

# The ecological system and the regionalization of landscape reconstruction in northwest of China

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**Abstract** The northwest of China is a vast area with abundant resources and significant potential for development. However, the ecological system is extremely vulnerable to damage and must be managed carefully. Thus, the Chinese government is strengthening research on improvement and reconstruction of the ecological system and landscape in northwest of China while moving forward with large-scale development in west China. The disadvantages and vulnerabilities in the northwest area in China are presented. It is suggested that the reconstruction of landscape should be conducted by step by step regionalization across the various ecological systems in the 3.04 million km<sup>2</sup> northwest area of China. The first level regionalization results of reconstruction of landscape are discussed.

**Keywords** reconstruction of landscape, ecological system, the northwest area of China, science and technology action

## 1 The definition of reconstruction of landscape in northwest area

The term landscapes used here means all types of land including highlands, desert, meadows, basins, mountains, wetlands, woodlands, fields, roads, irrigation areas and towns, covering first nature and second nature. Reconstruction of landscape is a new undertaking and scientific mission, so it is necessary to define it scientifically. After research and discussion, we think that reconstruction of landscape means protecting, repairing and remolding the “first nature” and the “second nature” using measures adjusted to local conditions to form a territorial and a social environment in a virtuous cycle habitat — beautiful landscape by means of advanced productivity. It is based on ecological principles, involving sustainable socioeconomic

development with the concepts of “civilization, glory, wealth, health and happiness.”

It is to create a world by popular and visible expression of “blue sky, green fields, flourishing mountains and rich people.”

Reconstruction of landscape involves heaven, earth and man and its aim is equilibrium increasing in ecology, economy and social benefit.

The northwest of China is a vast area with resource superiority, but its ecological system is vulnerable. So it is necessary to improve its condition for sustainable development [1,2]. In the last ten years, some scientific research on ecological system construction and reconstruction of landscape in northwest area of China has been carried out by the Chinese government. The advantage and disadvantage of ecological systems in the northwest were analyzed and the regionalization of landscape reconstruction was carried out. The advantages and disadvantages of the first level regionalization achievements are presented in this paper.

## 2 The main advantages of the ecological system in northwest area of China

The northwest of China is a vast area, including Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, with a total of 3.04 million km<sup>2</sup>, representing 58.7% of western China, and 31.7% of the whole country. Its population of 90 million, however, accounts for just 7% of the whole country. This vast territory with a sparse population, has a land area per capita of 3.8 ha, which is 4.75 times that of the whole nation. This includes 18.5 million ha cultivated land, per capita cultivated land is 0.2 ha, which is more than twice as much as the national per capita. Moreover, there are 65.4 million ha forage grassland in northwest of China, 0.76 ha per capita, and 14.1 million ha forest land. Thus, the northwest area has the most abundant land resources in China [3,4].

In addition to the land resource, the solar-thermal

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resource is also plentiful. The duration of sunlight in this area is longest in China, which is a benefit for developing agricultural production. For example, if the efficiency of solar energy utilization increased by 2%, the yield of sorghum will be doubled in Yulin in Shaanxi Province.

There are also abundant mineral resources in the northwest area. Coal, oil and natural gas are the most abundant in the nation. Nonferrous metals (including nickel, copper, lead, zinc, cobalt and molybdenum), rare metals (including palladium, iridium, manganese, beryllium, lithium, niobium and tantalum), precious metals (including gold, silver and platinum), chemical minerals (including salt, sylvite, boron and nitrate), non-metallic minerals (including gypsum, asbestos, mica, limestone and silicon) are found in the northwest. They occupy a very important position nationwide and provide a significant material basis for large-scale developing energy, heavy chemical, industrial and mineral industry. The Xinjiang Uygur Autonomous Region will be the base for the Chinese oil supply in the 21st century and the reserves of natural gas in the north of Shaanxi are the most abundant in China.

This shows that the northwest area, located in the Eurasian hinterland, will play a fundamental role in the future development of China and promotion of economic prosperity of the world. It is a vast area ready for exploitation. It is also a huge potential market. Its accelerated development will provide great vitality for the national economy in west of China and the whole country.

### 3 The disadvantages of the ecological system in northwest area of China

The ecological system in northwest of China is very harsh and vulnerable mainly in the following aspects [3].

