Sustainable Development and Ending Poverty in Bashang: With the Observations for Thirty Years (A Case)

Dayuan Hu and Xinjie Wang (Peking University)

Abstract: Bashang region of Hebei Province is located at the southeast of the Inner Mongolia Plateau, which is the nearest chronically poverty-stricken area to Beijing. Over the past century, reclamation led to deterioration of ecological environment and difficulty in agricultural development. During the past 30 years, great changes have taken place in the ecological environment and living conditions in Bashang. However, there are different opinions on how to achieve sustainable development through improving ecological environment in different periods. Tracing back to the 1980s, 1990s and the first 10 years of this century, we see what happened in Bashang and nearby regions and then discuss decision-making according to the changing situations, so as to explore the way of sustainable development and ending poverty.

1. Reclamation, Land Degradation and Poverty

1.1 Land desertification in the world

It is widely recognized that accelerated soil erosion related to agricultural activities is a serious global problem. According to the United Nations Environment Program (UNEP) (1991), each year, crop productivity on about 20 million ha is reduced to zero or becomes uneconomic because of soil erosion. Two primary natural causes of soil degradation are water erosion and wind erosion. The seriousness of land degradation and soil erosion on each continent is shown in Table 1-1.

Table 1-1. Global Extent of Land Degradation

Regions	Percentage of Degraded Inhabited Land (%)	Land Area Affected by Erosion (million ha)	
		Water Erosion	Wind Erosion
Africa	27	227	186
Asia	31	441	222
South America	18	123	42
Central America	--	46	5
North America	12	60	35
Europe	26	114	42
Oceania	19	83	16
World	**24**	**1094**	**548**

Source: Oldeman (1992)

Although wind erosion is only about half of water erosion by affected land areas on a world scale, the problem is severe in many semiarid and arid regions. In eight of ten great plain states in the U.S., wind erosion exceeds water erosion (Brady 1990). About 1.9 million ha of croplands have been damaged annually by wind erosion in the Great Plains since 1955 (Benson and Napier 1984).

Semiarid and arid regions experiencing wind erosion account for about one-third of the world's area and contain about one-sixth of the world's population (Gore 1979). The total area in the world prone to wind erosion is estimated to be around 20 percent of the land area (Zachar 1982). Wind erosion is not a recent phenomenon, but human activities have accelerated this problem around the world.

Nearly 3.6 billion ha or about 70 percent of all agriculturally-used dryland is affected by various forms of land degradation, including human-induced desertification (UNEP 1991). Wind erosion has been considered the principle factor responsible for desertification (Lal 1994).

Nearly 260 million ha of cropland or 72 percent of the total dry cropland is degraded (UNEP 1991). The percentage of degraded rangeland was estimated to be 63% by Mabbutt (1985), 80% by the Board on Science and Technology for International Development of the Office of International Affairs (1990), and 73% by UNEP (1991). Degraded rangeland of 3.3 billion ha comprises the largest area of desertified agricultural lands in the world (UNEP 1991). Rangeland degradation caused by overgrazing is a particular concern in developing countries. In many temperate or semi-arid regions, a main consequence of overgrazing is accelerated wind erosion (Mabbutt 1985).

1.2 Land desertification in China

In North China, wind erosion is considered one of the most important forms of dryland degradation, and wind erosion has been accelerated by inappropriate use of land by humans and their animals (Zhu and Liu 1981). In late 1970s, the total desertified land in China was estimated to be 170,000 km^2, approximately 30 percent of which has been created since 1920 (Zhu 1982, cited in Kebin and Kaiguo 1989).

Wen (1993) summarized investigation in China in late 1980s. The historically formed desertified land was estimated about 12 million ha, the modern desertified land formed in five decades of the mid 20 century was 5.6 million ha, and the potential desertified land was about 15.8 million ha. Thus the total desertified land would be 33.4 million ha, nearly double of the previous estimation. During the same time period, about 4 million ha of croplands, 5 million ha of rangelands, and 35 million people in 212 counties were threatened with serious desertification.

