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Assessment of China's economic loss resulting from the degradation of agricultural land in the end of 20th century

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Abstract: Land degradation is a consequence stemming from both natural processes and social economic activities. On the bases of analyzing general situation of agricultural land degradation in China, the monetary estimating methods such as market value method and shadow engineering method were used to quantitatively assess the economic loss resulting from land deterioration. Results showed that the economic loss in 1999 was 326.81 billion RMB Yuan, which accounted for 4.1% of GDP in the same year of China. If taking five items namely farmland conversion, soil erosion, salinization, decline in reservoir functions, and siltation in waterways and, comparing with that in 1992, the percentage of economic loss to GDP has increased by 1.5 in the only 7 years.

Keywords: agricultural land; degradation; economic loss; estimating method; China

Introduction

Under an integrated action of human economic activities and some adverse natural factors, farmland degradation is a dynamic process that can lead to an unbalancing of ecological systems, worsening of soil quality, a decline in soil renewable capacity, and a weakening of soil carrying capacity. Usually, the degradation of agricultural land includes a diminishing of vegetation, soil deterioration, and natural eco-environmental degradation. Farmland deterioration has a twofold meaning: quality and quantity. All of the phenomena and processes brought about by a decline in the environmental quality and/or quantity of soil belongs to the concept of soil degradation. Viewed from this perspective, soil deterioration is mainly soil erosion, salinization and secondary salinization, gleization and secondary gleization, soil acidification, soil pollution, extensive cultivation and, farmland non-agricultural conversion, especially excessive occupancy by non-agricultural use and farmland waste.

China is a typical agricultural country that has historically depended heavily on land. Although the absolute figure for her territorial size places China at the forefront among countries of the world, the per capita amount is only 0.777 hm^2, a number that is equal to one/third of the average of all countries in the world (Statistics Yearbook of China, 2001; SEPA, 2001). With only 7% of world's farmland, China has produced 22% of the world's grain and has kept 21% of the world's population alive (Statistics Yearbook of China, 1997). On the other hand, with 40% of the world's peasants located within her territory, China has kept only 7% of the world's non-peasant population alive.

An additional cause for worry is that China has serious land degradation problems and the quality of farmland is declining. With the rapid economic growth and expansion of its human population, there is a stronger and stronger pressure on China's cultivated land and, increasingly, ecosystems are being degraded and environmental pollution is worsening. On this score, China's environmental, economic and social sustainable development has been hampered by the "scissors" effect displayed in Fig.1. The relationship between population and cultivated land is an inverse one; that is, population is increasing and tillable land is decreasing. Therefore China is now faced with an immense conflict between population and cropland availability, and this situation has already become a significant factor in restricting the sustainable development of the environment, economy and society in China.

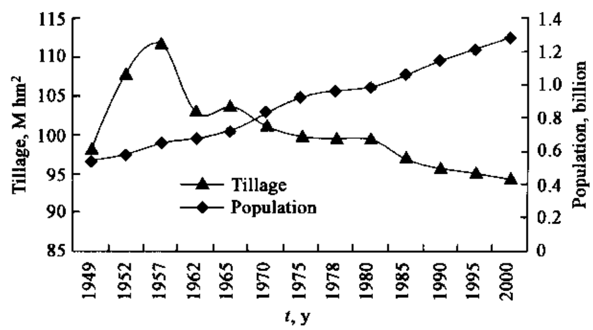

Fig. 1 Variation of tillage acreage and human population (source of population: 1949—1981 from Security Yearbook; 1982—2000 from National Statistic Yearbook; source of cultivated area: from National Statistic Yearbook)

1 Basic situation of the degradation of agricultural land in China

Since, for a long time, the application and management of land resources did not follow the laws of nature, the land was managed extensively and was excessively utilized and with a lack of eco-environmental awareness, there now exists a nationwide problem of serious land degradation that continues year by year.