#### 3.1 Low precipitation, drought and water shortage

The northwest area of China is located in the Eurasian hinterland, separated by mountains, and far from the ocean, so the ocean cannot affect it and the precipitation in most

areas is very low, the annual rainfall is lower than 400 mm, and the areas in this region are classified as arid to semi-arid. The annual rainfall in the loess plateau is between 300 and 500 mm, less than 200 mm in the Tsaidam Basin, less than 100 mm in the Hexi Corridor, only 29.5 mm in Dunhuang, less than 20 mm in Turpan and less than 10.9 mm in Nuoqiang, where there is hardly any rain in most years [5].

As a consequence of the low rainfall, the surface water capacity in the northwest is about 200 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  and groundwater dynamic reserves are about 65 billion  $\text{m}^3 \cdot \text{yr}^{-1}$ , 265 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  in total. It represents 9.4% of 2.81 trillion  $\text{m}^3 \cdot \text{yr}^{-1}$  total water resources in our country. Thus, the northwest area represents 31.7% of the national territory, but accounts for less than 10% of the water resources, which highlights the lack of water in the northwest. Moreover, the imbalance of spatial and temporal distribution and high sediment concentration in most rivers cause major problems for development and water resource utilization. In recent years, serious pollution has lead to increasing water shortage, which hinders economic development and improvement in living standards, in this vulnerable ecological system.

It is important to emphasize that drought and water shortage is the most serious problem for this ecological system.

Table 1 showed that if it develops as usual in the northwest area, the water deficit, which was 10.8 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  in 2010, will be 20.8 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  in 2020. The water demand will be 100 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  in 2030 and the water deficit will be 23.1–25.6 billion  $\text{m}^3 \cdot \text{yr}^{-1}$  [3].

Therefore, the problem of severe water shortage in the northwest is the main factor threatening this vulnerable ecological system and is a huge obstacle to development. According to the bottle-neck theory of regional development, the restrictive factors should be eliminated and the problem of a sustainable supply issue for development and reconstruction in western China should be resolved.

#### 3.2 Desert and gobi are widespread

The biggest deserts and gobis occur in northwest of China. The deserts include Taklimakan desert (338000  $\text{km}^2$ ),

**Table 1** The water shortage predication for each province (or autonomous region) in the northwest area

Provinces and regions	2010			2020		
	Water demand /billion $\text{m}^3$	Water deficit /billion $\text{m}^3$	Water deficient /%	Water demand /billion $\text{m}^3$	Water deficit /billion $\text{m}^3$	Water deficient /%
Shaanxi	14.40	5.270	36.6	17.50	8.34	47.6
Gansu	14.60	2.080	14.3	17.20	4.68	27.2
Ningxia	10.30	0.410	4.0	11.10	1.21	10.9
Qinghai	3.69	0.696	18.7	4.57	1.57	34.4
Xinjiang	46.90	2.360	5.0	49.50	4.95	10.0
Total	89.80	10.800	12.0	99.80	20.80	20.8

Gurbantunggut Desert (48800 km<sup>2</sup>), Badain Jaran Desert (44300 km<sup>2</sup>), Tengger desert (42700 km<sup>2</sup>), and Mu Us Sandland (32100 km<sup>2</sup>). The total area is 505900 km<sup>2</sup> representing 71.0% of 713000 km<sup>2</sup> of desert in China. The gobi area in the northwest is 418000 km<sup>2</sup>, representing 73.3% of the 570000 km<sup>2</sup> of gobi in China.

### 3.3 The area of desertization and desertification are continuously extending

The desertization area in Xinjiang is around 96100 km<sup>2</sup> (about 9.61 million ha), and approximately 125000 km<sup>2</sup> (about 12.5 million ha) in Qinghai. The problem of desertization also exists in Gansu, Ningxia and even Shaanxi province.

The area of grassland degeneration has also been increasing in the northwest. The meadow degeneration area in Qinghai is up to 11.7 million ha, accounting for 32.3% of the total meadow area. The yield of grass and grazing capacity has declined sharply because of grassland degeneration and desertification. The grass yield per unit area in Qinghai has decreased by 30% to 80% in different regions compared with the yield in the 1950s. The average grazing capacity in Xinjiang is only one in 1.49 ha because of grassland degeneration and desertification on a large scale [6].