According to a report (Research Group 1998) of Study on Combating Desertification/ Land Degradation in China, "Desertification is closely related to human activities, i.e. desertification process is a process of environmental degradation and relevant social-economic decline induced mainly by human activities". In 1990s, the total desertified/degraded land in China was estimated to be 66.4 million ha. Table 1-2 shows that wind erosion is much more than water erosion by affected land areas in China.

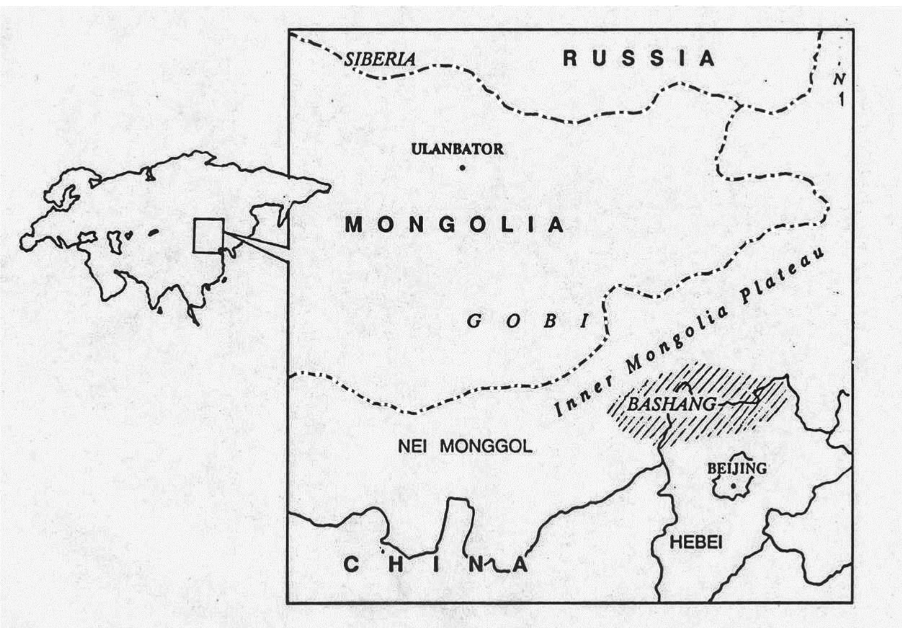
Table 1-2. Desertification in arid, semi-arid and dry sub-humid areas in China (million ha)

Extent	Wind Erosion and Accumulation		Water Erosion		Physical and Chemical actions		Total	
	area	%	area	%	area	%	area	%
Strong	9.54	25.8	4.80	22.2	1.42	17.9	15.76	23.7
Moderate	11.56	31.3	4.66	21.6	2.61	33.2	18.83	28.4
Light	15.80	42.9	12.14	56.2	3.87	48.9	31.81	49.9
Total	**36.90**	**55.6**	**21.60**	**32.5**	**7.90**	**11.9**	**66.4**	**100**

Source: Research Group of Study on Combating Desertification/Land Degradation in China (1998)

The Inner Mongolia Plateau is located in northern China. The southeastern part of the plateau is called **Bashang,** covering 18,391 km^2 (Ma 1999), and is located partly in Hebei and partly in Inner Mongolia (Nei Monggol). Within Hebei province, Bashang includes 4 counties (Zhangbei, Guyuan, Kangbao, and Shangyi) in Zhangjiakou, and 2 counties (Fengning and Weichang) in Chengde,

Figure 1-1 Bashang and other upwind regions of Beijing



Until the beginning of this century, most of the Bashang region was grassland, with few nomadic herdsmen and a small number of cattle and sheep. During the past century, population in the region has rapidly increased, primarily due to an influx of settlers. From 1950 to 1985, Inner Mongolia was experiencing the most rapid population growth in China (Population Census Office of the State Council of China and the Institute of Geography of Chinese Academy of Science 1987). The population in the central Bashang region has increased fivefold during this period (Ma et al. 1988). In consequence, more and more grasslands were cleared for crops over the past several decades.

