

6.2 Land degradation

Olli Varis

The population keeps growing. Food production should grow much faster than the population does since more and more meat is consumed. However, the area of arable land goes down. The unit yields must grow rather fast. Due to speedy urbanization and other factors that open material cycles the soils and waters are threatened by enhanced degradation. Competing land uses appear to restrict a remarkable growth in arable land.

Types of land degradation

At present, more arable land is lost than produced. It is estimated that about 12 million ha of arable land is lost annually because of soil degradation (Pimentel et al. 1995). Soil degradation is caused by erosion, the ground becoming waterlogged and saline, and impoverishment and acidification of the soil (Box 6.2). Desertification can be defined as the process of soil degradation in dry areas (cf. UNEP 1992). Land degradation is also touched in the watershed management chapter (Ch 10.5).

Settlement, industry and agriculture also compete for land, and it is often agriculture that loses. This is especially common in the best agricultural areas, in river valleys and estuaries where urban and industrial growth usually concentrates.

Erosion

Erosion by water and wind makes the topsoil thinner and in the worst case unfit for growth. About 1/3 of agricultural land on the earth is arable and 2/3 grassland. Around 80% suffer from erosion to some extent. Arable land is more susceptible to erosion because it is regularly cultivated and without vegetative cover for some months during the year. As for grassland, overgrazed areas suffer most from erosion. Such areas comprise more than half of the total grassland area.

Erosion has a negative effect on plant production because it makes the topsoil layer thinner and in this way changes the water and nutrient balance of the soil and makes the living conditions for microorganisms more difficult. The effect is case-dependent, however, and there is no reliable total assessment of the effect of erosion.

There is no reason to understate the problem caused by erosion; in agricultural areas of Asia, Africa and S America it amounts to, on average, 30-40 tons per ha per year and in Europe and the United States 17 tons per year (Barrow 1991). Natural generation of the topsoil is, according to Pimentel (1995), 20-40 times slower than soil degradation caused by erosion.

Salinity and waterlogging

Soil becoming saline is mostly a problem of irrigated areas but it can also take place in non-irrigated areas where a high rate of evaporation cumulates salts to the topsoil. The salts carried by evaporating water get stored in the root layer if water is not used sufficiently to wash the salts out from the soil.

Waterlogging is another important problem of irrigated areas. It is due to insufficient dewatering of soil. Irrigation in these areas causes groundwater to rise to the root layer, which renders the areas unsuitable for cultivation. According to the FAO (Alexandratos 1995) 0.2-1.5 million ha annually vanish from cultivation because they become waterlogged and saline.

Soil degradation and loss of fertility

The soil becomes less fertile if the nutrients and trace elements are constantly used without taking proper care of the mass balance of the soil. This is a problem especially in Africa, but also elsewhere. The total effects of this impoverishment are not known. The effect of the increasing acidity of the environment on the quantity and quality of plant production is also highly uncertain.

The arid—humid divide

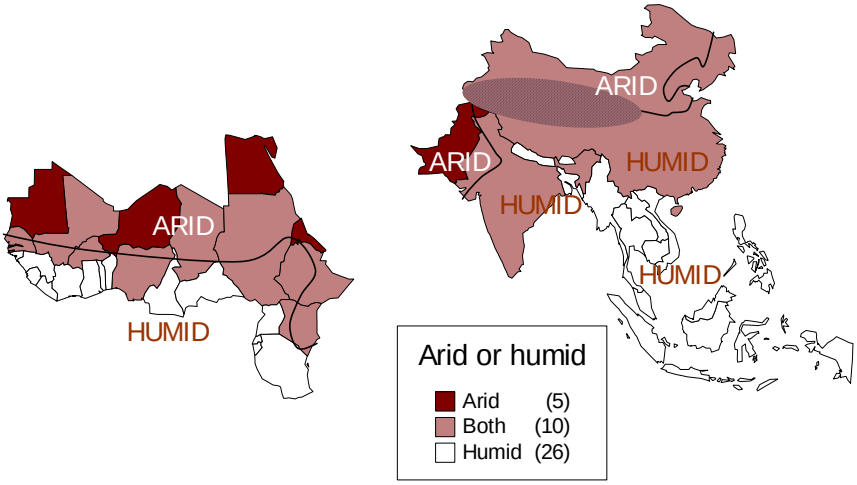
Among the myriad factors that determine the amount and type of soil degradation, the divide between the arid and dry climate is extremely important in macro-level studies. In humid climate, annual rainfall is greater than annual precipitation, and in arid climate, the relation is the opposite. Typical forms of land degradation for arid and humid climates are shown in Table 6.2a. All the study regions are crossed by the border between arid and dry

Figure 6.2a

The border between arid and humid climate is an important divide of land degradation types

The border region is most vulnerable region of desertification.

