Soil and water loss from the Loess Plateau in China

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The Loess Plateau in north China is famous for its deep loess. Due to the special geographic landscape, soil and climatic conditions, and long history (over 5000 years) of human activity, there has been intensive soil erosion which has resulted in prolonged and great impacts on social and economic development in the region. In this paper the factors causing soil and water loss from the Loess Plateau are discussed. Problems and measures for the comprehensive control of soil and water loss in the Loess Plateau are proposed. The objective of this paper is to provide a guide for the reconstruction of ecological and economic development in the region.

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Keywords: soil erosion; water loss; the Loess Plateau

Introduction

The Loess Plateau is located in the upper and middle reaches of the Yellow River, among the western Taihang Mt, eastern Riyue-Helan Mt, northern Qinling Mt, and southern Yinsan Mt (from 100°54’ to 114°33’E and 33°43’ to 41°16’N; Fig. 1). It covers a total area of 624,000 km² and has ancient deposits of thick loess. As the most severe soil and water loss area in the world, over 60% of the land in the Loess Plateau has been subjected to soil and water loss, with an average annual soil loss of 2000–2500 t km⁻² (Yang Wenzhi & Yu Cunzu, 1992). For example, the amount of soil erosion from some watersheds in the Huangpuchuan region can reach 59,700 t km⁻² year⁻¹, and maximum sediment content in the flowing water is measured as high as 1570 kg m⁻³ (Tang Keli et al., 1993).

Soil and water loss has seriously depleted land resources and degraded the eco-environment in the Loess Plateau. This directly affects local agricultural and industrial productivity. Furthermore, soil from the Loess Plateau is the major source of sediment load in the lower reach of the Yellow River. A sediment load of 16.4 × 10⁹ t year⁻¹ (Sediment Specificity Committee of Chinese Water Resources Association, 1989) was observed at the Sanmen gorge, which is the closest hydro-station in the lower reach.

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of the Loess Plateau (Table 1). This rate is 9 to 21 times greater than that of most major rivers in the world. For the Yellow River, 25% of the sediment load deposits along the river bed in the lower reach which causes an annual rise in the river of 8 to 10 cm. The Yellow River is an ‘above ground river’ that is seriously threatening the security of its lower reach.

Although management practices in the Loess Plateau have helped decrease soil and water loss for several decades (Xu Tingcan et al., 1994; Chang Maode et al., 1996), severe geographical, soil and environmental conditions in the Loess Plateau still remain. As the population increases, the negative impacts of humans on soil and water loss also increase. Therefore, the control of soil and water loss and the improvement of eco-environments remain critical issues in China.

**Physical factors in the Loess Plateau**

Xu Jiongxin (1994) analysed samples from more than 700 watersheds in China and found that sediment yield gradually increased from south to north, reaching peak values between 35° and 40°N. The region with the highest sediment yield is the Loess Plateau. Moreover, the monsoon climate plays a leading role in the physical geographical environment. From south-east towards north-west, the climate changes from humid to semi-humid, semi-arid, and arid, and the vegetation from forest to prairie-timber, prairie, and desert. Thus, a spatial interaction pattern of monsoon and erosion exists.

