Optimize Pattern of Comprehensive Renovation Technology for Grasslands Desertification and Degeneration in Arid and Semi-arid Area

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Abstract: Based on the ecological situation of Chinese typical grasslands and soil erosion characteristics, according to the principle of water-grass-livestock balance of animal husbandry development, making full use of the limited water resources, developing tame forage field under irrigation, solving it through linear programming mathematics method, an applied pattern of comprehensive renovation for grasslands desertification and degeneration was put forward, which make sure the degenerated grassland restore and start a improved cycle, economic benefit is the biggest. The pattern depends on natural restoration measures (fencing, rest-grazing) making up 94%, which accords with the demand matching the center for people, setting up harmonious, sustainable developmental view completely and person and the nature getting along harmoniously. The research will provide with scientific bases for ecology restoration and reconstruction of grasslands desertification degeneration in arid and semi-arid area in China.

Key words: grasslands; desertification and degeneration; renovation; pattern

1 Introduction

The study sites located at He Shuo Miao, Ming An Tu town, Zheng Xiang Bai banner of Xi Lin Guo Le League,Inner Mongolia. It involved 32 herding families, 140 people, 2560 hm^2 grasslands and 2560 sheep units. The area belongs to semi-arid and arid continental season climate in temperate zone. Its basic characteristics is that winter is long and cold, summer is tepid and rainless and it is blowy and has many sands in spring and autumn. The annual average air temperature is from 0 to 3 , cold season is about 200 days long. Annual average wind velocity is from 4m/s to 5m/s. Annual average rainfall is 360 mm and evaporation is from 1900mm to 2000mm.Therefore, cold, gale, little rain and drought is its distinct climate characteristics. The grasslands type is temperate zone typical grasslands, where surface water is lack and shallow layer groundwater resources haven't get fully exploited. The modulus of exploited groundwater is 1.58 ten thousand $m^3/a \cdot km^2$, water in single well is 10 m^3/h or so, water level is 3 m in deep or so and the mineral degree is smaller than 1 g/L, which has beneficial condition to exploit the shallow layer groundwater for irrigating grasslands. Average area of each herding family is 80 hm^2. Deducting basic water needed in ecology construction and local herder's drinking water. The shallow layer ground-water which can be used for irrigation is 21000 m^3/a in the research area.

Over a long period of time, influenced by natural factors, added it to over-grazing(over-grazing rate is up to 2.48), the ratio of sandy and degenerated grasslands area to total area increases from 43.12% in 1995 to current 69.8% and

reaches to above 90% in the serious degraded regions. The grasslands production ability reduces (edible hay yield is 450 kg/hm ^{2} or so), the grass quality is poor, the plant community structure is simple and the vegetation coverage is only 35% or so. The carrying capacity is 31.5 sheep unit and the income per person is only 2210 yuan or so. Desertification, degeneration and deterioration of the eco-environment not only restrict the development of local grassland animal husbandry, but also threaten the local people's production, life and living.

2 Optimize pattern of integrated renovation

2.1 Establishment of the model

Considering the present condition of the grasslands ecology and its production ways of the study district, at the premise of restoring ecology, we should consider the production characteristics of grassland animal husbandry exploit and utilize limited water resources to develop irrigation grass and forage base and provide feed needed in the process of grasslands improvement. Therefore, the pattern of comprehensive renovation for grasslands desertification and degeneration of the research area should make it as its object that grassland ecology restore to a good circulation state and its economic benefit is the biggest, then, according to the balance development principle of water- grass-livestock, using linear programming method, we put forward the renovation pattern of all kinds of measurement for carrying out all the targets mentioned before(forbidding grazing on natural grasslands, inter-seeding native grassland, irrigating perennial artificial grasslands, irrigating silage corns).The optimize pattern of comprehensive renovation is as follows:

$$\begin{cases} objF = y \cdot k \cdot E - (x_1) \cdot a - x_2 \cdot b - x_3 \cdot c \\ x_1 + x_2 + x_3 \le S \\ x_3 \le S_0 \\ x_2 \cdot M_2 + x_3 \cdot M_3 + y \cdot M_y \le Q \\ x_1 \cdot C_1 \ge y \cdot LC \\ x_2 \cdot D_2 + x_3 \cdot D_3 \ge y \cdot LD \\ x_1, x_2, x_3, y \ge 0 \end{cases}$$

