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Optimal Configuration Mode of Soil and Water Conservation Measures in Small Watersheds in Northern Grasslands

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Abstract. Prairie soil and water loss and eco-construction have been studied for many years. On the basis of the status quo and causes of soil and water loss in the north typical prairie areas, we put forward the disposition model of comprehensive control measures of small watershed in the north typical prairie areas. Centering on combining engineering measures with biological measures to improve grasslands eco-environment, we take beach shallow groundwater exploration as a breakthrough, and take close improvement and artificially planting grasses as methods aiming at improving grasslands productivity and promoting the development of animal husbandry so as to provide successful experiences for the comprehensive control of resemble small watersheds.

Keywords. Typical prairie, small watershed, comprehensive control

The north typical prairie areas refer to the Inner Mongolia Xilin Gol Prairie in the north sand source areas around Beijing and Tianjin. In these areas [1], it is cold in long winter, it is warm and short of precipitation in summer and it blows hard and has many sands in spring and autumn. Besides, there exists overloading phenomenon. All these not only aggravate its soil and water loss and expand its sandy prairie areas but also resist its animal husbandry development. Especially, sand-dust storm occurs frequently in recent years, which greatly threatens the eco-environment around Beijing and Tianjin. On the basis of test study on prairie soil and water conservation and eco-construction for many years and through the practice of prairie small watershed control projects of XiLinHaoTe City, ZhengXiang white League and Xiang yellow League, this model is put forward. Since starting eco-control projects of Beijing and Tianjin sand source from year 2000, more than 200km^2 Small watershed is finished per year [2]. This model will be of theoretical significance and practical use.

1. General Situation of the Region

1.1. Natural Condition

The XiLinGuoLe Prairie lies in the mid-north part of the Inner Mongolia autonomous

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region, with north latitude from 41º35′ to 46º46′ and east longitude from 111º09′ to 119º58′. The region belongs to semi-arid continental climate of mid-temperate zone. Its yearly average air temperature ranges from 0.7°C to 4.4°C. Its annual temperature and daily temperature are very different and its non-frost period is short. It always blows hard and has many sands. Its yearly average wind velocity is about 4m/s and its annual gale days is from 50 days to 80 days. Precipitation of it is from 200mm to 350mm and it weakens progressively from east to west. The precipitation from May to August is 80% of its annual precipitation. The annual amount of evaporation is from 1500mm to 2700mm and it increases progressively from east to west. In most areas, the amount of evaporation is from 6 to 10 times as big as its precipitation. Meadow soil, chestnut soil, podzol, brow calcium soil and windy soil are its regional soils [3].

1.2. Status Quo of Soil and Water Loss

Wind erosion and water erosion, which damage soil alternately, are its main erosion forms. According to RS data, the area of soil and water loss above light level of this region is 17233km^2 and its annual erosion amount is 0.7 billion tons [4]. Wind erosion mainly takes place between March and May and water erosion mainly takes place from July to Sep. All kinds of erosion makes soil and water loss very serious and does great harm to local eco-environment and animal husbandry. Water erosion leads to many gullies and exposed rocks. Making Xiang yellow League as an example, its gully density is 0.83km/km^2 and its annual erosion amount is up to 5000 tons per km^2 per year [5].

1.3. Cause of Soil and Water Loss

Topography, geology, soil, climate, vegetation and artificial factors are main causes leading to its soil and water loss happening and developing. Precipitation and gale are its main motive forces. Even in summer, concentrated and strong precipitation supply convenient conditions for it. What's more, its chestnut soil, light chestnut soil and sandy soil are very loose, cohesion is little and erosion resistant capacity is low, so it is easy to happen when gale and heavy rain take place. All these natural factors attaching artificial factors, such as reclaiming waste lands blindly, overloading, exploiting and digging excessively and so on [6], which destroy prairie ecosystem, do harm to plant root system and soil texture, reduce its wind erosion resistant capacity and water erosion capacity and aggravate its soil and water loss even more.