	Humid	Arid
Water erosion	x	x
Wind erosion		x
Soil fertility decline	x	(x)
Waterlogging		x
Salinization		x
Lowering of water table		x



climate, except SE Asia, which belongs entirely to the humid zone.

China

Land degradation is a serious problem in China (Figure 6.2b). From the early 1950s, the area of ecologically degraded land area has grown 38%. In the Yangtze (Changjiang) basin, the area from which severe erosion occurs has doubled in the last fifteen years (Niu and Harris 1996).

Water erosion is a great problem in most of China. It occurs primarily in regions, which are heavily populated and cultivated.

Chemical and physical deterioration are in growth. They, as well, influence primarily most important agricultural areas. However, the level of degradation is still lower than in many of the countries with intensive agriculture in S and SE Asia (Figure 6.2c).

The combination of wind and water erosion is a grand problem in the arid loess plateau, in the Yellow River basin—in the provinces of Saanxi, Sanxi, Gansu, Inner Mongolia, Ninxia, Qinghai, and western Henan. The area of the plateau is 600,000 km^2, which exceeds the size of France plus Switzerland together, and has 155 million people. Poverty is widespread in the region (See Box10.5a).

Figure 6.2b

Soil degradation in China, S Asia and SE Asia

Per cent of total land area, by region (Lynden and Oldeman 1997).