### 3.4 Water loss and soil erosion

Severe water deficit and soil erosion are the main problems for the ecological system even after many years of control and management, especially in the loess soil regions in Shaanxi, Gansu, Ningxia and Qinghai. The lack of water plus soil erosion in the area accounts for: 118000 km<sup>2</sup> in Shaanxi, representing 57.4% of its total land area; 396600 km<sup>2</sup> in Gansu; representing 87.43% of its total land area, including 105000 km<sup>2</sup> in the loess plateau; 17800 km<sup>2</sup> in Ningxia, representing 34.4% of its total land area and 75000 km<sup>2</sup> in the Yellow River basin region in Qinghai, representing 10.4% of its total land area.

Water loss and soil erosion in the northwest not only destroy local production and degrade the living environment, but also threaten the life and property downstream along the Yellow River, and even the lower reaches of the Yangtze River.

### 3.5 Salinization is reducing land productivity

The salinization area in Xinjiang is about 1.45 million ha, accounting for 45% of cultivated land area; the salinization area of cultivated land in Ningxia is 86700 ha, which accounts for 26.6% of cultivated land in the irrigated district. Moreover, it is possible to generate further salinization in new irrigation areas. The salinization problem also exists in Shaanxi, Gansu and Qinghai [7,8].

### 3.6 River and lake shrinkage and serious water quality deterioration

There are major problems concerning rivers and lakes in the region. The Wei River, the biggest river in the Guanzhong region of Shaanxi Province, sometimes dries up. Rainfall is rare and the ground water system is sparse. In recent decades and years, rivers and lakes have shrunk and water quality has sharply declined.

The Tarim River in Xinjiang is the longest inland river in China; its course has been shortened by 300 km because of human activity, leading to the disappearance of Lop Nor.

The water quantity is decreasing; wet land and marsh is shrinking and ecology is deteriorating badly in Jiangheyuan, the source region of the Yangtze River and Yellow River.

### 3.7 Destruction of the ecology of mountainous areas

There are nationally and internationally famous mountains, including the Qingling, Ba, Qilian, Altun, Kunlun, Tianshan and Altai Mountains, located in the northwest. Although these numerous huge mountain ranges create difficulties for transport and cultural development, abundant mineral, forestry and biologic resources are located in these mountain areas, which are also the repository of ice and snow, providing the water resource for the plains and basins below.

The ecology of the mountain area has suffered destruction by intensive human activity, especially in the Qingling Mountains. According to the statistics for the Ankang area, the forest vegetation coverage dropped from 37% in 1949 to 27% in 1985. This has made the tree lines retreat, and intensified, eco-catastrophe (including water loss and soil erosion, landslides and debris flows) and water quality and quality in river systems has declined. This is considered a worrying and deteriorating trend.

### 3.8 Harsh conditions for people and for maintenance of biodiversity

The survival conditions for human beings are harsh and biodiversity is threatened due to natural and anthropogenic causes. In recent years, the wildlife species under threat in this harsh habitat account for 22.3% of total species in Xinjiang, and some of them have already become extinct. The threatened species constitute 15% to 20% of total species in Qinghai, which is above the worldwide average of 10% to 15% [9,10].

### 3.9 Diseases of flora and fauna and insect pests endanger the ecological system and life security

The ecological system is very vulnerable in the northwest

and the struggle for existence is very intensive. As a consequence of reductions in biodiversity, some noxious animals with strong fertility and adaptability, such as murids, have become rampant, destroying grassland and vegetation. In addition, some forest and crop pests are a problem for the ecological system in the reconstruction of landscape project. If these problems are not taken seriously, the possibility of achieving “conversion of cropland to forest and return grazing land to grassland” will be destroyed.

### 3.10 Resource overexploitation and problems for the ecological and social systems

The ecological system problems are caused by natural and human factors. For example in the north and center of Shaanxi there is a long history of development and intense human activity. In the 60 years since the founding of the People's Republic of China, on the one hand, large-scale afforestation and small watershed integrated management have been carried out to alleviate the disadvantageous natural conditions that restrict agricultural production, to improve the local conditions for production and living. This made some improvements in the short-term in the face of powerful and harsh natural conditions. On the other hand, the demand for food, fuel and forage grass are increasing dramatically because of population growth, resulting in predatory production and operating activities, including disordered reclamation and deforestation, denudation of vegetation, overgrazing and picking of medicinal herbs. All these activities destroy vegetation, soil, water sources and land, and aggravate water loss and soil erosion. Although some local ecological systems have been improved, there has been an overall deterioration.

