CHINESE GEOGRAPHICAL SCIENCE
Volume 9, Number 2, pp. 120– 125, 1999
Science Press, Beijing, China

MODIFICATION OF AGRICULTURE LANDSCAPE IN THREE-RIVER AREA IN XIZANG

Wang Jiaji(王家骥) Gao Jixi(高吉喜) Shu Jianmin(舒俭民) Jian Xiaodong(菅小东)
Li Jingrong(李京荣) Chang Hong(常 虹) Tong Yan(童 岩)
Institute of Ecology, Chinese Research Academy of Environmental Sciences, Beijing 100012, *P. R. China*
(Received 24 August 1998)

ABSTRACT: The three-river area (the middle drainage area of the Yarlung Zangbo River between its tributaries of the Lhasa River and the Nyangqu River) is a rapid economic development area in Xizang(Tibet) Autonomous Region. As the weather in this area is frigid with frequent wind and little rain, the eco-environment condition is extremely bad, and the resistance and rehabilitation ability of the landscape system is weak. Therefore, in the implementation of agriculture development program in the area, it is not advisable to adopt the traditional method of changing grassland to agriculture land, instead, the agriculture landscape in the area should be modified. The primary contents of the modification plan are to improve the middle and low-yield fields to the high-yield fields with irrigation system, to transform the dry land on the slopes, uneven land, dry and low-yield fields to forest or grassland. So the problem of food demand will be solved and the degenerating trend of eco-environment will be controlled.

KEY WORDS: three-river area, modification of agriculture landscape, Xizang

The three-river area (the middle drainage area of the Yarlung Zangbo River between its tributaries of the Lhasa River and the Nyangqu River) is an economic developed region in Xizang Plateau. In recent years, with the population growth and the rapid economic construction, desertification of the river valleys here is becoming surprisingly fast, and the degraded pastures have been up to 23.1% of the total pastures, of which the desertified pastures have been up to 2.7% of the total. Thus, stopping the trend of rapid degradation of the eco-environment, and recovering and improving the degraded pasture of the natural resources caused by the interference of the human beings in a maximum degree are the focus of the agriculture development program. Modification of the agricultural landscape's structure has become the only way to go to a sustainable progress of economy and society in the area.

1 BASIC PATTERNS OF ECO-ENVIRONMENT IN THE THREE-RIVER AREA

1.1 Low Net Vegetation Productivity and Slow Soil Regeneration

The three-river area lies in the middle reaches of the Yarlung Zangbo River, with an area of 65 thousand square kilometers, including three prefectures (Lhasa, Xigazê, Shannan) and 18 counties and cities. Because of a high elevation and low temperature, net productivity of the vegetation here is only about one fourth of the average of the whole country, and soil regeneration is rather difficult.

According to the report by Liu Shuangjing (1990), in tropical and temperate zones, it takes 200– 1000 years to generate a layer of surface soil of 2.5 cm or 340 t/ha. While in the three-river area

where the average temperature is 4.7– 8.3℃ and the average rainfall is 251.7– 508 mm and aridity is 5– 10, it takes over 1000 years to generate the same thickness of surface soil, and regeneration speed of the soil here is lower than 0.3 t/ ha.

Since China's reform and opening to the outside world, along with the economic development and population growth, the reclamation of grassland for farmland in this area has been speeding up. As the reclamation has destroyed the grass layer of the plateau, soil loss increases from less than 10 t/ ha to more than 50 t/ ha, therefore soil desertification speeds up.

According to the prediction made by Lanzhou Institute of Desert Research, the Chinese Academy of Sciences, if the present occupation quality of the cultivated land per capita remains unchanged, due to the growth of population (1.896% per year) and the increasing of livestock (1.66% per year), the desertified area will increase by 12.2% and 26.3% respectively from the present 181.6 thousand ha by the year 2000 and 2010. This will make the contradiction between economic activities of human beings and fragile eco-environment become more acute.

1.2 Contradiction Between Rapid Population Growth and Lower Agricultural Productivity Deepens Gradually

By taking seven counties in Lhasa City as an example, it is found that in 1990 children under 15 years old were 30% of the population, people over 65 years old were only 3.4%, so the middle-aged was 23.8. Proportion of child-bearing group is going to be bigger, birth rate and natural growth rate of population are sure to become higher, a birth peak will occur in the coming 10 years. On an average, population growth in this region is 1.5%. The predicted relationship between population growth and agricultural productivity is shown in Table 1.