1.1 Soil erosion and water loss

With regard to soil erosion and water loss, China is one of the most seriously affected countries in the world. Since 1960s, the eroded area has expanded gradually and the erosion intensity has increased unceasingly. At present, the area of soil erosion and water loss amounts to 3.67×10^6 km^2, which makes up about 38.2% of China's territory. Furthermore, the area in which soil eroded occurs increases by approximately 10000 km^2 per year (Statistics Yearbook of China, 2001). The problem of soil erosion in the Loess

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Plateau, the Yangtze River Basin and the southern hilly country is particularly serious. From the 1950s to the 1990s, soil erosion and water loss had already caused a loss of tillage land accumulating to 2.66×10^6 hm^2, amounting to a mean annual loss of more than 6×10^4 hm^2. The direct monetary loss from this erosion amounted to about 10 billion RMB Yuan (Department of Nature Conservation, SEPA, 1999) and the amount of soil lost yearly was 5.0×10^8 t. The latter figure corresponds to a 1 cm thick layer of soil being washed out every year.

1.2 Soil desertification

In China, deserted land is distributed mainly over arid, semi-arid, and semi-moist zones of Northwestern and Northern China. By the end of the 1990s, the desertification area was 8.37×10^5 km^2, which made up 8.7% of China's territory. The existing desert area and the land that was subject to impacts leading to desertification was 2.25×10^6 km^2. This accounted for 23.4% of China's territory (Department of Nature Conservation, SEPA, 1999). In the period from the 1950s through the 1970s, the desertification area increased by an average of 1560 km^2/a. This figure has risen rapidly and at the present time it is 2460 km^2/a (Sun, 2001).

1.3 Salinization and gleization

In China, the area of land that is salinized amounts to about 8.18×10^7 hm^2, which comprises 8.5% of her territory. In addition, there exists 1.73×10^7 hm^2 of land that holds the potential for becoming salinized (Department of Nature Conservation, SEPA, 1999). Salinized land is scattered mainly over continental river basins of North China and along seashore zones. Secondary salinized land generally exists in irrigated regions, particularly those oasis regions of arid Northwestern China and the plain regions of semi-humid Northern China. In total, the area of these regions is 6.3×10^4 hm^2 (Yang, 1997). Besides this, the problem of soil gleization and secondary gleization is more serious in Southern China and currently the area of gleized paddy fields is 4.2×10^6 hm^2.

1.4 Soil acidification

In 1993, the area of acid rain in China was 2.8×10^6 hm^2. The impacted region included three severe regions: (1) the Southwestern and Southern China region with the provinces of Guangdong, Guangxi, Sichuan and most of Guizhou as the center; (2) the East China coastal region with Xiamen and Shanghai as the center; and (3) the North China region with Qingdao as the center. While at the present time, the damaged area of acid rain makes up more than 25% of the territory, of which the heavily polluted area is about 2.0×10^6 hm^2 (Department of Nature Conservation, SEPA, 1999).

1.5 Soil pollution

Since the rapid development of urbanization, industrialization, and chemical agriculture, the concentration of harmful elements in soil has been continuously increasing along with soil quality deterioration. Currently, more than 1.6×10^7 hm^2 is seriously polluted by pesticides. To gather with the areas of farmland polluted by the industrial "three wastes" and by county and township enterprises, the total polluted areas amount to 2.19×10^7 hm^2 (Department of Nature Conservation, SEPA, 1999).

1.6 Extensive cultivation

Since farmers have given much attention to exploiting land resources but have not given much thought to maintenance, the fertility of cropland throughout China has gradually declined, especially in those regions where extensive cultivation and predatory exploitation have brought about a decrease in land capability. From the data obtained from the second national soil survey, it has been determined that the cultivated land where the organic matter content is lower than 0.6% accounts for 10.6% of the total. In the total farmland acreage 52% lacks phosphorus, 23% lacks potassium, and 14% lacks both of these nutrients (Department of Nature Conservation, SEPA, 1999).

