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ORIGINAL RESEARCH ARTICLE

Status of grassland resources utilization in Ili River Valley and countermeasures for sustainable utilization

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ABSTRACT

From the perspective of grassland resources and their sustainable utilization, this paper expounds the type characteristics and utilization status of grassland resources in the Ili River Valley, and analyzes the main problems of grassland re-sources in the Ili River Valley, such as the annual increase of grassland degradation area, the increasingly serious soil erosion, the imbalance between seasons and years of grassland production, and the imperfect mechanism of grassland ecological protection, restoration and management. This paper discusses the driving mechanism affecting the productivity of grass-land resources, and puts forward the corresponding countermeasures in the sustainable utilization of grassland ecosystem, such as strengthening the management of grassland re-sources, establishing a grass seed gene bank and screening native grass species, implementing the construction of grassland ecological restoration, strengthening grassland ecological monitoring and actively promoting ecological tourism.

Keywords: Ili River Valley; Grassland Resources; Utilization Status; Sustainable Utilization; Countermeasure

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1. Introduction

Grassland is not only the production base of animal husbandry, but also plays an extremely important role in maintaining ecological balance. Grassland is the main body of the ecological environment in Xinjiang, accounting for 34% of the total area of Xinjiang. It not only provides an important material basis for the development of grassland animal husbandry in Xinjiang, but also plays an important ecological function in biodiversity protection, water and soil conservation, etc.[1]. Grassland resources are an important part of natural resources, the material basis for human grassland animal husbandry production, an important condition for national economic development and improving people's living standards, and an important source of social wealth. Grass-land has the ecological functions of wind and sand prevention and water conservation. It is the gene pool of biodiversity, can regulate the climate, and is the basis for the survival and development of all ethnic groups.

2. Natural overview

The Ili River Valley is located in the west of Xinjiang, at 80°09′~84°56′E, 42°14′~44°50′N. It is the largest Intermountain Valley in the Western Tianshan Mountains. It is surrounded by mountains in the North, East and South, with north-west-southeast Keguqin Mountain and Borokonu Mountain in the North, northeast-southwest Haktawu Mountain and Nalati Mountain in the South, and Wusun

Mountain and Awulale mountain in the middle, forming the geomorphic outline of "Three mountains with two valleys". The altitude is 600 ~ 1,500 m, and the altitude of the mountains on the North and South sides is 3,000 m. It is 350 km long from East to West and 180 km wide from South to North.

3. Grassland types and basic characteristics (see Table 1)

The available grassland area in Ili River Valley is 310.43 hm^2, accounting for 6.47% of the available grassland area in Xinjiang. The vertical distribution of grassland in Ili River Valley is relatively obvious. From below the glacier, there are alpine meadows, mountain meadows, mountain meadows grasslands, desert grasslands, lowland meadows, and marshes, with a total of 238 grassland types of 7 major types. The Ili River Valley is overwhelmingly dominated by the ephemeral plant—Artemisia desert[2], and the Ili natural grassland is famous nationwide for its many types, good quality and high productivity. The unique natural environment of the Ili River Valley breeds the world-famous grasslands such as Nalati, Tangbula, Karajun, Baraksu, Kerikante, and makes the Ili River Valley known as "Lush southern type fields north of the Great Wall".

Table 1. Grassland types and grass yield in Ili River Valley

Serial No.	Grassland type	Fresh grass yield (kg/hm^2)	Coverage (%)	Height of grass layer (cm)
1	Alpine meadow	22.81	75 ~ 90	5 ~ 15
2	Mountain meadow	52	85 ~ 100	25 ~ 80
3	Mountain meadow grassland	31.2	75 ~ 95	25 ~ 75
4	Mountain grassland	10.13	25 ~ 50	10 ~ 80
5	Desert grassland	6.67	25 ~ 45	10 ~ 35
6	Lowland meadow	32.67	50 ~ 85	15 ~ 50
7	Plain swamp	27.33	85 ~ 100	20 ~ 100

3.1 Alpine meadow

It is distributed between 2,400 ~ 3,300 m above sea level, with an average annual precipitation of 500~800 mm. The soil texture is coarse sand and gravel. Due to the cold climate in the area, the plant community structure is simple and the plants are low. The constructive species are *Kobresia capillifolia*, *Carex stenocarpa*, *Carex melanantha*, *Carex songorica*, *Polygonum viviparum*, *Alchemilla tianshanica*, *Poa alpina*, etc. Associated species include more than 20 families, more than 150 species, including *Phlomis oreophila*, *Caragana sinica*, *Thalictrum alpinum*, *Alpine Rock Jasmine*, and a total of 23 grassland types.

