RANGELAND DESERTIFICATION IN CHINA

W. Tao
Cold and Arid Regions Environmental and Engineering Research Institute
Chinese Academy of Sciences, Lanzhou 730000, China, wangtao@ns.lzb.ac.cn

Abstract

Land desertification is one of the most serious environmental and social-economic problems in the North China. The processes of desertification mainly have being controlled by the interaction of human activities and fragile eco-environment, that means the pattern and intension of landuse are major factors for development or reverse of desertification. Because of the increasing pressure of population, the rangeland in the North China has being cultivated decade by decade, which changed landuse from grassing to cropping in a large area and destroyed the natural vegetation cover. The result is to let the wind erosion become easier and the desertification has developed very quickly. According to the statistics of desertified land areas with different landuse purposes, the human impact on the contributing to the desertification in the rangeland region were as 25% of over-cultivation, 28% of over-grassing, 32% of over gathering firewood and 8% of mis-used water resources. The occurrence and development of desertification in the North China is accompanied by human civilization history, especially in recent one hundred years the development of desertification is quickest. Desertification processes aggravate soil wind erosion, deteriorate soil physical and chemical properties, reduce land productivity, cause great economic loss and seriously affect livelihood and living environment. During last 5 decades, desertified land has expanded continually in the North China, which total area has reached over 350,000 km^2 by middle 1990's. Based on the remote sensing monitoring, we found that the growth rate of desertified land has being increased decade by decade like as the annual average spread area has increased 1,560 km^2 of among 1950's and middle 1970's to 2,100 km^2 of between middle 1970's and late 1980's, to 2,460 km^2 of last decade. Accordingly, in-depth study of anthropogenic effects, in particular the effect of over-rangeland use on the desertification development has an important practical significance to elucidate the mechanism of desertification occurrence, enrich the theory of desertification study and formulate the policies and measures to combat desertification. But some successful models of combating desertification have improved that where the reasonable landuse has been adopted over some years, the sandy desertified land has reversed and can be used again for more effective farming or grassing. Desertification is one of the most serious environment and socioeconomic problems in the world today and China is one of the countries suffering from serious desertification, especially in the north China where sandy desertification is developing rapidly over large areas and receiving widespread attention. According to human activity and socioeconomic characteristics and their interactions, through nearly 20 years of theoretical research and practices, we give a conception of sandy desertification: sandy desertification is the process with sand drift activity as main mark

occurred in arid, semi-arid and partial sub-humid areas resulting from human irrational economic activities and inharmony between natural resources and environment (Zhu Zhenda, Wang Tao 1993). The occurrence and development of sandy desertification in the north China is accompanied by human civilization history, especially in recent one hundred years the development of sandy desertification is quickest. Sandy desertification processes aggravate soil wind erosion, deteriorate soil physical and chemical properties, reduce land productivity, cause great economic loss and seriously affect livelihood and living environment of the mixed agropastoral region in the north China. Accordingly, in-depth study of anthropogenic effects, in particular the effect of land use on the sandy desertification development has an important practical significance to elucidate the mechanism of sandy desertification occurrence, enrich the theory of desertification study and formulate the policies and measures to combat sandy desertification.

Introduction

Natural rangeland in China covers an area of $3.1908\times10^{8}hm^{2}$, accounting for 38% of China's total land area. In terms of rangeland area, China is the world's fourth largest country, next only to the Australia, former Soviet Union and United States. Available rangeland in China occupies $2.243\times10^{8}hm^{2}$, of which enclosed rangeland and artificial rangeland occupy 1.2% and 1.2% respectively. China's rangeland are mainly distributed in five major pastoral regions in Inner Mongolia, Xinjiang, Qinghai, Gansu and Tibet, or to the northwest of the line extending from the Da Hinggan Mountains to Yinshan Mountains to Luliang Mountain to Hengduan Mountains. Rangeland in China can be divided into four types: (1) typical rangeland, which is mainly distributed in the semiarid zone of east China; (2) meadow rangeland, which is mainly distribute on the west slope of the Da Hinggan Mountains; (3) desert rangeland, which is mainly distributed in the mid-west arid zone and (4) alpine cold rangeland is mainly distributed in the Qinghai-Tibetan Plateau, Pamir plateau, Tianshan Mountain, Kunlun Mountain and Qilian Mountain regions. The sacredly distributed sparse-tree rangeland in south China will not be covered in this review.