1.3 Three reclamation movements in Bashang

Cultivation has only a history about 100 years in Bashang. The first reclamation movement in Bashang took place around 1870~1880 with occasionally migrants' individual reclamation, and then gradually became large scale reclamation with more and more migrants moving to Bashang. For example, the total population of Zhangbei County was only 30,360 in 1730s, then increased to 100,300 around 1890s, and reached 208,896 in 1927.

The population of Weichang County was 36,399 in 1902. After the officially allowed reclamation in 1906, the number of migrants surged to 75,728 in 1908. However, until the early 1950s, Residents in Bashang were mainly relied on production of animal husbandry. Original vegetative cover in grasslands had not been damaged, and the natural landscape of Bashang still maintained pastoral style (Wang et al. 1991).

The cultivated area in Bashang expanded gradually. According to the research results of Zhao et al. (1997), the total croplands in 1949 was estimated as 350,000 ha， accounting for 20% of the total area in Bashang. In second half of last century, there were three reclamation movements with rapid population growth and increasing demand for grain. The first reclamation movement in Bashang was from 1950 to 1957. By 1957, about 488,000 ha of croplands were registered.

The second reclamation movement was from 1958 to 1965. Bashang was decided by local government officials as the key reclamation area. They made a combat task to cultivate 10 million mu (666,667 ha) grasslands within 3 years. By the end of 1965， 536,000 ha of farmlands has been registered, reaching the crazy reclamation peak period. However, the dominate farming practice still remained "rove around", a conventional farmland rotation, with farmers arbitrarily leaving some farmlands uncultivated in order to maintain soil productivity.

It was estimated that the real reclamation area at that time was around 103,000 to 107,000 ha， illegal black cropland started to appear from then on. Although registered farmland area was gradually decreasing since 1965, reclamation in Bashang never stopped.

The third reclamation movement was from the late 1970s to early 1980s. Table 1-3 shows: the actual cultivated land area of Bashang in 1984 was 716.4 (000ha), which was 152.1% of the registered cultivated land in that year, according to the national soil survey. Consequently the actual reclamation index (cultivated land area/total land area) of Bashang reached 41%, and there was an increasing tendency from east to west and from south to north. The difference between the actual cultivated land and the registered cultivated land increased from west to east. (Zhao et al. 1997)

Table 1-3. Survey Farmland vs Registered Farmland in Bashang

	Zhangbei	Kangbao	Guyuan	Shangyi	Fengning	Weichang	Total
Survey (000ha)	207.8	201.5	164.2	83.2	48.2	11.5	716.4
Registered (000ha)	143.3	120.4	111.3	63.1	27.7	5.2	471.0
Total land (000ha)	419.6	339.5	362.5	155.1	202.7	257.7	1737.1
Survey/Registered	1.45	1.67	1.47	1.32	1.74	2.24	1.52
Survey/Total	0.50	0.59	0.45	0.54	0.24	0.04	0.41

(Source: Zhao et.al. 1997)

The total crop sown area changed along with the cultivated land area. According to the registered calculation, the ratio of total crop sown area to cultivated area generally varies from 95% to 98.9%, showing a high utilization rate of cultivated land, which is related to the fact that a part of abandoned croplands and large number of newly reclaimed lands were not counted. From 1949 to 1994, the cultivated land area increased by 28.59%, while the sown area of crops increased by 31.54%, exceeding the growth rate of cultivated land area.

1.4. Reclamation in Bashang during 1980s

When the vegetative cover is removed, erosion is accelerated. With the strong winds in Bashang, several centimeters of topsoil, which would take a thousand years to form, can be lost in a few windy seasons without the protection of range grass (Guyuan Ranch 1985).

1.4.1 Desertification and Reduction of Average Crop Production

The Bashang region is characterized by dry weather and strong winds, particularly in winter and spring. Conventional farming practice (plowing) clear the natural vegetative cover, lead to accelerated soil erosion. Every winter and spring, when vegetative cover is least, very strong winds from Siberia to the Pacific Ocean pass the Bashang region. Wind blowing across unprotected soil accelerates the evaporation of soil moisture, making the soil more prone to wind erosion.