In the formula,

k-The ratio of livestock going out (%);

y- The quantity of sheep unit that the land can carrying after the engineering is carried out;

F- Gross revenue of a sheep unit (yuan/one sheep);

x_1, x_2, x_3-The area of improved natural grasslands, irrigated artificial grasslands, and irrigated silage corns area (hm ^{2})

a, b, c- Average cost for per unit area natural grasslands, irrigated artificial grasslands and silage corn field;

M_2、M_3 – The irrigation ration of irrigated artificial grasslands and silage corn field (m

^{3}/hm ^{2});
My- The amount of water needed by per sheep unit every year;
Q- Water can be supplied;
C_1-Hay yields after the natural grassland is improved (kg/hm ^{2});
D_2,D_3- Yields of irrigated artificial grasslands and silage corn per area;(kg/hm ^{2})

LC、 LD- The amount of grasses ate by per sheep unit during warm and cold seasons respectively;

S、S_0-Total grassland area and the biggest area of annual irrigation grassland areas.

2.2 Parameter selection

According to different renovation measurements of sandy and degenerated grasslands, parameters were gained as fellows(table1).

Table 1: Model parameters

Measurements	Improved natural grassland	Irrigated artificial grassland	Silage corn
Yield(kg/hm^2)	1200(after 3 year)	9000(after 2 year)	75000
Irrigation ration(m ^{3}/hm ^{2})	/	2625	3150
Annual cost (yuan /hm ^{2})	15	1800	4500

Note: The yield of silage corn is in fresh weight, but the rest all is Dry matter.

The edible yield of natural grasslands is 60% of the total yield. The fixed assets investment and circulation expenses refer to 《The grasslands ecosystem protection and water resources guarantee programming in the pasturing area of the whole country 》 to select. According to the local weather condition and the grazing styles, the warm season takes for 5 months; each sheep unit needs 2.0 kg hay per day, so the warm season needs 300 kg hay totally. Cold season takes for 7 months; each sheep unit needs 2.2 kg hay everyday, so the cold quarter needs 462 kg hay totally.

2.3 Comparison of different plans

In this research, the optimize pattern of comprehensive renovation for desertification and degeneration grasslands belongs to the linear programming system pattern, MATLAB6.5 was adopted to write the linear programming procedure to solve this mode. The result of 4 different plans from table 2 and graph 1 were showed below.