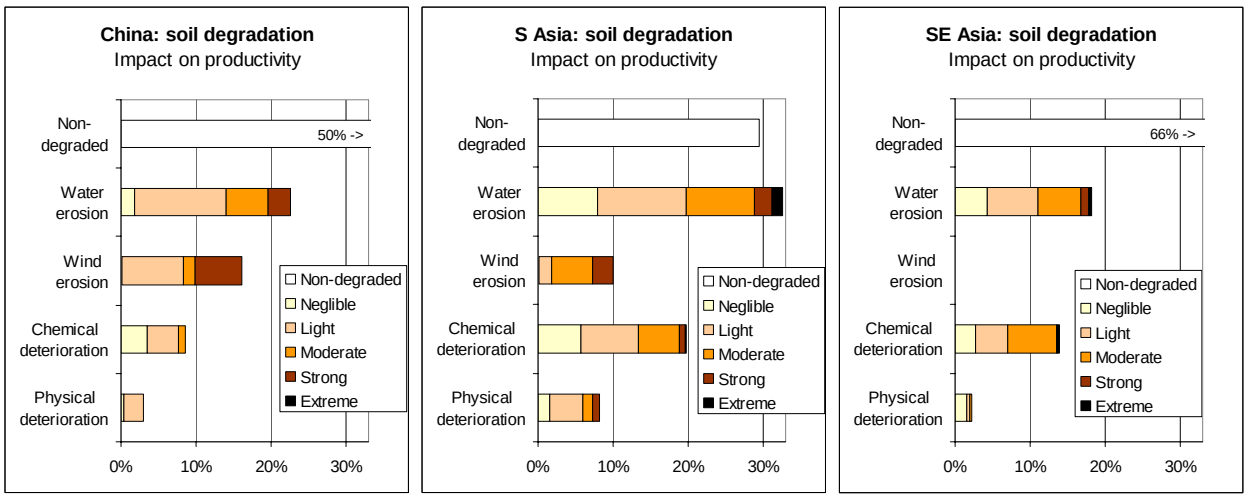
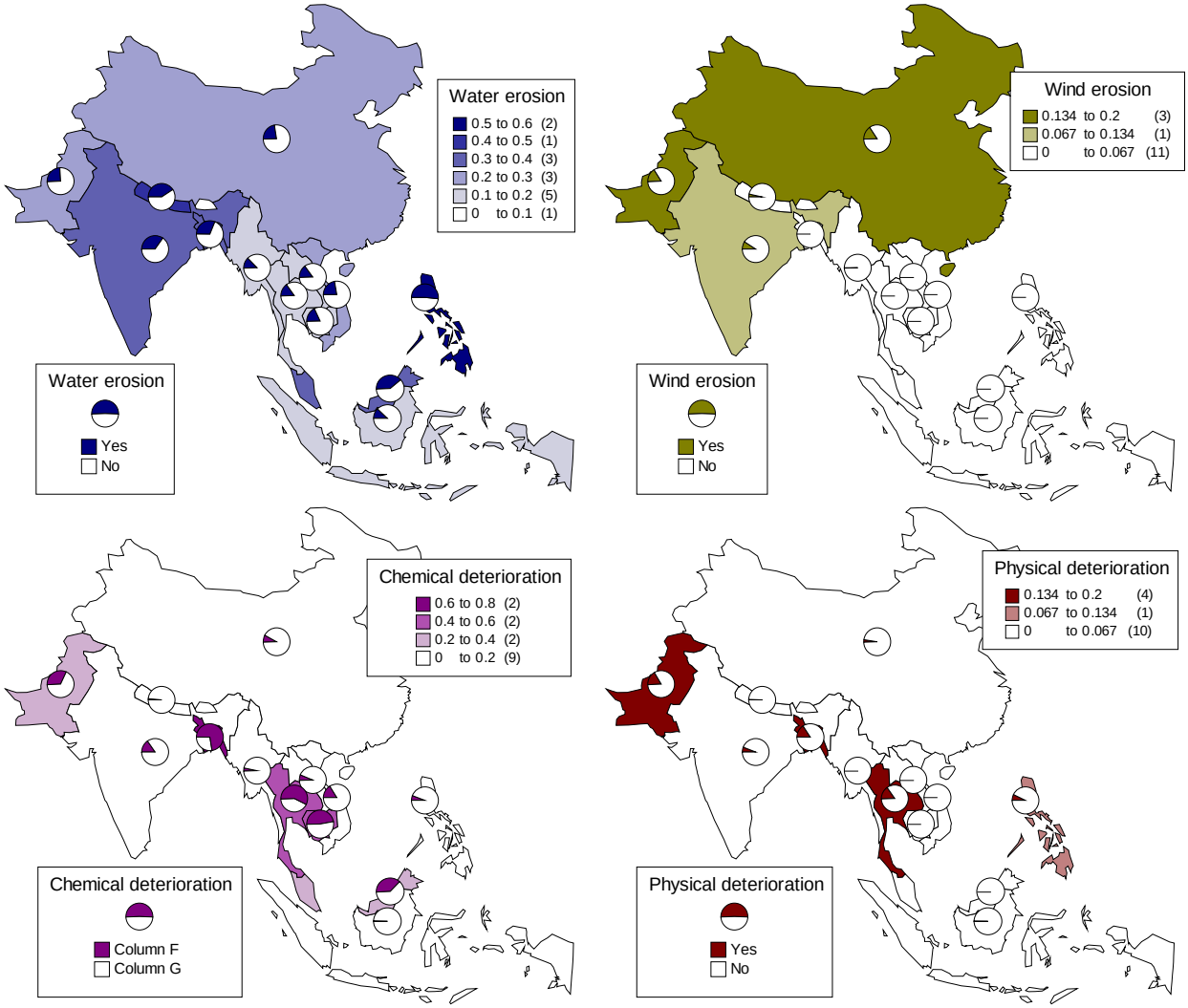


Figure 6.2c
Soil degradation in China, S Asia and SE Asia, by country
Proportion of total land area (Lynden and Oldeman 1997).



The loess plateau belongs to the most severely eroded areas of the world; annual soil losses have exceeded 20,000 tons per km^2 (FAO 1995b), which means 20 kg per m^2. The consequences are seen in the yellow-brownish color of the Yellow River (the river receives 1,600 million tons of silt each year—10 tons per basin dweller—and suspended solids content is up to 60% in some reaches), and in the sand storms of a large share of China, including Beijing.

S Asia

Pakistan suffers severely from all four types of land degradation (Figure 6.2c), as classified by Lynden and Oldeman (1997). India's plague is water erosion, and, in its arid parts, wind erosion. Nepal's main problem is water erosion, and Bangladesh has problems with all degradation types except wind erosion.

The picture is clearer in the FAO (1994) study for arable land degradation in S Asia: India is divided in arid and humid regions, and classification of degradation types is somewhat different (Figure 6.2d).

As Figure 6.2a shows, Pakistan and the western part of India are arid regions, whereas the rest of S Asia is humid. The boundary goes through the states of Gujarat and Rajastan, around the Aravalli Range, approaches Delhi, bends NW, to the direction of Hindu Kush, and includes most of Haryana and Punjab. After FAO (1994), about ¼ of India is arid.