Soil and water loss is the result of the interaction of erosion and anti-erosion forces in a given geographical region. The erosion force is mainly rainfall. The factors affecting rainfall erosion include intensity, variation, and duration. The anti-erosion force arises mainly from vegetation and ground cover (United States Department of
<table>
<thead>
<tr>
<th>River</th>
<th>Country</th>
<th>Basin area $(10^4 \text{ km}^2)$</th>
<th>Annual sediment discharge $(10^8 \text{ t})$</th>
<th>Annual runoff amount $(10^8 \text{ m}^3)$</th>
<th>Annual average sediment yield (kg m$^{-3}$)</th>
<th>Annual Erosion rate (t km$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow River</td>
<td>China</td>
<td>75.24</td>
<td>16.40</td>
<td>432</td>
<td>37.8</td>
<td>2480.0</td>
</tr>
<tr>
<td>Brahmaputra River</td>
<td>India, Bangladesh</td>
<td>66.0</td>
<td>7.26</td>
<td>3480</td>
<td>1.89</td>
<td>1089</td>
</tr>
<tr>
<td>Gange</td>
<td>India, Bangladesh</td>
<td>95.50</td>
<td>15.51</td>
<td>3710</td>
<td>3.92</td>
<td>1519</td>
</tr>
<tr>
<td>Yantze River</td>
<td>China</td>
<td>180.72</td>
<td>4.78</td>
<td>9211</td>
<td>0.54</td>
<td>280.0</td>
</tr>
<tr>
<td>Mississippi</td>
<td>U.S.A.</td>
<td>323.0</td>
<td>3.12</td>
<td>5645</td>
<td>0.55</td>
<td>96.6</td>
</tr>
<tr>
<td>Amazon</td>
<td>Brazil</td>
<td>580.0</td>
<td>3.63</td>
<td>57396</td>
<td>0.063</td>
<td>63</td>
</tr>
<tr>
<td>Missouri</td>
<td>U.S.A.</td>
<td>137.0</td>
<td>2.18</td>
<td>6160</td>
<td>3.54</td>
<td>159.0</td>
</tr>
<tr>
<td>Colorado</td>
<td>U.S.A.</td>
<td>63.70</td>
<td>1.35</td>
<td>49</td>
<td>27.5</td>
<td>212</td>
</tr>
<tr>
<td>Nile</td>
<td>Egypt, Sudan</td>
<td>297.8</td>
<td>1.11</td>
<td>892</td>
<td>1.25</td>
<td>37.3</td>
</tr>
</tbody>
</table>

Agriculture, 1978). The Loess Plateau has relatively small vegetation cover and is situated in a semi-arid and arid climate belt that has high rainfall variability with periods of high intensity storms. Thus, soil and water loss in this area is intensified by the combination of high erosion forces and low anti-erosion forces. The physical factors affecting soil and water loss on the Loess Plateau are described in the following sections.

Geology and landform factors

The Loess Plateau is one of the most active areas of tectonic movement in China. From the Quaternary period to now, there have been large areas of crustal uplift of about 150 to 200 m. With crustal uplift, valleys are formed and water concentrates into rivers in the valleys. The energy of water in the rivers causes increased soil erosion in the valleys. In addition, the Loess Plateau has become an area with frequent earthquakes due to tectonic movements. A harmful earthquake not only causes gravitational erosion but also destroys the structure of the loess, leading to large areas of collapse and sliding. Moreover, the composition of loess generated by rock and soil forming processes results in substantial amounts of fine sandy loam and silt loam with strong tensile and stress joints so that collapse of the soil may happen after only 1 to 2 minutes in water. This loess characteristic leads to high erodibility including channel and cave formation.

The main geomorphic landforms on the Loess Plateau are Yuan (a large flat surface with little or no erosion), ridge, hill and various gullies. The Yuan has little erosion because the landform is flat. When water flows towards a gully bottom, soil erosion gradually increases. Gully erosion accounts for more than 80% of soil erosion in a watershed. Strong erosion forms specific geomorphologic features with many gullies and fragmented landforms. Hence, gully density and ground-surface gradient may be taken as indicators of potential soil erosion intensity. For the Loess Plateau, the area with the highest gully density is near the Yellow River in the Shanxi and Shaanxi provinces. This area is the principal sediment source of the Yellow River (Qian Ning et al., 1980). Generally, in areas with high gully density, ground cracking is also well-developed and soil erosion intensity is high. The degree of slope is also an important factor affecting soil erosion. Soil erosion becomes more intense as the slope increases. Under normal conditions, land steeper than 25° should not be cultivated and should be covered by forest and grass, but in some areas of the Loess Plateau, slopes over 45° are still under cultivation.

Climate factors

The annual average precipitation on the Loess Plateau is between 200 and 600 mm and gradually decreases from the south-east to the north-west. However, the precipitation is mainly concentrated in July, August, and September. The rainfall in these 3 months often accounts for 60–70% of total annual precipitation, most of which is in the form of high intensity storms, so soil erosion predominately occurs in this period. Because the amount and intensity of rain in storms is great and often causes extreme soil erosion, sediment transport in the Yellow River and its tributaries increases greatly during these 3 months. For example, in 1977, rainfall at the centre of a storm reached a rate of 228 mm in approximately 30 min. The storm caused flooding on the Yanhe River and the measured sediment in one day was 1.5 times greater than the annual average value (Mi Dengshan, 1982).