Rangeland in China are facing three major problems, namely rangeland degradation, soil wind erosion and desertification. By the year 1995 the degraded grass and area had exceeded 50% of its total, and the combined area of severely degraded, sandy decertified and salinized rangeland reached 30%, of which sandy decertified rangeland occupies $0.51\times10^{8}hm^{2}$,or accounting for 16% of the total natural rangeland area.

After coming into the 1990s, sand-dust storms frequently hit the Northwest and North China, suggesting that rangeland desertification has been greatly exacerbated. Rangeland wind erosion and desertification not only hinder the development of animal husbandry in China but also affect the safe operation of traffic and production in the surrounding regions.

Status and characteristics of rangeland degradation, wind erosion and desertification

Rangeland degradation, wind erosion and desertification interact with one another as

both cause and effect and are still going on, finally they will convert into gravel or sandy deserts. Rangeland degradation is often manifested in the decrease of plant species diversity, low grass height and vegetation cover; the increase of undesirable and unpalatable grass species; the occurrence of toxic and harmful species, especially the sharp reduction of grass yield. If vegetation cover is too low to cover the ground surface, wind erosion and desertification will take place.

Owing to different soil texture, the rangeland desertification processes, forms and final landform types thus formed are different. In the rangeland degradation processes, wind force always plays an important role and therefore the frequent wind-sand activities are a general feature of the process. What we call the “desertification” here is not confined to the expansion and reactivation of the desert but will not deal with the land degradation caused by Tunning water erosion, salinization and waterlogging processes, that is to say, it belongs to a narrow sense of desertification.

Wind erosion is the process of surface material loss under the influence of wind force, it marks the onset of wind-sand activity and land desertification, and all the sub-processes of desertification are directly or indirectly initiated by wind erosion. Wind erosion can destroy the surface soil structure and remove fine soil particles, thus resulting in topsoil skeletonization, soil property deterioration, fertility loss and land productivity decline. This finally leads to the degradation of the whole ecosystem and the appearance of eolian sand microtopography. Depending on the soil texture, the desertification processes and the final landscapes are shown in Figure 1.

According to the “final” landscapes of desertification, the desertification can be divided into three types, i.e.sandy desertification, gravel desertification and badland formation (Zhu, 1994).

Desertification mechanism is characterized by feedback effect. Once desertification has occurred and there is sand moving wind blowing over the ground surface sand particles are first pushed forward and then lifted into the air to form into wind-sand stream. The erosivity and sandblast intensity of wind-sand stream is generally tens to a few hundred times higher then of clean airflow. Accordingly, there exist the feedback processes of exacerbating deflation by wind and wind-sand stream in the course of desertification: i.e. even at the initial stage of desertification, there are active wind-sand stream activities and their destruction processes, furthermore, its destruction velocity may be faster land desertification process can be greatly accelerated by increasing wind velocity.

Factorial analysis for rangeland desertification

Natural factor

Low vegetation cover and gross yield resulted from harsh natural conditions

Rangeland in China across the arid temperate continental climatic zone, the semiarid monsoon climatic zone and the alpine cold climatic zone on the Qinghai-Tibetan Plateau. Owing to marked continentally, annual precipitation in the rangeland zones is sparse and highly variable, ranging from 500mm in the east to less than 100mm in the northwest and spring drought often lasts for quite a long time. The number of days without effective

precipitation varies between 40—100 days per year, in some places even reaches 150-200 days per year. Annual evaporation rate ranges from 2500—3000mm, and aridity index varies between 0.7 and 20 or more. Winter is very cold and long, plant growing period is short, for example, the frost-free growing period in the Bashang region and on the North Slope of the Yinshan Mountains is less than 100 days. Spring is dry with frequent gales. Annual mean wind velocity in the rangeland region is 3—4m/s. and the figure in the China-Mongolia and China-Kazakstan bordering regions and on the Qinghai-Tibetan Plateau could reach up to 4.5m/s, the Qinghai-Tibetan plateau could velocity $\geqslant$5m/s varies between 30—50 day and in mountain pass region ranging from 60—80days Annual mean number of sand-blowing days ranges from 20—100days, the figure in the peripheral zones of deserts could reach up to 100—150day, and each sand-blowing event may last for 17—48 hours.