In fact, many other serious ecological system problems in northwest area are not included in the above account. We can consider that the northwest area of China has the most serious ecological system problems in the world. These problems will weaken the advantage of resource superiority and hinder economic development and social progress.

## 4 The regionalization of ecology-economy-society in landscape reconstruction in the northwest area

Scientifically based research on regional landscape reconstruction and the assessment of different types of experimental layout are essential in order to provide the evidence base for governmental macro decision-making [11].

The first level regionalization research has been carried out initially, focusing on ecological and economical factors. Social factors will be considered in second and third level regionalization research. In the first level

regionalization, the northwest area was divided into 12 first level regions considering ecological system and economic activity (Fig. 1). They are as follows in detail.

### 4.1 The strict conservation area of mountain ecological systems

Some famous mountains are located in the northwest, which are the natural barriers of plain and basin. The stored ice and snow and conservation moisture in mountains is an important water resource. Deforestation and denudation of vegetation, unmanaged mining and hunting leads to forest deterioration, decreasing grass coverage, water loss and soil erosion, landslides, debris flow aggravation, river water quality deterioration, water quantity reduction and biodiversity damage. In summary, intensive human activities are resulting in deterioration of mountain ecological systems and they should be protected by powerful measures [12].

### 4.2 The prevention area of desertification

The Taklimakan Desert is located in the Tarim Basin and the Gurbantunggut Desert in the Dzungaria Basin in Xinjiang. The Ulan Buh, Tengger and Badain Jaran Deserts surround the north boundary of Ningxia and Gansu, so it is an important ecological task to prevent deserts moving southward. The serious desertification and degeneration of vegetation and grassland influence the development of husbandry because of droughts and sand storms.

### 4.3 The ecological active maintenance area in Gobi and desert plateau

The barren gobi is distributed widely in eastern Xinjiang and western Gansu and represents an extremely harsh ecological system. It is a challenging issue to find ways to improve its condition. Gobi maintenance is the way to prevent its further expansion. If water is diverted to the gobi areas in the future, it might be possible to gradually form semi-oases and oases that allow for some development [13].

### 4.4 The reasonable development area of “conversion of cropland to forest and grassland” and water loss and soil erosion management area in the loess plateau

Severe water loss and soil erosion is a common ecological system problem in the northwest, especially in the loess plateau in Shaanxi, Gansu, Ningxia and Qinghai. There are thousands of furrows, loess hills and ridges in this region, because of wind erosion and water erosion. The water loss and soil erosion area is vast, and soil erosion huge. Also in this region, is the main source of sediments moving into the Yellow River. A strong and comprehensive treatment is



necessary to popularize large-scale reconstruction of landscape by promoting and applying previous achievements, as implemented in Zhuanglang County in Gansu Province [14].

#### 4.5 The conservation area for ecologically intensive governance in river valley plain

River plains are crucial zones for economic development in the northwest area, including the Wei River valley area (the Guanzhong Plain) and the Yellow River valley (the Yinchuan Plain). The ecological system is advantageous in this area. It has been a prosperous place since ancient times. Agriculture, industry, science, education and culture have been concentrated here, with developed urban traffic and a prosperous economy. The high level industrialization and dense population generate a big pressure and adverse impact on the ecological system, including environmental pollution, water contamination and reduced water flows. So we should pay attention to prevent the destruction of the ecological system by human activity, to pollution prevention and control, water saving and optimal allocation of water resources.

#### 4.6 The ecological maintenance and control area of the intermountain basin and plateau basin

The intermountain basin is a rich and populous place in the northwest area, such as Hami and Turpan basins in Xinjiang. The unique ecological system provides condition for production of specialty fruits and economic development in the basin. However, the stress on the ecological system is significant because of the dense population. For example, more karez (a kind of well) have been excavated in the Turpan Basin and the water quantity is decreasing gradually. So maintenance and protection of the local ecological system should be strengthened.