The arable lands of India's arid part suffer from wind erosion, salinization, waterlogging, and water erosion (Table 6.2a, Figure 6.2d). Pakistan has very similar problems, but they are far more severe than in India. Almost 90% of Pakistani arable land is degraded, while for arid India, the share approaches 50%.

Around 1970, 60 kg wheat grew with one kg of nitrogen in Pakistan. In twenty years, till 1990, N fertilization need tripled due to soil degradation: only 20 kg wheat were produced by a kg of N—which has been mostly applied as urea. After Tandon (1993): *"…nitrogen is simply used as a shovel to mine the soil of other nutrients."*

The land degradation is a severe problem for the agricultural lands of humid S Asia as well, yet the dominant degradation types are very different. Bangladesh suffers greatly from soil fertility decline, which means a negative soil nutrient balance. In Nepal and humid parts of India, water erosion dominates.

Figure 6.2d
Agricultural soil degradation in S Asia
The arid—humid divide is clear (FAO 1994).

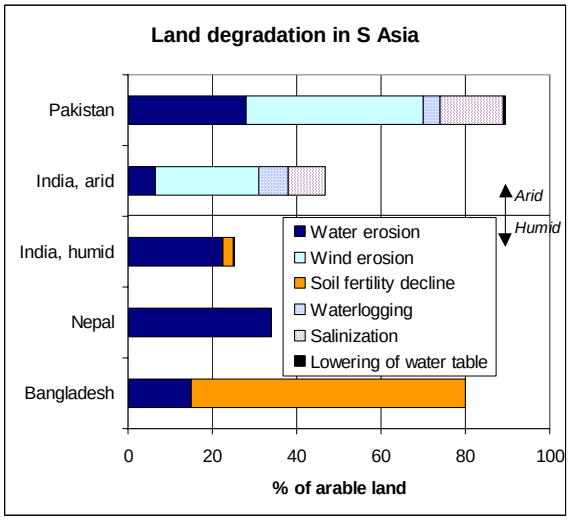
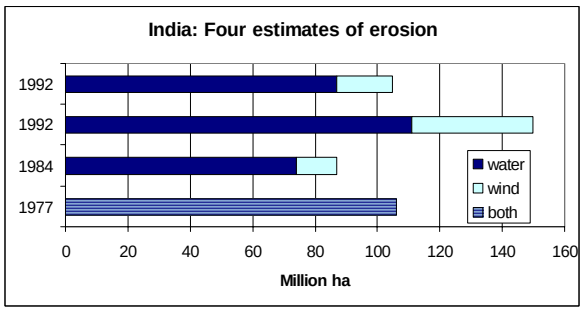


Figure 6.2e
Land degradation data is inconsistent
Four estimates of water and wind caused soil erosion for India. The years of assessment are shown (FAO 1994).



FAO (1995b) points out, that water erosion is the region's most severe land degradation problem, and the figures in Table 6.2a may be underestimates, particularly for India. The estimates from different sources deviate substantially, which is an indication of high uncertainties and definition problems in the data, leading to difficulties when comparing data from different countries (Figure 6.2e).

The economic losses of land degradation were estimated by FAO (1994) to be 2% of GNP of S Asia. The annual losses of agricultural yields were estimated to be 8% for India, 5% for Bangladesh, 3% for Pakistan, and 2% for Nepal.

SE Asia

Being a humid region, SE Asia has virtually no problems with wind erosion (Figures 6.2b and c). In contrary, due to intensive land use, chemical and physical degradation are serious problems in some countries; the former in Malaysia, the latter in the Philippines, and both in Thailand.

All countries have problems with water erosion. Yet, more modest than in China and S Asia, with the exception of the Philippines, Malaysia and Vietnam. The Philippines is seriously impacted by water erosion, and only Nepal can compare with it among the Asian study region countries.

FAO (1995b) estimates that erosion carries away 2 billion m^3 soil each year from the territory of the Philippines. Averaged over the land area, this would mean 7 mm loss each year! Calculated per person, this would be 3 m^3 of eroded land! The economic loss caused by land degradation would amount to 4% of GNP (World Bank 1989, Cruz and Repetto 1992).

The country-averaged data is very kind to Indonesia, which has a huge concentration of people on the island of Java. The island is worse off with land degradation than the Philippines.

