2. Land-use management in China

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INTRODUCTION

China accounts for 22 per cent of the world's population but has only 7 per cent of the world's arable land. Hence, despite its large land area, China has a relatively low resource base per capita. In 1989, the quantity of fresh water, cropland, forest and grassland per capita in China were 28.1, 32.3, 14.3 and 32.3 per cent of the world's averages respectively (PRC 1994a). In contrast, mountainous terrain accounts for about two-thirds of the country's total territory (Huang 2000).

The combination of resource endowment and population implies resource-use pressure, particularly in a country where self-sufficiency in agricultural production has been an expressed government policy objective. With growing evidence emerging that resource-use pressure is causing land and water degradation, more and more attention is being given to the ways in which natural resources are being managed.

In this chapter, the focus is on land-use management in China. In the next section, the current state of the Chinese land resources is briefly described. Section 3 provides an overview of land and water resource degradation with an emphasis given to North China. The consequences of land and water resource degradation are also outlined in this section. In Section 4, some of the causes that can be linked to the degradation of the land resource are discussed. Section 5 features the Chinese government's responses in tackling the problem of land degradation and land-use policy initiatives introduced by the government. Whilst it is acknowledged that a number of these policy initiatives are taking China in the right direction, challenges of land-use management are identified in Section 6. This chapter concludes with Section 7.

LAND AND WATER RESOURCES IN CHINA

China has a total land territory of 960 million ha. Cropland, grassland and forests (see Table 2.1), the three main terrestrial land systems, cover about 82

per cent of China's surface area (CCICED 2002; PTFDSSD 2003; SSB 2005). Mountainous terrain accounts for about two-thirds of the country's total territory (Huang 2000).

Table 2.1 Major land types in China

Land Type	Area (million ha)	Percentage
Cropland	127.0	13.23
Grassland	400.0	41.67
Forestland	263.3	27.43

Sources: Adapted from CCICED (2002), PTFDSSD (2003) and SSB (2005).

China's cropland area is small relative to its population. The total cropland area is about 127 million ha (SSB 2005), or approximately 0.1 ha per person. Furthermore, China's land is of relatively low productivity. For instance, China has 6.07 million ha (91 million acres) of land with a slope of more than 25 degrees. Over 70 per cent of this steeply sloped land is located in the western half of the country. The area of cropland with water available and/or irrigation facilities established covers 40 per cent of the total cultivated area (WRI 2003). Cropland with medium to low productive capacity makes up 79 per cent of the total cropland area (MLR 2000; CCICED 2002). In addition, as Table 2.2 indicates, the area of cropland in China declined from 1987 to 2001. The loss of cropland was largely due to conversion of land from cultivation to other forms of primary production and urban construction. Some land was also lost because of natural disasters (Heilig 1999; World Bank 2001).

China's grassland resource amounts to 400 million ha, which covers about 40 per cent of the nation's area, making it second only to Australia in the extent of its grassland resources. As Table 2.3 shows, the majority of the grassland is found in the Tibet, Inner Mongolia and Xinjiang autonomous regions and in Qinghai Province (MOA 1999). These autonomous regions and province are located in arid and semi-arid regions in North China, Northeast China, Northwest China, and West China. Grassland can also be found in the mountains, hills and coastal belts of the humid and semi-humid areas of Southern and Eastern China. An estimated 317 million ha of grassland, or about 74 per cent of the total, is considered suitable for livestock grazing (World Bank 2001). According to the Ministry of Agriculture (MOA 1999), about 32 per cent of all grassland in China is moderately to severely degraded and about 90 per cent is degraded to some degree.

Table 2.2 Cropland area in China, 1987–2001

Year	Total (1 000 ha)
1987	132 835
1988	132 530
1989	132 501
1990	132 601
1991	132 578
1992	132 283
1993	131 960
1994	131 522
1995	131 113
1996	130 039
2001	127 082

Note: The official estimate of cropland area in China from 1987 to 1995 was about 95 million ha (SSB 1999). This was found to be an underestimate of the true area (IIASA 1999) and can be proved by an official estimate of 30 per cent upward revision of cropland area statistics in 1996 (SSB 2001). Consequently the corrected land area during 1987–95 is used in this table (Heilig 1999). Official data for cropland area after 1996 was only available for year 2001 (SSB 2005).

Sources: Heilig (1999); IIASA (1999); SSB (1999); SSB (2001); SSB (2005).

Table 2.3 Grassland resources and degradation in China

Provinces	Grassland Area (million ha)	Grassland Area Moderately to Severely Degraded (million ha)	(per cent)
Tibet	82.4	21.4	26
Inner Mongolia	79.1	45.9	58
Xinjiang	56.4	26.0	46
Qinghai	36.0	10.8	30
Sichuan	21.1	6.1	29
Gansu	17.6	8.4	48
Yunnan	15.2	0.5	3
Other provinces	117.8	17.7	15
Total	425.6	136.8	32

Source: MOA (1999).

According to the Sixth Forest Resources Census conducted during 1999 to 2003, by 2003 China had a forest cover of 18.21 per cent of its total land territory (SFA 2004). Forest areas in China totalled 174.9 million ha. The total standing stock of timber was 12.5 billion cubic metres. Even though China ranks fifth in its forest area and seventh in its stock volume in the world, the per capita forest area and stock are about 21.3 per cent and 12.5 per cent respectively of the world averages (PTFDSSD 2003). Table 2.4 shows that despite an initial decline in forest area during the 1970s, the trend has been reversed since the 1980s due to major programmes of reforestation, afforestation and shelter belt establishment. However, it should be noted that the State Forestry Administration's definition of 'forests' has changed over the years and this has contributed to the seemingly large increase in forest area. Moreover, the state of natural forests in terms of volume and the share of mature forests continued to decline right through to the mid-1990s (Shi and Xu 2000; World Bank 2001).

Table 2.4 Changes of forest area 1976–2003

Forest Area	1st census (1973–76) (m ha)	2nd census (1977–81) (m ha)	3rd census (1984–88) (m ha)	4th census (1989–93) (m ha)	5th census (1994–98) (m ha)	6th census (1999–2003) (m ha)
Total	121.9	115.3	124.7	133.7	158.9	174.9

Source: State Forestry Administration (2004).

China has an uneven distribution of precipitation both spatially and temporally. It receives 5762 billion cubic metres of precipitation annually, most of which is concentrated in eastern and southern parts of the country. The amount of precipitation decreases progressively from southeastern coastal areas to northwestern inland areas. About 45 per cent of the country's territory falls into the category 'arid and semi-arid' with an annual rainfall of less than 400 millimetres. Precipitation is also uneven across different years. Precipitation falling between July and September makes up over 50 per cent of the annual total. This gives rise to frequent flood and waterlogging disasters (MWR 2005).

