resistant crop varieties and ecological methods of pest control (IPM).

### **Agriculture as a cause of air pollution**

Agriculture is also a source of air pollution. It is the dominant anthropogenic source of ammonia. Livestock account for about 40 percent of global emissions, mineral fertilizers for 16 percent and biomass burning and crop residues for about 18 percent.

Ammonia is even more acidifying than sulphur dioxide and nitrogen oxides. It is one of the major causes of acid rain, which damages trees, acidifies soils, lakes and rivers, and harms biodiversity. As other acidifying gases such as sulphur dioxide are brought under tighter control, ammonia may in time become the leading cause of acidification. Emissions of ammonia from agriculture are likely to continue rising in both developed and developing countries. The livestock projections imply a 60 percent increase in ammonia emissions from animal excreta.

The burning of plant biomass is another major source of air pollutants, including carbon dioxide, nitrous oxide and smoke particles. It is estimated that humans are responsible for about 90 percent of biomass burning, mainly through the deliberate burning of forest vegetation in association with deforestation and of pastures and crop residues to promote regrowth and destroy pest habitats. The massive forest fires in Southeast Asia in 1997 burned at least 4.5 million ha and covered the region with a pall of smoke and haze. The burning of tropical savannas is estimated to destroy three

Projections suggest that, by 2030, emissions of ammonia and methane from the livestock sector of developing countries could be at least 60 percent higher than at present.



times as much dry biomass each year as the burning of tropical forests.

### Pressures on biodiversity

As their numbers and needs have grown, human beings have taken up an increasing share of the planet's surface area and resources for their own needs, often displacing other species in the process. Estimates of the total number of species on earth vary wildly. The number that has been scientifically described is around 1.75 million, but the true total is unknown and may be anything from 7 to 20 million or more. Estimates of losses of biodiversity to extinction over the coming decades vary widely, from 2 to 25 percent of all species.

Loss of biodiversity owing to agricultural methods continues unabated, even in countries where nature is highly valued and protected.

Agriculture, forestry and fisheries are perhaps the most significant of human pressures on the biodiversity of land and sea.

Species richness is closely related to the area of a wild habitat. As the area declines, so does the number of species it harbours, though at a slower rate. Deforestation, field consolidation, with the accompanying reduction in field margins and hedgerows, and drainage of wetlands for farming reduce the overall area available for wildlife and fragment natural habitats. Grazing lowers species richness in pastures.

Agricultural intensification adds its own problems. Pesticides and herbicides directly destroy many insects and unwanted plants, and reduce food supplies for higher animals. Hence loss of biodiversity is not limited to the land clearing stage of agricultural development but continues long afterwards. It is unabated even in developed countries where nature is highly valued and protected.

Some of the affected life forms may be important soil nutrient recyclers, crop pollinators and predators of pests. Others are potentially a major source of genetic material for improving domesticated crops and livestock.

The pressures on biodiversity over the next three decades will be the outcome of conflicting trends. Extensive methods will tend to give way to intensification, which may in turn give way to organic agriculture or to NT/CA.


Loss of wildlife habitat to farming will continue, but at a slower pace. Deforestation will slow down, and extensive grazing will give way increasingly to industrial livestock production. Although intensification entails its own range of environmental risks related to pesticides, chemical fertilizers and animal wastes, the increasing inclusion of environmental considerations in agricultural policy will help to counteract these.

### Reducing agriculture's pollution toll

The spread of NT/CA will help to improve soil structure and reduce erosion. IPM will reduce pesticide use, while programmes to improve the management of plant nutrition should reduce the overuse of chemical fertilizers.

Other policies will help to reduce the conflict between agricultural intensification and environmental protection. Tighter regulations and national strategies on the management of animal waste and the use of chemical fertilizers and pesticides may be required, along with the removal of subsidies on chemical and fossil energy inputs. Pesticides should be subjected to more rigorous testing, and residue buildup more closely monitored.

Agriculture is an increasingly significant source of greenhouse gases, as well as a potential route to the mitigation of climate change through carbon storage in soils and vegetation.



# Agriculture and climate change

## Agriculture as source and sink

Agriculture is a major source of greenhouse gas emissions. It releases large quantities of carbon dioxide through the burning of biomass, mainly in areas of deforestation and grassland.

Agriculture is also responsible for up to half of all methane emissions. Though it persists for a shorter time in the atmosphere, methane is about 20 times more powerful than carbon dioxide in its warming action and is therefore a major short-term contributor to global warming. Current annual anthropogenic emissions are around 540 million tonnes and are growing at around 5 percent per year.

Livestock alone account for about a quarter of methane emissions, by way of gut fermentation and the decay of excreta. As livestock numbers grow, and as livestock rearing becomes increasingly industrial, the production of manure is projected to rise by about 60 percent by 2030. Methane emissions from livestock are likely to increase by the same proportion.

