Journal of Environmental and Agricultural Studies
ISSN: 2710-1401
DOI: 10.32996/jeas
Journal Homepage: www.al-kindipublisher.com/index.php/jeas

JEAS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Modernization Measures for Sustainable Development of Alpine Grassland Husbandry on the Qinghai-Tibet Plateau: An Example of Countermeasures to Pasture Degradation

Ziang Chai[1] ✉ Yuxiao Ren[1] and Yuwei Cao[2]
[1]*Zhangdian Shiyan Middle School, Zibo City 255022, China*
[1]*Zibo Shiyan High School, Zibo City 255022, China*
[2]*Ulink College of Shanghai, Shanghai 201615, China*
Corresponding Author: Ziang Chai, **E-mail**: azzhi3586385549@qq.com

| ABSTRACT
The Qinghai-Tibet Plateau, also known as the "third pole of the world", consists of widespread alpine grasslands, and the local community has taken advantage of this natural condition to develop alpine grassland livestock farming. In recent years, climate change and irrational human activities have led to serious degradation of the alpine grasslands on the Qinghai-Tibet Plateau, which has constrained the development of traditional grassland husbandry. In order to promote the ecological protection of the plateau and improve the livelihood of the people in this region, the traditional grassland livestock industry needs to be transformed and upgraded. The Qinghai-Tibet Plateau should study and reasonably learn from efficient modern pastoralism and development measures such as grass farming and migrant urbanization in the USA, Australia, and Northern Europe. Due to the special peculiarities of the natural environment and the limitations of the local socio-economic conditions, this essay combines the local natural and humanistic environment of the Qinghai-Tibet Plateau region and proposes modern measures such as grass-based storage, grazing in specific areas, and ecological migration to realize the sustainable development of alpine grassland animal husbandry, which is conducive to promote regional high quality development.

| KEYWORDS
Qinghai-Tibet Plateau; resources and environment; regional sustainable development; alpine grassland livestock husbandry

| ARTICLE INFORMATION
ACCEPTED: 11 December 2022 **PUBLISHED:** 19 December 2022 **DOI:** 10.32996/jeas.2022.3.3.9

1. Introduction

The Qinghai-Tibet Plateau lies between 26°00′ to 39°47′ N and 73°19′ to 104°47′ E, with a length of about 2,800 km from east to west and a width of about 300 to 1,500 km from north to south, a total area of about 2.5 million square kilometres, and is the highest average altitude and largest natural geographical unit in the world, and is an important pastoral area in China. Animal husbandry is the pillar industry of the alpine region of the Tibetan Plateau and an important part of the sustainable development of China's Qinghai-Tibet region. With 128 million square kilometres of alpine grassland, 13 million yaks, and nearly 50 million Tibetan sheep, the Qinghai-Tibet Plateau is an important pillar of production and livelihood for local farmers and herdsmen (Xu et al., 2020).

In recent years, the population of the Qinghai-Tibet Plateau region has continued to grow, with the total population of Qinghai and Tibetan provinces and regions has increased from approximately 7.75 million in 2000 to 9.59 million in 2020. With this increase in population, the local alpine grassland livestock industry is developing rapidly. However, natural environmental changes such as climate warming and drying, as well as human activities such as irrational grazing, have disrupted the ecological balance of the alpine grassland region, which has an inherently low environmental carrying capacity. Due to the contradiction between the supply and demand of grass and livestock and the sloppy management of livestock breeding, the productivity of alpine grassland livestock

breeding has been reduced, and the economic efficiency has deteriorated. Long-term overloading and overgrazing have led to serious degradation of the alpine grassland ecosystem, further reducing the carrying capacity of the resources and environment, intensifying the conflict between man and land, and making the lack of resources a constraint to the development of the local ecological grassland industry, which in turn has led to a decrease in grassland productivity and an increase in the conflict between supply and demand for grass and livestock, and has restricted the sustainable development of the grassland livestock industry in alpine regions.

2. Research Methods

This paper is mainly based on field investigation, literature collection, and other research methods to obtain relevant information on the current situation and problems and find solutions to issues that impede alpine grassland animal husbandry development on the Qinghai-Tibet Plateau, and to analyse and organize them to summarize the problems faced by the ecological grassland animal husbandry on the Qinghai-Tibet Plateau at the present stage and the measures for sustainable development.