River run-off in China totals 2711.5 billion cubic metres and groundwater resources amount to 828.8 billion cubic metres. Underground water resources are unevenly distributed, with the southern region being rich, and northern and western regions being poor (China Internet Information Center 2004). On a yearly basis, the total availability of water resources in China amounts to 2812.4 billion cubic metres. Even though China ranks fourth in the world in terms of the total volume of its water resources, its per capita water resources are less than one-third of the world average, at about 2200 cubic metres (ibid.).

China has a large number of rivers, about 1500 of which have a catchment area of over 1000 square kilometres each. The Yangtze River – 6300 kilometres long – is China's largest river. It originates in the Kunlun Mountains in the southwestern section of Qinghai Province. It flows generally south through Sichuan Province into Yunnan Province then northeast and east across Central China to its mouth in the East China Sea. The second largest river in China is the Yellow River with a length of 5463 kilometres. It originates in the north of the Bayankala Mountains in Qinghai Province, flows through nine provinces and autonomous regions and eventually empties into the Bohai Sea in Shandong Province (China Internet Information Center 2002).

With these climatic, geographic and land-use characteristics, China is vulnerable to land degradation (Li et al. 1997). In particular, China's unique topography with two-thirds of its total territory being mountainous terrain makes China more vulnerable to land and water degradation processes (Huang 2000).

LAND AND WATER DEGRADATION

As land-use change in the Northwest Provinces of China, the focus of this book, will have an impact on land and water resources in North China, land and water resource degradation are discussed here with a focus on this region. An overview of land and water resource degradation in China is provided, followed by a detailed discussion of the biophysical settings and major resource degradation issues in North China. Consequence of land degradation will also be discussed in this section.

Overview of Land and Water Degradation

Land degradation in China can be categorized into three main types: soil erosion, desertification and salinization (World Bank 2001). Using the percentage of eroded land to the total land area as a measure of the extent of the land erosion problem, China is one of the most seriously soil-eroded countries in the world (Huang 2000). The existing area of soil erosion¹ in China is 367 million ha, accounting for about 38.2 per cent of the national territory. This is more than three times higher than the average for the world of about 12.3 per cent (ibid.). Most of the soil erosion problems in China occur in four regions: the Loess Plateau, the Red Soils area in Southwest China, the North China Plain and the Northwest Grassland. Together these regions cover 70 per cent of China's land area (ibid.). About 45.4 million ha of cropland are eroded. This is 25 per cent of the total eroded area and nearly 50 per cent of total cropland (ibid.).

Among these eroded lands, water erosion affects 179 million ha. About half of the nation's water-eroded land is located in the Extended Loess Plateau

(ibid.). Elsewhere, water erosion is taking place on marginal cultivated land and so-called 'barren lands' that are not cultivated and have not been allocated for any use. According to the World Bank (2001), the total area of land in China moderately to severely affected by water erosion increased by an estimated 20 to 30 per cent over the 20-year period from 1975 to 1996. Water erosion also has significant off-site impacts, including reducing the hydraulic capacity of river systems.

The total desertified² area in China has more than doubled since the 1950s, and the rate of desertification had accelerated during both the 1980s and the 1990s (Jia 2003). An estimated 331 million hectares – roughly a third of China's total area – is prone to desertification. Of this total, desertification is occurring on about 262 million hectares, with an annual expansion of 2.46 million hectares (ADB 2003). According to the World Bank (2001), China has the highest ratio of actual-to-potential desertified land in the world. The two main geographical areas where significant desertification is occurring include: (1) the agro-pastoral transitional zone in Northern China; and (2) areas surrounding agricultural 'oases' on the internally draining river systems of Northwestern China (ibid.).

The area of salinized³ land in China is estimated at 82 to 100 million hectares, including about 7 to 8 million hectares of cropland. The area of salinized cropland increased by about 10 per cent over the 20-year period ending in 1996 but the rate of growth declined from 1.1 per cent in the 1970s to 0.65 per cent in the 1980s and 0.3 per cent in the 1990s (Huang 2000). Most of the salinized cropland in China is located in three geographical regions: the water-scarce and groundwater irrigated areas in the North China Plain and Northwest Dry Region, the Extended Loess Plateau and the Northeast (Huang 2000; World Bank 2001). Farmland salinization can cause significant reductions in farm productivity. Salinization has already become a severe problem in major grain production regions such as North China Plain and Northwest China (Rozelle, Yeck and Huang 1997).

In addition to these three degradation processes, deforestation has exacerbated soil erosion and the loss of biodiversity. Deforestation in China is regional and structural. Forestland is divided into two categories in China: natural forests and plantation forests. While natural forests located in Northeast and Southwest China account for 92 per cent of standing wood volume, plantations account for only 10 per cent of standing volume since most of them are newly established (Shi and Xu 2000). Although there has been an increase in plantation forests and hence a growth in both forest area and forest stock volume by the early 1990s, harvesting of natural forest has continued.

Prior to the logging ban applied by the government in 1998, China was the third largest timber consumer in the world and was facing a widening imbalance between supply and demand for wood products (World Bank 2002). This

deficit was being made up by imports but still 500 000 hectares of natural forest area were being harvested each year (Shi and Xu 2000). Structural change in China's forest resources is represented by the decline of the share of mature forests, most of which are natural forests under the jurisdiction of state-owned enterprises (*ibid.*). The loss of protective vegetation through deforestation makes soil vulnerable to being eroded by wind and water. Deforestation leads to biodiversity loss by damaging or depleting the habitats of animals and plants (CBD 2001).

Besides land degradation, problems associated with water resource degradation have also increased because of the substantial increase in demand for water caused by rapid economic growth. These water-use problems include shortages, pollution, falling groundwater tables and flood/drought damage (World Bank 2001). These problems are particularly acute in Northern China, and even more so in the catchments of the Huai, Hai and the Yellow Rivers (*ibid.*).

Land and Water Degradation in North China

North China can be divided into three broad regions: the Upper Reach of the Yellow River in Northwest China; the Middle Reach of the Yellow River where the Loess Plateau locates; and the North China Plain (NCP), which is the downstream area of the Yellow River. The Yellow River Basin (YRB) sits within these three broad regions.