Irrigated rice farming is the other main agricultural source of methane, accounting for about a fifth of total anthropogenic emissions. The area used for irrigated rice is projected to increase by about 10 percent by 2030. However, emissions may grow more slowly, because an increasing share of rice will be grown with better controlled irrigation and nutrient management, and rice varieties may be used which emit less methane.

Agriculture is a key source of another important greenhouse gas: nitrous oxide. This is generated by natural processes, but is boosted by leaching, volatilization and runoff of nitrogen fertilizers, and by the breakdown of crop residues and animal wastes. Livestock account for about half of anthropogenic emissions. Annual nitrous oxide emissions from agriculture are projected to grow by 50 percent by 2030.

## Agriculture can help mitigate climate change

Farming can also be a sink for carbon. However, it is generally believed that soils, like other

biological sinks (e.g. vegetation), have an inherent upper limit for storage. The total amount that can be stored is crop- and location-specific and the rate of sequestration declines after a few years of growth before eventually reaching this limit. In 1997-99 an estimated 590 to 1 180 million tonnes of carbon were locked up in cropland soils alone, in the form of soil organic matter from crop residues and manure. Projections of increased crop production imply that by 2030 this total could rise by 50 percent.

Other changes could boost the total even further. If only 2 million of the current 126 million ha of saline soils were restored each year, they could account for an extra 13 million tonnes of carbon annually. In developed countries, permanent set-aside land can sequester large amounts of carbon if it is left unmanaged, or reforested.

Depending on agroclimatic conditions, NT/CA can lock up 0.1 to 1 tonne of carbon per ha per year, in addition to cutting carbon dioxide emissions by over 50 percent through the reduced use of fossil fuel in ploughing. The growth potential for NT/CA is considerable. If another 150 million ha of rainfed cropland is converted to NT/CA by 2030 and the average sequestration rate on land managed in this way is 0.2 to 0.4 tonne per ha per year, a further 30 to 60 million tonnes of carbon could be soaked up annually during the first few years after conversion.

Should any of these practices be discontinued, the sequestered carbon would be released over a period of a few years. Agricultural carbon sinks of this kind are needed to “buy time” in which to cope with carbon dioxide emissions at source.

## Climate change will have very diverse impacts on agriculture

Climate change will affect agriculture, forestry and fisheries in complex ways, positive as well as negative.

Global carbon dioxide concentrations in the atmosphere are expected to rise from 350 ppm



In the next three decades, climate change is not expected to depress global food availability, but it may increase the dependence of developing countries on food imports and accentuate food insecurity for vulnerable groups and countries.

to over 400 ppm by 2030. Carbon dioxide causes plant stomata to narrow, so water losses are reduced and the efficiency of water use improves. Increasing atmospheric concentrations of carbon dioxide will also stimulate photosynthesis and have a fertilizing effect on many crops.

Average global temperatures are projected to rise by between 1.4 and 5.8 °C by 2100. By 2030 the increase will be rather lower than this, between 0.5 and 1 °C.

The rise will be greater in temperate latitudes. Here global warming may bring benefits for agriculture. The areas suitable for cropping will expand, the length of the growing period will increase, the costs of overwintering livestock will fall, crop yields will improve and forests may grow faster. These gains may, however, have to be set against the loss of some fertile land to flooding, particularly on coastal plains.

In less well-watered areas, especially in the tropics, the rise in temperatures will increase evapotranspiration and lower soil moisture levels. Some cultivated areas will become unsuitable for cropping and some tropical grasslands may become increasingly arid.

Temperature rise will also expand the range of many agricultural pests and increase the ability of pest populations to survive the winter and attack spring crops. In oceans, temperature rise may reduce plankton growth, bleach coral reefs and disrupt fish breeding and feeding patterns. Cold-water species such as cod may find their range reduced.

Higher global temperatures will also bring higher rainfall. However, this will be unevenly

distributed between regions. Indeed, some tropical areas such as South Asia and northern Latin America are projected to receive less rainfall than before.

The climate is also expected to become more variable than at present, with increases in the frequency and severity of extreme events such as cyclones, floods, hailstorms and droughts. These will bring greater fluctuations in crop yields and local food supplies and higher risks of landslides and erosion damage.

Mean sea level is projected to rise by 15 to 20 cm by 2030 and by 50 cm by 2100. The rise will lead to the loss of low-lying land through flooding, seawater intrusions and storm surges. Subsidence due to the overextraction of groundwater may exacerbate the intrusion problem in some areas. There will also be damage to vegetable growing and aquaculture in low-lying areas and to fisheries dependent on mangrove swamps for their spawning grounds. The impact will be most serious in coastal zones, especially heavily populated deltas used for agriculture, of the kind found in Bangladesh, China, Egypt, India and mainland Southeast Asia. In India alone, losses by 2030 could range from 1 000 to 2 000 km<sup>2</sup>, destroying perhaps 70 000 to 150 000 livelihoods.