Table 1 Agricultural productivity and population growth

Item	1990	2000
Population (thousand)	784.5	949.1
Cultivated land per capita (ha)	0.21	0.18
Yield of grain (kg/ ha)	2257	3510
Yield of oil (kg/ ha)	967.5	1961
Average grain per capita (kg)	439.8	360.5
Average oil per capita (kg)	15.2	12.6
Average meat per capita (kg)	18.2	15.2

1.3 Disturbance Intensity to the Natural Environment Increases Day by Day

The disturbance of human beings to natural environment in the area appears in the following three aspects: forest destruction, over-grazing and over-reclamation.

The three-river area is densely populated and short of energy. Agricultural and living energies mainly rely on dung and firewood. It is deduced from typical survey that firewood used as fuel is about 0.175 billion kilograms every year. Except for a small amount purchased from Linzhi and Yadong forestry centers, most of the firewood is cut on crude arbors and shrubs in this area.

Calculated at the biomass of 11 t/ ha, there would be about 15 909 ha of crude forest ruined each year. In 1989, the area of forests in Lhasa alone had been reduced by one-third compared to that 30 years ago. Over 76% livestock in the area is concentrated in the river valley area.

For a long time, because of the unplanned production, blindly pursuing the amount of livestock on hand, and continuous expansion, the grass-cattle contradiction becomes prominent, which causes the cold season pasture over-grazing, and the productivity of the pasture is destroyed seriously. Besides drought, rats and pests disasters are speeding up the pastures' desertification. According to the statistics of 1990, the degraded pasture area went up to 9 723 000 ha, rats-ridden area was 1161.4 ha. In the worst rats-ridden areas, productivity of the pastures was reduced by 35% – 40%

According to the statistics of 1988, the sown area of the three-river area was 88 thousand ha, average unit yield higher than 3000 kg/ ha was only 42%, lower than 3000 kg/ ha was 58%, of which irrigation secured area was about 40%. In this area dryland

farming is still the main focus. Therefore, the losses of water and soil resulted from soil erosion is serious, especially in the sloping fields and in the uneven fields at the wind gaps. During the strong wind seasons (average days of gale are 27.5– 90.7d) these places become sand sources or sand covered areas.

2 PRESENT SITUATION AND PROBLEMS OF THE AGRICULTURAL LANDSCAPE

The agricultural landscape of this area is formed through uplifting of millions of years after Himalayan mountain making. As the weather is dry and cold with frequent wind and little rain, the elevation is high and the topography is complex, the ability of the natural components of landscape, especially the vegetation and soil to resist interference is so weak that little interference is enough to destroy the ecological balance.

2.1 Irrational Spatial Structure

Method of component dominant value is used to analyze the rational level of the landscape space structure. The result shows that there are 13 counties composed of 91 township having sandy, desertified and stony low level pastures, of which 65 townships' dominant value of the sandy and desertified pastures is greater than 8%. According to the matching principle of the landscape biological structure and its functions (Xu *et al.*, 1990), it is known that the irrational layout problem here has already come up to be a pressing issue need to be addressed.

2.2 Weak Stability and Low Function

Landscape is similar to the ecosystem, its stability and unstability is a dialectical unity. Because unstability always creates conditions for stability, stability is temporal. The basic stable type of all living phenomena on which human being relies is the species with high biological quantity and long period of life (such as trees and big mammals). Behavior of this type appears recovering stability.

2.2.1 Analysis of biological resilience of landscape

The restoring force is the regenerating ability of basic elements of landscape. It depends on whether the high-metastable elements will become the leading factors, and the growth amount and area of the arbor-bush factors in the three-river area are shown in Table 2.

Table 2 Forest composition and growth amount in the three-river area

Region	Total area	Natural forest		Artificial forest		Sparse forest		Bushes		Others		Total forest	
	ha	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
The whole area	6665212	7557.8	0.11	8616.8	0.13	471.9	0.01	140210.2	2.11	3004.1	0.045	159860.8	2.34
Lhasa	1946775	2.7	0.0	582.1	0.03	28.3	0.0	100490.4	5.16	1380.6	0.07	102484.1	5.26
Shannan	1039531	4703.2	0.46	2935.9	0.28	5.7	0.0	35298.9	3.42	1091.6	0.11	44035.3	4.24
Xigazê	3678906	5.5	0.0	3031.5	0.08	438.9	0.01	4420.8	0.12	531.9	0.01	8428.6	0.23
Growth amount (kg/ha·a)		500						650					

Table 2 shows that the forest coverage and growth amount are low, so the biological restoring ability is weak here.

2.2.2 Analysis of ecological framework of agriculture landscape

For a fine landscape system, its natural components, especially the forest, possess a high degree of internal heterogeneity, which helps resist the surrounding disturbance and provides an anti-disturbance plasticity. High heterogeneity makes landscape have strong recovering stability (Zonneveld *et al.*, 1990). Because the eco-environment condition in the area is

extremely bad, the plant species are relatively poor and the green component species are monotonous, and this area's resistance against disturbance is very weak. Therefore, the entire green components face the danger of extinction once disturbance of source comes into being.