Runoff is a main force of erosion and the main means of sediment transport. For a watershed where the surface condition is thought of as constant, there exists a close
relationship not only between runoff and sediment yield for a single flood, but also between annual runoff and sediment transport and tributaries (Jiang Zhongshan & Song Wenjing, 1980). Because soil and water loss mainly occurs during the period from June to September, the relationship between runoff and sediment transport is closer during this period than that throughout the year. Erosion and sediment yield are also affected by regional geographical and geologic characteristics, and by soil and vegetation factors that also affect the influence of runoff on sediment yield.

Soil types and composition

Quaternary loess is the most widely distributed material on the Loess Plateau, covering more than 40% of the total area (Liu Dongsheng, 1984). Loess is the main source of sediment in the Yellow River due to its high erodibility. Generally, the coarser the texture of loess, the smaller the natural porosity and strength. This infers that there is a close relationship between particle composition and sediment yield. The erosive potential produced by 100 mm of runoff per unit area rises with an increase in soil particle size content larger than 0.05 mm as the material is less cohesive (Cao Yinzheng, 1980).

Runoff is affected by rainfall factors and soil infiltration capacity. Infiltration is closely related to soil porosity, texture, profile layers, and soil moisture. The infiltration rate is higher for sandy soil than for clayey soil. For soils developed on the same loess parent materials, there are great differences in infiltration capacity associated with different intensities of soil formation and profile development. Heilou soil developed on newly formed loess has a better profile structure, more root and soil fauna channels, bigger non-capillary pores, better infiltration capacity and is less erosion-prone than soil which developed on amorphic loess.

Vegetation factors

Vegetation is an important factor affecting soil erosion. Areas with serious soil and water loss are often also areas where natural vegetation has been destroyed and the environment has been degraded. For areas with copious natural vegetation, there is normally little or no erosion even if the geomorphology is hilly with precipitous slopes and gullies. For example, the erosion in a woodland on a gully slope was only 14.4 t km$^{-2}$a$^{-1}$, but after being developed, it increased more than 1500 times (Table 2). That is, when there is copious vegetation on the ground, geomorphology and rainfall factors do not play a leading role in soil erosion.

For several decades, natural vegetation on the Loess Plateau has been severely destroyed. Presently, forest cover is only 6.5%, and can even be as low as 3% in some areas. Grass cover is only 25 to 65%. The Ziwuling forest boundary has moved back 20 km since the 1950s, and runoff and sediment has increased significantly (Mi Dengshan, 1982). According to hydrographic data from 1959 through 1962 from the Liugou hydrological station in Ziwuling, the average maximum runoff at that time was 61.6 m$^3$s$^{-1}$ and average sediment content was 59.6 kg m$^{-3}$. Between 1969 and 1971, the average maximum runoff and sediment values were 151.9 m$^3$s$^{-1}$ and 126.3 kg m$^{-3}$, which is 1.5 and 2.1 times that of the values 10 years earlier. Similarly, destruction of grass resources also causes serious soil and water loss. Comparing the soil erosion of 17 gullies (2000–10 000 m length, 100–300 m width, 100–300 m depth) in Guyuan county by aerial photographs from 1957 to 1979, the average travelling speed of the gully heads was 5.32 m per year and the maximum was 15.7 m per year (Comprehensive Investigation Group of Guyuan County, 1996).
Table 2. Comparison of soil erosion with forest, grass and cultivation land uses