The Qaidam Basin in Qinghai is a large-scale basin in the northwest area. It is famous for its abundant mineral resources nationwide, such as sylvite, sodium salt, lithium magnesium grit and mirabilite. However the strong sandstorms, vegetation degradation, desertification, soil salinization and ecological system deterioration caused by mine exploitation need to be actively prevented and controlled.

#### 4.7 The ecological preservation area in piedmont plain (including oases)

Different sized pluvial alluvial plains in the piedmont area are distributed in the submountain region of most mountains in the northwest area, such as the piedmont plains to the north and south of the Tianshan Mountains, the north of the Kunlun Mountains in Xinjiang, and the north of the Qilian Mountains in Gansu. These plains are important areas of industrialization and economic devel-

opment with abundant land and water resources. There are different size oases in some regions with good soil and water conditions. Most oases are located in the middle to lower part of piedmont plain, and soil salinization is a common problem. The water quantity is reduced sharply downstream in some rivers, leading to desertification in natural oases in downstream plains because of the building of reservoirs and retention of water in the upper and middle reaches. The piedmont plains in the arid and semi-arid areas play a key role in economic development, so it is necessary to maintain ecological systems and enhance the reasonable allocation of water resources and the prevention and control of salinization [15].

#### 4.8 Conservation areas of alpine plateau grassland, the source regions of Yangtze and Yellow Rivers with rare flora and fauna

The alpine plateau in Qinghai contains the headstream of the Yangtze River and Yellow River. It is famous rare animals and plants in the alpine grassland. This region is subject to alpine drought, desertization, intensive desertification, wetland and greenbelt shrinkage, declining water conservation and salinization problems, grassland degradation, rat and pest problems, and biodiversity reduction. The ecological system has significant importance for this region, so it is necessary to develop effective measures to actively manage and protect it [16–19].

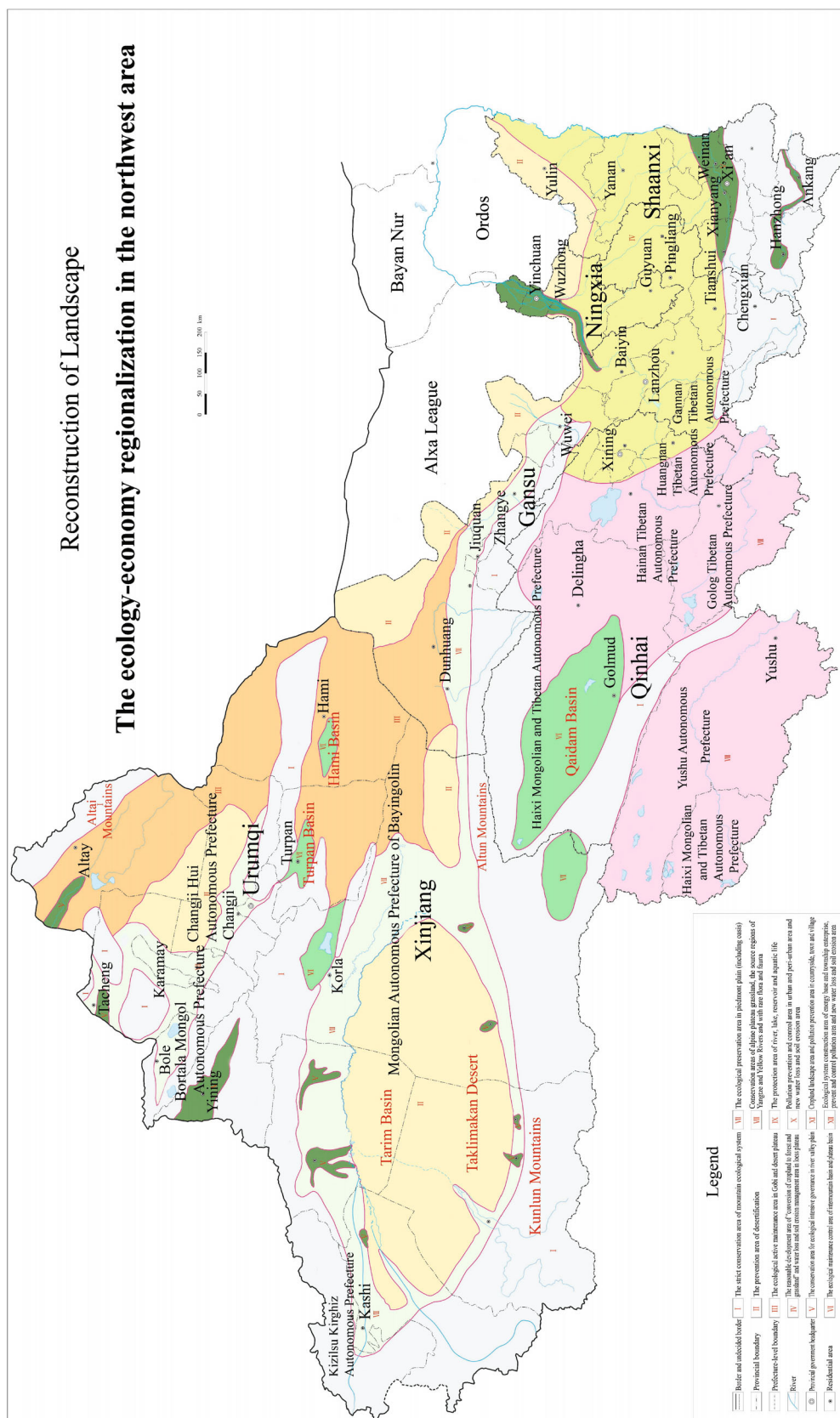
#### 4.9 The protection area of river, lake, reservoir and aquatic life