2. Guiding Ideology and Technological Route of the Comprehensive Control

In accordance with the important instructions of the CPC Central Committee and the State Council on vigorously strengthening the construction of the ecological environment, preventing and controlling desertification, and controlling soil erosion, sands prevention and control and harnessing soil and water loss, we implement following guiding ideology, i.e., proceeding from the local actual situation, making suiting measures to local conditions, planning rationally, laying stress on the key points and carrying out them step by step as basic guiding principles, insisting on the principle of arranging mountains, water, grasses, forests and roads comprehensively [4, 7], basing on soil and water conservation comprehensive control, on the premise of scientific disposition of water resources, basing on methods of water-saving irrigation and soil and water conservation projects, making science and technology as guide and making laws as guarantee.

Through soil and water conservation comprehensive control to control soil and water loss effectively and improve regional eco-environment through developing water-saving irrigation and making full use of limited water resources to quicken the transformation from traditional animal husbandry to modern animal husbandry so as to improve production conditions as soon as possible, reduce prairie pressure, increase incomes of the masses and make green hills and clear water, prosperous economy and rich lives come true.

3. Excellent Disposition Model of Comprehensive Control Measures

On the principle of unified planning with due consideration for all concerned and comprehensive prevention and control, we divide the small watershed comprehensive control system of typical prairie into three parts, i.e., slope preventive subsystem, ditch preventive subsystem and river plain and beach comprehensive development subsystem (Figure 1). According to topography, soil [8], vegetation and erosion form to dispose control measures of all subsystems excellently so as to achieve total excellence.

3.1 Slope Preventive Subsystem

3.1.1. Engineering Measures

(1) Level Ditch

In order to make full use of slope surface runoff caused by precipitation and retain water, fertilizer and soil, we should dig level ditches along contour line on the 6º-20º shady slopes and semi-sun slopes with more than 30cm soil layer [9]. We plan the distance between two level ditches and its section on the principle of rainstorm under planning frequency not leading to soil and water loss. If slope is steep, soil layer is thin and precipitation is big, the distance between two level ditches should be small. Otherwise, it should be bigger. The ditch is deep and narrow if slope is steep. The ditch is shallow and wide if slope is gentle. Generally, the distance between two ditches is from 3m to 5m, the width of the ditch mouth is from 0.7m to 1m and the depth of the ditch is from 0.5m to 1m. The region lies in the wind erosion and water erosion crisscrossed belt, so we should arrange level ditches with wide distance and big section along contour.

(2) Water Logged Ponds

In order to retain surface runoff still further, make full use of natural precipitation, irrigate orchard and soil and water conservation forests and reduce soil and water less, we can arrange waterlogged ponds on the top of ditches where it is not easy to dig level ditches and carry out other engineering measures [10].

(3) Closing Land for Control

In order to recover its vegetation as soon as possible and prevent the phenomenon of damaging it while controlling it from happening, we close the whole watershed for control so as to reduce artificial damages. Combining it with grasslands improvement measures to contain its soil and water loss on the whole. Generally we use cement stakes and galvanized wire net added barbed wires on the top and lower parts of it to make net defensive wall [11].

