Chapter 5
Current State of Multifunctional Use of Grasslands

Shaoshan An, Man Cheng, Zhijing Xue and Rentian Ma

Grasslands are one of the main land-use forms in a dryland ecosystem. They provide many benefits for humans (e.g. herbal medicine and animal products) and the environment (e.g. promote water infiltration, sustain biodiversity and reduce soil erosion). China has abundant grassland resources. They cover 40% of the terrestrial area and are mainly distributed in arid and semi-arid regions. These areas are located in the upper and middle reaches of the major rivers in China such as the Yangtze River, the Yellow River and the Lancang (Mekong) River. The socio-economy in these regions is far behind the other parts of China. Therefore, the grassland ecosystem plays an important role in both sustaining environmental quality and contributing to regional socioeconomic development. However, as the population grows, overgrazing and other human activities have resulted in severe degradation of grassland ecosystems.

5.1 Grassland Ecosystem Services

This section summarises the ecosystem services provided by the grassland ecosystem on the Loess Plateau region, including environmental and socioeconomic-related services.

S. An (✉) · R. Ma
Institute of Soil and Water Conservation, Northwest A&F University,
No. 26 Xinong Road, Yangling, Xi'an 712100, Shaanxi, China
e-mail: shan@ms.iswc.ac.cn

M. Cheng
Institute of Agricultural Environment and Resource, Shanxi Academy
of Agricultural Sciences, No. 81 Longcheng Avenue, Taiyuan 030012, Shanxi, China

Z. Xue
Tourism and Environment Collage of Shaanxi Normal University,
No. 620 West Chang'an Avenue, Xi'an 710119, Shaanxi, China

L. Zhang and K. Schwärzel (eds.), *Multifunctional Land-Use Systems for Managing the Nexus of Environmental Resources*, DOI 10.1007/978-3-319-54957-6_5

5.1.1 Soil and Water Conservation

The soil in grasslands has rich fine roots, organic matter and microorganisms that interact with each other. They promote the formation of soil aggregates through the cementation of humus and calcium, thus leading to improved soil structure and fertility, and finally increases soil erosion resistance (Li et al. 2005). In some cases, grass is more capable of protecting soil than are shrubs and forests. For example, grass is a better option in areas that have a high content of gravel and a lack of nutrients since these factors constrain tree growth. In addition, many practices suggest that in steep mountainous areas on the Loess Plateau, where there are often cases of serious soil erosion, planting grasses or mixing them with woody plantation is more effective in reducing soil erosion than to rely merely on woody plantation (Wu et al. 2010).

Some studies (e.g. Jiao and Wang 2000; Gornish and Santos 2016) show that grasslands are only able to conserve soil effectively when the coverage of grass reaches a certain level. To evaluate the efficiency in soil conservation, two values are commonly used, namely critical coverage (lower tolerance) and effective coverage (upper tolerance). The critical coverage refers to the coverage level at which soil erosion reaches the highest allowable rate without hampering soil fertility in a certain region, while the effective coverage refers to the coverage level at which soil erosion reaches the minimum rate. At this point, the soil erosion rate will not decrease anymore with increasing grass coverage. Zhang and Liang (1996) found that the effective coverage is correlated with precipitation, terrain, soil and vegetation. For a given grassland, the effective coverage (percentage) shall fall between critical coverage and 100%. A simulation on flow and sediment yields in manmade grasslands indicated that soil erosion decreased with increased grassland coverage exponentially; 70% can be considered as the average effective coverage under experimental conditions (Zhang and Liang 1996). On the Loess Plateau, the coverage of grass has been investigated on many plots under different rainfall intensities and slope gradients (Jiao and Wang 2000). The results suggested that at a slope gradient of 20°, 25°, 30° and 35°, the critical coverage is 55, 60, 65 and 70%, whereas the effective coverage is 63.4, 71.1, 77.3 and 82.6%, respectively.

Apart from soil conservation, grasslands also intercept rainfall and promote water infiltration, thus are significant for water conservation. This is particularly important in water tower zones (e.g. sources of large rivers) in mountainous and hilly areas for purifying water, regulating runoff and alleviating flash floods. In arid and semi-arid regions, herbaceous plants convert surface runoff into soil water efficiently. Investigation on rainfall interception and partitioning in arid regions showed that the rainfall interception by herbaceous vegetation (38.4% ± 32.3%) is greater than that by trees (23.6% ± 14.9%) and shrubs (24.8% ± 12.9%) (Wu et al. 2010). In addition, the litters of grasses protect soils from evaporation thus increase soil water content. Taking the natural grasslands in the semi-arid Loess Plateau as examples, investigation showed that there were significant positive correlations between aboveground biomass, litter quality and soil water content (Zhang et al. 2014).