From 1975 to 1987, desertification land area in Bashang expanded rapidly, from 2522.78 km^2 to 4608.61 km^2, with an increase of 2055.53 km^2 and an average increase rate of 82.68%. The fastest growing segment is the aggravating desertification land, which extended from 2281.24 km^2 to 4010.71 km^2, with an increase of 1729.47 km^2, accounting for 82.92% of the increased desertification land area. (Wang et al. 1991)

Ma Li (1999) compared two soil quality surveys in 1960 and 1978, and found that the average organic matter in all kinds of soils decreased by 1.45% in 18 years. The prominent manifestations of this soil degradation process are: the rapid wind erosion and desertification, the sharp reduction of available agricultural land area. The wind erosion and desertification land area reached 639,000 ha in four western counties of Bashang. In mid 1980s, the ratio of desertified land to total land area was 24.2% in Zhangbei, 39.6% in Kangbao, and 27.4% in Shangyi, while the same ratio was up to 60-67.5% in nearby Inner Mongolia counties, such as Huade and Shangdu. Bashang become a typical severely desertificated region.

As a result, land productivity severely declined and there were less suitable lands for reclaiming and crop rotation. Soil fertility of most of the land decreased due to years of cultivation and wind erosion, resulting in lower crop yields and larger desertification area. Followed by that, grain production was vulnerable and kept decreasing. For example, in Fengning, grain production was 1335kg/ha in 1960s, 1275kg/ha in 1970s, 900kg/ha, while only 450 kg/ha in 1988 (Research Group of Study on Combating Desertification/Land Degradation in China 1998) .

From 1949 to 1979, although the total grain output of the four western counties in Bashang increased by 2.3 times, the faster population growth caused a decline in the per capita grain output, which was 909 kg in the 1950s and 809 kg in the 1970s. (Wang et al. 1991)

1.4.2 Overgrazing and Rangeland Degradation

Grassland traditionally used for grazing was first reclaimed in Bashang. According to statistics, the grassland area in 1949 was about 1,500,000 ha, accounting for more than 80% of the total area. By 1980, the grassland area had reduced into about 420,000 ha, accounting for only 23% of the total area (Ma 1999). From 1959 to 1978, the area of grassland in four western counties of Bashang decreased from 380,000 ha to 78,000 ha, with a decline of 80%, and the land for animal husbandry decreased from 730,000 ha to 230,000 ha, with a decrease of 68%. The area of grasslands including grazing streambanks in nearby Fengning County also decreased from 61,000 ha in the late 1950s to 13,000 ha in the early 1980s, with a reduction of 78%.

As population in Bashang increased, large scale reclamation caused a dramatic reduction in grassland area. However, at the same time, number of livestock also increased greatly. In the long run, over-grazing of grassland led to serious degradation. In 1980, there were still 420,000 ha natural grasslands in Bashang, but overemphasizing the increase in livestock number break the balance of grassland and livestock. In the mid-1950s when Guyuan Ranch started, per hectare rangeland can raise 2 sheep, so that the stocking capacity was 2.1 Chinese standard livestock per ha. By 1983, due to the degradation of the rangeland, it needed a rangeland of 1.3 hectare to raise a sheep. The gap between the grass needed and actually yield was as high as 58%. (Guyuan Ranch 1985)

The long-term overgrazing of grassland damaged the regeneration capacity of grassland, degradation in the original top layer vegetative cover reduced the yield and quality of herbages. According to Guyuan Ranch Survey, in 1952, the vegetative coverage of rangeland was 90%, the height of grass was 50-l00 cm, the forage yield per ha was 4500-6000 kg, and the high quality forage accounted for 58%; in 1956, the vegetative coverage of rangeland was 75%, and the forage yield per ha was 3750-4500 kg; in 1964, the coverage of grassland was 60%, and the forage yield per ha was 3000-3750 kg; in the late 1970s and early 1980s, the degradation of rangeland was aggravated, with only 40% of grass coverage， 15-20 cm of grass height and 900-1500 kg of forage yield per ha. The proportion of weeds and poisonous grasses increased, and the high-quality forage accounted for less than 40%. (Guyuan Ranch 1985)

