

Analysis on influencing factors of gully control in Loess Plateau

Na Lei ^{1,2,3,4,*}, Panpan Zhang ^{1,2,3,4}

¹Technology Innovation Center for Land Engineering and Human Settlements, Shaanxi Land Engineering Construction Group Co., Ltd and Xi'an Jiaotong University, China

²Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, China

³Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, China

⁴Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Land and Resources, Xi'an, China

⁵Shaanxi Provincial Land Consolidation Engineering Technology Research Center Xi'an, China

Abstract. There are about 270,000 gullies over 500 meters in length on the Loess Plateau, and the average soil water content in the gullies is nearly three times that of the slope surface of the Loess Plateau. In the crisscrossed gullies on the Loess Plateau, there are very rich reserve resources of cultivated land and potential for increasing grain production. How to manage channel ecologically and make full use of channel resources is a problem that needs to be paid attention to. This study puts forward five factors affecting gully governance, and pays more attention to the systematization, integrality and coordination of protection, governance and utilization, which can provide reference standards for more comprehensive and accurate implementation of gully governance and land construction projects, and provide technical support for promoting economic development, ecological environment improvement and new rural construction in western China and old revolutionary base areas. It is conducive to ecological protection and high-quality development of the Yellow River Basin.

Key words: Channel management; Water resources; Soil erosion; Land degradation; Geological disaster.

1. Introduction

The Loess Plateau is crisscross with gullies and gullies, and the natural ecological environment is fragile. It is one of the most serious soil and water loss areas in the upper and middle reaches of the Yellow River [1-2]. The loess has the characteristics of light texture, loose soil, strong permeability, easy disintegration, fast consolidation and dehydration [3-4]. The people in the Loess Plateau region have made full use of the loess characteristics to create an effective measure of soil and water conservation in the practice of fighting against soil erosion for a long time -- silting dam, which has a history of hundreds of years. It can not only intercept sediment, preserve soil and water, but also silt and cultivate farmland and increase grain production [5-6]. Since the 1960s, gully damming has been popularized, and some achievements have been made in soil and water conservation and increasing cultivated land.

However, due to the lack of technical level and understanding of the occurrence law of water resources, gully governance still has some problems. Only by clarifying the factors affecting gully governance, Combining soil and water conservation, disaster prevention and reduction, agricultural production development, arable land increase, cultivated land quality improvement, and construction of high standard farmland

in gully, realizing coordinated promotion and common development of gully control and land reclamation, and combining economic development, ecological environment construction and social development, can meet the needs of land consolidation in gully such a special landform and realize regional sustainable development. Only by comprehensively controlling gullies and slopes on the Loess Plateau, making full use of scientific protection, and realizing reasonable design and construction of gullies on the Loess Plateau, such as organic soil reconstruction and water resources regulation and utilization, can we scientifically control gullies with a clear target [7].

2. Uneven distribution of water resources

2.1 Spatial and temporal characteristics of water resources distribution

Water resources in the hilly and gully region of the Loess Plateau are generally poor, but some gullies are very rich, showing great spatial variability. At the same time, the precipitation in the area is uneven in distribution and changes between the years, 70% of the precipitation is mainly concentrated in July to September, often resulting

* Corresponding author: 619648133@qq.com

in drought no water available, flood season flood disaster, the shortage of effective water resources, agricultural production mainly depends on natural precipitation, a rain-fed agriculture. In order to get rid of these limiting factors, it is urgent to carry out engineering measures such as dam building, flood drainage channels, etc., to trap rainwater, flood control and disaster reduction, and to benefit and eliminate harm.

The regional difference of precipitation is: annual precipitation decreases from southeast to northwest. The annual average precipitation in some parts of the southern Qinling Mountains can reach more than 900 mm, while the annual average precipitation in northern Inner Mongolia is only 100 mm. The 400 mm precipitation contour crosses from northeast to southwest to north-central. In the south of the line, precipitation increases gradually, and it is subhumid and humid area, which is the main agricultural area. The rainfall in this region is mainly concentrated from June to September, and the precipitation accounts for more than 60% of the annual precipitation. In addition, the abundance and blight ratio of wet and dry years is very large, which makes drought and flood disasters occur frequently in this area, especially drought, almost nine droughts in ten years, but the scope and degree of disaster are different.