5.1.2 Carbon Sequestration and Climate Regulation

Grasslands are a potential carbon sink, but this is strongly influenced by human activities. According to Cui et al. (2000), the grassland ecosystem mainly serves as a carbon source during the non-growing season (from October to April) on the Loess Plateau, while it mainly serves as a carbon sink during the growing season (from May to September). On an annual basis, it remains a carbon sink. Deng et al. (2014) estimated that the average soil carbon fixation rates on the Loess Plateau after the farmland is returned to forests, shrubs and grassland are 0.19, 0.29 and 0.52 Mg ha^{-1} y^{-1}, respectively. This indicates that grasslands have the highest carbon fixation potential among the three land covers. In addition, Liu et al. (2011) estimated the average soil organic carbon content within a depth of 100 cm for natural grassland on the Loess Plateau and the result showed that the organic carbon content of natural grassland (5.4 kg m^{-2}) is lower than the national average (8.5 kg m^{-2}), which is attributable to the loss of soil organic material resulted from soil erosion.

Grasslands have the functions of shading, lowering wind velocity and reducing ground evaporation, and can thus moderate the changes in surface temperature, increase air humidity and accelerate vertical movement of vapour. As a consequence, rainfall occurs more frequently on vast grasslands, because the higher the grassland coverage is, the lower the reflectivity is, therefore more precipitation will fall. In contrast to large barren lands, air humidity on grasslands is 20% higher; even for small grass patches, air humidity is still 4–12% higher than that of an open area (Zhao et al. 2004).

5.1.3 Nutrient Pool

Grasslands are a prominent nutrient pool of carbon, nitrogen, phosphorus and potassium that provide products of high quality. Cheng (2014) investigated the accumulation and allocation of nutrient elements in the ecosystem of the *Stipagrandis* grassland. It is found that the plants accumulate most of the nitrogen, phosphorus, potassium and magnesium in underground. The underground accumulation of nitrogen and magnesium accounts for more than 90% of the total accumulation. The total accumulation of nitrogen, phosphorus, potassium and magnesium is 23.5, 0.3, 5.0 and 2.0 g m^{-2}, respectively. Nutrients in grazed pastures move between several various pools, including the atmospheres, soils, plants and grazing animals (Fig. 5.1) (Silveira et al. 2012). Several factors, such as climatic conditions, soil type, plant species and grazing management, can affect nutrient dynamics in these pools. Animal manure (excreta) and plant litter represent the most important pathways for nutrients to be recycled in grazed pastures. For example, in the grazing process, a large amount of animal excreta is scattered on the grassland, and degraded through natural weathering, leaching, biological fragmentation and microbiological decomposition; thus nutrients return to the soil and ecosystem (Silveira et al. 2012).

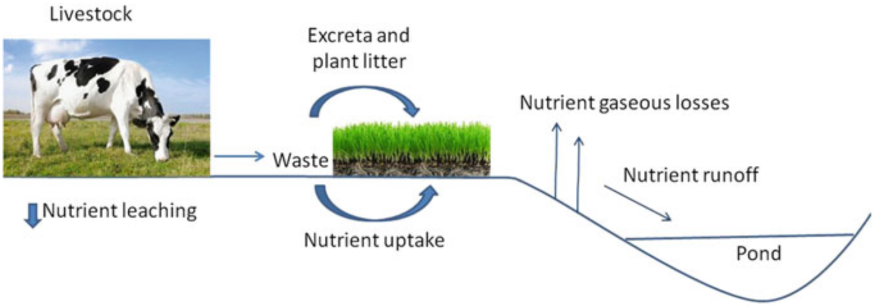

Fig. 5.1 Schematic diagram showing how nutrients move between several pools, including the atmospheres, soils, plants, and animals (Silveira et al. 2012)

