On Some Problems of Vegetation Ehabilitation in the Loess Plateau

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Abstract: The Loess Plateau is one of the regions where the soil erosion is the severest and the eco-environment is the most fragile. The key factors, which influence on the environmental changes of the Loess Plateau, are soil erosion, soil and water conservation, bearing capacity of water resources and vegetation rehabilitation. The vegetation repairing and rehabilitation is the key for the ecological construction in the area. An unprecedented achievement of soil and water conservation in the Loess Plateau has been obtained since 1949, but the efficiency of the forest and grassy vegetations for soil and water conservation in the whole engineering of eco-environmental construction in the area is very low, for example, the amount of blocking sands of the vegetations accounted only 0.2% for the amount of blocking sands of the whole engineering, the comprehensive benefit of the vegetations can't completely be brought into play. The paper discussed the problems related to the vegetation repairing and rehabilitation for soil and water conservation in the Loess Plateau, in order to quicken the speed and to better the quality of the eco-environmental construction engineering. The problems mainly discussed as follow: A. Selecting community types: the zonal vegetations of the Loess Plateau are confirmed by precipitation, temperature and aridity, and non-zonal vegetations are decided by the micro habitats forming from landform, relief, soil, slope position, slope degree, exposure and so on. B. Selecting varieties or species of trees and grasses: keeping to the principle which trees or grasses are planted by their suitable sites, the dominant and constructive species are selected as afforesting trees and planting grasses in the area according to the distribution of the zonal and non-zonal vegetations and vegetation community composition. C. Determining the densities of vegetations: the optimum vertical configuring patterns of arbors, shrubs and grasses are determined according to the vegetation biological and ecological characteristics, physiological consumption and ecological requirement water, and the eco-environmental construction objectives, so are the optimum densities at the beginning of planting and the dynamic management of the densities. D. Forest or vegetation coverage: the optimal forest or vegetation coverage in the Loess Plateau is determined in the light of the eco-environmental construction objectives, regional economic development level, climatic fluctuations, environmental bearing capacity, especially bearing capacity of water resources. E. Response of water resources to implementing the measures of soil and water conservation: the influences of water resources in the region and whole Yellow River from the different eco-environmental construction objectives for soil and water conservation at different stages in the future.
Keywords: soil and water conservation, vegetation construction, loess plateau

1 Foreword

The eco-controlling and environmental protection on the Loess Plateau should base on the controlling of soil erosion and water loss, aim at cutting down the sand into the Yellow River and at rehabilitating vegetations and bettering eco-environment and improving the living and producing conditions for the masses, through readjustment of the industrial structure and economizing and protecting and reasonably exploiting and optimized allotment of the water and soil resources in the region. The objective of the paper is to guide the construction of eco-barriers on the Loess Plateau in order to

provide the scientific and technological support and guarantee for controlling and exploiting of the Yellow River, for the social and economic sustainable development in the region and the successful implementation of the West Development in China.

The natural conditions in the Loess Plateau are the crashed landforms, loosening soil textures, sparse vegetations, concentrated rainstorms, more rich natural resources with frequent natural disasters. The topography is higher in the northwest and lower in the southeast, the main types of relieves are highlands and hills grown gradually up by the lithosphere movement, river descending, loess pileup and natural erosion in the geologic period. The Loess Plateau has been one region of the most sever soil erosion in the world because of the waving hills, vertical and horizontal ravines, eroding the surface of the plains and gouging gullies to shape the steep slopes and deep gullies and bitty girders and hills.

The Loess Plateau had been fertile soil with abundant forests and rich grasses in the historical periods, but the forests sharp decreased, the grasslands degenerated, soil eroded and desertificated owning to the multiple devastation from the frequent chaos caused by wars, the people reclamation and army crops storage, building palaces and temples, cutting forests about and denudation, and other social behaviors of destruction, this led to worsen the eco-environment and hardship of the natural disaster for the local people.

2 Location

The Loess Plateau, which is located at the northwest of China with the total area of 640 thousand km^2 including 7 Provinces or autonomous regions, such as Qinghai, Gansu, Ningxia, Shaanxi, Inner Mongolia, Shanxi and Henan, is the region of the most severe soil erosion and frailest eco-environmental zone in China even in the World. Since many years, Chinese Government has been carrying through long-term and large-scale integrating controlling to conserve soil erosion and restore the eco-environment of the Loess Plateau, and acquired some achievements in evidence, but where are the key areas to control and how will the vegetation be rehabilitated and what is the direction for the controlling soil erosion and other problems are difficult to reach the same knowledge, so the complexion, which each does thing in own ways for the eco-construction and headache cures head and feet-ache cures feet and lower surviving rate and saving rate and benefit for the vegetation rehabilitating, was shaped.

