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Causes and Measures of Soil Erosion in Loess Plateau, China

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Abstract. Soil erosion is one of the key research topics in the world today, and it is a serious hazard to the natural environment and economic and social development. The researcher has found that soil erosion in China is regional, widespread and high-intensity. Of all the erosion areas, the Loess plateau is the most severe and the most representative. Therefore, this paper investigates the current situation of soil erosion in China and focuses on the erosion on the Loess Plateau, for its causes and remediation measures. Loess plateau has an inferior erosion-carrying capability, so the gully slopes and hilly areas of the Loess Plateau are prone to landslides and crumbling phenomena. Other erosion reasons include the fragmented high loess terrain with a lot of gorges and ravines, heavy rainfall, and low vegetation coverage. This study also proposes remediation measures by analyzing the different natural characteristics that cause soil erosion on the Loess Plateau. It is found that soil erosion control has a regional dimension and control measures should be closely related to the regional environment and the causes of soil erosion. Practice shows that the erosion control measures proposed in this paper greatly improve erosion in the Loess Plateau region, but the current state of soil erosion on the Loess plateau remains bleak.

Keywords: Soil erosion, Loess plateau, Control factors, Remediation measures.

1. Introduction

Soil erosion can slit up rivers, lakes and reservoirs, reducing their flood distribution and making them prone to flooding in the summer and autumn. Soil erosion also polluted water quality and affects the ecological balance. Soil erosion degrades the natural environment and poses a serious risk to human development. Severe soil erosion causes a reduction in the area of cultivated land, and the loss of fertility-rich soil caused by rivers or rainwater washing over the land surface reduces soil fertility, reducing crop yields and increasing the conflict between man and land. At the same time, farmers must continue to expand the area of reclaimed sloping land to survive, resulting in a disgusting cycle that degrades the environment, constrains economic development, and increases poverty. China has one of the most serious soil erosion in the world. In China, soil erosion consists of water erosion, wind erosion and freeze-thaw erosion. At present, in addition to 3569200 km^2 of water and wind erosion, there is also 1278200 km^2 of freeze-thaw erosion in China. If freeze-thaw erosion is included in the total area of soil erosion, the total area of soil erosion in the country is 4847400 km^2, accounting for 51.1% of the total area of the country. The proportion of light and moderate soil erosion in the country is greater, at 68.6%. of all the erosion types, water erosion is the most widespread and harmful type of erosion, with a total area of 1612200 km^2. In China, there is a relative concentration of serious area for

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each type of erosion, and the most serious area of water erosion is the Loess plateau area in the middle reaches of the Yellow River [1].

The main causes of soil erosion are high-ground slopes, inappropriate land use, destruction of ground vegetation, unreasonable farming techniques, loose soil, indiscriminate logging, overgrazing and so on. The characteristics and causes of soil erosion vary from region to region, depending on the natural conditions, geographical environment and economic development. For example, soil erosion in the red soil hilly areas of the south, where there is a special form of erosion called collapse hillock in addition to general surface erosion and gully erosion. The cause of erosion are both natural, such as precipitation, topography and soil quality, and anthropogenic such as over-cultivation and destruction of vegetation. In comparison, the human factor accounts for a greater proportion of the damage caused by soil erosion than the natural factor. Soil erosion in the plains is characterized by the siltation of rivers and the collapse of river slopes. The main causes of erosion are natural and human factors, such as uneven spatial distribution of rainfall, lack of vegetation protection in the north, severe wind erosion in April and May due to the high winds of the monsoon atmospheric circulation. And human factor, mainly in development and construction, road building and excavation of foundations [2]. Therefore, to improve the erosion situation and the rational exploitation of soil and water resources, it is necessary to consider the natural and human factors of different regions and the different characteristics of erosion, and to adopt different control measures to achieve maximum effectiveness. This paper, therefore, discusses the causes of soil erosion in the loess plateau and proposes relative countermeasures to address the different reasons.

2. Background of soil erosion on the Loess Plateau

2.1 The concept and damages of soil erosion and the natural features of the Loess Plateau

Soil erosion is a very complex natural geographical phenomenon. It refers to the destruction and loss of soil and water resources and land productivity under the action of external forces such as water, gravity and wind. It also includes the loss of land surface erosion and the erosion of soil and water [3].

The Loess Plateau is the largest area of loess deposits in the world and is located in the midstream part of the Yellow River. Amongst other things, the Loess Plateau has a typical temperate and monsoonal climate with uneven seasonal distribution of precipitation, high annual variability and uneven distribution within the year. The Loess Plateau is located in an area with many rivers and branches and has a rugged surface with gullies covering fifty percent of the total land area, a scarcity of groundwater resources and abundant coal resources leading to over-mining and deepening of the gullies [4]. The water and sand content of the Yellow River is highly uncoordinated, and the unbalanced water and sand content during the annual flood season is the main cause of the uncoordinated water and sand content affecting the Yellow River throughout the year.