2.2 Extreme Rainfall

From the perspective of precipitation characteristics in gully region of Yan 'an Loess Plateau, there are two extremes: most of the rainfall days do not produce runoff, and the runoff rainfall is more than 10 mm. The annual runoff rainfall in this region is 200-250 mm, and it is mainly concentrated in rainstorm period, thus forming two extremes of river runoff or surge or close to cut-off. As a result, drought and flood disasters occurred frequently in the loess hilly region, and the agricultural harvest could be reduced by 2-3%. There is a general lack of large reservoirs that can regulate and store runoff in the loess hilly region, and the regional water surface area is very small, mainly concentrated along the river bay. There are only some small tangerines in other towns and townships, with water storage capacity below 10,000 m³. Due to the lack of matching water conservancy projects, surface water resources are drained away in flood season, and people and animals have difficulties in drinking water in dry season. Therefore, attention should be paid to the problem of time mismatch between water supply and demand. It is necessary to strengthen the saving of water resources in rainy season for use in dry season. In addition, in some gullies, such as Yangwan Gully and Jiulongquan Gully in Baota District, there are rich groundwater resources. Coupled with the regulating effect of small watershed climate, the water resources in this region are relatively rich, and waterlogging disasters are more frequent, which is easy to produce soil flow. Therefore, it is urgent to reasonably regulate the local rich water resources, solve waterlogging disasters and realize the efficient utilization of water resources.

3. Serious land degradation and soil erosion

3.1 Land degradation

The problem of soil nutrient imbalance in the Loess Plateau has always been prominent. The application amount of organic fertilizer is low, and the excessive use of nitrogen and phosphorus fertilizer damages the soil structure, aggravates the phenomenon of soil compaction, shallower surface and poor water and fertilizer retention performance. In addition, frequent tillage also resulted in the reduction of soil organic matter and the deterioration of local soil conditions. Taking Yan 'an City as an example, the problem of soil and water loss is very prominent in the Loess Plateau region. The average sediment discharge in Yan 'an River basin for many years is more than 300 million tons. In Yan 'an, about 11 percent of the land is affected by soil erosion, and the content of soil organic matter decreases at a rate of 2 % every year.

3.2 Soil and Water Loss

In the hinterland of the hilly region of the Loess Plateau, the loess is thick and loose in structure, which is one of the most serious areas of soil and water loss in the middle reaches of the Yellow River. Although the project of returning farmland to forest has slowed down soil and water loss significantly in recent years, the problem of soil and water loss is still serious in this area, especially the short period of rainstorm is easy to form runoff flood peak, which seriously affects the safety of the gully dam. To control soil and water loss, it is necessary to treat ditches and slopes at the same time, construct auxiliary stormwater storage facilities such as stormwater storage, dam, pond and cellar, and build terraces, DAMS or gully on gentle slopes and gully, so as to achieve the comprehensive goals of soil and water conservation, agricultural development and farmers' income increase. The severe soil and water loss in the hilly and gully region of the Loess Plateau has caused the deterioration of regional ecological environment, and the land resources and soil quality have become short and barren due to soil and water loss. The soil organic matter content in the Loess Plateau region is low and the grain yield is mostly less than 1%, the land productivity is low, and the soil is very unstable. In the implementation of ditch treatment and land construction project, some areas in order to one-sided pursuit of cultivated land area, open terraces on steep slopes, mechanical excavation of slope, resulting in serious destruction of slope vegetation, stability deterioration, destruction of farmland to forest (grass) results, causing new soil and water loss.

4. Frequent geological disasters

As one of the most vulnerable ecological areas in China, the unique geological geomorphology, meteorology, hydrology and soil vegetation in the loess Gully region lead to unique natural disasters. The region is riddled with gullies, serious soil erosion, scarce groundwater resources, fragile ecological environment, frequent occurrence of

geological disasters such as landslides and collapses, which have caused huge losses to society and people's lives and property, and seriously restricted the sustainable development of regional economy and society. Up to 2003, geological disasters in the loess gully region of northern Shaanxi have caused more than 1,000 casualties, damaged 30,000 kilns and houses, and caused a direct economic loss of more than 300 million yuan. The main types of geological disasters in this area are landslide, collapse, unstable slope, ground collapse, debris flow, ground fracture, ground subsidence, loess collapse and soil erosion, and the most prone ones are landslide, collapse and debris flow. The frequent occurrence of geological disasters in gully region of Loess Plateau makes gully regulation urgent and difficult at the same time.