The Yellow River Basin (YRB) (see Figure 2.1) has a total area of almost 800 000 square kilometres and is home to 110 million people. If the flood zone in the surrounding lower reach were included, the figure would rise to around 190 million people or 15 per cent of China's total population (Giordano et al. 2004).

According to the plan of the Yellow River Conservancy Commission, of the total run-off of 58 billion cubic metres per year, 37 billion cubic metres is to be used for irrigated agriculture and municipal and industrial purposes, while the remaining 21 billion cubic metres is to be used for sediment flushing in the lower reach of the Yellow River (Huo 2000). However, Giordano et al. (2004) note that over the last ten years, run-off has averaged less than 50 billion cubic metres, sediment loads have been closer to 1 billion tons and the Yellow River delta is retreating rather than expanding.

The Upper Reach of the Yellow River comprises three provinces – Shaanxi, Gansu and Qinghai – and three autonomous regions – Ningxia Hui, Xinjiang Uygur and Tibet. It has precipitation ranging from 300 to 600 millimetres per year and relatively low population densities (Giordano et al. 2004).

The Northwest Provinces have the most severe land and water degradation in China. Water shortages, soil erosion and biodiversity losses are considered by researchers as well as in policy circles to be major environmental concerns

Source: Xu (1998).

Figure 2.1 Map of the Yellow River Basin

in the area (PTFDSSD 2003). In Qinghai Province alone, the area of water-induced soil erosion has reached 7.5 million hectares, accounting for 17.5 per cent of the total erosion area in the Yellow River Basin (Si 2001). Run-off from Qinghai Province makes up 49.2 per cent of the total water volume of the Yellow River. In Maoduo County of Qinghai Province where the Yellow River originates, more than 1000 lakes among the total of 4077 have dried up (*ibid.*). As a result, the outflow of the Yellow River from Qinghai Province decreased by 22.7 per cent and the main stream in the source area in Qinghai Province dried out for a period of eight months in 1999 (Si 2001; Huo 2000).

For two decades, the Northwest has been lagging behind China's coastal regions in market-oriented reforms and openness to trade and investment. Ecological deterioration in this area has been very severe (PTFDSSD 2003). Altogether, Shaanxi, Gansu, Ningxia, Qinghai and Xinjiang Provinces and Autonomous Regions in Northwest China make up one-third of the national territory, yet they have a forest cover of only 3.34 per cent of their total land territory, while historically, forest cover in this area was around 10–20 per cent (*ibid.*). Xinjiang, Qinghai and Ningxia have the lowest percentage of forest coverage in China with 1.57, 2.65 and 4.2 per cent respectively (Wang and Pei 2004). About 80 per cent of water erosion and 90 per cent of desertification in the country takes place in this area (PTFDSSD 2003). The annual sandstorms originating in West China are increasingly impacting neighbouring and more distant states.

The Loess Plateau lies in Central West China, in the middle reaches of the Yellow River (see Figure 2.2). Loess is defined as a terrestrial windblown silt deposit that forms in semi-arid continental climates (Hessel 2002). The Loess

Plateau has an arid to semi-arid climate and covers large parts of the Gansu, Ningxia, Shaanxi and Shanxi Provinces. Having an area of 667 000 square kilometres, it is a heavily dissected landscape consisting of unique loess hills, sand-loess hills and loess tablelands, with many gullies (McVicar et al. 2002).

Source: Adapted from McVicar et al. (2002).

Figure 2.2 Locations of the Loess Plateau and the North China Plain

Run-off from the Loess Plateau contributes 24 per cent of the current river volume in the Yellow River. Average annual rainfall ranges from 650 millimetres (in the Southeast) to 200 millimetres (in the Northwest), with over 60 per cent of this occurring in the summer monsoon season from July to September (McVicar et al. 2002). With a low level of vegetation cover and intense summer monsoon rainfall, soil erosion has become a severe problem on the Loess Plateau. The Chinese Academy of Sciences estimated that a total of 2.2 billion tons of topsoil are washed away every year on the Loess Plateau, with 70 per cent flowing into the Yellow River (Huang 2000). This equals to an average of 1.6 billion tons of sediment being carried each year by the Yellow River in recent decades. The Loess Plateau is the source of about 90 per cent of all the sediment that enters into the Yellow River (Hessel 2002). Sediment concentrations in run-off on the Loess Plateau are over 1000 grams per litre (*ibid.*). Of the total

sediment, only about 25 per cent is carried through to the sea, and the remainder is deposited in the river bed and flood plains (Giordano et al. 2004).

The North China Plain (NCP) is the downstream area of the Yellow River (see Figure 2.2). It is one of the greatest plains in China, comprising the alluvial plains of the Yellow, Huai and Hai Rivers. It includes five provinces – Hebei, Henan, Shandong, Anhui and Jiangsu – and two major cities – Beijing and Tianjin. It is a low-lying area of 303 585 square kilometres, supporting a population of over 300 million. Annual precipitation in the region ranges from 550 to 650 millimetres, of which 50–75 per cent falls between July and September (McVicar et al. 2002). Some of the most fertile and densely populated lands in China are in the lower reach of the Yellow River, mainly in Henan and Shandong Provinces (*ibid.*).

Major resource degradation issues in the NCP include severe flooding, water shortages, poor water quality and low levels of groundwater. The flooding threat posed by the Yellow River is caused by a major peculiarity, its unparalleled sediment content, which has caused rapid sedimentation in its lower course. This in turn has led to regular major changes in its course in the past. Continuing sedimentation has raised the river bed to several metres above the surrounding landscape, so that breaching of the dikes results in severe flooding (Hessel 2002). The Yellow River bed in parts of the NCP is 10 metres above the surrounding plain (McVicar et al. 2002).

While the possibility of flooding remains a key issue in the management of the YRB, water scarcity especially in the downstream area has become an issue of public concern in recent years (Zhu et al. 2004). Large amounts of water are extracted from the river for irrigation. Yellow River 'dry-out' has become more and more severe since the 1990s (Huo 2000). In 1997, more than 90 per cent of the lower reach of the Yellow River, with a total length of 704 kilometres, stopped flowing and there were 226 days without water flowing into the sea (Huo 2000). In addition, with reservoirs in the downstream area filling up with silt, water is less well regulated. This results in reduced water being available for irrigation. As a consequence, downstream agriculture and ecosystems suffer from water shortages.