3.2 Mountain meadow

It is distributed between 1,600 ~ 2,400 m above sea level, with an average annual precipitation of 600 ~ 1,000 mm. It is the area with the most abundant precipitation in Tianshan mountain area, and the soil is chernozem. Mountain meadow is the essence of the natural grassland in Ili River Valley. It has the characteristics of large area, wide distribution, many plant species, good forage quality, rich nutrition, good palatability and high grass yield. The constructive species include *Dactylis glomerata*, *Poa angustifolia*, *Roegneria sinkiangensis*, *Ligularia macrophylla*, *Rumex acetosa*, *Phlomis oreophila*, *Geranium pratense*, etc. Associated species include *Trifolium pratense*, *Bromus inermis*, *Poa pratensis*, *Festuca rubra*, etc., with a total of 58 grassland types.

3.3 Mountain meadow grassland

It is distributed at an altitude of 1,100 ~ 2,600 m. It is distributed in a narrow strip along the front edge of the middle mountain belt in the Ili River Valley. The annual average precipitation is 350~500 mm, and the soil is mainly dark chestnut soil. The constructive species include *Bromus inermis*, *Elymus dahuricus*, *Uraria cristina*, *Festuca ovina*, *Stipa capillata*, *Poa annua*, *Dactylis glomerata*, *Artemisia sacrorum*, *Salvia japonic*a, *Phlomis pratensis*, *Medicago falcata* and *Glycyrrhiza uralensis*. The

sub constructive groups include *Cannabis sativa*, *Onobrychis viciifolia*, *Ziziphora tomentosa*, *Geranium pratense*, etc. Associated species include *Potentilla chinensis*, *Medicago lupulina*, *Achillea millefolium*, *Leymus secalinus*, *Iris loczyi*, etc., with a total of 48 grassland types.

3.4 Mountain grassland

It is distributed between 1,100 and 2,200 m above sea level, with an average annual precipitation of 350 mm. It is mostly distributed on sunny slopes, rich in heat, and the soil is mainly chestnut soil. The constructive species include *Stipa capillata*, *Bothriochloa ischaemum*, *Carex liparocarpos*, *Iris ruthenica*, *Sophora alopecuroides*, *Caragana sinica*, *Ajania fastigiata*, *Spiraea hyperifolia*, *Rosa multiflora*, etc. Associated species include *Agropyron cristatum* and *Leontopodium leontopodioides*, with a total of 39 grassland types.

3.5 Desert grassland

It is distributed at an altitude of 750 ~ 1,500m, with an average annual precipitation of about 200 ~ 250 mm. The soil is calcareous soil. The constructive species include *Seriphidium transiliense*, *Kochia prostrata*, *Ceratoides latens*, *Ceratocarpus arenarius*, *Carex onoei*, etc. Associated species include *Salsola collina*, *Achnatherum splendens*, *Trigonella*, etc., with a total of 10 grassland types.

3.6 Lowland meadow

It is distributed in the fan edge low-lying land of the alluvial proluvial plain in the Ili River Valley. The soil is mainly meadow soil, light chestnut soil, and locally light saline alkali soil. The constructive species include *Agrostis alba*, *Aeluropus pungens*, *Hordeum bogdani*, *Trifolium pratense*, *Iris lacteal*, *Achnatherum splendens*, *Taraxacum mongolicum*, *Glycyrrhiza uralensis*, *Plantago asiatica*, *Phragmites communis*, *Calamagrostis epigeios*, etc., with a total of 35 grassland types.

3.7 Plain swamp

It is distributed in the flood plain and seasonal ponding zone in the lower reaches of Kashi River, Gongnaisi River, Tekes River and the middle and lower reaches of Ili River, and the soil is marshy soil. The constructive species include *Phragmites communis*, *Calamagrostis epigeios*, *Juncus effusus*, *Cyperus rotundus*, etc. There are two grassland types.

4. Current situation of natural grassland utilization (see Table 2)

The natural grassland in Ili River Valley is used in two ways: grazing and grazing-mowing. Grazing is divided into four kinds according to seasons: summer grassland, winter grassland, spring-autumn grassland and winter-spring-autumn grassland. Among them, summer grassland, spring-autumn grassland and some winter grassland are pure grazing grassland, most of which are divided into winter grassland and winter-spring-autumn grassland for grazing and mowing.