5. Weak agricultural infrastructure

5.1 Current situation of agricultural infrastructure

Backward supporting facilities of farmland and poor agricultural production conditions are the main bottleneck factors restricting the sustainable development of agriculture and rural areas at present. This situation is not conducive to the intensive management of land, nor to the increase of farmers' production income. At present, there are widespread prominent problems in agricultural land in gully area of Loess Plateau, such as serious water damage of gully dam, disrepair of fields and roads, inadequate irrigation and drainage facilities, and inadequate ecological and environmental protection measures for gully and gully slopes. As a result, most of the dam land, once known as "life saving land", is difficult to cultivate, land utilization rate is not high, crop yield is low and unstable, and farmers' income cannot be guaranteed. In Yan 'an City, the sown area of crops in 2010 was 261,400 hm², while the cultivated land area at the end of 2010 was 361,300 hm². Nearly 30% of the cultivated land could not be effectively used, and the utilization rate and yield rate of cultivated land were low. In 2010, the grain output in Yan 'an was only 17.4 kg/ hm², much lower than the national average of 24.2kg/hm². However, the dam land is mainly the silt and alluvial soil washed down by the surface soil of the slope, which has rich organic matter and high soil fertility. It can be built into a high and stable yield field, and has greater agricultural production potential. According to the survey, the yield of maize in Yan 'an dam land is 33.3-40 kg/ hm², and some high yield dam land can reach more than 50 kg/ hm².

5.2 Ways of agricultural infrastructure construction

How to solve the restricted factors such as water resource shortage, serious soil erosion and weak farmland infrastructure in land utilization in the loess Plateau gully region, strengthen farmland infrastructure construction and consolidate the foundation of agricultural development has become the key to the sustainable development of modern agriculture in this region.

Therefore, we will carry out major projects to improve ditches and land, repair and renovate washed away or abandoned DAMS and rivers and roads, improve infrastructure such as fields, DAMS, canals, roads and forests, implement measures to improve soil improvement and fertility cultivation, improve infrastructure such as field irrigation and drainage ditches and mechanized Wells, water conservation, small rainwater harvesting and storage, mechanized roads, Bridges and culverts, and farmland and forest networks, and improve agricultural production conditions. Improving the utilization rate of land is a necessary measure to construct the national modern agriculture demonstration area in Yan 'an City.

6. Backward rural economic development

6.1 Rural economic development

At present, our country has entered an important period of urban and rural transformation and coordinated regional development. The implementation of the major land renovation project is an important platform of cracking the urban-rural dual structure and promoting industrialization, urbanization, agricultural modernization and the overall development of the city and countryside. For a long time, the loess Plateau gully region has been deeply affected by regional factors such as inconvenient road traffic, sterility of market development and fragile ecological environment, resulting in slow economic and social development. Yanchuan County, Yanchang County and Yichuan County of Yan 'an City are still national-level poor counties, and Wuqi County, Ansai County and Zichang County have just taken off their poverty titles. Although the gross domestic product of Yan 'an exceeded 100 billion yuan in 2011, the per capita exceeded 5200 yuan, and the total economic aggregate jumped to the fifth place in the province, the driving force of economic growth mainly came from the exploitation of coal and oil and gas resources. In the three industrial structures, the industry dominated, the industrial structure was unreasonable, and the regional development was also unbalanced. The vast rural areas were still poor and backward. Lack of characteristic industry and rural economic growth point, rural hollowing problem prominent, urban and rural overall planning and regional coordinated development of the task is quite arduous.