As the rainfall is low and variable, agricultural productivity is low without irrigation. With no reliable surface water for irrigation, groundwater is used. This has, in turn, caused groundwater levels in the region to fall. The average water resource per capita and per area in this area is about 14 per cent of the average for China and the amount of groundwater available for irrigation is decreasing (McVicar et al. 2002). Moreover, low flows in the Yellow River, combined with the increased pollution loads, have resulted in a poor water quality (Giordano et al. 2004). Degradation of water quality has severe consequences for the ecology of the Yellow River delta and the coastal and marine environments of the Bohai Sea as well as their commercial fisheries (*ibid.*).

Consequence of Land and Water Degradation

Land and water resource degradation has the potential to slow economic development. It has been estimated that reduced grain yield in China due to nutrient loss was at 5 per cent per annum for the period 1976–89. This is equivalent to 6 million tons of grain with a value of US\$700 million (Huang and Rozelle 1995). Floods in the lower reaches of the rivers have brought severe destruction to farmlands and cities, threatening the lives of thousands of people and causing billions of dollars of damage (World Bank 1993). Major floods on the Yellow River could threaten the lives of 90 million people (Giordano et al. 2004). Efforts to fight floods have included the building up of the levees, which have to be raised every ten years at a cost of about US\$2 billion each time and have to be maintained every year at a cost of US\$70 million (World Bank 1993).

Most provinces in China have been affected by land degradation, with the annual national soil loss estimated at 5 billion tons (ADB 2003). A wide area is affected by dust storms, including Beijing, where the nearest shifting dunes are less than 100 kilometres away. Sand invasion and dune movement have buried some 670 000 ha of arable land and 2.35 million ha of range land and steppe areas (ibid.). About 15 to 20 per cent of fauna and flora species in the upper reach of the Yellow River are being threatened by the deteriorating environment (Si 2001). In addition, poor degraded areas are also characterized by severe human health impacts including malnutrition, disease resulting from poor water quality and respiratory diseases from dust and other contaminants (Berry 2003). As Table 2.5 indicates, total direct costs of land degradation at the national level were estimated at US\$7.7 billion per year in 1999, or 4 per cent of GDP, while indirect costs were around US\$31 billion a year (ibid.).

Table 2.5 *Economic costs of land degradation*

	Economic Cost (US\$ billion)
Direct	7.738
Indirect	30.952
Breakdown	
Water Erosion	4.80
Wind	0.43
Salinization	2.24
Sand storms	0.16

Source: Berry (2003).

CAUSES OF LAND DEGRADATION

The fundamental causes of land degradation in China share common characteristics with many other countries. Research work has demonstrated that besides increasing demand for food and associated pressure on agricultural land, incomplete land tenure, agricultural price policies, imperfect markets, government intervention and even macroeconomic mismanagement intensify land degradation (Mahendrarajah, Jakeman and McAleer 1999: 6; Groom et al. 2006).

Population and Poverty

Population in China increased from 400 million in 1949 to 1.3 billion by the end of 2005 (SSB 2006). With 22 per cent of the world's population and only 7 per cent of the world's arable land, China has a per capita arable land area of 0.11 ha. This is about one-third of the world's average (PRC 1994a; ADB 2003). Furthermore, China's land is of relatively low productivity. The demands of nearly 1.3 billion people for food, water and shelter has increased pressure on China's land resources. More marginal land is coming under cultivation for grain production at the expense of soil structures and organic matter content (ADB 2003). About 33 per cent of land with slopes greater than 8 degrees is used for growing crops. More than 7 per cent of cropland has slopes that are greater than 25 degrees. Cultivation on steep slopes and hills, together with other unsustainable practices such as excessive grazing, illegal logging, hunting and mining have all intensified land degradation (World Bank 2001).

In China, there is a strong linkage between land degradation and rural poverty. Almost 90 per cent of rural people living in poverty are located in areas suffering from land degradation (ADB 2003). Land degradation exacerbates rural poverty, which leads to further degradation of land resources, which leads to increased poverty (World Bank 2001).

Urbanization

Although China has a large agricultural population, it has experienced rapid urbanization since the early 1980s, with a rapid increase in the number and size of towns and cities (Heilig 1999). Urbanization causes erosion mainly indirectly through its occupation of agricultural land. This has added pressure to intensify remaining agricultural land use and to bring more marginal land under cultivation. According to the Regulations on the Protection of Subsistence Cropland issued by the State Council in 1994, any cropland used for construction should be offset by setting aside land elsewhere for agriculture (PRC 1994b; Brown 2001). The fast-growing coastal provinces, which are losing cropland to urban expansion and industrial construction, are paying other provinces to plough

new land to offset their losses. This provides an initial economic windfall for provinces in the Northwest, but is unsustainable because more marginal land is ploughed in the region, leading to intensified wind erosion (Brown 2001). About 20 per cent of cropland lost over the 1987–95 period was due to the effects of infrastructure and urban construction, particularly in the North and East regions. Much of the lost cropland was highly productive (World Bank 2001).

Incomplete Land Tenure

In many parts of the world, incomplete or unclear property rights and the breakdown of authority to ensure compliance with those rights may be the basic cause of land and resource degradation (Mahendrarajah, Jakeman and McAleer 1999: 6; Groom et al. 2006). The ownership of the land and other natural resources in China has always resided with the state or collectives on behalf of the local governments, as stipulated in the Constitution of the People's Republic of China (PRC 1982). They are, therefore, state-property rights regimes. Under a state-property rights regime, ownership and control over use rest with the state. The state may directly manage and control the use of natural resources through government agencies, or lease the natural resource to groups or individuals who are thus given usufruct rights for a specified period of time. State-property rights regimes normally remove most managerial discretion from the user, and generally convey no long-term expectations in terms of tenure security (Bronley 1991).

This property rights regime contributed to land degradation in China. Property institutions in China have been through two stages since the founding of the New China in 1949. Before the late 1970s, land in China was owned by the state and the collectives and was managed as a production factor under the centrally planned economy. Since 1978, China has gradually moved its policy orientation toward what it terms a 'socialist market economy'. This mixes strong government intervention with some autonomous price formation in commodity markets (USDA 2002). This second stage of property institution evolution was marked by the introduction of the Household Responsibility System (HRS) in 1978. This rural economic land reform featured the decollectivization of communal land and its redistribution among households depending on their family size or a combination of family size and labour (Huang 2000). Even under the HRS, agricultural land still belonged to rural collectives, and hence the state. Individual farm households do not have the legal titles to the land but instead have only the right to cultivate parts of the land under lease.