Table 2. Grassland area and livestock carrying capacity in Ili River Valley

Serial No.	Seasonal grassland	Area (million hectares)	Theoretical stocking capacity (million sheep units)	Actual stocking capacity (million sheep units)	Stocking capacity (overload –, underload +)
1	Summer grassland	101.14	887.22	758.11	129.11
2	Spring-autumn grassland	84.23	338.99	485.13	–146.14
3	Winter grassland	83.66	559.63	629.48	–69.85
4	Winter-spring-autumn grassland	38.87	228.01	228.01	0

4.1 Summer grassland

The grassland area in summer is 101.14 million hectares, with a theoretical livestock carrying capacity of 887.22 million sheep units and an actual livestock carrying capacity of 758.11 million sheep units. The utilization period is from mid to late June to mid to late September, mainly distributed in mountain meadows and alpine meadows with an altitude of more than 1,700 m; the plant species are mainly miscellaneous grasses, as well as mesophyt-

ic grasses, Kobresia, sedges and other fine grasses.

4.2 Spring-autumn grassland

The spring-autumn grassland covers an area of 84.23 million hectares, with a theoretical livestock carrying capacity of 338.99 million sheep units and an actual livestock carrying capacity of 485.13 million sheep units. It is distributed in low-mountain belts, piedmont hills and some piedmont plains. The grassland types are mainly mountain desert grassland, plain desert and some mountain grassland. The plant species are composed of *Artemisia semi shrubs*, *Tufted grasses* and *Small sedges*. The utilization period is from mid and late April to mid and late June in spring; autumn from mid to late September to mid to late November.

4.3 Winter grassland

The winter grassland covers an area of 83.66 million hectares, with a theoretical livestock carrying capacity of 559.63 million sheep units and an actual livestock carrying capacity of 629.48 million sheep units. It is distributed in the middle mountain forest belt of the river valley and the mountain meadow grassland. This kind of grassland has high forage yield, and the plant species are composed of mesophytic and mesoxerophytic grasses, miscellaneous grasses, leguminosae, artemisia semi shrubs, etc. From the mid to late November to the mid to late April of the next year, the sunny slope in this area has less snow in winter and can be used for grazing, while the shady slope is mostly natural grassland, which is the main grassland for livestock to spend the winter and spring under traditional grazing conditions.

4.4 Winter-spring-autumn grassland

The winter–spring–autumn grassland area is 38.87 million hectares, with theoretical stocking capacity of 132.08 million sheep units and actual stocking capacity of 228.01 million sheep units. It is mainly distributed in the plains and foothills in the middle and upper reaches of Turks River, Gongnaisi River and Kashi River. The utilization time is from the mid to late September to the mid to late April of the next year. The grassland types are mainly meadow grassland, lowland meadow and mountain grassland; the main plants are composed of mesophytic-xerophytic, mesophytic, and xerophytic grasses, leguminous grasses, artemisia subshrubs, miscellaneous grasses, etc.

5. Problems in grassland resource utilization

5.1 The degraded area of grassland increases year by year

The seasonal grasslands in the Ili River Valley with serious degradation are mainly summer grasslands and spring-autumn grasslands. The grassland types with the most serious degradation are mountain meadow, mountain desert grassland, plain desert, mountain grassland, lowland meadow and mountain meadow grassland. In summer, the alpine meadow in the grassland basically did not appear obvious degradation. The most obvious characteristics of grassland degradation are: the species and components of grass groups have changed, the number of tufted grasses has decreased, the coverage of grass groups has decreased, and the exposed area has increased[5]. The degradation process of grassland is the reduction of edible grass, and the composition of grassland grass has changed accordingly[6]. The succession trend of grassland vegetation landscape to desertification vegetation landscape has led to a sharp decline in grass yield and a significant reduction in vegetation coverage[5], and grassland degradation has become a bottleneck restricting the development of local animal husbandry[7].

5.2 Soil erosion in grassland is becoming more and more serious

Grassland degradation succession occurs under the interference of climate change and human factors[8], resulting in grassland vegetation degradation and vegetation coverage reduction. The deterioration of climate further intensifies the degradation and desertification of grassland and water and soil loss. The interaction between them promotes the reverse succession of grassland ecosystem, and the grassland ecological environment falls into a vicious circle[9]. Grassland degradation weakens the ability of grassland to conserve water and soil ero-

sion, and the increase of instantaneous strong convection climate change intensifies the frequency of natural disasters such as landslides and debris flows.