6.2 Transformation of rural economic development mode

Over the past 30 years and more of reform and opening up, industrialization and urbanization have played a limited role in driving rural areas, and people in old areas still live in poverty or low income. It is imperative to comprehensively improve rural production, living conditions and ecological environment. In recent years, the characteristics of urban and rural development transformation in the Loess Plateau region are increasingly apparent, and the employment structure, income structure and consumption structure of urban and rural residents are undergoing obvious changes. In

particular, the large-scale project of returning farmland to forest has brought about "two changes", that is, the focus of cultivated land protection has changed from slope to channel, and agricultural production has changed from wide planting and low harvest to intensive and efficient. At present, the development of urban and rural areas in the Loess Plateau generally presents a new situation of "three increases and three decreases", that is, the increase of urban population, the increase of grain yield per unit area and the increase of farmers' income, while the decrease of rural population, the decrease of arable land and the decrease of soil and water loss caused by the conversion of farmland to forest. This transformation situation has created favorable conditions for the construction of basic farmland, the moderate scale management of land and the development of modern agriculture in this area. Therefore, in view of the urgent needs of urban and rural overall development and regional coordinated development, through further promoting the major ditch treatment and land construction projects, greatly improve the rural production conditions and farmers' living environment; promote hollow village renovation, new rural construction and modern agricultural development.

7. Summary and outlook

In the 1980s, the comprehensive management model with small watershed as the unit was popularized, silt DAMS were constructed, terraced fields and reverse sloping fields were constructed, and water conservation ecological agriculture was developed, and remarkable progress and achievements were made. In the 1990s, the country carried out the western development strategy and the ecological project construction of returning farmland to forest, so the traditional comprehensive construction mode of silt-dam is no longer suitable. Yan 'an's ecological construction led by the conversion of farmland to forest is in the forefront of the country. Since the implementation of the project, the total amount of farmland to forest has been 600 thousand hm², accounting for 2.5% of the country and 27% of the province. The forest coverage rate has reached 45.4%, and the regional ecological environment quality has changed significantly. The deterioration of the ecological environment in the past has been effectively checked, and the mountains and lands have initially realized a historic transformation from yellow to green. However, in order to stabilize the results of returning farmland to forest, farmers must first have enough grain allotment. In order to cooperate with the policy of returning farmland to forest, the mode of "gully improvement" is explored. Based on the actual situation of gully regions on the Loess Plateau, gully treatment and land construction are promoted according to local conditions, and comprehensive land improvement measures such as gully filling, dam restoration and construction, slope modification and so on are implemented to improve the design level and construction standards. It has achieved remarkable results in increasing the area of cultivated land, improving the quality of cultivated land, reducing soil erosion and improving the

ecological environment by storing water resources, preventing flood and removing waterlogging, and optimizing the allocation of soil and water resources. Therefore, on the basis of summarizing the influencing factors of gully, it is of great significance to further accelerate the comprehensive improvement of gully, innovate the land improvement mode of gully treatment and construction of high standard basic farmland for consolidating the conversion of farmland to forest, protecting and improving the ecological environment, effectively improving people's livelihood and consolidating the rural foundation, and realizing the coordinated development of man and nature in the Loess Plateau area of northern Shaanxi.

Acknowledgments

This work was financially supported by Technology Innovation Center for Land Engineering and Human Settlements, Shaanxi Land Engineering Construction Group Co., Ltd and Xi'an Jiaotong University (2021WHZ0092).

References

1. Z. S. Li, L. Yang, G. L. Wang. Current situation, problems and countermeasures of soil and water loss control in Loess Plateau. *Acta ecologica sinica*, 39(2019)7398-7409.
2. C. H. Hu, X. M. Zhang. Soil and water loss control and water and sediment change of Yellow River in Loess Plateau. *Water conservancy and hydropower technology*, 51(2020)1-11.
3. B. P. Zhang, Z. X. Hua, X. X. Cheng. A review on the mechanism of loess erosion and its disaster effects. *Chinese Journal of Geological Hazards and Control*, 32(2021)41-52.
4. J. M. Sun. Loess deposits interact with the earth's sphere. *Quaternary Research*, 40(2020)1-7.
5. X. Y. Liu, Y. F. Gao, S. B. Ma. Sediment reduction effect and timeliness of silt dam in Loess Plateau. *Journal of Hydraulic Engineering*, 49(2018)145-155.
6. H. Bao, D. X. Wang, T. Zhang. Some thoughts on the construction and management of silt dam in Loess Plateau in the new period. *Soil and water conservation in China*, 2(2020)23-26.
7. Y. S. Xie, Z. P. Li, J. J. Wang. Hierarchical structure and evolution of soil and water loss control model in Loess Plateau. *Journal of Soil and Water Conservation*, 25(2011)211-214.