3. Development of alpine grassland animal husbandry and degradation of grassland on the Qinghai-Tibet Plateau

3.1 Reasons Why the Alpine Grassland Animal Husbandry Develops

As the "third pole of the world", the Qinghai-Tibet Plateau is extremely rich in natural and cultural resources. It has developed tourism and other industries based on natural resources such as the Danniang Buddha's Palm Dune and cultural resources such as the Potala Palace, as well as animal husbandry and river valley agriculture. While tourism and ethnic handicrafts are part of the economy of the Tibetan Plateau, livestock breeding and river valley agriculture consist of the majority. The space for the development of river valley agriculture is limited by the small size of the river valleys in the Qinghai-Tibet Plateau region, while the vast alpine grasslands, which occupy a much larger area, make it extremely necessary to develop livestock farming on the alpine grasslands. Due to its cold climate, which is not suitable for the growth of crops, and the extensive natural grasslands, which occupy up to 58.45% of the total land area (as shown in Figure 1) (Ding, 2021), livestock farming has been developed.

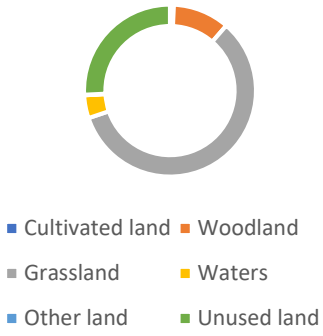

Figure 1 Extensive natural grasslands

3.2 Causes of Alpine Grassland Degradation

3.2.1 Natural causes

Climate change is the most important natural cause of the alpine grassland degradatuib in the Qinghai-Tibet plateau. In the past 40 years, the average annual temperature in the Qinghai-Tibet alpine grassland region has been increasing significantly, with an average increase of about 0.532°C in 10 years (Zhao et al., 2018). The Qinghai-Tibet Plateau is an early warning zone for global climate because its fragile ecosystems are always sensitive and quick to respond to climate change. This phenomenon is reflected in the Tibetan alpine steppe region. As the climate warms, the perennial stable permafrost zone is transformed into an unstable permafrost zone, which is causing the groundwater levels that depend on it to continue to decline or even disappear. The reduction of groundwater, which is essential for the development of alpine grasslands, will lead to the degradation of grasslands. In addition, the increase in extreme weather events in the context of climate warming has also contributed to the degradation of the Tibetan alpine grasslands (Wu et al., 2013).

As the climate has warmed in recent years, precipitation is also changing. Some alpine grassland areas on the Qinghai-Tibet Plateau show a certain trend of warming and drying. Table 1 shows precipitation data for Shiqu County, located in the southeastern part of the Tibetan Plateau. According to the analysis, the rise in winter temperatures has increased the amount of water vapour that can be carried by air, which in turn has led to an increase in precipitation. However, this climate change does not bring much benefit but rather increases the risk of snowstorms in winter. At the same time, summer precipitation tends to decrease, exacerbating droughts. Not only that but the warming and drying are accompanied by data showing a lower rate of warming in spring and a premature fall in autumn, which, because of the same reasoning as before, shortens the duration of the rainy season.

This has led to a delay in the return of pasture in spring and an earlier withering in autumn (Wang et al., 2004). This climate change has been detrimental to the growth of pasture and has brought about some changes in the vegetation cover, with the original forest turning into grassland and the southward expansion of grassland leading to a reduction in the forest area.

Table 1: The climate data of Shiqu

Particular year	average precipitation											
Monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1971–2000	6.3	8.1	14.8	24.4	59.8	113.9	114.0	92.7	91.7	38.1	5.7	3.8
1981–2010	6.5	9.3	14.2	25.1	58	107	114.1	92.5	86.2	42.1	6.2	3.7
Change	+0.2	+1.2	-0.6	+0.7	-1.8	-6.9	+0.1	-0.2	-5.5	+4.0	+0.5	-0.1

Source: CIMISS.

2.2.2 Anthropogenic Causes

Sparse grass populations caused by overgrazing can lead to a reduction in high quality pasture and edible forage, while the number of toxic weeds will continue to increase. Firstly, the overloading of pastures due to overgrazing over-utilises grassland resources and leads to the degradation of pastures. Secondly, due to the trampling of grazing herds, the gaps between the soil will become larger, and its air permeability and water permeability will decrease, leading to the deterioration of the soil's properties. Forage grasses are thus unable to extract nutrients and water, greatly reducing the yield of the pasture as it should. Even if it does produce, the quality is far inferior to that of pasture raised in healthy pastures, and the utilisation of the whole area is progressively reduced and its value diminished.

3.3 Problems Caused by Alpine Pasture Degradation

Degradation of pastureland most directly leads to a reduction in the availability of pasture, which in turn means a reduction in the amount of grass available for livestock, leading to a range of problems, such as malnutrition, reduced yields, and famine; these phenomena directly reduce the income of local people on the Tibetan plateau, where livestock is the main source of income.