African regions

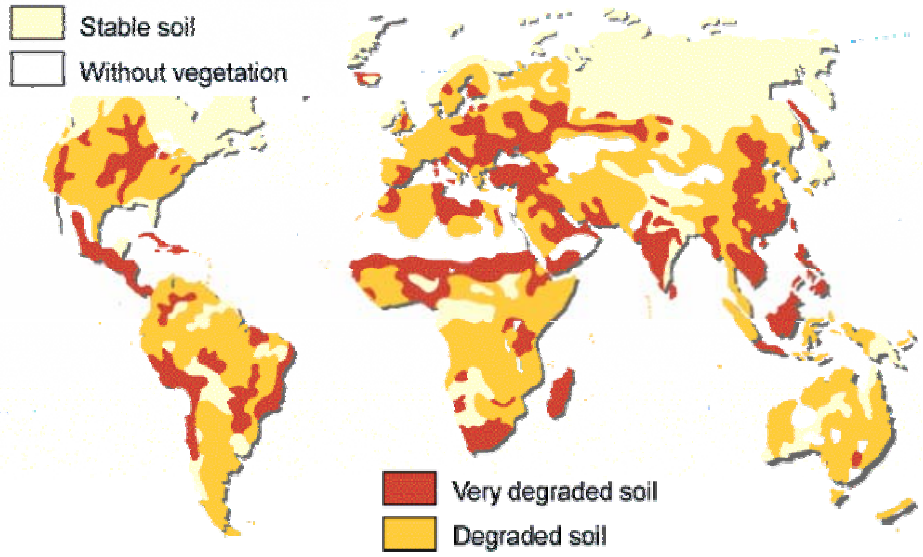
Similar in-depth studies of land degradation—such as those by FAO (1995b) and Lynden and Oldeman (1997) for Asia—are unfortunately not available for the African continent. However, the problems of the African study regions are equally serious, if not more serious than those of the Asian study regions.

After FAO (1995c): "*Little reliable data is available on the extent of land degradation in Africa. However, anyone who has traveled through the continent has observed that land degradation is widespread and serious*."

One-third of Africa's land surface area is desert or subjected to desertification. At the southern area of Sahara, an approximated 650,000 km^2 have desertified within the past fifty years (FAO 1990). The desert has been estimated to conquer 50,000 to 70,000 km^2 land each year within that zone.

It is interesting to compare the region of the most severe land degradation in Africa (Figure 6.2f) with the divide between arid and humid zone that was discussed above (Figure 6.2a). It is striking how well they coincide. Indeed, the edge of the monsoon zone is the most vulnerable climatic region in Africa to land degradation. In this respect, the situation is somewhat different to Asia and other continents.

Figure 6.2f
Land degradation in the world
Data by UNEP/GRID (2001) (reproduced by permission).



By this, most of the inhabited areas of Senegal, Mauritania, Mali, Burkina Faso, Niger, Chad, Egypt, the Sudan and Ethiopia have very degraded soils. Also large areas around the great East-African lakes are very degraded.

Scherr and Yadav (1996) summarize, that erosion alone causes yield reductions of 6.2% per year in Sub-Saharan Africa. By 2020, this may increase up to 14.5% if erosion remains unabated.

Causes of land degradation

It is clear, that the causes of land degradation are many. Overgrazing dominates in Africa. Drying climate together with herds that exceed the carrying capacity of the pastoral ecosystems accounts for 60% of soil degradation in Africa. Unsustainable farming practices and deforestation cause 30% and 10%, respectively (Figure 6.2g).

In Asia, deforestation is far more important than in Africa. Water erosion is the most frequent consequence of deforestation in Asia (Table 6.2a).

Asia and Africa dominate in the world scene of land degradation.

Figure 6.2g
Causes of land degradation by continent
Data by FAO (1996).

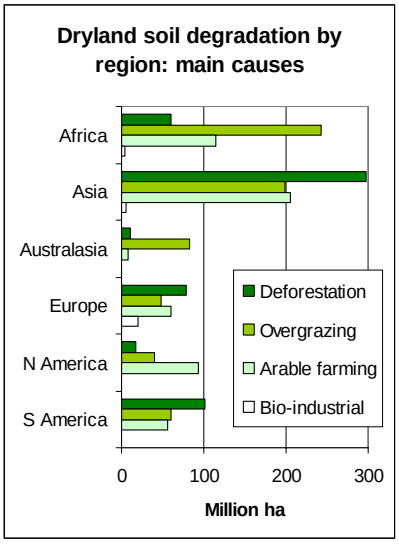
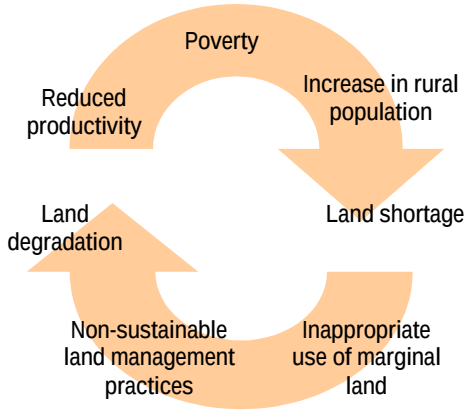


Table 6.2a
Causes of arable land degradation in S Asia
Up to two causes are given for each degradation type (FAO 1994).