Under the planned economy before 1978, the institutional arrangement of agricultural collectivization was adopted to achieve grain self-sufficiency in order to support the development of heavy industries. 'People's communes' were established with the goal of maximizing the productivity of rural resources

to support industrialization. Farmers were organized to carry out large-scale agricultural production according to production plans set by the central government. Featuring a high degree of unified management with little individual decision-making power and the egalitarian distribution of collective income, collectivization had an adverse effect on farmers' incentives to be productive (Lin and Zhang 1998; Brown and Chen 1999). Land productivity was further undermined by the state-monopolized procurement and marketing system (SMPMS), which featured low prices of grain and oil and the monopoly purchase of these products by the government (Lin and Zhang 1998). The lack of private property rights over land and the lack of rights to make production choices caused disincentives for farmers to use land resources in efficient ways. On the contrary, farmers overused land resources for short-term benefits. In addition, the centralized decision-making took little notice of local resource constraints (*ibid.*). These factors led to the unsustainable use of natural resources and hence land degradation.

Since the late 1970s, China has changed from a planned and essentially state-driven economy to a more market-oriented, demand-driven economy. The HRS introduced in 1978 brought about fundamental changes towards more decentralized decision-making. The HRS for land is a village-based communal land tenure system, in which farmers are assigned land-use rights instead of rights to the land asset itself. For forestland and grassland, trees that farmers grow and livestock raised on the grassland belong to individual households (Shi and Xu 2000; Banks et al. 2003). Land is owned by the collectives rather than individual farmers. Farm households now constitute the basic production units and they are responsible for individual profits and losses (Brown and Chen 1999). Even though the HRS generated incentives for production by giving farmers freedom of decision-making and linking rewards closely with their performance, there were limitations and weaknesses inherent in the system.

First, the land tenure is incomplete under the HRS system, in which case only the use rights of lands instead of asset rights are assigned to individuals. This severely undermines the incentives for land conservation and has become a prominent issue especially in pastoral regions. In these regions, grassland was allocated to groups of households, varying in size from several households to several hundred households. Long-term use rights of typically 50 years were assigned to individual households. Former commune livestock were distributed in ownership to households (Banks et al. 2003). Under this common property regime, individuals had an incentive to expand their own herds on the collectively owned grassland for more profits. Moreover, since only the use rights were assigned to individuals instead of asset rights, incentives were provided to individuals to 'mine' the grassland for short-term benefits. The classic 'tragedy of the commons' led to the unsustainable use of the grassland (Huang 2000; Banks et al. 2003). As a result, China's sheep population grew from 170 million

in 1978 to 256 million in 1997 (Huang 2000). The failure to establish household tenure in the grassland led to overstocking (Banks et al. 2003), which in turn has been the main cause for grassland degradation. However, despite this problem of the 'tragedy of the commons', some authors argued that many pastoral areas developed their own community-based institutional arrangements for regulating grassland use that were advantageous (Richard, Yan and Du 2004).

Second, the frequent redistribution of land due to changes in family size and the 'sovereign risks' arising from occupation of farmland for urbanization or other development purposes were fundamental problems (Chen and Davis 1998). Because of insecure land tenure, farmers worried about the risk of losing their land and hence their investment. Therefore, they had little incentive to undertake land conservation or to invest in agricultural infrastructure. Instead, they tended to overexploit the soil to pursue short-term returns. As Bromley (1991) explains, in the absence of consistent and coherent institutional arrangements, resource use is reduced to a first come, first served basis.

Third, farmers' land-use rights were insufficient. Their rights were weakened by the state procurement system and distorted prices (Gale, Lohmar and Tuan 2005). In return for land allocation, farmers were obliged to deliver a grain quota that was bought by the state grain bureau at prices determined by the government. Livestock, vegetable and fruit producers may pay cash instead of delivering a quota (USDA 2002).

Finally, in some cases, farmers were prohibited from transferring their land-use rights (Chen and Davis 1998). Land readjustments served as an obstacle to the development of markets for rural land-use rights. Even though the transfers of land rights were permitted in theory, few could take place for more than one season or one year, since potential transferees fear that the land could be adjusted away the following season or the following year (Li 2003: 65). Uncertainties with tenure rendered land-use rights of rural households of little or no market value (*ibid.*).

Policy Failure

Land use is affected by government development policies relating to agriculture, grassland and forestry. Poor agricultural and forestry policies contributed to land degradation in China. Chinese agricultural policy featured government intervention in the grain market (Gale, Lohmar and Tuan 2005). After the reform and opening up policy was adopted, the central government increased the artificially low price of grain many times. In 1993, both the procurement and retail price of grain were decontrolled. The market price of grain rose after market liberalization. However, the government reverted to administrative intervention in the grain market. In 1995, the central government held each provincial governor responsible for the balance of grain demand and supply

in their province. This intensified the local governments' interventions in grain production and marketing. The industrialized provinces had to use their scarce resources to produce grain at high opportunity cost. On the other hand, agriculture-oriented provinces wasted some of their grain production capacities, which caused the misallocation of resources within and among provinces.

Similarly, policy failure led to grassland degradation. By the early 1980s, the central government withdrew its support for grassland conversion for grain production, redirecting policy toward the promotion of livestock and animal husbandry in grassland areas. However, the policy emphasis was on maximizing production, with much less concern for the sustainability of the production system. As a consequence, the grassland was overgrazed, leading to degradation (World Bank 2001).

Deforestation is more serious in state-owned forest areas than in collective forest areas due to poor forest development and management policies. The state-managed part of the forest sector covers about 20 per cent of the forest resource area but contains most of the highest-quality timber forest resources. In the past two decades, even though the whole economy was under reform, real changes in the forest sector were slow. Economic development concentrated on the utilization of forest resources, imposing pressures on the resource, and hence deforestation (Shi and Xu 2000).

In the collective forest area, the government expanded ownership arrangements by declaring that trees are owned by whoever plants them and that trees will be managed at their owners' discretion (Yin 1994). However, the realization of private ownership has been restricted by the imposition of a rigid marketing system. First, before cutting a tree, a farmer is required to apply for a permit from the local administration. Transportation of the logs also needs a permit. All the timber procurement has to be carried out by forest companies designated by the government. All timber transactions are heavily taxed. This system seriously damaged farmers' abilities to make profits out of their regular forest operation (Shi and Xu 2000).

Price control is another reason for forest degradation. Prices bear little or no relation to the scarcity value or opportunity cost of the resources used, including the costs of sustainable management. In addition, forest management evaluation processes and monitoring systems have also had impacts on forest degradation. Forest management evaluation has an emphasis on economic performance, with profit being the most important criteria to judge the performance of forest managers. This mechanism provides incentives for short-term forest over-extraction. The state-owned forests are much less comprehensively monitored than the collectively managed forests, as it is generally assumed that the state-owned forest enterprises would automatically follow relevant forest management guidelines and directives (*ibid.*).