1.7 Farmland conversion

As urban areas and townships expand rapidly, large areas that were once tilled are converted to other uses. In 1996, China's urban areas comprised a total amount of land that was larger by 94.5% than the corresponding amount in 1978. In the same year, the organic area of towns was larger by 30.9% when compared with 1985. Besides this, there was a serious farmland waste. In 1997, the unused non-agricultural land amounted to 1.17×10^5 hm^2 (Li, 2000).

2 An assessment of the economic loss resulting from degradation of agricultural land

2.1 Assessment methods

2.1.1 Estimating method

The assessment on economic loss of agriculture land degradation is to present the damage to social-economy by means of monetary form quantitatively or semi-quantitatively. Which can be expressed in conceptual modal as follows (Xu, 1995):

$$C = \sum_i ED_i \cdot MV_i .$$

Where, C is the economic loss resulting from agriculture land degradation; ED_i is the amount of damaged things to its function i; MV_i is the monetary value of agricultural land to its function i.

Agricultural land is one of natural resources with ecological significance. Nowadays, environmental economics has advanced some ponderable estimate methods on the eco-environmental computation, which major points are to account the charge from viewpoints of the benefits caused by environmental quality and the prevention expense of environmental degeneration (Wang, 1993; Zhang, 1998).

2.1.2 Estimation model

To assess the economic losses resulting from the degradation of agricultural land in this study, it is necessary to determine the socio-economic damages in quantitative or semi-quantitative monetary forms (the fixed prices of 1999 are adopted for estimation purpose in this report). The factors causing farmland deterioration are many. Therefore, the general mathematical expression is given as follows:

$$C = \sum_{i=1}^{7} C_i ,$$

where, C is the total monetary loss due to agricultural land deterioration; C_i is the ith monetary loss, and

$$C_i = f(Q_i, P, \vec{V}_i),$$

where C_i is the economic loss resulting from farmland conversion to other uses, desertification, soil erosion and water loss, salinization, soil pollution, reservoir function degradation, and silting in waterways, respectively.

Q_i = amount or volume caused by the ith damage; P_i

= market price per unit of product caused by the ith damage; $\vec{V_i}$ = major coefficients in the ith damage;

The calculation methods of economic loss resulting from various forms of agriculture land degradation are: market value method, market value replacement and shadow engineering method. The major coefficients are as follows: annual increment of farmland area that cannot be tilled due to the land use change; economic loss per hm^2 of farmland created by desertification; yearly decreased area of farmland caused by desertification; soil erosion amount as an annual average; chemical fertilizer content of annual eroded soil; area increment of salinized tillage as a yearly average; yield or output value of farmland per hectare; total area of polluted farmland; yield or output value of farmland per hectare. Volume of lost storage capacity resulting from silt load.

2.2 Economic losses resulting from farmland deterioration

2.2.1 Economic losses of farmland due to excessive occupancy, waste and conversion to other uses

According to official statistics of the State Statistic Bureau, the national tillage acreage of 1.11×10^8 hm^2 in 1957 reached its maximum record (Bi, 2000; Li, 2000; Chen, 2000), and then, the general trend went down year after year. Since "the Land Management Law" was implemented in 1987, the tendency toward excessive occupancy, infrastructure occupancy in advance and farmland waste resulting from urban and rural construction projects has been contained to a certain extent. By the end of October in 1996, actually, China's tillage area was 0.95×10^8 hm^2 (Bi, 2000; Li, 2000; Chen, 2000). In the 10 year period from 1985 to 1995, farmland area has been cumulatively decreased by 6.79×10^6 hm^2 as a result of non-agricultural uses, agricultural structural adjustments, and calamity damages. In the period from 1986 to 1990, the yearly mean decrement of farmland area was 7.11×10^5 hm^2. Of this total, construction projects accounted for 1.77×10^5 hm^2 (25%); the use for agricultural structural adjustments made up 3.25×10^5 hm^2 (46%); and natural calamity damages, such as water scouring and sandification, accounted for 2.09×10^5 hm^2 (29%) (Li, 2000).