5.1.4 Source of Forage Material

Forage material refers to all herbaceous and woody plants (including shrubs, twigs and leaves of trees) that can be used for livestock breeding. Forage materials can be grouped into four categories, namely gramineous, leguminous, cyperaceous and miscellaneous plants. The latter includes all of the forage plants excluding gramineous, leguminous and cyperaceous plants. Gramineous plants are common in existence in all but the alpine desert-steppe grass ecosystem in dryland China. In terms of composition, it often accounts for >50% in contrast to leguminous, cyperaceous and miscellaneous plants, according to a national grassland resource survey (Liu 1996). Leguminous plants have the most varieties among all categories of forage plants, but the presence of leguminous plants is generally low in most of the grassland ecosystems. Yet, they contain a high nutritional value and are a major source of proteins for animals. Similar to gramineous plants, cyperaceous plants have a wide distribution in natural grassland ecosystems and are particularly valuable for animals on alpine meadows and wetland meadows. In comparison, miscellaneous plants are large in quantity and widely distributed in many grassland ecosystems, but they are rarely dominant and often have low nutritional value except for a few species.

5.1.5 Source of Livelihood

Livestock husbandry is an important part of the agro-ecosystem of the Loess Plateau. Due to the natural and climatic constraints, grasslands in arid parts of the Loess Plateau can be low in productivity. Input of supplemental livestock feed from artificial grassland is necessary, in which leguminous plants such as alfalfa (*Medicago sativa*), erect milkvetch (*Astragalus adsurgens*), sweet clover (*Melilotus suaveolens*) and sainfoin (*Onobrychis vicifolia*) are the main species. Animals and associated products have become major sources of rural livelihoods (e.g. in the northern Loess Plateau area). For instance, the output of animal husbandry in Ningxia Province was always half of the output of agriculture in the past three years. Besides, grasslands provide abundant raw materials for food, fuel, pharmaceuticals and textiles, which make additional contribution to the livelihoods of farmers.

Grasslands in northwest China are widespread and feature an exotic landscape owing to a combination of unique animal and plant resources and cultural history. Due to the benefits that it potentially brings in terms of the development of tourism and protection of the grassland ecosystem, ecotourism has attracted more and more attention from local governments and farmers on the Loess Plateau. The development of grassland ecotourism increases rural income and attracts more investments from outside due to an improved local environment. In addition, it drives the developments of other related businesses along the progress of tourism development, such as special local products, trade and infrastructure construction (e.g. highway and public transportation), which promote local economic development.

5.2 Possibilities for Multifunctional Grassland Utilisation

5.2.1 Protection-Based Grazing Management

In the arid part of the Loess Plateau, the primary functions of grasslands are to protect land/soil from degradation/erosion and to promote groundwater recharge. Additionally, grasslands can also provide some secondary socioeconomic functions. The key for protection-based (such as soil and water conservation) grazing management is to determine a feasible stocking rate and method without harming the primary functions (Galt et al. 2000; Batabyal and Godfrey 2002). Proper grazing can stimulate the tillering of grass and promote nutrient cycle (nitrogen and phosphorus), thus increase biodiversity/species richness and the productivity and sustainability of natural grasslands (Silveira et al. 2012), but improper grazing/overgrazing will cause soil compaction and land degradation, finally reducing biomass and the quality of grass (Bedunah and Angerer 2012). The multifunctional use of grasslands for protection and grazing can bring maximum benefits for both the environment and economy. In special cases, such as severely degraded land, a complete ban on grazing can be implemented, while in other parts where protection-based grazing is acceptable, efforts should be made to study and determine the stocking rate, rotational grazing techniques and the use of leguminous plants.

5.2.2 Coupled Agriculture and Livestock

On the Loess Plateau, the transitional area of agriculture-dominant semi-humid zone and grassland-dominant arid and semi-arid zone has relatively higher water and heat availability. Farmlands and grasslands may combine and alternate with each other depending on the site specific soil, water and heat conditions. More attention should, on one hand, be paid to soil erosion and nutrient control and increasing soil water pool (as mentioned in the previous chapter on multifunctional agriculture) to ensure a high and sustainable agriculture production; on the other hand, a sustainable livestock and grazing management in grassland to prevent degradation needs to be established. This may serve as a leading model in the semi-humid and semi-arid transitional zone as they can ensure more sustainable environmental and economic benefits through non-intensive agriculture and non-pressured livestock breeding.