The rivers, lakes reservoirs and groundwater provide precious water resources in the northwest area. They are the foundation of the ecological system and are crucial for future development. The rivers and lakes are shrinking, drying up and being cut off, groundwater is overexploited, water polluted and aquatic life decreasing because of inappropriate utilization over many years, leading to deterioration of the water environment. The impacts of this water shortage have led to the deterioration of oases and ecosystems, recession of vegetation and desertification, and effective measures are urgently needed to protect all bodies of water [20].

#### 4.10 Pollution prevention and control area in urban and peri-urban area and new water loss and soil erosion area

Urban beautification is the key characteristic of urban modernization, including building beautification, attractive layout, gardens, greening, roads, and traffic and so on. It is called “Building a city like a garden” for short. Peoples who live and work in cities developed under this program will enjoy the beauty.

In recent years, urban construction has been rapid. Cities now have completely new outlook because of the great



**Fig. 1** The ecology-economy regionalization in the northwest area

attention given to urban landscaping and water body construction. However, the pollution problem in the rural-urban fringes is still serious, such as black sewage, foul water and garbage. Moreover, repairing roads and laying all kinds of pipelines leads to some environmental problems, such as water loss and soil erosion, excessive noise and dust.

The urban environment and its periphery is a local window, and it is necessary to strengthen governance to build good urban ecological systems.

#### 4.11 Cropland landscape area and pollution prevention area in countryside, town and village

The countryside, towns and villages account for a vast area. It is necessary to change concepts and build new beautiful countryside, towns and villages. There is a construction model of “village beautification” in every province and region and beautiful new villages and small towns should be built according to local conditions.

Cropland improvement is mainly directed toward forest protection and “organically produced food” areas [21]. Meanwhile, we should pay attention to environmental health and the possible arrangement of people, livestock and birds to create new villages within a graceful environment and reconstructed landscape.

#### 4.12 Ecological system construction area of energy base and township enterprises, prevention and control pollution area and water loss and soil erosion area

The northwest area, with abundant resources, is the main construction area for national energy resources and heavy chemical industry. The development of the energy supply should be conducted so as to protect the environment, prevent and control pollution, reduce further water loss and soil erosion with attention given to the ecological system restoration and landscaping construction after exploitation.

Township enterprises should change the inappropriate practices of “producing but ignoring the ecological system” to prevent and control pollution and new water loss and soil erosion, and protect and maintain ecological systems. This is the basic condition of prosperous enterprise.

The first level regionalization mentioned above was the beginning of regionalization research; the second and third level regionalization research has to be positively integrated with the whole process.

## 5 Conclusions

Even though it is a harsh and fragile ecological system, there is huge development potential in the northwest area of China because of local abundant photothermal and mineral resources. Speeding up development will provide

the vast space for nation-wide economic development. However, because of the complexity of the ecological system in the northwest area, the reconstruction of landscape should be carried out in stages in different area. The outcome and achievement of this research will be the scientific and theoretical basis for development and construction of the northwest area of China.

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