From 1992 to 1999, the annual cropland yielded 3880 kg/hm^2 of grain on the average[1]. If the yearly loss of farmland is 7.11×10^5 hm^2, taking 1.23 RMB Yuan/kg as the grain price (average market price in 1999) (Price Yearbook of China, 2000) and adopting the market value method for estimation purposes, then the annual economic losses stemming from farmland conversion during this period would be 3.39 billion RMB Yuan. Since lost tillage for other purposes, however, has a long-term influence on farmland yields, we taking 2.4% as the annual social discount rate, its present value is then 141.25 billion RMB Yuan.

2.2.2 Economic loss of farmland resulting from desertification

The economic losses of desertification harm exist in two aspects: tillage acreage reduction and a decrease in productivity. Since the farmland area reduction has already been included in the above farmland area loss resulting from calamity damages, therefore it should not be calculated repeatedly.

From a nationwide perspective, the annual loss of organic matter N, and P stemming from desertification may be as high as 5.59×10^7 t. This figure corresponds to approximately 2.68×10^7 t of chemical fertilizers and has a cost of about 17 billion RMB Yuan with a present price of 1999 of 29 billion RMB Yuan (Dong, 1989).

2.2.3 Economic loss resulting from soil erosion and water loss

Soil erosion and water loss have a grievous adverse impact on agricultural production, which can make crop yields decline to nothing. Since the cultivated area reduction has already been included in the part about natural calamity damages, only the part of soil nutrient loss should be taken into account in the monetary loss.

The yearly amount of eroded soil in China is approximately 5.0×10^9 t. It contains 40 to 50 million tons of N, P, and K fertilizers. This corresponds to 1.8 times as much as China's annual total output from its chemical fertilizer industry in 1995 (Department of Nature Conservation, SEPA, 1999). Using 1178 RMB Yuan/t as an average market price of chemical fertilizer in 1999 (Price Yearbook of China, 2000), then the monetary cost stemming from soil erosion would be 54.03 billion RMB Yuan.

2.2.4 Economic loss resulting from salinization

At present, the salinized land area in China has been increasing annually at a rate of 165000 hm^2. Under ordinary circumstances, cropland affected by slight salinization can decrease grain yields by 25%; medium salinization by 50% and severe salinization by 75% (Ning, 1998). Suppose the rate of grain production caused by salinization decreases by 1940 kg/hm^2 and the average market price of the grain is 1.23 RMB Yuan/kg, then the economic loss resulting from salinization would be 390 million RMB Yuan.

2.2.5 Economic loss resulting from soil pollution

Statistical data show that taking pesticide pollution alone, the area of polluted farmland is 1.6×10^7 hm^2. If other kinds of soil pollution are considered together with it, the decrease of grain yields caused by soil pollution is 1.25×10^9 kg/a. In addition, there are also more than 2.5×10^9 kg of polluted cereal crops per year (Li, 2000). If estimating the annual economic loss resulting from only soil pollution (polluted grain excluded due to data not available) in accordance with the market price of 1.23 RMB Yuan/kg. The result would be 1.54 billion RMB Yuan.

2.2.6 Economic loss resulting from deterioration of reservoir functions

Within the past half century, 85120 reservoirs nationwide with a storage capacity of 5.18×10^{11} m^3 have been built. It is evident that the build-up of silt seriously threatens various hydraulic engineering systems that are part of reservoirs. The siltation rate in China's reservoirs is 2.3% on an annual average (Jin, 1995).

Statistical record proves that in the past 50 years the lost volume of nationwide reservoirs due to siltation has made up about 1/10 of total storage capacity (Zhang, 1996), and the yearly mean lost storage capacity is 1.037 billion m^3. Suppose the storage capacity per cubic meter costs 2.25 RMB Yuan, the direct monetary loss would be 2.33 billion RMB Yuan. Since the economic loss of reservoir function deterioration has a long-term effect, and we taking 2.4% as the annual social discount rate, then its present value is

[1] The Center of Water and Soil Conservation, The Ministry of Water Resource: National Situation of Soil Erosion and Water Loss

97.08 billion RMB Yuan.