According to field investigation, simply taking hilly land around Yamzhou Lake as an example, its elevation is about 4 500 m, there are about 18 000 rat holes per ha, the meadow is destroyed, the turf is heavily damaged, and soil erosion is serious.

3 MEASURES FOR THE STRUCTURE MODIFICATION OF AGRICULTURE LANDSCAPE

The general idea of the modification to the area is to raise the productivity of the middle-high yield fields, to meet the grain requirement through raising per unit yield, returning some of the agriculture land to forest or grassland, in such a way to stop the trend of furthering degradation of the eco-environment in the area. The modification involves two aspects. The first is the adjustment of the components in the landscape, and the most important thing is that, by the year 2000, the forest coverage should be raised from present 2.40% to 3.66%, in the valley area, from present 1% to 10%. The second is the adjustment of component pattern, especially the high-metastable elements(forest and bush) should be made rational. That is, the area of forest elements should be comparatively large, and the spatial layout should be well-designed; their connectivity should be high; the look of their splicing blocks should be protruded, so as to facilitate the control over other factors through species exchange.

3.1 Feasibility Study of the Modification Program

As the eco-environment condition in the area is extremely fragile, any development activity of human beings will affect the natural system, and it often causes an irreversible consequence, because the resistance and restoring ability of the natural system is very weak.

Therefore, the modification plan should strictly control the activities and intensity of natural resources exploitation, and the agricultural development in this area should follow the principle of protecting nature system. Transforming the middle-high yield fields will be the only way to increase farming output. If the land is uneven or without reliable irrigation condition, the reclamation of grassland to agriculture land should be forbidden.

3.1.1 Feasibility of recovering dry farmland to forest or grassland

There are 133 000 ha of middle-low yield fields in this area, occupying 75.4% of the total cultivated land, in which the middle yield is lower than 3000 kg/ha, the low yield is lower than 1500 kg/ha.

Among the middle-low yield fields, dry type is 40.32%, low lying and waterlogging type is 21.59%, poor soil type 32.99%, high-frigid type 5.1%(Table 3).

Table 3 Middle-low yield farmland distribution in the three-river area

Region	Dry type		Low-lying type		Poor soil type		High-frigid type		Total (ha)
	Area(ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%	
Lhasa	14714.27	30.55	9031.8	18.75	22651.53	47.03	1763.93	3.66	48161.53
Shannan	13598.92	49.18	621.05	2.21	11832.17	42.79	1608.83	5.82	27651.98
Xigazê	25315.53	44.7	19069.4	33.34	9394.47	16.43	3409.40	5.92	57188.80
Total	53628.72	40.32	28713.25	21.59	43878.14	32.99	6782.18	5.10	133002.29

Dry type is mainly distributed in the high terraces of the river valleys, such as the Yarlung Zangbo River, the Nyangqu River, the Saja River, the Lhasa River, etc., and in their tributary valleys, where the

elevation is high and the water source is low, irrigation is difficult. Some of the dry types are formed due to no water source or less precipitation. As the output of dry lands is too low, its expansion makes little contribution for the growth of grain output in the area. The transformation of this type of land is difficult, and the soil and water erosion is serious, so it becomes the main sand source of this area.

Therefore, the sloping fields, uneven fields and dry low-yield fields (e.g. remote gullies) which are not closely related to the local inhabitants' grain supply should be returned to the forest or grassland in batches. The loss of the grain could be made up by improving the productivity of middle-high yield fields. Low-lying and waterlogging type lies in the lowest place of the river valley terraces and in the low-lying places of the valleys, the obstructed drainage there leads to the reduction of productivity. High-frigid type results from high elevation, catching frost easily. And the poor soil type is caused by the shortage of manure, some due to the steep slope that causes serious soil erosion.

These three types of farmland should be improved through related treatment. At least they should be transformed to marshland, forest and grassland.

According to the agricultural planning for this area, within the 20 800 ha dry land, there are only 2300 ha that have conditions to be transformed into irrigation secured fields. In the remaining 18 570 ha of arid land, 8428 ha should be returned to forest or grassland, so that the low-yield fields of the dry type could be remained to be about 10 142 ha. It is clear that to transform all the dry middle-low yield fields into high yield fields with reliable irrigation is unrealistic because the irrigation investment is too high.

3.1.2 Potential of middle-high yield field

Middle and high yield fields in the area are comparatively spoken, of which all the high yield fields and part of the transformed middle yield fields possess the basic conditions to be transformed into steady high output fields. The conditions includes good irrigation and drainage system, advanced shelterbelt, fertile soil, not easy to be adversely dried or flooded, etc.