5.3 Seasonal grassland imbalance and annual imbalance of grassland yield

The amount of natural grassland varies from year to year due to the limitation of climatic conditions in that year[10]. The grasslands in the Ili River Valley are complete in four seasons. However, due to different geographical locations and great differences in natural conditions, there are great differences in the vegetation composition, production capacity, forage quality, livestock carrying capacity and utilization conditions of grasslands in different seasons. Spring-autumn grasslands and winter grasslands are seriously insufficient, and there is a serious imbalance between seasonal grasslands. The grass yield of grassland is directly restricted by natural conditions. The imbalance between years is mainly affected by climate, and the level of grass yield is determined by the amount of precipitation.

5.4 The long-term mechanism of grassland ecological protection is not perfect

To curb the deterioration of grassland ecological environment and establish the benign development of grassland ecosystem is the fundamental goal of realizing the sustainable development of grassland ecosystem. The grassland compensation policy has played a good role in promoting the balance between grass and livestock[11]. Subsidies and rewards have been given to herdsmen who implement the prohibition of grazing and the balance between grass and livestock. However, these compensations still have a certain gap compared with the actual needs of ecological protection. The compensation standard is single and the standard is low. It is necessary to strengthen governance and improve governance standards.

5.5 Lack of late management and protection funds to consolidate the effectiveness of grassland ecological restoration

In the grassland ecological restoration and management, the effect of the implementation of supplementary sowing, grassland pest control and other projects reached the standard in the same year and the next year, and the vegetation was restored well. However, in the later project management and protection, the local financial situation is very difficult, and there is no financial guarantee. On the other hand, the technology of grassland management and protection is backward, the technical team is not perfect and unstable, the strength of the regulatory agency is weak, and the consolidation of the results is difficult, which affects the ecological restoration and management.

6. Sustainable utilization of grassland resources

6.1 Strengthen grassland management and make rational use of grassland resources

According to the characteristics of grassland types in Ili River Valley, we should strengthen the management of natural grassland, strengthen the legal management and scientific utilization of grassland resources, determine livestock by grass, and control grazing intensity. In the construction of grassland, based on the enclosure of fences, measures such as the prevention and control of grassland pests, the prevention and control of toxic weeds, supplementary sowing and improvement, and supplementary irrigation are combined to carry out comprehensive management. Further promote the ecological restoration and management of natural grasslands, implement the responsibility of herdsmen to protect and build grasslands, and mobilize their enthusiasm.

6.2 Establish forage seed gene bank and screen local excellent forage varieties

According to the environmental and climatic factors and the actual situation of Ili River Valley, local grass varieties with good ecological and economic benefits are selected, and the local grass seed base is established. Natural grassland ecological restoration project, according to the relationship between forage species and climate environment, reasonably plan the layout of grass species, and promote high-quality native grass species. For example, in mountain meadow, mountain meadow

grassland and mountain grassland, *Onobrychis viciifolia*, *Dactylis glomerata*, *Phleum pratense*, *Bromus inermis*, *Elymus sibiricus*, *Elymus dahuricus* and other varieties are mainly used; in desert grasslands and some mountain grasslands, drought tolerant varieties such as *Agropyron cristatum*, *Seriphidium transiliense*, *Kochia prostata* and *Ceratoides latens* are dominant.

6.3 Increase technical input and implement grassland ecological restoration construction

Increase investment in grassland science and technology, popularize grassland scientific and technological knowledge, and improve grassland management level. By using the techniques of supplementary sowing improvement, supplementary sowing irrigation and fence enclosure, we can increase the species composition and coverage of grassland plants, improve the yield and quality of grassland, rejuvenate the grassland, restore the plant community of dominant species of grassland, and reduce water and soil loss.

6.4 Strengthen grassland ecological monitoring to ensure the sustainable utilization of grassland resources

Based on the dynamic monitoring of grassland, the basic situation of grassland should be scientifically evaluated to grasp the changes of grassland productivity. It provides a systematic and scientific basis for grassland resource evaluation, livestock carrying capacity regulation, natural disaster prediction and so on.

6.5 Actively promote ecotourism

On the premise of protecting the grassland ecological environment, based on the scientific and rational utilization of grassland resources, and from the perspective of the advantages of grassland tourism resources in the Ili River Valley, carry out a reasonable development of grassland tourism. While improving the infrastructure of pastoral areas, optimizing scenic spots, exploring local cultural connotation, and improving comprehensive service functions, creating a green, ecological, environmental protection, and sustainable eco-tourism economic development path is conducive to combining grassland utilization mode with ecological protection, and advocating grassland eco-tourism with grassland natural landscape as the object and grassland folk custom tourism with grassland customs as the main.

Conflict of interest

The authors declare that they have no conflict of interest.

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