2.2 Current status of soil erosion on the Loess Plateau

In recent year, the flow and sand content of the Yellow River have tended to decline significantly, because of certain policy protection. With soil erosion on the Loess Plateau reaching 430000 km^2 and sand transport in general areas averaging around 80000 tones per square kilometer per year, with some areas above 10000 tones [4]. The strong hydraulic erosion has formed the surface of the loess Plateau and its unevenness, full of ravines, which not only causes the fertility of the soil in the Loess Plateau to decrease, the arable land area to decrease, the conflict between man and land to increase, but also causes the deterioration of the ecosystem. The lower basin of the Yellow River flows slowly, and the sediment carried by the river rends to accumulate in the lower river channel, raising the riverbed and forming a “river on the ground”, which reduces the flooding capacity of the river and poses a serious threat to the safety of farmland and people on both sides on the river.

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2.3 General patterns of soil erosion

There is a close relationship between topography, precipitation, vegetation coverage and soil erosion. High-intensity and very high-intensity rainfall are the dominant factors in determining the total amount of erosion during a rainfall event, with very high-intensity rainfall causing severe erosion, and the severity of erosion depending on the intensity of rainfall over a period of time. Under various rainfall intensity scenarios, the amount of erosion is generally proportional to the slope, but the growth rate of erosion varies considerably as the slop increases. When the rainfall intensity is low, the growth rate of erosion is also small, while very high-intensity rainfall can significantly increase the growth rate of erosion. The grade also impacts erosion, with erosion per unit area decreasing with increasing grade length in light rainfall (I30in<0.25mm), and there is a positive relationship between grade length and erosion per unit area when I30min > 0.25mm/min. Vegetation plays an important role in sand fixation and soil consolidation. When the vegetation cover is less than 40%, the effect on reducing the sand content in run-off in erosion is significantly reduced. Therefore increasing the vegetation ground cover is the fundamental way to prevent erosion [5].

3. Causes of soil erosion on the Loess Plateau

Loess has a loose soil texture. Loess is the main constituent of the Loess Plateau and has a distinct vertical structure, making it susceptible to disintegration when washed by water. Also, it has a very poor erosion-carrying capability, so the gully slopes and hilly areas of the Loess Plateau are prone to landslides and crumbling phenomena. The softness and depth of the loss is directly related to the poor resistance of the Loess Plateau. The spatial distribution of loess cohesion varies from south to north, showing a gradual coarsening of the loess particles and a consequent weakening of the cohesion, while at the same time, the soil's erosion modulus gradually increases from south to north.

The high loess terrain is fragmented, with a lot of gorges and ravines. In the Loess Plateau area, the gully banks are seriously slipping, the gully heads are moving forward, and the gully beds are also severely undercut, and the anadromous erosion in the area is also highly active. It has a large damage of the area. Serious soil erosion caused high-density gullies in the Loess Plateau, with more than eight million gullies of 0.5 to 30 km between Hekou town and Longmen area alone. Moreover, the slopes in the area are very steep and the gullies are very deep, with cuts of up to 100 to 300m. The slope of the ground is mostly above fifteen degrees, especially in the hilly areas, and the density of gullies is very high, about 3 to 7 km/km^2. In local areas in northern Shanxi, gullies' density is 12 km/km^2 [6]. The gullies are prone to erosion by running water, which creates more gullies and slopes, thus creating a vicious cycle of erosion on the Loess Plateau.

Heavy rainfall is concentrated. The loess plateau is characterized by sparse and very concentrated rainfall, with an uneven annual distribution of rainfall. The rainfall during the flood season accounted for about 70% of a year, the rainfall in the middle of the flood season is concentrated in several very heavy rainfall, its heavy rainfall has characteristics of short time, sudden and strong, high intensity, so its easy to cause a short period of surface run-off surge, and sediment content, prone to flooding, and easy to cause serious soil erosion.

Vegetation coverage is low in the Loess Plateau. People have cleared the lands to develop agriculture, thus destroying the surface vegetation and extensive deforestation and grassland. The reduction in vegetation cover is also directly related to irrational farming. The area has suffered from surface erosion and the nutrients in the soil have been carried away by running water, so when crops run out of nutrients, people abandon the land and look for another place, making it impossible for the origin vegetation to recover itself.