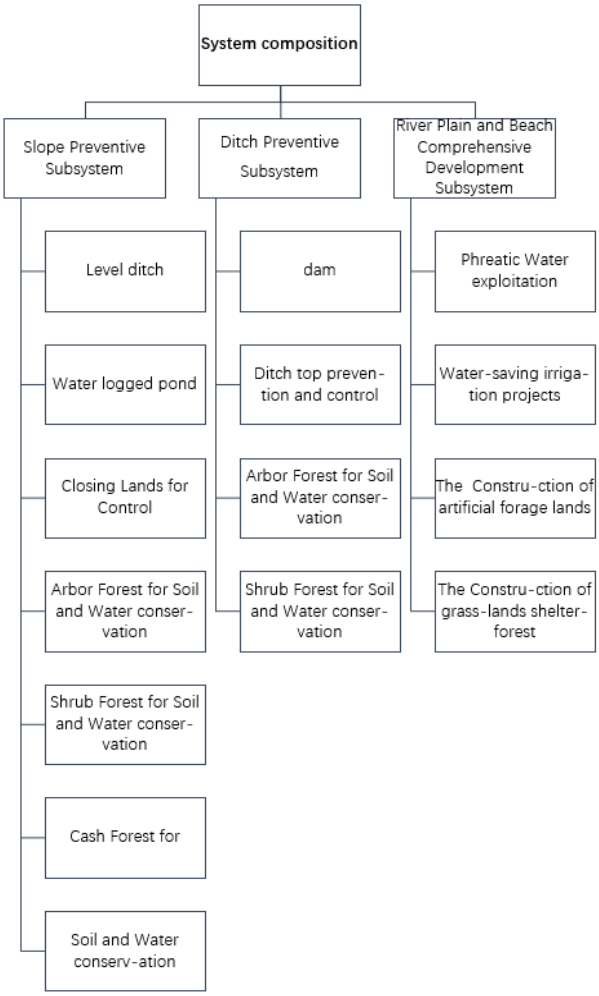

Figure 1. Sketch map of prairie small watershed comprehensive control system.

3.1.2. Biological Measures

In order to prevent sands and gale, conserve soil and water, retain surface runoff, reduce soil and water loss, regulate air temperature, ground temperature and humidity and improve its microclimate condition, we arrange following biological measures combined with above engineering measures.

(1) Arbor Forest for Soil and Water Conservation

According to its soil texture, we usually plant arbor forests for soil and water conservation on the gentle slopes of 3º-5º with more than 50cm soil layer. In order to retain precipitation [12], accelerate the growth of grasses and increase vegetation coverage we mainly select willows and sandy dragon spruces.

(2) Shrub Forest for Soil and Water Conservation

Through level ditch soil preparation, we plant shrub forests in the integrated areas with slope of 5º-15º and more than 30cm soil layer Mountain apricots and Ningtiao are mainly selected. In order to reduce soil mound wind erosion [13], we usually plant two lines of shrub on soil mounds under the level ditch. Initially we don't plant trees in the

pits of the level ditches but after a few years we plant trees on deposited lands. We plant mountain apricots on the gentle slopes with better soil and moisture content conditions.

3.2. Ditch Protective Subsystem

3.2.1. Engineering Measures

(1) Dam

In order to fix and raise erosion datum plane, prevent ditch bed from cutting downwards, reduce the damage of mountain torrents and mud-rock flow, change ditches to plains and form dam terrace, we arrange dams in small branch ditches, lash ditches or cut ditches. We usually arrange a group of dams according to its topography, landforms and slopes in a systematic way in order to bring its whole benefits into play [14]. We should select dam types suitable to local condition on the principle of suiting measures to local conditions and using locally available materials. We select galvanized wire net dry stone dams because stones distribute widely there and they are easy to be exploited and transported.

(2) Ditch Top Prevention

In order to detain flood, retain upper reaches slope runoff and prevent runoff from being drained to ditches, we put up some closing ditch dikes approximately parallel to ditch edge on slopes above top of the ditch and at same time, we dig water storage ditches parallel to the dike in the areas 1m-1.5m away from top of the dike so as to retain slope runoff. Generally, its section is like trapezoid. We put up continuous ditch dikes when the slope topography is intact [14, 15], otherwise we put up intermittent ditch dikes.