GOVERNMENT RESPONSE

Though China has experienced strong economic growth in recent years, this growth has come at a cost to its land. Land degradation and ecosystem malfunction are among the numerous environmental problems that China is now facing. The Chinese government has indicated an awareness of the issue and has announced a shift in its policy emphasis to long-term development (PRC 1994a). In the government's land-use and natural resource development policies, especially since the 1990s, the relationship between economic and social development and environmental sustainability has been increasingly emphasized. In 2007, the new Property Law was adopted by the National People's Congress, in which further protection of agricultural land is attempted through addressing improper transfers of agricultural land for construction purposes (PRC 2007). This section reviews the framework of China's sustainable land-use management by looking into its overall framework, the legal and regulatory settings and major government strategies and policies.

Overall Policy Framework

Since the 1980s, the Chinese government has considered its two policies of family planning and environmental protection to be fundamental to its modernization process. Environmental protection has been included in annual and medium-term plans for national economic and social development. The government has formulated and implemented a series of laws and policies concerning environmental protection. This was especially the case after the United Nations Conference on Environment and Development (UNCED), held in 1992, when the China Agenda 21 was drafted and approved by the Chinese government. The China Agenda 21 states that the government will aim to coordinate the relationships between economic and social development, resource utilization and environmental protection (PRC 1994a).

According to China Agenda 21, the sustainable utilization of resources and preserving a healthy environment will be a major component of China's sustainable development strategies (*ibid.*). It states that:

[T]he country is obliged to shoulder the following obligations: protect all life supporting systems; protect the integrity of ecological systems and biodiversity; address major ecological issues such as soil erosion and desertification; protect natural resources; maintain sustainable supply capabilities; reduce damage to fragile ecological systems; extend forest coverage; improve urban and rural environmental conditions; prevent and control environmental damage and pollution; reclaim and restore damaged and polluted environments; take an active part in international cooperation in the fields of environmental and ecological protection. (*ibid.*)

Sustainable land-use management thus can be seen as a vehicle to achieve the strategy of sustainable utilization of resources and preserving a healthy environment.

Actions have also been taken to reconcile the conflicts and confusion between the ownership and use rights of natural resources. In China, natural resources belong to the state. A lack of clear guidelines defining the economic relations between the central government, the local government and various economic entities have resulted in the inefficient allocation and use of natural resources (*ibid.*). To tackle the issue, the Chinese government has taken actions to achieve the following objectives (*ibid.*):

1. To establish and clearly define the property rights for natural resources and to ensure the transferability of the rights.
2. To identify the roles to be played by the central government, enterprises and individuals with respect to the ownership, obligations and rights over the use of natural resources.
3. To introduce a market mechanism for the use and allocation of natural resources, which would follow the 'user pays' principle to facilitate the efficient use of natural resources in favour of the environment.
4. To improve the existing legal and management system based on the principles of a market economy.
5. To apply economic instruments and market incentives as an important supplement to legislation, and to ensure appropriate government intervention in case of market failure and price distortions.

The Legal and Regulatory Settings

China has established a basic regulatory framework for environmental protection. Political and institutional mechanisms for addressing the interrelated environmental, social and economic problems have been constituted. By the time China Agenda 21 was approved in 1994, four environmental laws, eight resource management laws, more than 20 administrative regulations on the environment and resource management and more than 260 environmental standards had been established, to form the basis of the legal system for environmental and resource protection (PRC 1994a). The government has indicated that full consideration will be given to the development of trade and environmental policies that promote sustainable development and trade liberalization along with China's entry into the World Trade Organization (Sun and Chen 2006).

Laws and regulations have been adopted in particular to enhance land-tenure rights for rural households and to provide increased protection of China's limited arable land base. The duration of the land-use rights has been extended twice in 1984 and 1993 to 15 years and 30 years respectively to encourage the

rural farmers to increase their investment in fostering the fertility of the soil and in practice of intensive farming (Li 2003). However, the 30-year tenure policy was widely ignored and land was contracted for short-term use subject to readjustment for household population changes (*ibid.*). The revised Land Management Law adopted in 1998 contained breakthrough provisions to address the major shortcomings related to rural land-tenure security in China: the short or uncertain length of the use term; the lack of written land-use contracts; and the practice of frequent land readjustments (*ibid.*).

To further secure land-use rights of rural households, the Chinese government adopted the Rural Land Contracting Law in 2002. This law is the first modern Chinese law to deal exclusively with the issue of rural land-tenure to replace the single article of the Land Management Law on farmers' land-tenure rights (*ibid.*). The new law reaffirms that farmers are entitled to 30-year rights to use the land. For forestland, the contracting term is 30 to 70 years and can be extended for special tree species. Under the new law, land readjustments according to changes in family size or other reasons are prohibited. Rural households' land-use rights and their rights to transfer, exchange and assign their land-use rights to other households are reiterated (PRC 2002). The new law is expected to have great significance for promoting agricultural development, increasing farmers' incomes and maintaining social stability in rural areas.

In 2007, China passed a new Property Law, which recognizes that an individual's private property rights are protected to the same level as that afforded to collective and state property rights. The law stresses the protection of arable land and stipulates that the transformation of agricultural land into land for construction is strictly restricted (PRC 2007). However, agricultural land would remain a collective possession under the new law. This would undermine the protection of agricultural land and would also not allow for the use of farmland as collateral by private citizens.

The legal reforms in rural land tenure were accompanied by a number of agricultural policy reforms to increase farm incomes and alleviate rural poverty. The most recent agricultural policy reforms, undertaken in 2004, featured the phasing out of the agricultural tax, direct subsidies to farmers, subsidized seed and machinery purchases and increased spending on rural infrastructure (Gale, Lohmar and Tuan 2005). These policies were given a secondary goal of promoting grain production after the rapid increases in grain prices following the 2003 grain harvest, as grain typically provides relatively low returns to Chinese farmers. However, there have been worries that heavy use of chemical fertilizer, pesticides and groundwater and cultivation of marginal cropland to maximize grain production may conflict with the objective of achieving environmental sustainability (*ibid.*).