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall during July–Sept</th>
<th>Cultivated land</th>
<th>C. Korshinskii ripewood (planted in 1958)</th>
<th>Robinia pseudoacacia ripewood of 6–15 years</th>
<th>Robinia pseudoacacia young wood of 1–6 years</th>
<th>Astragalus dsurgens grassland of 2–8 years</th>
<th>Uncropped slopeland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>t km⁻²</td>
<td>%</td>
<td>t km⁻²</td>
<td>%</td>
<td>t km⁻²</td>
<td>%</td>
</tr>
<tr>
<td>80</td>
<td>270.9</td>
<td>4417.8</td>
<td>100</td>
<td>8.0</td>
<td>0.18</td>
<td>37.5</td>
<td>0.85</td>
</tr>
<tr>
<td>81</td>
<td>412.1</td>
<td>2010.9</td>
<td>100</td>
<td>14.4</td>
<td>0.72</td>
<td>161.4</td>
<td>8.00</td>
</tr>
<tr>
<td>82</td>
<td>235.1</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>83</td>
<td>402.6</td>
<td>4430.5</td>
<td>100</td>
<td>1.7</td>
<td>0.04</td>
<td>73.3</td>
<td>1.65</td>
</tr>
<tr>
<td>84</td>
<td>518.6</td>
<td>5347.8</td>
<td>100</td>
<td>5.9</td>
<td>0.11</td>
<td>21.4</td>
<td>0.40</td>
</tr>
<tr>
<td>85</td>
<td>539.0</td>
<td>8142.8</td>
<td>100</td>
<td>1.4</td>
<td>0.02</td>
<td>11.4</td>
<td>0.14</td>
</tr>
<tr>
<td>86</td>
<td>246.2</td>
<td>23.4</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>87</td>
<td>213.1</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>88</td>
<td>566.5</td>
<td>1043.4</td>
<td>100</td>
<td>8.4</td>
<td>0.80</td>
<td>1.31</td>
<td>0.13</td>
</tr>
<tr>
<td>89</td>
<td>353.3</td>
<td>4860.8</td>
<td>100</td>
<td>7.3</td>
<td>0.15</td>
<td>27.4</td>
<td>0.56</td>
</tr>
<tr>
<td>Average</td>
<td>375.7</td>
<td>3027.7</td>
<td>100</td>
<td>4.7</td>
<td>0.15</td>
<td>33.4</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Decreased compared with cultivated land 99.85 100 76.9 85 38.95 38.95

This data is from the Ansai county of Yanan prefecture of Shaanxi province.
Effect of human activities on soil and water erosion on the Loess Plateau

There are natural processes of erosion leveling and moving of substances controlled by physical factors. However, soil and water losses do not result from natural processes alone but also from human activities. When natural erosion is intensified by human activities it is called accelerated erosion. Soil and water loss on the Loess Plateau is a combination of natural erosion and accelerated erosion. The accelerated erosion arises from cultivation, uncontrolled development, overgrazing, mining, road construction and other human activities.

According to historical records, the Loess Plateau was formerly an area with a wide flat Yuan, few gullies, luscious grasslands, and forests (Shi Nianhai, 1981). With population increases large areas of forest and grassland were destroyed by poor land utilization. Soil and water loss was accelerated and this can be verified from the records of the flooding of the Yellow River. Before the Sui dynasty (A.D. 581 to 618), the Yellow River flooded only 1·1 times per century, while in the Ming dynasty (A.D. 1368 to 1644) it flooded 155 times per century. During the 25 years from 1912 to 1936, flooding occurred 103 times (Committee of Flood and Drought of the Yellow River Basin and North-western China, 1996). For several decades of the 20th century, the population increased faster than ever before. During the 33 years from 1953 to 1985, the total population of the Loess Plateau increased from 38,374,300 to 81,392,200 and the natural increase rate of the population was 33·93% per year. In some areas, it even reached 65·23% per year (Comprehensive Investigation Group of Guyuan County, 1996). Hence, in order to satisfy the requirement of food for the increasing population, there was a destruction of natural vegetation and an increase in arable land. Table 3 shows this tendency with an example in Xiji, Haiyuan, and Guyuan counties in the Ningxia Autonomous area.

Zheng Fenli et al. (1993) studied the characteristics of natural erosion in woodlands and accelerated erosion after development of the Ziwuling forest area (Table 4). They found that in woodlands, soil erosion was 1·0 to 14·4 t km$^{-2}$ year$^{-1}$ but after development associated with human activities, it increased to 9700–21,700 t km$^{-2}$ year$^{-1}$.

The cultivation of slope land is a major factor associated with serious soil and water erosion. For the Loess Plateau, 50% of the total arable land is on slopes and up to 70% of arable land is on slopes in the loess hilly and gully areas. Research indicates that erosion rises greatly when the slope is steeper than 25° (Tang Keli et al., 1998). Therefore, slopes greater than 25° should be returned to forest and grassland.