2.2.7 Economic loss resulting from the build-up of silt in waterways

The distance involved in interior water transportation was 157.7×10^3 km in 1949, while in 1990 it was 70×10^3 km, which represents a reduction by 55.6% when compared with 1949 (Department of Nature Conservation, SEPA, 1999). In the early 1990s, the cost of the reduced navigable distance in waterways stemming from build-up of silt was at least 1.5 billion RMB Yuan(Ren, 1997). Converting this figure into a fixed price at 1999 levels, the monetary loss was 3.0 billion RMB Yuan. Furthermore, the cost of increased investment for flood control must be considered. A conservative estimate in terms of the flood control investment in China's seven water systems, such as the Yellow River and the Yangtze River, shows that the yearly increment may be at least 300 million RMB Yuan(Ren, 1997). Converting this estimate into price levels of 1999, the present price could be 520 million RMB Yuan.

2.3 Analysis of economic loss stemming from degradation of agricultural land between 1992 and 1999 in China

To sum up the above-mentioned contents by taking into account the fixed prices at 1999 levels and the discount rate of 2.4%, the calculation proves that the yearly direct economic losses stemming from degradation of agricultural land in China would be at least 326.81 billion RMB Yuan. Thus it can be seen that:

(1) Of the various losses, the greatest one is the loss caused by reduction in farmland area and its conversion into alternative uses. This loss accounts for 42.5% of the total. Secondly, the deterioration of reservoirs makes up 29.9% of the total(Table 1). The fundamental reason lies in the fact that the implementation of the policies of "Economic reform" and "Open the door to the outside world" has resulted in swift development in urbanization and socio-economy, as well as serious waste of cropland. These things have made China's tillage area appear to suffer a gradual net decrease after balancing the new cultivated land and that which has been lost.

(2) Socio-economic growth has aggravated soil pollution. In the past ten years, with the development of urbanization, industrialization and chemical agriculture, the issue of soil pollution continues to get worse. The monetary loss caused by the decline in grain yield has already exceeded the one caused by salinization (the monetary loss of grain quality degradation resulting from soil pollution excluded). Consequently, there is an urgent need to take some necessary countermeasures in order to mitigate the soil pollution.

(3) It is still true that the main concentrating factor to tillage degradation is soil erosion. Besides a reduction in the area of cultivated land, soil nutrients being washed away and grain quality worsening, the losses due to a lowering of reservoir capacity and build-up of silt in waterways hold a considerable portion.

China's annual economic loss stemming from cultivated land degradation in the early of 1990s was 59.3 billion RMB Yuan(Ning, 1998). Converting this figure based on the 1999 price index, the result is a present price of 110.96 billion RMB Yuan(Table 2).

Table 1 Annual economic loss stemming from cultivated land degradation in China (fixed price in 1999)

Classification	Method of calculation	Major coefficient	Pecuniary loss, billion RMB Yuan	Proportion, %
Farmland conversion	Market value method	· Annual decrement of farmland area	141.25	43.2
Desertification	Market value method	· Economic loss per hm^2 of tillage caused by desertification · Yearly reduced area of tillage caused by desertification	29.00	8.9
Soil erosion & water loss	Market value replacement method	· Soil erosion amount in annual average · Chemical fertilizers contents in annual eroded soil	54.03	16.5
Salinization	Market value method	· Area increment of salinized cropland on yearly average · Yield or output value of farmland per hectare	0.39	0.1
Soil pollution	Market value method	· Total area of polluted farmland · Yield or output value of farmland per hectare	1.54	0.5
Reservoir function deterioration	Shadow engineering method	· Volume of lost storage capacity resulting from silt load · Yearly engineering investment required per cubic meter of storage capacity	97.08	29.7
Waterways silting-up	Shadow engineering method	· Yearly mean decrement of inland water navigable mileage resulting from siltation · Cost per kilometer for silt removal	3.52	1.1
Total			326.81	100

Table 2 Annual economic losses stemming from degradation of farmland in China, 1992