	Deforestation (%)	Overgrazing (%)	Agricultural Activities (%)	Overcutting of vegetation (%)
Water erosion	**61**	**67**	2	44
Wind erosion	21	46	1	**98**
Soil fertility decline	25	0	**75**	0
Salinization	34	30	14	**87**
Waterlogging	0	0	**85**	33
Lowering of water table	12	22	**65**	34
All types of degradation	37	46	15	**63**

Figure 6.2h
The vicious circle of land degradation
Modified from FAO (1995b).



Mitigation and prevention

The world is rich with various guidelines and suggestions how land degradation should be stopped –and the negative development (Figure 6.2h) reversed to positive direction. The basic idea is that since the causes are very many and mixed, the approaches to reverse the development need also be multidisciplinary.

Due to the fact that there is an immense spectrum of wiser and wiser guidelines, only one example is taken, without an attempt of providing a comprehensive analysis. The example comes from FAO (1995b). The many components to be included in the framework of action against land degradation are listed in Figure 6.2i. The scheme illustrates well the complexity of the issue.

Box 6.2
Acidification by atmospheric depositions
After Kuylenstierna et al. (2001).

Although the acidification of soil and water due to increased concentrations of sulfur and nitrogen compounds that precipitate from the polluted atmosphere is not traditionally counted among the basic land degradation types, it should be. The sensitivity of soils to acidification are a product of the amount of the deposition and the sensitivity of soils to acidification. The latter is governed by the buffering capacity of the soils to tolerate acidic loads.

Among the study regions, the African areas do not need to worry about this problem (Table 6.2b).

China is by far in the most problematic situation, and its problems are expected to grow. China will lead the world also in this respect in the close future, as it passes US, perhaps already on this decade. China's most problematic regions will be in the SE coast between Guangzhou and Shanghai.

S Asia has not serious problems thus far, but Nepal and parts of India will be exposed to acidification in coming decades. India's most problematic area will be the Western Coast, from Kerala to Mumbai.
SE Asia is also under augmenting acidification problems. This goes almost throughout the region, but sharpest growth in exceedance of critical loads is expected to be in Singapore and Malaysia. Myanmar is projected to have less problems than the other countries.

Table 6.2b
China has the most serious acidification problems among the regions, SE and S Asia follow
Depositions and exceedance of critical loads in 1990 and 2050 after Kuylenstierna et al. (2001). Annual total depositions of sulfur (scale: 1: 0-199 mg S m^{-2}, 2: 200-499, 3: 500-999, 4: 1000-1999, 5: > 2000) and exceedance of critical loads (scale: Low: 0-50 meq m^{-2}, Medium: 50-100, High: >100). China is divided into SE and NE regions. The border is a straight line between the Yunnan province and Beijing.

	Deposition 1990	Deposition 2050	Exceedance of critical loads 1990	Exceedance of critical loads 2050
China				
China, SE	4	5	Medium	Medium
China, NW	2	3	No	No
S Asia				
Bangladesh	3	5	No	No
India	2	4	No	Low
Nepal	2	3	No	Medium
Pakistan	1	2	No	No
SE Asia				
Singapore	2	4	No	Medium
Cambodia, Lao PDR, Philippines, Thailand, Viet Nam	2	4	No	Low
Indonesia	2	3	Low	Low
Malaysia	2	3	No	Medium
Myanmar	1	3	No	No
Nile basin				
Burundi, Rwanda, Uganda	2	3	No	No
Egypt, Kenya	2	2	No	No
Ethiopia, Sudan, Tanzania	1	2	No	No
W Africa				
Cameroon, CAR, Côte d'Ivoire, Ghana, Liberia	2	2	No	No
Benin Gambia Guinea Guinea Bissau Nigeria Senegal Sierra Leone Togo	1	2	No	No
Burkina Faso Chad Mali Mauritania Niger	1	1	No	No

Figure 6.2i
FAO's approach to mitigation and prevention of land degradation
Modified from FAO (1995b).