There are still considerable uncertainties in most of the projections. The overall effect on global food production by 2030 is likely to be small: cereal yields, for example, are projected to decline by about 0.5 percent by the 2020s. But there will be large regional variations: in temperate regions an increase in yields is thought possible; in East Asia, the Sahel and Southern Africa the outcome could be either positive or negative; in other developing regions a decline in yields is thought more likely. In all of these cases the potential yield changes are up or down by 2.5 percent or less by 2030 and by 5 percent or less by 2050.

It is important to note that these are only the changes that may result from global warming *in the absence of any other factors*. In practice, changes in technology are likely to reduce or outweigh the impact of climate change. Among the most important technological changes will be improved crop varieties and cropping



practices, which will raise yields. Factors such as the spread of NT/CA and the expansion of irrigation will combine with the dissemination of new crop varieties to reduce the sensitivity of some systems to climate change.

#### **Inequalities in food security may accentuate**

Overall, global warming seems likely to benefit agriculture in developed countries located in

temperate zones but to have an adverse effect on production in many developing countries in tropical and subtropical zones. Hence climate change could increase the dependency of developing countries on imports and accentuate existing North-South differences in food security.

Some future trends will cushion the blow. Improved communications and roads will allow

### **Technology and policy choices**

Many of the measures needed to reduce or adapt to climate change are valuable in coping with existing problems such as water and air pollution, soil erosion, and vulnerability to droughts or floods.

#### *Measures to reduce greenhouse gas emissions:*

- Removal of subsidies and introduction of environmental taxes on chemical fertilizers and energy inputs
- Improvement of fertilizer use efficiency
- Development of rice varieties emitting less methane
- Improved management of livestock waste
- Restoration of degraded lands
- Improvement of crop residue management
- Expansion of agroforestry and reforestation

#### *Measures to promote adaptation to climate change:*

- Development and distribution of crop varieties and livestock breeds resistant to drought, storms and floods, higher temperatures and saline conditions
- Improvement of water use efficiency through:
  - No-till/conservation agriculture in rainfed areas
  - Appropriate water pricing, management and technology in irrigated areas
- Promotion of agroforestry to increase ecosystem resilience and maintain biodiversity
- Maintenance of livestock mobility in pastoral areas subject to drought

#### *Measures to reduce food insecurity:*

- Reduction of rural and urban poverty
- Improvement of transport and communications in areas vulnerable to disasters
- Development of early-warning and storm-forecasting systems
- Preparedness plans for relief and rehabilitation
- Introduction of flood- and storm-resistant and salt-tolerant crops
- Introduction of land use systems to stabilize slopes and reduce the risk of soil erosion and mudslides
- Building of homes, livestock shelters and food stores above likely flood levels.



food to be transported more quickly into drought- or flood-affected areas. Economic growth and rising incomes will still allow most people in most countries to improve their nutrition levels. A continuing shift out of agricultural occupations into industry and services, and out of rural and marginal areas into urban centres, will leave fewer countries unable to pay for food imports, and fewer people vulnerable to local declines in food production.

But the food security of poor people and countries could well be reduced by climate change. Even by 2030 there will still be hundreds of millions of such people, who will be either undernourished or on the brink of undernourishment. They will be especially vulnerable to disruption of their incomes or food supply by crop failure or by extreme events such as drought and floods.

As long as agricultural trade is not entirely free and communications with marginal areas remain poor, differences between local, national and international prices will persist, with the result that food prices in areas hit by extreme events could rise steeply, even if only temporarily. For example, in the south of Mozambique maize prices in the spring of 2000 increased rapidly following the floods, while in the north they remained at half the level in the

south or even declined somewhat, because transport between the two zones was difficult.

The adverse impacts of climate change will fall disproportionately on the poor. Hardest hit will be small-scale farmers and other low-income groups in areas prone to drought, flooding, salt water intrusion or sea surges, and fishers affected by falling catches caused by higher sea temperatures and shifts in currents. The areas most likely to suffer increased climate variability and extreme events are mostly those that are already handicapped by these same phenomena. Many of the areas at risk from rising sea levels are currently poor and may not enjoy the economic development necessary to pay for flood protection.

The problem of increased vulnerability to food insecurity caused by climate change is likely to be most serious in some 30 to 40 countries. Major concern centres on Africa. Some estimate that, even as early as 2020 or 2030, climate change could depress cereal production in this region by 2 to 3 percent, enough to increase the numbers at risk of hunger by 10 million. This is the projected effect *in the absence of other changes* and could be offset by even a modest annual increase in yields, but it still represents an additional hurdle that agriculture in Africa must leap.