Recently, with the development of the oil, coal and natural gas industries on the Loess Plateau, along with the construction of an energy industry, unregulated accumulation of large amounts of discharged stones and waste has increased erosion intensity in some areas. During industrial development large amounts of soil, stones and rocks are removed, piled up and disturbed, thus their stability under the natural state is destroyed. Meanwhile, as mine construction has taken large areas of agriculture and forest land, forest and grass vegetation is destroyed, and production activities like traffic, construction and mining may result in landslides and soil collapse, which may lead to serious soil and water loss. If rational conservation measures are not implemented, the annual erosive amount will reach 120,765,000 t, an increase of 230% of the current value (Comprehensive Investigation Group of Chinese Academy of Sciences, 1990).

Comprehensive erosion control on the Loess Plateau

Soil and water loss results from the interaction of rainfall and land surfaces. Because man cannot easily manage rainfall, the prevention of soil and water loss is mainly through rational land engineering and surface biological management.
Table 3. Relationship of population increase and development in three counties in Ningxia Autonomous area

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population (10⁴)</td>
<td>Arable land (10⁴ ha)</td>
<td>Per capita arable land (ha)</td>
<td>Population (10⁴)</td>
<td>Arable land (10⁴ ha)</td>
<td>Per capita arable land (ha)</td>
<td>Population increase (10⁴)</td>
<td>Arable land increase (10⁴ ha)</td>
<td>Developing land per increased capita (ha)</td>
<td>Soil and water control area (ha)</td>
</tr>
<tr>
<td>Xiji</td>
<td>8.9</td>
<td>16</td>
<td>1.8</td>
<td>29.2</td>
<td>22.1</td>
<td>0.8</td>
<td>20.3</td>
<td>6.1</td>
<td>0.3</td>
<td>2.15</td>
</tr>
<tr>
<td>Haiyuan</td>
<td>6.8</td>
<td>6.5</td>
<td>1.0</td>
<td>22.8</td>
<td>19.1</td>
<td>0.87</td>
<td>16.0</td>
<td>12.6</td>
<td>0.79</td>
<td>5.9</td>
</tr>
<tr>
<td>Guyuan</td>
<td>20.6</td>
<td>21.5</td>
<td>1.0</td>
<td>50.7</td>
<td>27.9</td>
<td>0.59</td>
<td>34.8</td>
<td>6.4</td>
<td>0.18</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Table 4. Natural and accelerated erosion amount before and after vegetation destruction on runoff plots

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Year</th>
<th>Natural erosion amount</th>
<th>Natural erosion amount/accelerated erosion amount</th>
<th>Accelerated erosion amount</th>
<th>Accelerated erosion amount/natural erosion amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Woodland on gully slope</td>
<td>1989–1991</td>
<td>14.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Developed fallow on gully slope</td>
<td>1990–1991</td>
<td>14.4</td>
<td>0.07</td>
<td>21774.1</td>
<td>1512.1</td>
</tr>
<tr>
<td>3</td>
<td>Developed crop land on gully slope</td>
<td>1990–1991</td>
<td>14.4</td>
<td>0.11</td>
<td>13179.4</td>
<td>915.2</td>
</tr>
<tr>
<td>4</td>
<td>Crop land on hillslope</td>
<td>1989–1991</td>
<td>1.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Developed fallow on hillslope</td>
<td>1990–1991</td>
<td>1.3</td>
<td>0.01</td>
<td>10324.5</td>
<td>7941.9</td>
</tr>
<tr>
<td>6</td>
<td>Developed crop land on hillslope</td>
<td>1990–1991</td>
<td>1.3</td>
<td>0.01</td>
<td>9703.7</td>
<td>7464.4</td>
</tr>
<tr>
<td>7</td>
<td>Woodland on hillslope + gully slope</td>
<td>1989–1991</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Developed fallow on hillslope + gully slope</td>
<td>1991–1991</td>
<td>1.0</td>
<td>0.01</td>
<td>15286.9</td>
<td>15286.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>0.04</td>
<td></td>
<td></td>
<td>6624.1</td>
<td></td>
</tr>
</tbody>
</table>