Therefore, besides improving the basic farmland construction and paying much attention to nourishing the soil, adopting the modern agricultural advanced techniques, such as decomposable film, low quantity high-effective fertilizing, application of breed improved seeds, zero tillage and so on, can transform the original 116 000 ha of middle yield fields into the high yield fields, making the total area of high yield fields up to 128 000 ha. If per unit yield is 3000 kg per ha, grain output will come up to 0.384 billion kg. About 31 000 ha of high yield land can be transformed into steady high yield land. If per unit yield is 4500 kg per ha, the output is 0.14 billion kg. Put the two calculations (excluding low yield fields) together, the output is 0.526 billion kg, it surpasses the target of 0.389 billion kg by the year 2000. It confirms that it is reasonable and feasible to realize the general grain output objective through increasing unit yield of middle-high yield fields.

3.2 Contents of Modification Plan of Agricultural Landscape

The original plan of agricultural development program in the area is shown in Table 4.

Table 4 Plan of irrigated field and dry field

Time	Irrigated field		Reliable irrigated field		Dry field		Total field area ($\times 10^3$ ha)
	Area ($\times 10^3$ ha)	Growth (%)	Area ($\times 10^3$ ha)	Growth (%)	Area ($\times 10^3$ ha)	Growth (%)	
Present situation	98.9	100	56.7	100	20.9	100	176.4
Objective of Eighth Five-Year Plan	112.9	114	42.7	75	20.8	99	179.4
Objective of Ninth Five-Year Plan	142.8	145	15.0	26	20.3	97	178.1

The figures show that the plan is to transform 100 ha of dry fields and 14 000 ha of irrigated fields into irrigation secured fields in the Eighth Five-Year Plan, and 500 ha of dry fields and 27 700 ha irrigated fields into irrigation secured fields in the Ninth Five-Year Plan. By the end of the Ninth Five-Year Plan, reliable irrigation field will go up to 142 800 ha. This plan only considered the improvement of irrigation works, no other agricultural techniques involved, so the grain output objective was set to 0.389 billion kg. However, the potential of grain production of the area is still great. If the secured irrigation conditions are met and other advanced technologies is adopted, grain yield will in crease further. The contents of agricultural landscape modification plan are shown in Table 5.

Table 5 Agricultural landscape modification plan

Time	Stable-high yield field		High yield field		Middle-low yield field to be recovered to forest or grassland		Total field area
	Area ($\times 10^3$ ha)	Growth (%)	Area ($\times 10^3$ ha)	Growth (%)	Area ($\times 10^3$ ha)	Growth (%)	($\times 10^3$ha)
Present situation	–	100	43.4	100	–	100	176.4
Ninth Five-Year Plan	–	310	126.8	295	8.4	84	168

These figures show that the tasks of the modification in the Ninth Five-Year Plan are the following three items:

(1) To transform the original 31 000 ha of high yield fields into stable-high yield fields. In these fields, apply modern agricultural techniques to raise the unit area yield from the present more than 3000 kg/ha to more than 4500 kg/ha, so as to reach the target of 0.14 billion kg.

(2) To transform 114 400 ha of low-middle yield fields into high yield field. As present farmland with reliable irrigation and irrigated fields add up to 155 500 ha, except 31 000 ha to be transformed into stable-high yield fields, there are 124 500 ha possessing conditions for becoming high yield fields. Therefore, the aim of transforming 114 400 ha of low yield land to high yield land is practicable. The unit area yield of these fields can be raised from 2250 kg/ha to more than 3000 kg / ha so as to reach the goal of 0.384 billion kg of grain output.

(3) The area of present cultivated fields in the three-river area is 176 400 ha. Except the two transformation objectives mentioned above, there are still 18 600 ha of middle-low yield fields, in which some drought sloping fields, uneven fields and the fields not closely related to the local inhabitants' living could be selected to return to forest or grassland so as to realize the primary modification of the structure of the agricultural landscape.

3.3 Other Measures

To modify the structure of the agricultural landscape in this area, except limiting reclamation of forest and grassland to farmland, there are still three important measures. The first is to slow down the speed of desertification; the second is to prevent and control the degradation of pastures; the third is to plant trees. It is only after taking the comprehensive controlling actions above-mentioned that the plateau's ecological environment could be preserved from degrading so as to realize the sustainable development of the regional economy and society.

REFERENCES

Liu Shuangjing *et al.*, 1990. *World Nature Reserver*. Beijing: China Science and Technology Press, 10, 54– 55. (in Chinese)

Xu Hui, Wang Jiaji, 1993. *Theory and Application of Landscape Ecology*. Beijing: China Environment Sciences Press, 123 – 127. (in Chinese)

Zonneveld I., Forman R., 1990. *Changing Landscape. An Ecological Perspective*. New York: A. S. Springer– Verlag. 105– 135.