4. Remediation measures for the natural and human causes of soil erosion on the Loess Plateau

The Loess Plateau has developed a characteristic model for managing soil erosion in small watersheds. It has different modes of erosion management in different watersheds, but the overall similarity is due to the act that the management philosophy is people-oriented. The Loess plateau erosion management has two basic objectives. The first is to repair the environmental damage caused by irrational human

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activities and immature farming techniques. The second is to improve the infrastructure of the watershed for regional development and production. The following are examples of undertaking integrated small watershed management.

This model of ditch management and land creation is representative of the management of the Yan'an Sheep Circle Gully watershed. The area of forested land in this watershed. The area of forested land (1.53 km^2) accounts for 72.24% of the total area of the watershed. This watershed has seen a rapid increase in the area of forested land and a decrease in the area of grassland and arable land through policy support and reforestation projects [7]. Therefore, in order to solve the problem of the reduction of arable land after the return of farmland to forest, the basin has started to promote the construction of ditches, and the area of dam land has reached 6.14% of the total area of the basin, and the area of high standard farmland has increased significantly. The model is based on the spatial layout of creating land by ditch management under the mountain as well as returning arable land to forest on the mountain [8]. Drought-tolerant shrubs and trees such as lemon, buckthorn and cypress are used to build protective forests on the top of the beams, and fish scale pits and horizontal steps are used to ensure the survival rate of the plantations. Slope management is based on ecological restoration of the slope and the construction of a vegetation protection system, with grasses and shrubs planted on a large scale on steep, broken slopes to strengthen the slope and soil. Complete reforestation of arable land on slopes above 25° is carried out as its replacement for terraced agriculture in densely populated areas and gatherings, intercepting the soil on the slope under surface run-off, reducing the sand content of the run-off and reducing soil erosion. In order to stabilize gullies and slopes and increase the area of arable land, graded cut and fill gullies are adopted on both sides of the main gullies and in steep areas. Flood control systems are also constructed to increase the flood resistance of the area, mainly through the construction of drains and drainage channels in the gullies and interceptor ditches on the marginal slopes, which are used to improve the storage and drainage capacity of the basin and to achieve stable and productive agriculture in the dammed areas. A system of dams and reservoirs is built in the gullies to retain and control the soil in the run-off. The storage capacity of the silt dams is fully utilized, and the sand and water intercepted are reused to create land. This model is suitable for watersheds with a good governance base based on agricultural development. The model is used to solve the problem of land and people conflicts in ecological restoration, including the protection of environmental achievements, but also to ensure the agricultural land area. In contrast, planting a flat and fertile dam can reduce farmers growing costs [9].

Carrying out the industrial development of characteristic terraced orchards, the model arose in the Luoyu ditch watershed. The primary and secondary industries, such as the fruit industry and its processing industry, are vigorously developed through the integrated management of the upper beams, slopes and ditches. The beams are mainly treated by building ecological protection forests to prevent water and wind erosion on the beams, effectively reducing the loss of soil and water resources and thus creating a good ecological environment for the development of orchards and other industries in the watershed [10]. By terracing the gently sloping surfaces, rainfall infiltration rates are enhanced, and run-off is impounded while rainwater is collected to irrigate the orchard terraces, efficiently using rainwater resources and providing a quality growing environment and water and fertilizer conditions for the development of the orchard industry. The climate is moderate, light hours are long and rainfall is sparse, and the sugar content of the fruit is high, making it one of the most suitable areas for developing fruit trees on the Loess Plateau. The planting measures include monopoly mulching, fruit bagging, reasonable intercropping and planting, integrated pest control and soil improvement to increase soil fertility and other high technology to improve the quality and quantity of fruit production and ensure the economic income of fruit people in the region. The development measures optimize the industrial structure, train professional research and development teams, and establish high-tech demonstration parks to create a perfect chain of governance, planting, operation and marketing for the development of the fruit industry in the watershed [11]. The use of terraces as the main mode of fruit development in the watershed has effectively shifted the low-value forest and grass farmers in the watershed to higher-value fruits and vegetables, balancing the needs of farmers in the region to get rid

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of poverty and get rich with ecological construction, making environmental management and economic development a win-win situation.

5. Conclusion

This paper analyses the phenomenon of soil erosion in watersheds on the Loess plateau and finds that both natural and human factors cause it and that targeted measures are needed to address the region's different geographical and economic contexts. The small watershed erosion control measures implemented on the Loess Plateau have distinct regional characteristics. This paper also analyzes the characteristics of the terraced fruit industry in the hilly and semi-arid areas and finds that small watershed management has fundamentally improved the ecological environment of the watershed, providing a suitable living environment and a higher economic income for the local population. At the same time, soil and water management in the Loess Plateau is a complex and long-term management system that is still being improved in the medium term, thus making managing the watershed more efficient.

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