Some of the laws and regulations were reviewed and amended to adapt to the changing conditions caused by rapid economic and social development

and also to comply with the ecological orientation of the government's new undertakings. In addition to the Land Management Law, Rural Land Contracting Law and the Property Law, laws and regulations related to environmental and natural resource management in China include the Land Administration Law, the Forestry Law, the Grassland Law, the Water Law, the Water and Soil Conservation Law, the Desertification Control Law, and a suite of relevant regulations such as the Regulation on the Implementation of the Land Management Law, the Regulation on the Protection of Basic Farmland, the Regulation on the Rehabilitation of Land, the Provisional Regulation on Land Appreciation Tax, and Measures for Management of the Construction-used Land, etc. Moreover, illegal land use was included in the revised Criminal Law of the People's Republic of China. In addition, related local laws and regulations have been enacted by local governments accordingly. Land management monitoring and inspection systems have been gradually established and completed, thus bringing land management into the realm of legal administration (China Internet Information Center 2002). All of these efforts are intended to provide a powerful and legal guarantee for the strengthening of land management, the protection of cropland as well as ensuring the rational utilization of land resources.

Major Strategies and Programmes

Major strategies and policies for sustainable land-use management in China include some key ecological policy programmes implemented in the late 1990s. These include the Great Western Development Program, the Natural Forest Protection Program (NFP) and the Conversion of Cropland to Forest and Grassland Program (CCFGP). Both the NFP and the CFCGP were incorporated into the Great Western Development Program. These new ecological undertakings were mainly driven by the 1998 Yangtze River flooding and the 1997 Yellow River dry-out. These events heightened public awareness of the severity of the ecological degradation in China and its potential environmental and economic consequences (World Bank 2001).

Since the mid-1990s, the development of China's Western Provinces has been a priority of the national development strategy (Liu, Baas and Ni 2001). The ecological system in this area has been deteriorating, and this highlights the urgency for an environment-friendly development programme. Through the Great Western Development Program, the sustainable development concept was introduced into the rural development. The main policy options of the Program focus on: (1) poverty alleviation through the promotion of local sector development; (2) sustainable management of natural resources, including the control of environmental degradation and (3) provision of an improved infrastructure and local institutional capacities, including the capacity for dealing with natural

and social vulnerabilities. Protecting pastoral land in the upper reaches of the Yellow River and Yangtze River has also become a key issue (*ibid.*).

The NEPP was initiated in 1998 to counter the impacts of deforestation. The Program featured a logging ban on the 30.38 million ha of currently existing natural forest area in the upper reaches of the Yangtze and upper and middle reaches of the Yellow River. For the planted forest and unplanted forestland in that region, the government adopted a policy of 'closing mountains' or 'complete stoppage' of logging activities. For degraded lands in that region that are appropriate for afforestation, trees and grasses will be planted. For other state-owned forest regions, the policy has been lightened to a logging reduction (CCICED 2002).

Measures to counteract the economic and social problems resulting from the logging ban include reassignment of forestry workers, provision of central government subsidies to local governments whose revenues have been impacted, tax reductions and subsidies to forest enterprises for reorientation of activities and basic living allowances for laid-off workers (*ibid.*).

Another major undertaking by the Chinese government was the CCFGP, implemented in late 1999. The planting of annual crops and the grazing of livestock on deforested lands with a slope of over 25 degrees have led to accelerated rates of soil erosion in China. This has put the future of agricultural production on these lands at risk and has also led to significant off-site impacts such as increased incidence of flooding and sandstorms, which disrupt the daily lives of people living in downstream areas. There is a reported total of 6.07 million ha of agricultural land on slopes of over 25 degrees, of which over 70 per cent is located in the Yangtze River and Yellow River Basins in the West (PTFDSSD 2003).

Although China has long made efforts in water and soil conservation, the CCFGP is a major initiative to integrate water and soil conservation with agricultural restructuring, poverty reduction and sustainable development. It involves millions of smallholders and includes a broad set of government agencies and a great diversity of land-use types. The policy focus is the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River (CCICED 2002). Also known as the Grain for Green Program and the Sloping Land Conversion Program, the CCFGP calls for the return of cropland to forest or grassland on steep slope land or lands that are severely degraded (State Council 2003). It also calls for the simultaneous afforestation/greening of barren mountains and lands. Farmers who convert their farms back to trees or grassland cover are subsidized with cash and grain, and are also provided with free seeds and saplings for reforestation activities (CCICED 2002). Experimentation for the CCFGP was first carried out in 1999. In January of 2002, it was formally launched. A total of 25 provinces and autonomous regions were included in the Program (PTFDSSD 2003).

CHALLENGES FOR SUSTAINABLE LAND-USE MANAGEMENT

For the implementation of these major strategies and policies to initiate sustainable land-use change, substantial financial and technical support from central and provincial governments has been mobilized and delivered to the fragile areas for rehabilitating the vegetation, improving the grassland ecosystem and eradicating poverty. However, the intention expressed in broad policy instruments is not being adequately translated into concrete action on the ground. There is a weak linkage between ecological conservation and rural development. Many 'ecological construction' programmes in China have a focus almost entirely on construction itself, with less attention being paid to the underlying social and administrative issues, which are often at the heart of natural resource management problems (Huang 2000; World Bank 2001). Without taking into consideration farmers' incomes in these conservation programmes, farmers lack incentives to participate actively in the programmes. This undermines the land management goals of these ecological programmes and projects. Sustainable land-use changes require that the programmes be positioned within an array of policies focused on the rural economy so that the dual goals of environmental improvements and poverty alleviation can be achieved. Some of the main challenges for sustainable land-use management are discussed in this section.

Security of Land Tenure

The long-term security of the land-use rights for China's 210 million farm households remains a key determinant of sustainable land-use management in China. Loopholes in existing laws and regulations allow malpractice and mismanagement to thrive. For instance, according to China's Constitution, farmers collectively own the farmland. The government is authorized to use the land for the sake of the public interest. However, the Land Management Law fails to define what constitutes the 'public interest'. Furthermore, there is no strict stipulation of how to secure farmers' interests when land transfers occur. Thus, with 'public interest projects' as their reason, local governments tend to take land from farmers at very low prices and then transfer them for commercial use in order to make profits (Li 2003). Excessive occupation of farmland has already become a major concern of the Chinese government in its land-use management policy. Similarly, the Rural Land Contracting Law gives no direction on inheritance of farmers' rights to arable land nor does it authorize mortgage of arable land-use rights, and this limits the breadth of farmers' land rights (*ibid.*).

Although the Chinese government has made progress towards strengthening farmers' tenure security under the HRS through a series of policy and legal

reforms, whether the incomplete land tenure that China has experienced in the past two decades will be fully addressed by these reforms is still uncertain. Unless a clearly defined land-tenure arrangement is made available, farmers will have limited incentive to manage their land resources in a sustainable manner. Land resources will continue to be overused for short-term benefits and investment in the long-term sustainable use of the resources will be inadequate. Effective land-use management is unlikely to be achieved and land degradation is likely to remain an ongoing problem.