Table 2 The comparison of different renovation plans after carried out 3 years

Plans	status quo	Plan 1	plan 2	plan 3
Desertificated and				

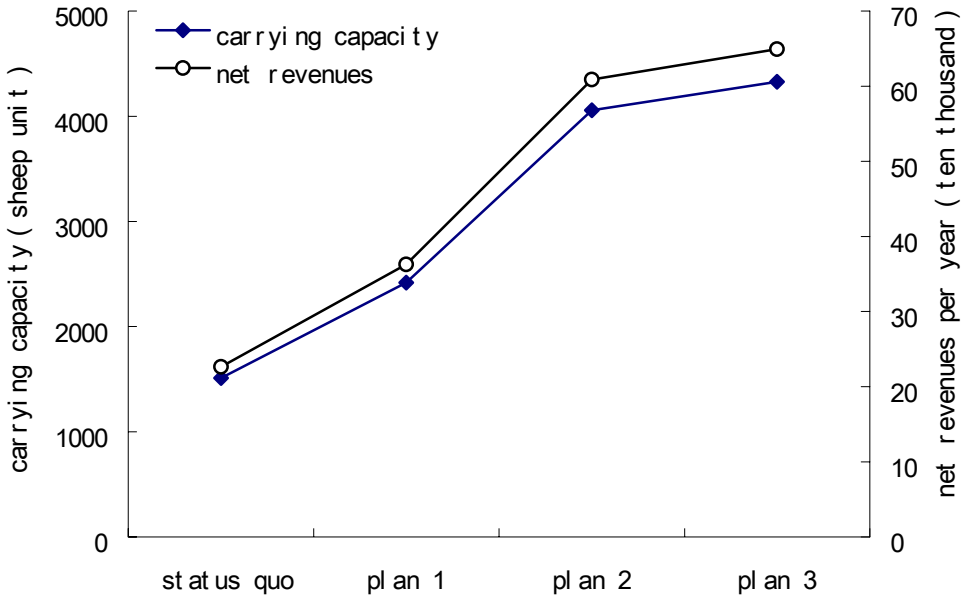
degenerated grasslands (hm^2)	2560			
Improved natural grassland (hm^2)		2560	2409	2412.5
Artificial irrigation grassland (hm^2)			151	132.7
irrigation silage corn(hm^2)				14.7
Carrying capacity (sheep unit)	1511	2418	4058	4329
Annual net revenue (ten thousand Yuan)	22.67	36.27	60.87	64.93

In table 2:

Plan 1 - adopting the improvement measure of forbidding grazing only;

plan 2 - construction part is irrigation artificial grassland, but the rest adopts forbidding grazing;

plan 3 - construction part is irrigation, mainly silage corn and the rest adopts forbidding grazing.



Graph 1 The comparison of economic benefit of different plans

2.4 Result analysis of different plans

Through solving and analyzing the corresponding model of the 4 plans, the following conclusions can be getting.

(1)Because of grassland desertification and degeneration, its productivity reduces extremely. At present, the theoretical carrying capacity of natural grasslands is only

1511sheep units, but the actual sheep units is 2500. The over-grazing is up to 69%, which accelerates the desertification and degeneration of the grasslands. Through improving measures fencing and rest- grazing for 3 years, grasslands vegetation ameliorates greatly, its carrying capacity also reaches 2418 sheep units and corresponding economy benefit can raise to 36.27 ten thousands yuan.

(2)The patterns of plan 2 and plan 3 are all based on the balance of water, grass and livestock. Through the principle of using water to settle grasses and using grasses to settle the amount of livestock, we apply system engineering theory to solve the complicated relation of the corresponding water, grass and livestock system. The result indicates that the 2 plans of grasslands desertification and degeneration harnessing based on the balance of water, grass and animals all have high ecological benefits. The annual revenue of plan 2 can attain 60.87 ten thousand yuan.

(3)Silage corn measurement was integrated in plan 3, which can increase the amount of compensatory feeds. At the same time of promising the ecological benefits, which means the coverage ratio of vegetation is up to 75% above and yields raise 1200kg/hm^2, its carrying capacity raises to 4329 sheep units, corresponding economic benefits rise to 64.93 ten thousand yuan, so we gain double success both in ecological benefits and economic benefits in deed. In plan 3, optimal implement area of corresponding every measure is 2412.5hm^2 natural grasslands improvement,132.7hm^2 irrigation artificial grasslands and 14.7hm^2 irrigation silage corns.