Harsh natural conditions make the eco-environment quite fragile, thereby affect the grass yield and quality of rangeland. The unit area yield of grass in the best rangeland in northeast China could reach 5016kg/hm^2, available grass amount 3316kg/ hm^2, and 0.53 hm^2 of rangeland could support a sheep-unit animal. The biomass unit area yields of the rangeland in Inner Mongolia, Xinjiang, Ningxia. Qinghai and Gansu are 2429kg/ hm^2, 1790kg/ hm^2,1603kg/ hm^2,1532kg/ hm^{2}and 923kg/ hm^2 respectively, while available grass amounts are 1108kg/ hm^2, 877kg/ hm^2, 865kg/ hm^2, 984kg/ hm^2 and 462kg/hm^2 respectively. On an average, the biomass unit area yield of the country's rangeland only reaches 2120kg/ hm^2 and available grass amount is 1061kg/ hm^2.

Rapid desertification resulted from recent aridification

Since the mid-1960s, vast regions in North Africa, Middle East, China and Japan have entered a relative drought period. The aridification in northern China is mainly manifested in several aspects: (1) drought and rain-deficient years occur at a higher frequency, precipitation is concentrated in a short period and drought period is concentrated in a short period and drought period is significantly prolonged; (2) water level of lakes drops, lake area shrinks even dries up; (3) river runoff decreases or even turns into a seasonal river; (4) glacier retreats and become thin, and snowline rises; (5) indicator plants decline, die and show a succession tendency towards xeric habitats. Obvious expansion of desert and desert and desertification themselves also reflect the rapid development of aridification. The Qinghai Lake basin can be quoted as a typical example, in recent 30 years the lake level fell by 3.16m and is still falling at an annual rate of 10.53cm; its water surface area decreased by 7% compared to the 1960s, on an average, each year decreased by 12.46km^2; each year about 1.48km^2 of fixed and semi-fixed sand dunes were reactivated and desertified land area is increasing at an annual rate of 6km$^{2(2)}$.

Present warm-winter climate increases soil moisture evaporation and winter evaporation has a crucial influence on soil moisture condition in spring. Experiments demonstrated that as soil moisture content exceeds 1%, soil particles generally cannot be blown away by wind; if no precipitation occurs, the thickness of dry sandy soil (soil moisture content $\leqslant$1.0%) in many places could reach up to 20cm, such a dry soil surface creates a condition for wind erosion.

This year we experienced another warm winter. The drought situation in North China

was even severer and the high-temperature duration created a new historical record. In Hexicorridor Region, Shansi, Inner Mongolia and Shaanxi, almost no precipitation occurred for about 100 days, this predicted a spring with frequent and strong sand-dust storm events.

Human factors

Cultivation in grazing rangeland destroyed vegetation cover and backward cropping system damaged soil structure and left behind 100se surface to wind erosion.

Reclamation of rangeland in northern China began in the late 19th century and after the founding of new China many rangeland went through another several large-scale reclamation. For example, in the Ih Ju League and ulangabLeague in Inner Mongolia, Bashang region in Hebei Province, north Shaanxi and Gansu, some $1693\times10^4 hm^2$ of rangeland have been reclaimed as croplands, two-thirds of which were reclaimed after the founding of new China and most of them are rainfed-land. Since 1960s some $800\times10^4 hm^2$ grazing rangeland have been cultivated in China. Dryland agriculture often has a low productivity, with low yield and extensive cultivation as its common feature. According to author's investigation in the Bashang region, Nanwu Banner in Xilin Gol League and Houshan region in Ulanqab League of Inner Mongolia per capita cropland ranges from 0.53—$0.87hm^2$, per male labor force manages 2—$3.3hm^2$ of cropland, in normal years per hm^2 spring wheat yield varies between 750—900kg. The ratio of output to input of desertified rangeland is 1.08 or 60% lower than the country's arrearage.

Traditional dryland farming adopts the system of autumn plough and spring harrowing, Ploughed land often creates 100se surface to wind erosion.