The degradation of pastureland also leads to famine in winter and spring. The Qinghai-Tibet Plateau region has an unbalanced seasonal supply of forage, with more in the summer and autumn and less in the winter and spring, and with the current degradation of pasture, this has led to famine in the winter and spring. As a result, it is difficult to produce enough forage to meet the long-term needs of the herds, and it is impossible to predict yields or to make specific plans for the future economy. The phrase "full in summer, fat in autumn, hungry in winter, dead in spring" is a good illustration of the problems faced by pastureland today.

4. Responses to Pasture Degradation

4.1 Determine Livestock Number by Pasture Carrying Capacity

Grass-based livestock farming is the process of judging the amount of pasture and the actual amount of storage to achieve an appropriate number of animals. If grass-based livestock is to be used, priority should be given to educating local herders and changing the traditional concept of measuring wealth by the number of livestock. Grass for livestock requires a balance between pasture production, livestock, and their reproduction by calculating the amount of livestock that the pasture can carry, at the same time avoiding overloading the pasture and taking too much damage. This is highly beneficial for the healthy development of alpine grasslands and the enrichment of pastoralists.

$$\text{Grazing capacity} = \frac{\text{Reserve of forage grass(Kg/ha)} \times \text{utilization}}{\text{Daily feed of livestock(Kg/day gper)} \times \text{grazing days}} \quad (1)$$

In winter and spring, when pasture production is low, the living conditions of herds decline, and it is difficult to survive; to ensure that livestock pass through this period smoothly, local people can meet their needs for grass and food in winter and spring by storing pasture in advance. Appropriate storage methods not only help the herdsmen to distribute and utilise the grass in a rational way but also ensure that there is no loss of nutrients as far as possible. At the same time, forage can also be purchased as an alternative to pasture. Although the purchase of forage can be costly, it can also have the effect of increasing yields by supporting the herd through the winter and spring famine, so buying forage is a good way to get through difficult times. Stockpiling and forage not only provide options for herds to survive the winter and spring but also buy some time for pastures to naturally repair their function.

Table 2: West Ujimqin banner Livestock population count

Particular year	Large livestock (in thousands)	Sheep (in thousands)	Stock of livestock in cold season (in thousands)	Stock of livestock in warm season (in thousands)
1994	238.3	1066.6	2083.2	3436.5
1995	259.6	1240.7	2306.1	3404.6
1996	255.3	1280.2	2744.4	3016.3
1997	231.3	1327.0	2489.7	3636.5
1998	208.8	1445.7	2483.5	3846.0
1999	214.4	1672.4	2556.7	4099.7
2000	164.8	1482.1	2538.7	4011.9
2001	104.0	1563.2	2258.1	3357.8
2002	90.8	1703.0	2163.3	3656.4
2003	90.8	1544.0	2201.8	3149.2
2004	97.8	1299.2	2186.9	3405.0
2005	86.7	1221.5	2246.0	3413.9
2006	102.3	1350.4	2033.3	3212.6
2007	88.1	988.5	1893.8	2897.5
2008	91.0	940.9	1705.2	2574.9

Source: Ba (2012).

4.2 Zonal Rotational Grazing

Zonal rotational grazing is a form of sequential or cyclical grazing according to seasonal pastures and grazing plots. The length of the rotation cycle depends on the growth conditions of the local grasses (approximately 30-35 days). The advantage of this scheme is that it ensures a reasonable amount of time for forage growth and gives the grass some protection, with studies showing that zonal rotational grazing can increase forage production by 23-28%, grass cover by 10%-15%, and grass height by 22.5% (Li & Gong, 2017). Zonal rotational grazing is therefore conducive to ecological improvement and management and can alleviate grass-livestock conflicts and plan the use of resources more rationally; at the same time, it can reduce the frequency of livestock switching, retain more energy and improve yields, and it reduces the area of herd activity, which is also beneficial to herders' management. It is also less difficult to implement, benefits from simple and inexpensive technology, and has a wide range of factors that can be used.

Figure 2: General Regionalization Map for Agricultural Development on the Tibetan Plateau

Taking the natural environment into account, land use types, and distribution of ecological reserves on the Tibetan Plateau, government departments have proposed a zoning scheme for the regulation of agriculture and animal husbandry on the Tibetan Plateau geared towards ecological conservation, dividing the plateau into eight zones. Among them, the Hengduan Mountains Agricultural, Forestry, and Animal Husbandry Development Zone, the Central and Southern Tibetan Agricultural, Animal Husbandry Development Zone, and the Frontier Belt Agricultural and Animal Husbandry Development Zone are the main distribution zones of alpine grazing. To implement zonal rotational grazing, the above zoning can be referred to, or the above zoning can be refined into more zoning along these lines, and the process strategy of rotational grazing can be arranged by combining the different environmental characteristics of each zone.