With the reduction in grassland quality, the summer grazing time had to be extended, the source of forage supplementation in winter and spring was insufficient, and the ability of livestock resisting natural disasters was getting worse. The area of rangeland in Zhangbei, Kangbao and Shangyi counties was 70% less than that in the 1950s, and the forage yield in rangeland decreased by 70-80%. Sheep and cattle did not have enough forage for most of the year. Their health conditions and production ability greatly worsen and their ability to prevent of disasters was getting weaker. During a heavy snow in spring 1979, more than 5,000 cattle and 50,000 sheep died in four Bashang counties. (Wang et al. 1991)

1.5 Damaging Ecological Balance Increased Poverty

Bashang is located on the southern edge of Inner Mongolia Plateau at average elevation of 1000 meters. There is a typical continental climate with a long severe cold winter, and an average of 40 to 70 strong windy days per year. The maximum windstorm days per year are 119, and the largest wind speed is 25 meters per second. Along with strong winds, Bashang has low precipitation with an average from 367 to 479 mm per year. (Zhao, 1997)

In the 1950s, most of Bashang area had excessive precipitation. But in the 1960s, there was a decreasing precipitation trend from northeast to southwest of Bashang. In the 1970s, there was less rain in Bashang with an exception of Shangyi County. In the 1980s, rainfall continued to decrease and the drought is aggravating (Liu 1994). There were insufficient water supply and poor irrigation conditions, so that the crop production was greatly affected by weather conditions varying from year to year, as shown in Figure 1-2 and Figure 1-3. (Source: Guyuan Ranch 1985)