Overgrazing accelerates rangeland degradation and exposes low-vegetation-cover or bare ground surface to wind erosion and speeds up desertification.

Over the years the management of rangeland and animal husbandry in China has been lacking the commodity and value conceptions, managers often put one-sided emphasis on the total number of livestock and used it as the indicator to assess the development level of animal husbandry. With the development of animal husbandry, the number of livestock increased rapidly. According to statistical data, the total number of livestock in 1985 in Inner Mongolia, Shaanxi, Gansu, Ningxia and Xinjiang was 1.88—1.94 times higher than that of 1949(Bao, 1996). Increased livestock number and decreased rangeland area, coupling with rangeland degradation and lowered grass yield, resulted in serious unbalance between livestock number and grass yield.

According to calculation, the theoretical grazing capacity of rangeland in northern China is 10205.3×10^4 sheep unit. The overloading rate in 1985 reached 2872.87×10^4 sheep unit, or equivalent to an overloading percentage of 28.15%(Zhang, 1998). The actual ratio between livestock number and natural rangeland carrying capacity was 1.6 in Inner Mongolia, 1.15 in Qinghai, 3.5 in Ningxia, 2.33 in north Shaanxi, and 2.55 in northwest Shanxi. In China, on the one hand, the warm-season rangeland area is large but its grazing period is short; on the other hand, the cold-season rangeland area is small but its grazing period is long, thus

exacerbating the contradiction between livestock number and grass yield. Although crop straw provides part of fodder in the mixed agropastoral region, the forage grass output is still far from meeting the demand. Table 1 shows the stocking rate and livestock overloading status in some counties of Inner Mongolia.

Overbrowing and trampling are the common causes of rangeland degradation. In addition, uncontrolled digging medical herb, licorice roots, and collecting edible Nostoc fiagelliforme (ground hair) directly destroyed the rangeland. Hunting rat's natural enemies such as owl and fox, almost led to the entire extinction of some species. Rangeland degradation created a favorable environment condition for rats and thus promoted their spread, and exacerbated the destruction processes of rangeland.

To the rangeland regions in China, human factors are the main causes of rapid development of modern desertification. In recent years great attention has been paid to stop cyltivation and establish artificial vegetation in some typical reclamation areas in the rangeland regions of North China, including some areas in Inner Mongolia and Bashang region of Hebei Province, thus slowing down the development rate of desertification. Although attention has also been paid to the socio-economic and ecological benefits of rangeland, the idea "depending on Heaven for animal raising" has not been completely given up, grazing pressure on rangeland is still increasing and rangeland degradation it still continues. All ghese, coupling with further aridification predict the rapid development of soil wind erosion and desertification. Observations in recent years also show that the onset date of sand-dust storms has been advanced and the sand-dust storm events caused even greater damages than previous years.

Desertification controlling strategies

Desertification control schemes in rangeland region should follow the general disaster reduction principle "laying emphasis on prevention, both prevention and rehabilitation measures are adopted simultaneously". Consideration must be given both to long-term eco-environmental benefit and short-term economic benefit. Rationally handle the relations among protecting environment, developing agriculture and animal husbandry production, and improving people's living standard. Working out landuse planning, establishing demonstration plots, enhancing people's awareness, protecting environment and arresting wind and disasters should become people's conscientious actions. Main measures include:

Restricting agricultural development and supporting forage grass production in the mixed agropastoral region

Rangeland reclamation law should be formulated go restrict unplanned reclamation of rangeland. Great efforts should be made to practice crop-grass rotation system, establish artificial rangeland in the already reclaimed, developing irrigated agriculture and high-benefit agriculture, and coverting cropland into rangeland on the basis of ensuring people's food demand.

Increasing rangeland investment, speeding up construction of artificial rangeland and improving natural rangeland

Rangeland construction planning should be worked out to construct capital rangeland and create the condition for shelter feeding animal husbandry. Strengthening the management

of artificial rangeland, introducing hardy and improved grass varieties, developing irrigated rangeland and speeding up the construction of artificial rangeland (Li, 1993).