This data is from the Fuxian county of Yanan prefecture of Shaanxi province. Source: Zheng Fenli et al. (1993).
Principles of comprehensive erosion control on the Loess Plateau

Through long-term practice of soil and water conservation, the basic principles of comprehensive erosion control on the Loess Plateau can be summarized as follows (Chen Yongzong & Jing Ke, 1988):

(1) Retaining rainfall locally. Storm runoff is the basic force producing soil and water loss, but runoff is an important water resource. Through engineering and biological measures, the course of storm flow can be changed to make the runoff infiltrate locally (Huang Bingwei, 1983). This can make the surface runoff become a soil moisture resource to augment the water cycle. Thus, the erosive damage of storms could be lessened and in addition, water made available for increased agriculture production.

(2) Treating a small watershed as a basic unit for comprehensive management. The small watershed should be analysed as an integrated system for erosion control, sediment yield and water and sediment transportation on the Loess Plateau. Soil type and structure in small watersheds have a common pattern, so it is easily arranged for farming, forestry and husbandry production. Hence, taking a small watershed as a basic unit, land utilization can be changed by applying forestry and grass management practices and by increasing engineering measures, such as construction of terrace, small-scale reservoirs and dams etc.

(3) Combination of prevention and control of soil and water loss. During the past 40 years comprehensive erosion control of the Loess Plateau has achieved some success, but soil and water loss is still very serious. If measures to prevent and control soil and water loss are combined to arrest further degradation, the degree of soil and water loss on the Loess Plateau could be greatly reduced. Nanxiaohu watershed is a typical model. Before the 1970s, 1033 ha of strip land, 49 ha of level terrace, 225 km of long ridge along the edge of Yuan, 45 gully head protection projects, 256 ha of forest land, 173 ha of grassland, three small reservoirs and 12 silt-trapping dams had been constructed. But the erosion was still as high as 4300 t km\(^{-2}\) a\(^{-1}\). One of the key reasons for this was the failure of some of the soil conservation works. In the 1980s, work was undertaken to protect existing restoration works and to minimize further human impacts in the watershead. In addition, priority in new conservation works was given to the areas most severely affected. These actions reduced the rate of soil erosion to 2000 t km\(^{-2}\) a\(^{-1}\) (Chen Yongzong & Jing Ke, 1988).

Achievement of comprehensive control of soil and water loss on the Loess Plateau

By the end of 1993, the accumulated area of soil and water management on the Loess Plateau had reached more than 150,000 km\(^2\), which is 34% of the total area affected by soil and water loss. Among which 4,280,000 ha is basic farming land, 8,833,000 ha is woodland, and the remaining 3,330,000 ha is grassland. Moreover many silt-trap dams and small-scale soil and water conservation projects have been constructed (Chang Mao et al., 1996). The large areas of comprehensive management will greatly decrease soil and water loss. Soil and water conservation measures have increased soil fertility and cultivated land by 2,500 km\(^2\), thus greatly alleviating loss of land resources with the increasing population. The structure of village industry is rationally adjusted. This not only increases grain yield but also improves the ratio of economic crops to form special niche industries. For example, in the four regions with the most serious soil and water loss on the Loess Plateau, production conditions and the economic situation greatly improved after soil and water conservation was implemented. Total grain yield and the agricultural value has doubled, and per capita grain and income now exceeds 500 kg and 500 yuan. This made it possible for 500,000 people to have sufficient food and to be removed from poverty (Li Jing, 1995).
Existing problems with comprehensive control of soil and water loss on the Loess Plateau

Although comprehensive management of the Loess Plateau has achieved some measure of success, there still exist some problems. First, comprehensive management conducted on a small-watershed basis only considers natural resources and is rarely concerned with regional social and economic conditions. The comprehensive management of small watersheds can only consider small-scale agriculture, forest and animal husbandry production. The economic scope is relatively small and difficult to adapt to the requirement of a large market economy, and has some limitations for economic development. Adapting management patterns to co-ordinate with the market economy is a problem that needs a solution. Second, how can large-scale energy industry construction be accomplished with comprehensive management of soil and water loss on the Loess Plateau? Research concerning mechanisms of soil and water loss should be carried out for better management.

References