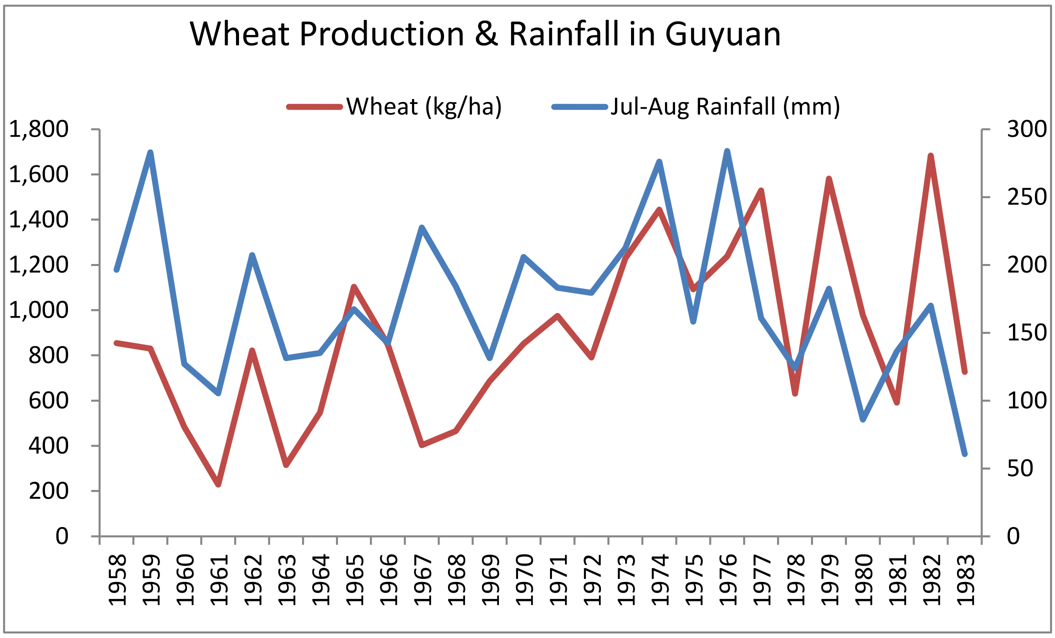


Figure 1-2 Crop production and rainfall

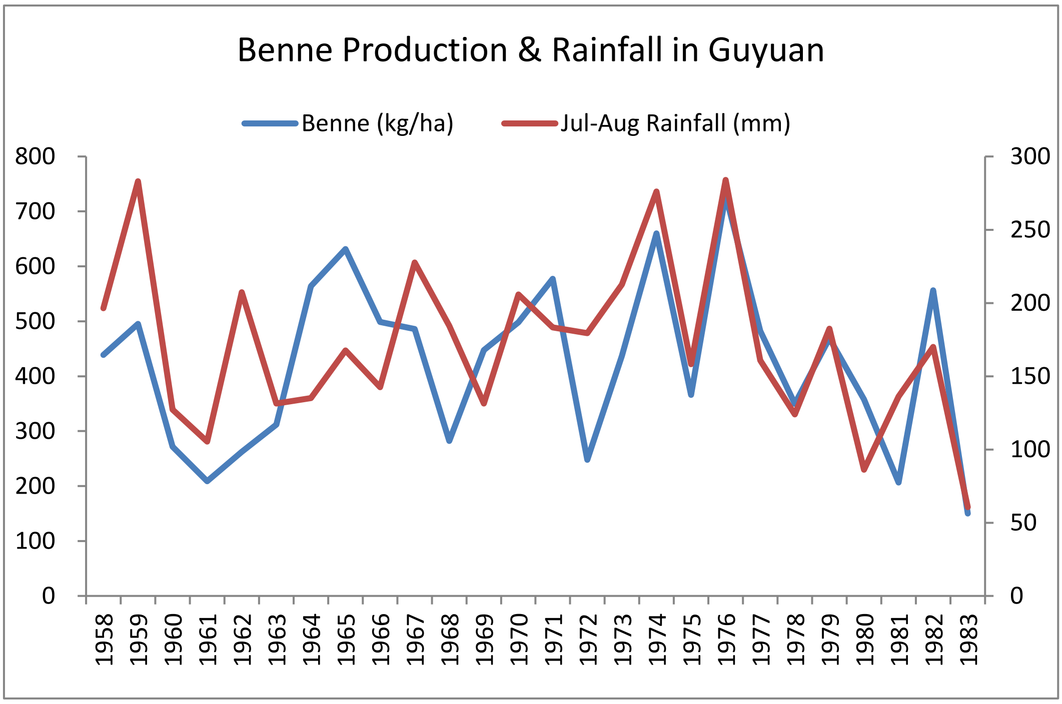


Figure 1-3 Benne production and rainfall

For a long time, grain production played the critical role in nationwide government agricultural policy, however limited by the severe weather conditions in Bashang, large areas of cultivated land produced low and unstable yields, as shown in Figure 1-4. At the same time, the animal husbandry and rural industry received much less support for development.

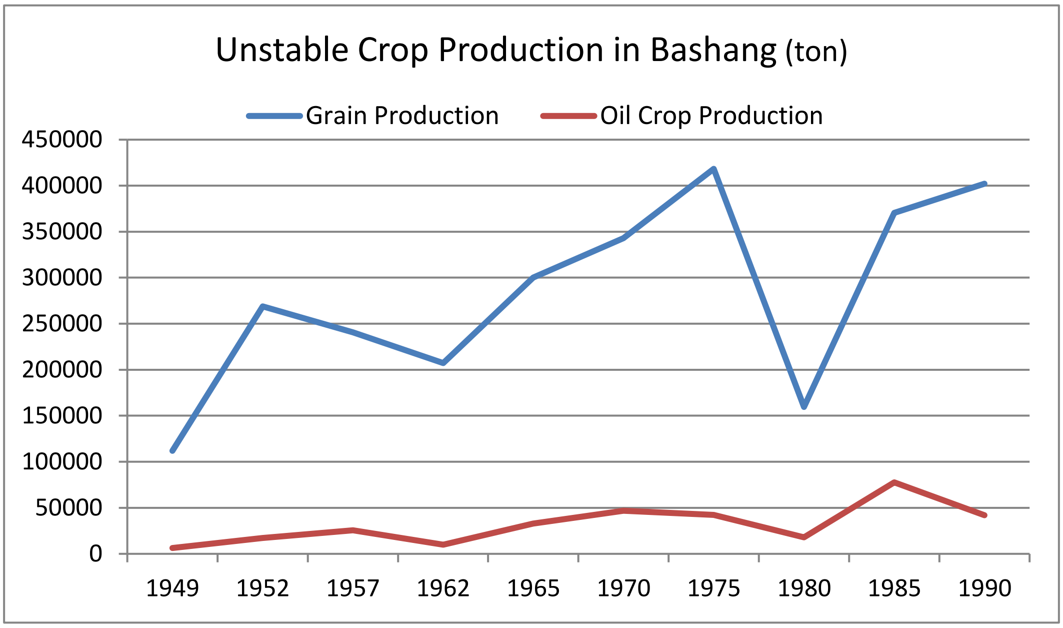


Figure 1-4 Unstable Crop Production in Bashang
Data Sources: 1) Zhao et al. 1997, 2) Statistic Bureau of Hebei Province.