5.2.3 Grassland Ecotourism and Featured Goods and Services

Ecosystem and tourism have merged into a new genre of environmentally sound and socially responsible recreation (Honey 2008). The International Ecotourism Society (TIES) provides a substantial, contemporary definition of ecotourism, denoting the key features of ecotourism as minimising human impacts, improving the public's awareness of nature conservation, providing direct financial benefits to local residents and nature conservation and conserving local culture (Honey 2008). China has made significant efforts to reconcile environmental protection and social improvement with economic growth in areas with ecological fragility and poverty (Jiang 2006; Liu 2008). Ecotourism is viewed as an ecological approach to socioeconomic development and poverty reduction (Donaldson 2007), to the conservation of endangered species and habitats in developing countries (Bookbinder et al. 1998), and to manage protected areas (Cengiz 2007). Having various types of grasslands, northwest China is able to offer a variety of tours, such as grassland sightseeing tours, ethnic culture tours and minority life experience tours, while special goods and commodities are provided.

5.3 Challenges in Multifunctional Grassland on the Loess Plateau

5.3.1 Land Degradation and Grazing

Grasslands have encountered severe degradation over the past several years. As a result, the beautiful scenery as captured by the famous verses 'moderate wind blowing, flourishing grass swaying, flocks and herds playing' has almost disappeared. The causes for soil erosion are twofold: unfavourable climatic conditions and uncontrolled human behaviours. On the one hand, insufficient water availability due to the frequent drought in recent years has retarded grass growth. Furthermore, the fragile ecosystem has become more vulnerable to locust disasters, which further reduces the chances of grassland recovery. On the other hand, based on the Household Production Responsibility System, grasslands were distributed to herders, thus the economic interests of herders are directly reflected in the production of grassland. In order to increase their income, herders tend to increase livestock numbers and stocking rate. As a result, livestock numbers have increased three to four times over the past years (Zhang 2002), which have severely exceeded the carrying capacity of the pastures. In turn, grassland degradation can restrict grazing potential. The economic losses due to environmental degradation accounted for almost half of total expenditure (Li 2000). To ensure benefits for both the environment and economy, an alternative sustainable management strategy has to be implemented, such as grazing management strategy (stocking rate, grazing intensity, variety of livestock), nutrient addition, and the introduction of legumes to the grassland system.

5.3.2 Grassland Conservation and Ecotourism

In general, ecotourism is considered as a more environmentally friendly industry with strong economic motive, thus is a beneficial choice to partly replace livestock breeding and alleviate overgrazing and land degradation. The International Union for Conservation of Nature (IUCN) defines ecotourism as the 'environmentally responsible visitation to relatively undisturbed natural areas, in order to enjoy, study, and appreciate nature that promotes conservation, has low negative visitor impact, and provides for beneficially active socioeconomic involvement by local people' (Hanley 1989). This means it should (i) minimise negative social (culture) and environmental impacts (land degradation); (ii) maximise involvement and economic benefits of local people; (iii) increase the people's awareness of environmental conservation. Similarly, different from common tourism, grassland ecotourism on the Loess Plateau shall emphasise the significance and priority of environmental conservation, which may cover four essential aspects: (i) realise sustainable development of natural resources; (ii) obtain the maximum economic benefit from tourism and benefit local residents; (iii) improve the public's consciousness of natural conservation, and (iv) implement sustainable ecosystem management (Zhang 2002). However, currently, the economic benefit from ecotourism is still not substantial enough for local people to replace or partly reduce their livestock numbers to adapt to the carrying capacity of the grasslands. Therefore, it is important to investigate how to involve the local community in tourism and to ensure economic benefits. They are a key aspect in restoring the degraded grassland through developing tourism. In addition, strategies to prevent water pollution, waste accumulation and species losses in nature reserves have to be created (Li and Han 2001).

5.4 Concluding Remarks

Multifunctional grassland plays an important role in the sustainable development of the Loess Plateau. The grassland ecosystem provides a number of environmental and socioeconomic-related services, including soil and water conservation, carbon sequestration, nutrient pool and so on. At present, protection-based grazing, coupled agriculture and livestock, and grassland ecotourism are implemented for achieving multiple utilisation and benefits of the grassland ecosystem. These management strategies were found to be useful and beneficial for a more sustainable regional development. However, the inappropriate multifunctional utilisation of grasslands can also cause disservices of environment in the fragile ecosystem. Therefore, environmental protection and economic growth have to be balanced and harmonised in an optimal relation in multiple uses of grassland. This requires innovative frameworks of multifunctional grassland, cross-sectoral research, applicable approaches and supportive policy.