Through analysing the rotational grazing data in the Yumin County area of the Tacheng Basin in northwestern Xinjiang, it can be concluded that zonal rotational grazing is beneficial to pasture restoration. Comparing the data before and after the first rotational

grazing, the second rotational grazing, and the time period between them, it can be concluded that rotational grazing can help regenerate and utilise grassland, thus achieving sustainable use and development of alpine grassland (Du & Zhao, 2009).

Table 3: Grassland yield analysis for the GEF project in Yumin County

	Rotational grazing group I (g/m^2)		Control group VI (g/m^2)	
	hay	grass	Hay	grass
Before the first rotational grazing	134	325	131	320
After the rotational grazing	197	530	208	574
Before the second rotational grazing	281	645	190	482
After the second rotational grazing	185	388	112	302

4.3 Ecological Migration

Ecological migration is one of the key measures to solve the ecological problems of the Tibetan alpine grassland region. The concept of ecological migration is understood differently by different scholars. Overall, it should be defined as the practical activity of relocating the population in ecologically fragile areas to areas with high environmental carrying capacity in order to protect and restore the ecological environment and promote economic and social development (Liao, 2012). The alpine grassland region of the Qinghai-Tibet Plateau is one of the ecologically fragile areas in China. The carrying capacity of the local environment is low, and natural causes such as climate warming and man-made causes such as unreasonable grazing have led to environmental overload, ecological degradation, and intensified conflicts between people and land; for pastoralists, because of their remote location, communication and transportation are quite inconvenient, education and medical resources are also lacking; there are also risks in life such as human-animal conflicts. The implementation of ecological migration is, therefore, crucial.

For the Qinghai-Tibet Plateau region, the implementation of ecological migration faces a series of problems: ethnic minorities have their own special language and customs, and there are certain communication barriers after moving out, while beliefs such as mountain gods may be a major psychological barrier for herders to move out (Zhang, 2022). Therefore, the main measure to implement ecological migration should be government-led relocation of residents from alpine grassland areas with low environmental carrying capacity to towns with higher environmental carrying capacity. On the other hand, the government can make the herders move on a large scale within a short period of time. At the same time, in the process of implementing ecological migration, it is necessary to actively strive for welfare policies, adopt the method of scattered resettlement or nearby resettlement, and thoroughly solve the problem of households left behind in ecological migration areas; introduce subsidy policies for spontaneous migrant households in ecological migration areas, improve preferential policies for settlement and employment in cities and towns, give one-time financial subsidies for a land replacement to spontaneous migrant households, and release collective land contracting relationships, so as to move out of a piece of land to the greatest extent possible and restore the ecology. To the greatest extent possible, a piece of land will be moved out and the ecology restored.

The implementation of ecological migration will have a positive impact on the development of the areas that have moved out, the areas that have moved in, and the region as a whole. In the case of the out-migrating areas, i.e., the Tibetan alpine grasslands, ecological migration is conducive to alleviating the conflict between people and land, protecting the ecological environment, restoring the ecological balance, and preventing further degradation of the grasslands. For the relocated areas, it is conducive to increasing the number of people and accelerating the level of urbanization; the relocation of people into towns and cities brings separated populations together, making the labour force more abundant, and herders can enjoy quality medical and educational resources. Meanwhile, after the population has moved into the cities, enterprises with national characteristics in animal husbandry should be actively developed to protect the environment while helping to accelerate economic development; on the other hand, the construction of transport and communication networks should be strengthened to establish more convenient and fast contact with the outside world, and the development of other industries also provides great help. Finally, benign links should be established with pastoral areas to provide scientific breeding, animal quarantine, and stock improvement supervision and assistance (Dai & Min, 2008). For the whole region of the Qinghai-Tibet Plateau, ecological migration can effectively promote the coordinated development of the region and achieve sustainable ecological and economic development. In summary, ecological migration can be considered as a multi-benefit.

5. Discussion and Conclusion

5.1 Discussion

Through collecting and collating relevant information and data, we have summarised the situation of grassland degradation in the alpine grassland region of the Tibetan Plateau and the countermeasures to solve the degradation of grassland. However, due to the vast area and complex topography of the alpine grasslands on the Tibetan Plateau, the regional and vertical differences in the environment are relatively large, so the grassland environment varies somewhat from region to region and from altitude to altitude.