As a result, from 1958 to 1979, the per capita rural income in the four western counties of Bashang fluctuated between 60 and 80 yuan/year, (Wang et al. 1991) much lower than the rural poverty line of 120 yuan announced by the government of Hebei province in the early 1980s. (Hebei Economic Statistics Yearbook 1986)

High population density, single production structure and poverty are three primary socio-economic characteristics closely linked together in desertified areas in China. To meet the need of population growth, grain production was overemphasized by central government. In vulnerable ecological areas, converting grassland to cropland in purpose to meet the current needs for livelihood, however leads to degradation of natural resources, eventually declines agricultural productivity and results in poverty.

From the 1950s to the 1980s, the industrial structure of Bashang area has changed from pastoral to agro-pastoral style. However, the local farmers still followed the traditional management mode in the “roving around” time. Their input to land is far less than taking from land, leading to a decline in soil fertility, and eventually turning the dropped cropland to aggravating desertification land. Figure 1-5 shows a drop in crop land since 1960s. In order to increase the total agricultural output, farmers had to reclaim more grasslands, thus trapped themselves in a vicious circle of reclamation and poverty.

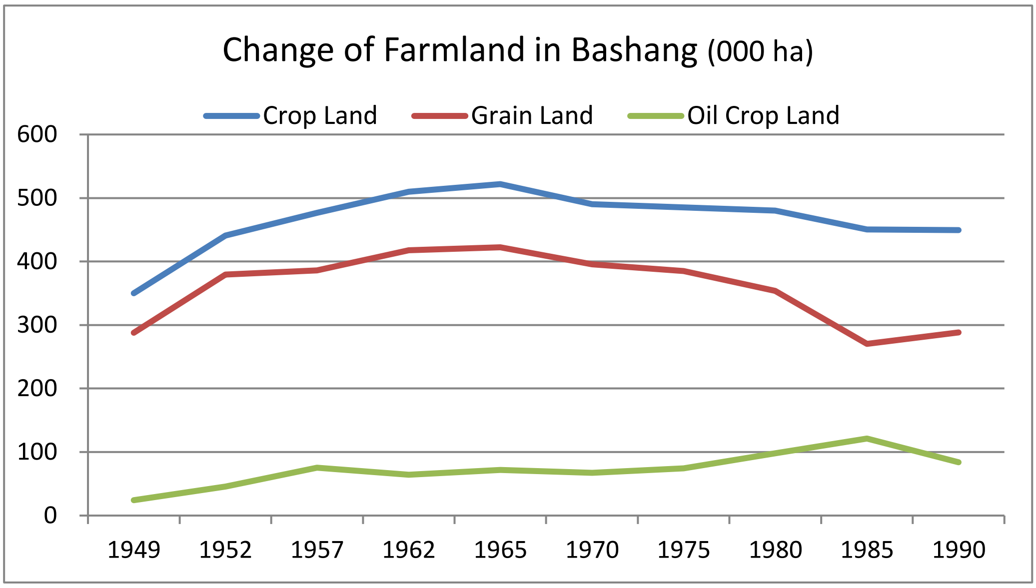


Figure 1-5 Change of Farmland in Bashang

During the same time period, two factors also contribute to overgrazing of rangelands: lack of property rights and regulation ability. All rangelands in Bashang are state property, but the central government does not have adequate capacity to regulate farmers' behavior. As a result, many rangelands in Bashang effectively had been open access, available to nearby farmers.