Enforcement of Laws and Regulations

The adoption of laws and regulations simply provides an institutional framework for solving land-use and natural resource management problems more systematically than it would be without such laws and regulations. The ultimate resolution to these problems depends on a full implementation of the laws and development of institutions supporting this implementation. Despite the complex system of legislative and policy tools already in place, compliance with environmental and natural-resources management regulations remains low in China (WRI 1998). According to the World Resources Institute (1998), the government revised its criminal code to punish violations against the environment and natural resource use as part of its effort to strengthen environmental law enforcement. This has provided law enforcement agencies with some power. However, the vagueness of wording in many laws and regulations, coupled with the lack of a comprehensive enforcement regime, has led to a situation where many environmental and natural resources laws still reflect deals cut between different sectors.

A lack of coordination among sectoral policies also poses a threat to sustainable land-use management in China. The land-use and natural resource management agenda is complex. In China, natural resources have been managed by many different departments, according to specific environmental elements. Policy-making, implementation and coordination related to natural resource management and conservation has become the mandate of a range of different departments. The major land and natural resource management agencies include the Ministry of Land and Resources, the Ministry of Agriculture, the State Forestry Administration and the Ministry of Water Resources. It is common for different sectors to have sector-specific initiatives in their development strategies. Sometimes policies are not able to complement each other and there are overlaps, gaps and even contradictions. The lack of coordination among sectoral policies and the failure to maximize synergies and adjudicate disputes regarding the work of different agencies have adversely affected sustainable land-use and natural resources management.

Compatibility of Government Policies

Various policy measures have been taken to address the multiple imbalances brought about by the rapid economic growth in China. The multiple objectives addressed by these policy measures are often in conflict with one another (Gale, Lohmar and Tuan 2005). For instance, subsidizing farmers to plant more grain conflicts with the goal of increasing rural income, as grain earns little income compared with other crops such as vegetables and fruits. Subsidized machinery and fertilizer purchases conflicts with objectives of environmental protection and reducing chemical residues. Another example is the different land-use incentives created by the agricultural subsidies targeted at grain producers and the CCFGP subsidies that encourage farmers to convert their cropland to forest and grassland. This may give rise to conflicts in farmers' land-use decisions and pose a threat to sustainable land-use practice.

Development of Environmental Markets

Command and control instruments have played a key role in land-use and natural resources management in China. The performance of these instruments on the ground proves that they have not been effective in achieving environmental objectives. This is because in most cases they have failed to provide an incentive framework to encourage sustainable management of natural resources. For instance, an incentive mechanism has not yet been set up in China for farmers to provide environmental services in their land-use management. Moreover, pricing of natural resources at levels below marginal costs has resulted in destruction and waste and malpractice in managing natural resources.

The lack of land conservation activities to provide environmental goods and services may be due to the high transaction costs that are potentially involved. As in many other countries, the cost of charging beneficiaries who enjoy improved environmental services in China is often prohibitive so that the free-riding problem makes it impossible to raise sufficient funds through voluntary transactions to pay the landowner to provide environmental goods and services (Chen 2002). Second, the fragmented landownership in China makes the transaction costs too high for a person or group trying to aggregate many small parcels into one that is large enough to produce the desired environmental goods and services. Third, the transaction costs of market transactions are associated with the contract between the producer and consumer of the environmental goods and services. On one hand, producers of environmental goods and services must be able to assess the willingness of conservationists to pay for a particular amenity. On the other hand, the producers must be able to exclude non-paying free-riders from enjoying the amenity. Due to these high

potential transaction costs, the market for environmental goods and services in China has not developed.

CONCLUSION

Land use represents a critical intersection of the economy and the environment. Although China has experienced rapid economic growth in the past three decades, the evidence shows that land degradation is serious and appears to be worsening. The increasing population and per capita consumption will tend to put more pressure on China's natural resources. Current trends also indicate that there will be a rapid transition from an agricultural to an industrial and service society. A substantial increase in urbanization will take place over the next ten years (World Bank 2001). This will lead to the expansion of infrastructure and areas of settlement and hence encroachment on cropland (Heilig 1999). In addition, unless reformed, imperfections in the institutional arrangement will continue to be a key underlying cause of land degradation in China.

The Chinese government has recognized that land degradation and the consequent environmental degradation will be a major obstacle to the country's further economic development. To address the issue, the government has prioritized the sustainable natural resource management and rural development in its policy agenda, and has recently initiated a number of key ecological programmes to protect the fragile natural environment and eradicate rural poverty. However, some of the unresolved issues in the existing policy programmes are fundamental. They may eventually lead to policy failure. Among these, land-tenure arrangement is the most important issue. Different structures of property rights will yield different outputs and efficiency. Land-tenure arrangement that would enable well-defined, enforced and transferable property rights would improve social welfare, thus achieving the government's policy goal of environmental improvement and poverty alleviation. Secure and tradable property rights should be well defended by the further improvement of the rule of law. Another fundamental issue leading to policy failure is that the government's policy programmes have not fully considered their socioeconomic implications. Since land-use changes result primarily from economic decisions, environmental economic analyses of existing and proposed land-use management strategies would provide a comprehensive assessment of the real economic implications of these strategies and systems, including environmental and social externalities. This would provide a better basis for decision-making or further improvement for policy implementation.

Last, but by no means the least, policy alternatives should be extensively explored. One distinctive feature of the existing policy programmes is that they are mostly administrative measures. As the market reform in China further

deepens, administrative measures will become less effective and in some cases will even be socially disruptive. In this context, future emphasis should be put on exploring alternative policy instruments, including economic incentives, by applying the principle of the new institutional economics.

NOTES

1. Soil erosion is a physical process and refers to the wearing away of the land surface by rainfall, run-off or wind as well as to the reduction in soil productivity due to physical loss of topsoil, reduction in rooting depth, removal of plant nutrients and loss of water (Enters 1998).
2. The United Nations Convention to Combat Desertification defines desertification (UNCCD) as 'the degradation of land in arid, semi-arid, and dry sub-humid areas' and 'a gradual process of soil productivity loss and the thinning out of the vegetative cover because of human activities and climatic variations' (UNCCD 2003).
3. Salinization is the build-up of salt within the soil and is mainly a problem associated with poorly designed and/or managed irrigation development in arid and semi-arid zones, but it is also a natural phenomenon (Huang 2000).

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