3 Rehabilitating vegetations faced problems

3.1 Zonal vegetations distribution

Vegetation not only is limited by the landforms, climate, soils, parent materials and other factors but also is the comprehensive response of various environmental factors. The vegetations from south to north in the Loess Plateau are divided into four vegetation zones in turn, such as forest zone, forest-grassland zone, typical grassland zone and desert grassland zone, which distributional rule is markedly correlation with the corresponding to the climatic, soil, topographical, physiognomic and other factors (Table 1). But because of coming to light, the original vegetations in the Loess Plateau do not already existed and are replaced with the natural secondary vegetations or by the artificial vegetations. The main forest communities, which distribute mostly in Qiaoshan Mt, Huanglongshan Mountains, Ziwuling Mountains, Helanshan Mountains, Laoshan Mountains and other remote mountainous regions, have *Pinus tabulaeformis*, *Platycladus orientalis*, *Juniperus formosana*, *Populus davidiana*, *Qercus liaotungensis*, *Populus cathayana* and so on in the Loess Plateau. The main shrubberies have *Nitraria tangutorum*, *Rosa hugonis*, *Hippophae rhamnoides*, *Wikstroemia chamaedaphne*, *Periploca seoium*, *Prunus armeniaca* var. *ansu*, *Ostryopsis davidaana*, *Syringa* sp., *Caragana microphylla* , etc. The grassy species in the grassland as follow: *Stipa bungeana*, *Artemisia argyi*, *Thymus mongolicus*, *Lespedeza daurica*, *Artemisia desertorum*, *Cleistogenes squarrosa*, *Astragalus melilotoides*, *Poa* sp., *Stipa grandis* P. Smirn, *Pennisetum centrasiaticum*, *Artemisia capillaris* and so on.

Table 1 Zonal vegetations and its' characteristics of climates and soils in the Loess Plateau

Vegetation zones	Forest zone	Forest-grassland zone	Typical grassland zone	Desert grassland zone
Locations	Locates at the southeast of the Loess Plateau. Begins at Pu County in the north to southwest through Ji County and cross the Yellow River into Shaanxi Province, through northern Huanglong County and southern Huangling County, along with northern Lingyou and Longxian County, turning over the southwestern till the southern of Tianshui Prefecture. The region includes the most of Huanglong Mt and the southern Guanshan Mt.	Connects the forest zone at the southern, begins the southern of Xinxian County at the north, to the west through the Yellow River, crossing Suide and Zhiduan County, along with Guyuan, Xiji and Huining County to the southwest direction till to the southwest of Dingxi Prefecture. The region includes the north of Huanglong Mt, Ziwuling Mt and Liupanshan Mt.	Abuts the forest- grassland zone at the southern. The north boundary begins at the northern boundary of the Loess Plateau to the west through Dingbian County and turns over the southwest through Tongxin County till to the south of Lanzhou City.	Locates at the northwest of the Loess Plateau, neighbors the typical grassland zone at the southeast direc-tion.
Landforms	Tableland and ravines, rocky mountainous regions and part of loess hills	Loess hills, loess remnant tableland and rocky mountainous regions	Loess hills, loess hills covered by loess, bottomland and sands	Gently hills and wide valleys
Altitude (m)	800 m—1,200 m	1,100 m—1,900 m	1,200 m—1,800 m	1,400 m—1,900 m
Annual average tem. (℃)	9℃—12℃	6℃—9℃	6℃—9℃	6℃—9℃
⩾ 10 ℃ cumulating tem. (℃)	>3,200℃	2,800℃—3,100℃	2,300℃—3,000℃	2,200℃—2,600℃
Annual rainfall (mm)	550 mm—650 mm	450 mm—550 mm	300 mm—450 mm	300 mm
Aridity	1.3—1.5	1.4—1.8	1.8—2.2	2.0—3.5
Soil types	Brown soil	Black loamy soil and grey brown soil	Black loamy soil, light chestnut calcium soil and sandy soil	Grey calcium soil and sandy soil
Status of soil water	Compensating or basic compensating zone of soil water during the annual water cycling	Deficient zone of soil water during the annual water cycling	Deficient zone of soil water during the annual water cycling	Severe deficient zone of soil water during the annual water cycling