Natural rangeland planning should be formulated to define rational grazing intensity, correctly divide seasonal grazing rangeland and cutting rangeland and construct complete set of grass-animal enclosures. Such measures as fencing off, reseeding and irrigation etc. should be adapted to regenerate already degraded or endangered rangeland species, Biological and chemical or artificial methods should be adopted to control insect pest and rodent damages. In addition, toxic plant species should be wiped out and good strains of seeds should be timely sowed by airplane to enhance the carrying capacity of rangeland.

Practicing scientific animal raising, enhancing productivity of animal products and lightening livestock grazing pressure on rangeland

The traditional idea “raising old animal” derived from chasing high livestock number should be given up to increase off take rate, optimize herd structure, improve livestock variety, advocate shelter feeding, popularize compound feed and develop feed processing industry. Great efforts should be made to steed up dry-lot feeding, finish dry-lot feeding and off takd in the same yrat, enhance commodity percentage and economic efficiency, ensure sustainable and stable development of animal husbandry, restore ecological balance of rangeland region and control wind erosion and desertification disasters.

With grass resources as foundation in rangeland regions, rationally arrange farming, forestry, animal husbandry, side-line occupation and fishery; unify ecological benefit, economic benefit and social benefit; take the establishment of benign eco-environment as the only way to control wind erosion and desertification disasters.

References

Zhenda, Z. and Guangting C. (1994). Land sandy desertification in China, Science press.

Bao Wenzhong, Shan Wei, Yang Xiaodong et.al. (1996). Ecological crisis of rangeland resources in northern China and countermeasures, Rangeland of China. **2**: 68-71.

Qiang,Z., Xue Z. and Halin Z. (1998). Rangeland in desert regions of China, Meteorological press.

Bo,L. (1993). Rangeland degradation and countermeasures in northern China, Agricultural science in China, **6**: 1-9.

Table 1 - Stocking rate and livestock overloading status in some counties of Inner Mongolia (sheep unit)

Banner or county	Natural Grassland	Artificial grassland	Forest grassland	Field bund	straw	Agricultural by-product	Tree Branches and leaves	Carrying capacity	Over--loading rate
Huade	129113	10908	2070	12913	51783	40655	3436	250878	197039
Shangdu	112487	13833	7566	26897	105012	77865	12540	356190	247845
Qahar youyi Houqi	228327	13343	2708	15408	35983	33771	4496	334031	203881
Qahar youyi Zhongqi	53709	8921	11128	17726	61272	44250	18468	215474	343926
Siziwangqi	940739	11376	1729	26156	43047	42346	28700	1094093	201009
Damaoqi	770697	17981	1952	13016	18619	16500	3240	842011	249413
Wuchuan	184316	28398	6101	21519	45508	40412	10126	336380	178371
Tota	2419388	104760	33244	133635	361224	295779	81006	3429057	1621484

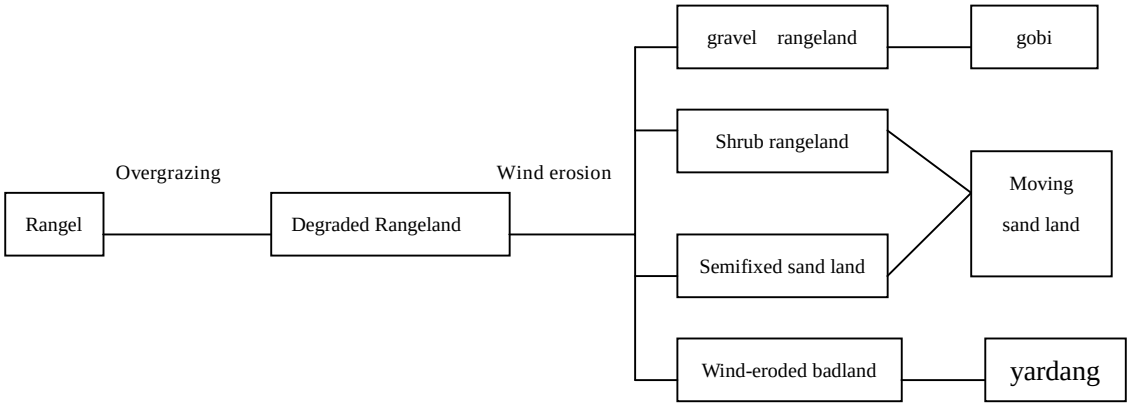

Figure 1 - Rangeland wind erosion, desertification processes and final landscapes