2.5 Dynamic analysis of comprehensive renovation optimize pattern on desertificated and degenerated grasslands

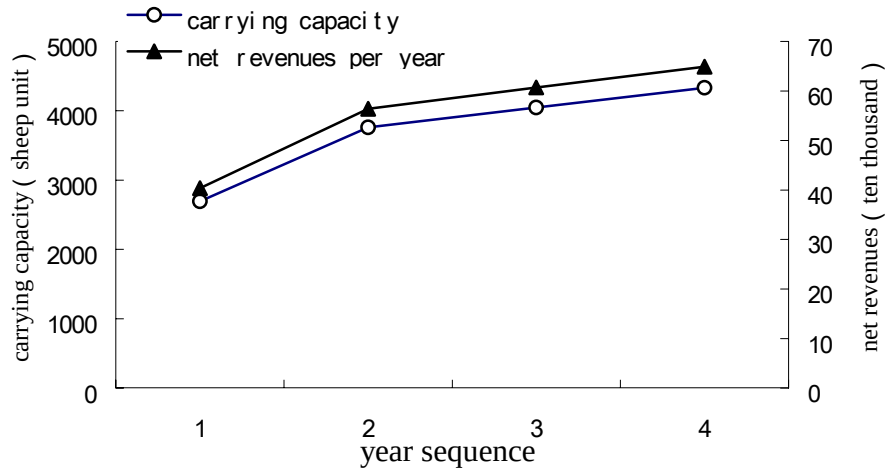
The construction of above plans is a dynamic course. Within 3 years of fencing desertificated and degenerated grasslands, animals are fed on artificial irrigation grasslands, silage and grasses in autumn. Yield of grasses of artificial irrigation grasslands is only about half of natural value in the first year, we use 4500kg/hm^2 in the study, but it can reaches to the potential at the second year.

Table3 and graph 2 is dynamic carrying capacity and benefits in the period of construction of the optimize program. In the first year, because natural grasslands is fenced and productivity of artificial irrigation grasslands is lower, although the economic benefits can keep the status quo, grasslands ecology still not restore. In the second and third year, because the productivity of irrigation artificial grasslands reaches to the potential, the carrying capacity rises to 4050 sheep units and corresponding net benefits also reach 60.67 ten thousand yuan, but grasslands ecology still does not reach the potential. After 3 years, the carrying capacity is up to 4329 sheep units, net benefits rise to 64.93 ten thousand yuan, and grasslands ecology attain the biggest restoring potentiality (vegetation coverage is 75% and forage yield is 1200kg/hm^2).Net income per capital will raise from present 2210 to 4637 yuan in the study area, thus a double success both in ecological benefits and economic benefits were gained.

Table 3 Dynamic variety process of the optimize model

year sequence	year 1	year 2	year 3	year 4
Improved natural grassland (hm ^{2})	2412.5(450)	2412.5(900)	2412.5(1050)	2412.5(1200)
irrigation artif-icial grasses(hm ^{2})	132.7(4500)	132.7(9000)	132.7(9000)	132.7(9000)
irrigation silage-corn(hm^2)	14.7(75000)	14.7(75000)	14.7(75000)	14.7(75000)
Carrying capacity (sheep unit)	2692	3760	4045	4329
net revenues per year(ten thousand)	40.38	56.40	60.67	64.93

Note, the figure inside the brackets is the output of the same year, its unit is kg/hm^2, the unit is kg/ hm ^{2}, natural grasslands and artificial grasses are computed based on dry matter ,but the silage corn is based on fresh weight.



Graph 2 Dynamic of the optimize program during construction period

3 brief's Summary

Based on the test studying of comprehensive benefits of all technologies (fencing grasslands, inter-seeding of native grassland, irrigation artificial grasses, irrigation silage corns, etc) of ecology restoration and re-construction of desertification and degeneration grasslands, by using object layout methods, the optimizing results was gained. Through adjusting of measurements and parameters selecting and practical validating, can advance the model's practicability.

References

[1] Compiled by agricultural water department of water conservancy department etc. The grasslands ecology protection and water resources guarantee program of the whole country pastural area. [M].Peking: The Chinese water conservancy water electricity science publishing house, 2003.
[2]Zhang zheng,Yang wen ping,etc. The MATLAB program design and practical example application [M].Peking: Chinese railroad publishing house, 2003.
[3] Mou xin-dai. The grasslands system engineering [M].Peking: Chinese agriculture publishing house, 1997.
[4] Zhao feng-zhi. The linear programming computing methods [M].Peking: Science publishing house, 1981.
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This research is a demonstration study content of the comprehensive renovation technologies of grasslands desertification and degeneration, which is funded by the social commonweal research special funds item of science and technology department.