3.2 Species of the vegetations

The selection of the biological materials for the rehabilitating vegetations in the Loess Plateau must follow the rules of the right site suitable for trees or grasses, the setting up defenses for the disasters and the harmony between ecological benefits and social benefits. The main plant species in the different vegetation zones as follows: *Pinus tabulaeformis*, *Robina pseudoacacia*, *Populus* sp., *Platycladus orientalis*, *Ailanthus altissima*, *Ulmus pumila*, *Morus alba*, *Fraxinus* sp., *Catalpa speciosa* and so on in the forest zone. The arbors of *Pinus tabulaeformis*, *Robina pseudoacacia*, *Populus* sp., *Platycladus orientalis*, *Ulmus pumila* and the shrubs of *Hippophae rhamnoides*, *Amorpha fruticosa*, *Caragana microphylla*, *Prunus armeniaca* var. *ansu*, *Prunus persica* and other species in the forest-grassland zone. The vegetation rehabilitated in the typical grassland zone give priority to the shrubs as *Hippophae rhamnoides*, *Caragana microphylla*, *Amorpha fruticosa*, *Tamarix chinensis* in the southern of the regions and to *Artemisia desertorum*, *Hedysarum scoparium* and so on in the northern of the regions. The typical grassland zone is suitable for planting *Astragalus adsurgens*, *Melilotus officinalis*, *Medicago sativa*, so which has important meanings for the development of stock raising. The stock raising in the desert grassland zone is possessed of most proportion, where does not exist complete stands and are planted a few of arbors as *Elaeagnus angustifolia*, *Ulmus pumila*, *Salix matsudana* and etc., and where there are large-area of artificial shrubberies with mostly *Astragalus adsurgens*.

The Loess Plateau has expansive territory, complicated relieves and great different climates from east to west and from south to north, therefore the re-combination of the various ecological factors from

the different zones comes into being the local micro-habitats. For example, there are different biological materials with the different precipitation, erosion characters, soil and temperature at the between hilly ravine regions and tableland ravine regions, between the east and west in the Loess Plateau and among mountain ridge, shoulder, peak, gully, slope, bottomland and so on, therefore flakes of forests can be planted in the typical grassland zone and the savanna can be built in the desert grassland zone.

3.3 Densities of rehabilitating vegetations

The key problem to rehabilitate vegetations in the Loess Plateau located mostly at the arid and semi-arid region is water, in other words, water decides all in the region. The densities of the rehabilitating vegetation are based on the carrying capacity of the regional water resources, aimed finally at constructing plant communities or ecosystem of stability and everlasting and efficiency by the physiological and ecological characteristics of plants, in order to improve the regional eco-environment, to promote the local economics and to help the local people into the rich out the poor. The objectives of all measures are to realize the social, economic and resources sustainable development at last.

The main reasons of the lower efficient vegetations or "trees with old before ones' time" in the Loess Plateau are the improper botanical materials or too high densities planted so as to aggravate the water competition among plants and to make soil drought, therefore base on the right site suitable for trees or grasses the densities of rehabilitating vegetations must be controlled. For instance, the canopy cover ratios of the black locust in the regions of 600 mm rainfall may be controlled at 0.7—0.8, but that in the regions of 450 mm rainfall must be controlled at 0.3—0.4. of course, the limited atmospheric rainfalls are redistributed at spatial and temporal with the techniques for the rehabilitating vegetations of anti-drought or run-off forestry to create suitable environment for plants growth and to improve the water resources using efficiency.

3.4 Forest coverage

At present the forest coverage in the Loess Plateau is not enough to 10.0 percent and less 3.5 percent than the average of the whole country in China, which is the co-effecting result from long-term climatic succession and human being activities. The historic materials recorded that the forest coverage in the Loess Plateau at Xizhou Epoch was 53 percent (Zhu Junfeng, 1985), the forest was destroyed beginning at Qing and Han Dynasty, and the forest coverage was still more than 40 percent from Qing and Han Dynasty to Nanbei Dynasty. After then, the forest coverage sharply decreased because of the multiple destruction of forest vegetation from chaos caused by wars of past dynasties, building royal courts and temples and reclamation and felling for the expanded population, for example the forest coverage in the Loess Plateau during Tang, Song, Ming and Qing Dynasty was 33 and 15 percent respectively (Shi Nianhai, 1982). The total forest area was only 37 thousand km^2 with the forest coverage 6.2 percent in 1949. During 1949 to 1985, especially the periods of the "Tree Years Difficult" and "Cultural Revolution", the sparse forest resources in the Loess Plateau was much destroyed by cut about and denudation, deforestation and reclamation and overgrazing owning to population sharply expanding and the policies misplaying. It is obvious that the population increasing almost synchronizes with the forest destruction in the Loess Plateau, namely the period when the population increased the quickest was the forests were destroyed the highest speed.