Therefore, this research focused on the analysis and summary of countermeasures for the overall situation, while different regions still need to develop more specific countermeasures that are more in line with local conditions. If we have more time, we will conduct further research through data surveys and document collection.

The Qinghai-Tibet Plateau is an ecological barrier for China and the world. The alpine grasslands of the Qinghai-Tibet Plateau are widespread; preventing pasture degradation and protecting the ecological security of the alpine grasslands is conducive to the sustainable development of the plateau as a whole. Both today and in the future, more attention needs to be paid to the ecological protection of this region so that the "third pole of the world" can continue to be revitalized.

5.2 Conclusion

Animal husbandry is the mainstay of the alpine grassland region of the Qinghai-Tibet Plateau. In recent years, climate change and destruction by human activities have led to alpine grasslands tending to degrade. The degradation of alpine grasslands has led to a series of problems, such as disruption of the ecosystem, disruption of the grass-livestock balance, and lower income of herders, which has seriously restricted the sustainable development of the local area. In order to prevent the continued degradation of alpine grasslands, it is necessary to measure the carrying capacity of the local resources and environment in order to formulate relevant countermeasures.

Through field research and literature collection, we believe that measures such as grass-determined livestock, zonal rotational grazing, and ecological migration are more suitable for solving the ecological problem of local grassland degradation and then solving the outstanding contradiction between local people's production, living and ecological environment. These countermeasures have a positive effect on the sustainable development of the alpine grassland areas of the Tibetan Plateau.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

References

[1] Ba, T. E. (2012). *Evaluation of the current situation of grass-livestock balance in Xi'uzhu Muqin Banner and discussion of new models* [Master's thesis, Inner Mongolia Agricultural University]. CNKI. https://cdmd.cnki.com.cn/Article/CDMD-10129-1013153821.htm

[2] Dai, Z., & Min, W. Y. (2008). A study on the special characteristics and policy orientation of urbanization in pastoralist areas on the Qinghai-Tibet Plateau. *China Tibetology,* (1), 139-144.

[3] Ding, J. (2021). *Land use change on the Qinghai-Tibet Plateau based on multi-source data* [硕士, Taiyuan University of Technology]. CNKI. https://doi.org/10.27352/d.cnki.gylgu.2021.001406

[4] Du, B. J., & Zhao, F. B. (2009). Analysis of the effects of grassland zoning and rotational grazing implementation. *Contemporary Animal Husbandry,* (1), 44.

[5] Li, J., & Gong, Z. F. (2017). Comparative study of zonal rotational grazing and continuous grazing system. *Contemporary livestock and poultry farming,* (4), 8-9+32. https://doi.org/10.14070/j.cnki.15-1150.2017.04.004

[6] Liao, S. S. (2012). A review of ecological migration research. *Rural Economy and Science, 23*(4), 173-176.

[7] Wang, M., Li, Y., Pan, S., Bai, X. Z., & Huang, R. Q. (2004). Impacts of climate change on sustainable development in the Tibetan Plateau hinterland. *Chinese Journal of Population Resources and Environment,* (3), 94-97.

[8] Wu, G. X., Duan, A. M., Zhang, X. Q., Liu, Y. M., Ma, Y. M., & Yang, K. (2013). Extreme weather climate change and its environmental effects on the Qinghai-Tibet Plateau. *Chinese Journal of Nature, 35*(3), 167-171.

[9] Xu, T. W., Zhao, X. Q., Zhang, X. L., Wang, X. G., Geng, Y. Y., Hu, L. Y., Zhao, N., Mao, S. J., Liu, H. J., Kang, S. P., Ma, L., Han, X. P., Jia, G. X., Zhao, L., Dong, Q. M., Chai, S. T., & Xu, S. X. (2020). Sustainable development of ecological grass-pastoralism in alpine regions of the Qinghai-Tibet Plateau: principles, technologies, and practices. *Acta Ecologica Sinica, 40*(18), 6324-6337.

[10] Zhang, Y. (2022). Reflections on ecological migration in Inner Mongolia Daqingshan National Nature Reserve. *Journal of Inner Mongolia Forestry Science and Technology* (7), 35-37.

[11] Zhao, W. J., Ren, D. P., Pei, Y. F., Zhao, W., & Shen, J. (2018). Characterization of climate change on the Qinghai-Tibet Plateau in the past 30 years. *Chinese Science and Technology Journal Database,* (7), 250.