Besides, the total number of animals had been used by the government as the primary statistical measure of achievement in livestock production during the same period. Consequently, increasing animal stock was encouraged and its effects on grass stock, soil loss, and animal performance were ignored. These problems have been realized and the situation has been changed since the late 1980s. Although property rights issues are far from resolved, both central and local governments have attempted to solve the overgrazing problem by reducing animal stocking rate. (Hu et al. 1997)

1.6 How to Break the Vicious Circle of Poverty and Ecological Degradation?

Even in 1980s, not only farmers but also government officials recognized that it was necessary to change agricultural production structure according to particular situation and relative advantages in Bashang. However, many problems had to be solved, such as poverty, population pressure, animal stocking rate, change of production structure, economic institutional reform, erosive croplands and overgrazed rangelands. The complex linkages between the changing social-economic system and unbalanced ecological system made the solution exploring process very challenging.

Ma (1988) and his colleagues in the Agricultural University of Hebei analyzed the social-economic system and ecological system in Bashang using the system dynamic method. Their research approaches are summarized as follows.

1. Identify the main problems based on field experiments in the Guyuan Ranch
    a) Problem of livestock production and overgrazing rangelands. The increasing population need more food and want improve the living standard. But the overgrazed rangelands could provide less and less forage for animal husbandry.
    b) Difficulty in adjusting production structure. Returning croplands to grasslands or forestlands would result in reduction of crop production, leading to lack of food supply for local residents.
2. Analyze the causal relationship of the social-ecological system
    a) From a dynamic perspective, the relationship among population growth, crop production, animal husbandry, energy consumption and financial resources were analyzed in a social-ecological system of the Guyuan Ranch.
    b) Appropriate assumptions and mathematical methods were used to develop a system dynamic model according to the causal relation analysis in the social-ecological system.
3. Utilized the statistic and experimental data collected in the Guyuan Ranch to train and adjust the parameters of the system dynamic model.
4. Discuss the model simulation results interactively with the experienced decision makers, and then test the solutions in the following years.

Their major findings and concluding remark include:

1. To beak the vicious circle of poverty and ecological degradation, one should consider the social-ecological system as a whole, and explore solutions in the interactive and dynamic perspectives, making adjustments or changes based on practice.
2. With the statistic and experimental data of the Guyuan Ranch, the simulation results show that rapid returning cultivated lands to grasslands or forestlands could lead to a number of negative influences in agricultural production as well as farmers' income.
3. Ecological and economic benefits should be taken into consideration at the same time. So is the short-run and long-run effects. The ecological environmental improvement could play more important role in the long run.
4. In policy making and government official evaluation of the ecologically unbalanced region, such as Bashang, one should make judgement based on relatively longer time and from more comprehensive perspectives.

Appendix

System dynamics was originally developed by Prof. Jay W. Forrester of MIT. System dynamic models has been frequently used to study social-economic problems from 1980s to 1990s when system engineering methods were popular in China. For further study, refer to MIT SDEP: what is System Dynamics.

Introduction of system dynamic model:

The central concept to system dynamics is understanding how all the objects in a system interact with one another. System dynamic model deals with understanding how complex systems change over time. Internal feedback loops within the structure of the system influence the entire system behavior.

System dynamicists look at things as a whole. The objects and people in a system interact through "feedback" loops, where a change in one variable affects other variables over time, which in turn affects the original variable, and so on.

What system dynamics attempts to do is understand the basic structure of a system, and thus understand the behavior it can produce. Many of these systems and problems which are analyzed can be built as models on a computer.

System dynamics takes advantage of the fact that a computer model can be of much greater complexity and carry out more simultaneous calculations than can the mental model of the human mind.

Two examples of important questions addressed by system dynamics models are:

- What causes American cities to degenerate? And what can be done to revitalize these stagnant urban areas? (Forrester 1969.)
- Can the Earth's resources support mankind, with its present economic and population growth rates, in the next millennium? What can be done to confront possible global collapse? Is a sustainable future possible? (Meadows, et al. The Limits to Growth. Universe Books. New York: 1972)

(For further reading, refer to: http://web.mit.edu/sysdyn/index.html and http://web.mit.edu/sysdyn/sd-intro/)