According to the geographical, ecological and environmental characteristics and the objectives for the eco-construction in the Loess Plateau, so far as the forest coverage in the region reaches 30 percent to 35 percent and the forests with the scientific configuration are distributed evenly, the soil and water loss in the watershed of Yellow River could be obviously decreased (Zhu Jinzhao, 2001). The forest vegetations in the Loess Plateau with its' function are divided into the farmland shelter-forests, forests for soil and water conservation, self-restraint forest for water sources and wind-break and fixing sand forests, which efficient coverage are determined by themselves and the optimum forest coverage in the Loess Plateau is 38.7 percent (Wu Qinxiao, 1996).

3.5 Impacting of the regional water resources from vegetation rehabilitation

In a general condition, the relationship between run-off amount and the atmospheric rainfall is markedly positive without exception in the region of the Loess Plateau. It is common knowledge that the global climatic change profoundly influences on the atmospheric precipitation and run-off amount of rivers in the Loess Plateau in the future. But here we discuss that the coverage change of the forest and grassy vegetation affects to the run-off amount of rivers in the Loess Plateau.

The rehabilitation of forest and grassy vegetation in the Loess Plateau is the cut-in point, what completely transforms the situation of soil and water loss and eco-environmental exasperation day by day. The increasing of the vegetation coverage plays markedly an important role in conserving soil and water and also decreases the run-off amount in the rivers, because the modeling of water resources cycling in the original ecosystem are changed through the canopy interception, stem flow, interception of the under-plants and litter layers, and increasing soil water permeability. Only 60 percent to 70 percent of the atmospheric rainfalls reach the surface and fewer that into soil in the forest ecosystems, on the other hand the forest and grassy vegetations consumes a lot of water with evapo-transpiration and act as the function of “pumper” in the arid and semi-arid regions, which make soil drought and have appeared 1—8 meters drought layers under the surfaces in some areas of the Loess Plateau, and destroy the fine cycling of the “five waters”(atmospheric rainfall, surface water, soil water, groundwater and plants water), the atmospheric rainfalls are consumed and vaporized or transpired completely on the spot without the surface water for supplying the groundwater, therefore the vegetation rehabilitation in the Loess Plateau could cut down the run-off amount in the rivers.

The relationships between forest and precipitation have been already carried out thorough and wide studies at home and abroad. What forest increases the horizontal rainfall is the well-known facts plays a very important role in the arid and semi-arid regions, but whether or not forest increases the vertical rainfall does not compass the common knowledge and exits lots of divarications from theories to practices and their research methods, because the problem is much complex itself and the nature is changing in thousands of ways. The most regions of the Loess Plateau are located at the arid and semi-arid zones, and the high-altitude air is dryness even un-saturation. Under general conditions, the water vapor from the vegetation evapo-transpiration enters into the air and then winnows far off with the wind, so is difficult to gather in the sky over the vegetations, to stagnate the neighbor areas and to achieve the objectives for assembling the clouds together into raining. Therefore the increasing area of forest and grassy vegetations in the Loess Plateau cannot enhance the vertical rainfalls in the regions.

It is obvious that the increasing area of forest and grassy vegetations in the Loess Plateau makes for soil and water conservation and the eco-environmental improvement, but holds back and stores up the run-off amounts namely cuts down the total amounts of the surface water resources. According to the objective for the eco-construction in the book of “National Planning for the Eco-environmental Construction”, the planning area for the forest and grassy vegetations planted will be 29 550 thousand hm^2 till 2050. The run-off amounts hold back and stored up by the rehabilitating vegetations are more than 40 percent, and which are 10 percent at average by the conservative estimation owning to the Loess Plateau having too much steep sloping fields with exceeding permeating flows. The run-off amounts hold back and stored up by the rehabilitating vegetations are annual 75 cubic meters per hectare and are totally 22.23 hundred thousand cubic meters in the Loess Plateau (Huang He, 1999).

4 Summary

According to the climatic, soil, topographical and other environmental factors the vegetations in the Loess Plateau are divided into four vegetation zones in turn, such as forest zone, forest-grassland zone, typical grassland zone and desert grassland zone from south to north, where give respectively priority to arbor, shrub, grass and grass species with the characteristics of anti-drought and lower water consumption, and the selection of the biological materials for the rehabilitating vegetations in the region must follow the rules of the right site suitable for trees or grasses, the setting up defenses for the disasters and the harmony between ecological benefits and social benefits. The densities of the rehabilitating vegetation are

based on the carrying capacity of the regional water resources. The forest coverage in the region reaches about 35 percent and the forests with the scientific configuration are distributed evenly, and the vegetation rehabilitation in the region should be taken the shrubbery and grassy species as the dominant factors. The run-off amounts hold back and stored up by the rehabilitating vegetations are annual totally 22.23 hundred thousand cubic meters estimated by the objective for the eco-construction in the Loess Plateau till 2050.