Classification	Method of calculation	Major coefficient	Monetary loss, billion RMB Yuan	Converting to 1999, billion RMB Yuan	Proportion, %
Farmland conversion	Market value method	· Annual decrement of tillage area	14.4	26.9	24.3
Soil erosion & water loss	Market value replacement method	· Soil erosion amount in annual average · Chemical fertilizers contents in annual eroded soil	16.2	30.3	27.3
Salinization	Market value method	· Area increment of salinized cropland on yearly average · Yield or output value of farmland per hectare	0.5	1.0	0.8
Reservoir function deterioration	Shadow engineering method	· Volume of lost storage capacity resulting from silt load · Yearly engineering investment required per cubic meter of storage capacity	25.0	46.8	42.2
Waterways silting-up	Shadow engineering method	· Yearly mean decrement of inland water transportation mileage resulting from siltation · Cost per kilometer for silt removal	3.2	6.0	5.4
Total			59.3	111.0	100.0

The economic loss resulting from five aspects (farmland area reduction, soil erosion and water loss, reservoir function deterioration, siltation in waterways, and salinization) in 1999 was 2.67 times as high as that in 1992. In this amount, the greatest increment of monetary loss comes from the different forms of farmland occupancy and waste, while salinization loss appears a trend of being controlled.

Since China's tillage acreage continually declined over a long term, the yearly decrement of cropland at the end of the 20th century is greater than it was in the early of 1990s. On this account, the monetary cost appears to be increasing trend. To probe its roots, the reasons would be:

(1) Urban areas and townships developing swiftly. The percentage of urbanization between 1992 and 1997 has been enhanced from 27.63% to 29.8%, and there was an increasing rate of 2.17% within the past 5 years. In the three years of "the craze of economic and technical development zone" from 1992 to 1994, 7.3×10^3 hm^2 of cultivated land was occupied for other purposes (Li, 2000).

(2) Existing problem of land being excessively occupied and wasted. Many towns, especially medium and small towns, blindly expand outwards. In the period from 1992 to 1996, 1.16×10^5 hm^2 of unused land was left in China. Of this total there were 6.28×10^4 hm^2 of fertile farmland and it made up 54% of all idle land. To date, there is 3.45×10^4 hm^2 of unused farmland that is now difficult to till due to sealing of soil, destruction of structure and a wearing down of soil fertility (Du, 2000).

(3) Serious flood and other calamities. In 1998, China has been hit by catastrophic floods, which brought about a series of destructions including submerging of tilled land, soil erosion, build-up of silt in reservoirs and the waterways choked with silt. On this account, the annual economic loss stemming from soil erosion is more than that in the early of 1990s. The serious reservoir siltation in the 1990s led up to reductions in storage capacity; as a result the monetary cost due to reservoir function degradation has been enhanced by an average of 107.7% per year.

Gratifyingly, in the most recent few years the monetary loss resulting from salinization has gone down by 61.4%, a marked decrease. The reason for this is that governments have devoted major efforts to remedy salinized fields. On the other hand, the utilization rate for salinized cropland has been increasing, as scientific and technological development occur year in year out. With regard to the calculation on the cost due to the build-up of silt in, a conservative estimate in the early of 1990s indicated that its economic loss would be at least 1.8 billion RMB Yuan. Converting this figure to the fixed price in 1999, the pecuniary loss is 3.52 billion RMB Yuan.

3 Conclusions

China's total economic loss stemming from the seven items as shown in Table 1 in 1999 was 326.81 billion RMB Yuan, which accounted for 4.1% of GNP at that time; the monetary cost of five items (farmland conversion, soil erosion, salinization, decline in reservoir functions, and siltation in waterways) stemming from land degradation was 296.27 billion RMB Yuan in the same year, and this figure constituted 3.7% of the GNP at that time. In 1992, however, the loss in the same five items constituted 2.2% of the GNP. Only seven years have passed, and the percentage has increased by 1.5%. It can be seen from this that the adverse effects on this national economy from land degradation is growing year after year.

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