References

Batabyal AA, Godfrey EB (2002) Rangeland management under uncertainty: a conceptual approach. J Range Manage 55(1):12–15

Bedunah DJ, Angerer JP (2012) Rangeland degradation, poverty, and conflict: how can rangeland scientists contribute to effective responses and solutions? Rangeland Ecol Manage 65(6):606–612

Bookbinder MP, Dinerstein E, Rijal A, Cauley H, Rajouria A (1998) Ecotourism's support of biodiversity conservation. Conserv Biol 12(6):1399–1404

Cengiz T (2007) Tourism, an ecological approach in protected areas: Karagöl-Sahara National Park. Turkey Int J Sust Dev World 14(3):260–267

Cheng JM (2014) Grassland ecosystem of the Loess Plateau in China-Yunwushan national nature reserve. Science Press, Beijing pp 481

Cui X, Chen Z, Chen S (2000) Progress in research on soil respiration of Grasslands. Acta Ecol Sin 21(2):315–325 (in Chinese with English Abstract)

Deng L, Shangguan ZP, Sweeney S (2014) "Grain for Green" driven land use change and carbon sequestration on the Loess Plateau, China. Sci Rep 4:7039–7040

Donaldson J (2007) Tourism, development and poverty reduction in Guizhou and Yunnan. China Quart 190:333–351

Galt D, Molinar F, Navarro J, Joseph J, Holechek J (2000) Grazing capacity and stocking rate. Rangeland J 22(6):7–11

Gornish ES, Santos PAD (2016) Invasive species cover, soil type, and grazing interact to predict long-term grassland restoration success. Restor Ecol 24(2):222–229

Hanley ND (1989) Valuing rural recreation benefits: an empirical of two approaches. J Agr Econ 40:361–374

Honey M (2008) Ecotourism and sustainable development: who owns paradise?, 2nd edn. Island Press, Washington DC, p 568

Jiang H (2006) Decentralization, ecological construction, and the environment in post-reform China: case study from Uxin Banner, Inner Mongolia. World Dev 34(11):1907–1921

Jiao JY, Wang WZ (2000) Effective cover rate of Woodland and Grassland for soil and water conservation. Acta phytoecologica Sinica 24(5):608–612 (in Chinese with English Abstract)

Li WJ (2000) Study on Ecotourism management for China's nature reserves. In: Chinese National Committee for MAB (eds) Study on sustainable management policy for China's Nature Reserves Science and Technology Press. Beijing (In Chinese with English abstract)

Li W, Han N (2001) Ecotourism management in China's nature reserves. Ambio 30(1):62–63

Li M, Yao WY, Li ZB (2005) Progress of the effect of grassland vegetation for conserving soil and water on Loess Plateau. Adv Earth Sci 20(1):74–80

Liu Q (1996) Distribution of forage plant resources in grassland of China. Grassland China 3:45–48 (in Chinese with English Abstract)

Liu L (2008) Sustainability efforts in China: reflections on the environmental Kuznets curve through a locational evaluation of "eco-communities". Ann Assoc Am Geogr 98(3):604–629

Liu W, Cheng JM, Chen FR, Gao Y (2011) Characteristic of organic carbon density and organic carbon storage in the Natural Grassland of Center Loess Plateau. Acta Agrestia Sinica 19 (3):424–431 (in Chinese with English Abstract)

Silveira ML, Vendramini JMB, Da Silva HM, Azenha M (2012) Nutrient cycling in grazed pastures. SL376, series of the Soil and Water Science Department, UF/IFAS Extension

Wu Q, Yang CX, Chen YE, Guo LN (2010) Present status and progress of study on erosion reduction effect of grass vegetation. Soil Water Conserv China 6:44–46. doi:10.14123/j.cnki.swcc.2010.06.010 (in Chinese with English Abstract)

Zhang Q (2002) Eco-tourism's role in alleviating overgrazing in Xilingol biosphere reserve. MAB Young Scientists Award Research Report, UNESCO

Zhang GH, Liang YM (1996) A summary of impact of vegetation coverage on soil and water conservation benefit. Res Soil Water Conserv 3(2):104–110 (in Chinese with English Abstract)

Zhang ZN, Wu GL, Wang D, Deng L, Hao HM, Yang Z, Shangguan ZP (2014) Plant community structure and soil moisture in the semi-arid natural grassland of the Loess Plateau. Acta Prataculturae Sinica 23(06):313–319 (in Chinese with English Abstract)

Zhao TQ, Ouyang ZY, Zheng H, Wang XK, Miao H (2004) Analyses on grassland ecosystem services and its indexes for assessment. Chinese J Ecol 6:155–160 (in Chinese with English Abstract)