3.2.2. Biological Measures

In order to control ditch top going forward, ditch bottom cutting downward and ditch bank expanding, as for heavy eroded ditches, we plant arbor forests on the top of ditches so as to fix soil, increase scour resistant capacity and raise vegetation coverage [14, 15]. Besides, we plant shrubs such as Ningtiao on the dam terrace deposited by dams so that they are harnessed comprehensively. As for ditches erosion of which has stopped on the whole, we should utilize present lands and select some places where moisture content and fertilizer are better and ditches are wide to develop artificial grasslands and construct orchard on gentle ditch slopes with deep soil layer and exposed to the sun.

3.3. River Plain and Beach Comprehensive Development Subsystem

3.3.1. Water Source Development and Water-Saving Irrigation Projects

In middle areas and beaches of the valley, it is rich in shallow ground water, so we should make full use of it to irrigate artificial grass lands, cash trees, arbor and shrub forests for soil and water conservation. According to regional hydro-geological conditions, water lever should be from 5m to 10m depth and the amount of surging water per well is about 7-10 tons per hour, which can irrigate 15-20 acres artificial forage lands [16, 17]. We usually select box- well and well is made of prefabricate concrete tubes.

In order to make full use of water resources and increase the coefficient of irrigation water use, we supply water-saving irrigation projects. In this region we mainly select micro-motive spray-irrigation.

3.3.2. Construction of Irrigated Forage Lands

The contradiction between grasses and animals is main factor influencing prairie eco-

environment. In order to resolve this contradiction, increase grassland productivity substantially, ensure the supply of forages sufficiently, improve the sustained development of animal husbandry, increase vegetation coverage, conserve soil and water and control soil and water loss effectively ,through adopting water-saving irrigation, introducing excellent planting technologies and comprehensive high-productivity planting technologies, we construct irrigated forage lands in the areas where it is smooth and broad [17], its soil quality is fine and its soil layer is deep and fertile.

3.3.3. Construction of Grassland Shelter-Forest

Adopting the way to combining nets, belts with parts and combining arbor with shrub, we plant grasslands shelter-forests in order to protect prairie, improve eco-environment and reduce soil and water loss. In pastoral areas, there are many lands and less forests, its regional condition is bad and climate is draught, so its forest belt is wider. Its main belt is from 10m to 20m and assistant belt is from 7m to 10m [18]. We usually plant 4-6 lines of arbor, plant a line of shrub on both sides of it respectively and form sparse texture. In order to ensure afforestation quality, we should adopt soil preparation measures before afforesting and protect them rigidly after afforesting so that they can grow rapidly. We should irrigate them in time if we have irrigation condition and cut shrubs at suitable time.

4. Benefit and Application of Comprehensive Management Model

We adopted this model in the Beijing and Tianjin sand source control item of the inner Mongolia XiLinHaoTe City in 2018, i.e. the construction of Donggou small watershed control project. Its basic benefits conserving soil and water benefits, Economic benefits, ecological benefits and social benefits are very remarkable. The control area of this small watershed is 5km^2, which can retain water 11.54 thousand m^3 and conserve soil 62.5 thousand tons per year. Through closing grasslands, planting grasses artificially and constructing forage grass lands with high productivity, we can increase 566.3 thousand kg forage grasses and fodders. Through developing soil and water conservation forests, we can increase 229.5 thousand kg branches per year. Through planting cash trees, we can increase 980 thousand kg fruits and its output value of annual growth is 630 thousand yuan. The vegetation coverage increases from 30%to 60% and personal incomes increases from 1210yuan to 2800yuan. Besides, the implementation of this item change its animal husbandry management way completely, I e from natural herding to shed-feeding and semi-feeding, thereby improve its natural calamity-resistant capacity. Consequently, this model not only can control soil and water loss in prairie small water shed but also can improve its eco-environment effectively, thus it defends and improves the balanced development from water, grasses to animals.

Although this model also applies to the whole north typical prairie areas universally, because of the difference and complexity of different regional conditions, prairie control measures should not only confine to this model. We should consider all-round and regulate it according to the local conditions and then select the best comprehensive control model of different regions to protect prairie eco-environment and improve stable development of animal husbandry.

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