The Land Desertification Dynamic Monitoring and Driving Factors Analysis in YLN Region of Tibet

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Abstract. In this paper, we study the land desertification status and distribution in YLN region of Tibet and analyzed the driving factors using Landsat satellite image of 2000-2009 and some observational materials. The result show that, in 2009, total desertified land area is 4253km^2 which included 1388km^2 sandy type desertified land and 2864km^{2}gritty typedesertified land. In research area, distribution of desertified land was uneven. The area of sandy land in the westernwas more than that of the eastern. From 2000 to 2009, sandy land area increased 17 km^2, the average annual growth rate of0.44‰. Desertification in the study area was the result ofcombination of natural and social factors. The influence of wind and evaporation were the biggest factor in nature, and the influence of human behaviorwas the most in social.

1. Introduction

Desertification is a global issue, one of the most serious ecological problems in our country. Desertification severely damages the ecological environment, restricteconomic development,endangering national resources and environmental safety and affect sustainable development. Tibet is the country hardest hit by desertification and it is also an important ecological barrier in western China. The ecological environment problem of this region is a hot spot and focus. The State Council not only consider the anti-desertification projects in Tibet as the effective measures to fundamentally solve the problem of the herdsmen, also the important measures to protect ecological source.

There are many researchers studied the desertification problem. Dong Guangrong studied the YLN Region Land desertification status and obtainsthat basin land desertification was a serious problem and causes including natural and social factors [1]. Kim Jiong studied the progress of the desertification in Tibet and the types, character and differences of sandy soil. He concluded that desertification distribution wasa process that caused by natural factors and human factors, accelerated by human behavior [2]. Luo Huaibin used the spatial and statistical analysis function of Arcinfo, from the aspects of climate, geomorphology and land use, to study the distribution of sandy land in different types regions [3]. Li Yongxia and Jiang Ping Fang studied the spatial distribution of sandy solid, obtained that desertification area accounted for a total land area of 6.44% and desertified land area of eastern and middle was much higher than that of the western region [4]. There are many studies on the causes and distribution of land desertification in Tibet area, but a few studies on the dynamic changes of land desertification in this region. In this paper, we took the YLN region as study area, analyzed the dynamic changes of land desertification and explored the reasons and driving factors with the decision tree classification method combined with the terrain map,2000 land use symbol library and remote sensing data.

2. Overview of Research Area

The YLN region in Tibet, the middle region of Brahmaputra River, Lhasa River and Nien-chu River in Tibet, located in the south of the Qinghai Tibet Plateau. Latitude range is 28°20′-30°20′E and 87°00′～92°35′ [5]. Land area is 66,500 km^2. The population is more than 80 million. The climate here is plateau monsoon temperate semi-arid climate featuring with severe air temperature

changes and relatively big temperature differences.In spring and winter, it is always dry and rarely rains while it rains intensely in summer and autumn .There is always gale in spring. The ground vegetation is mainly mountain shrubby-grassland and alpine steppe, which is thin and low, thus the eco-environment here is extremely vulnerable. The YLN region has 18 counties (city, district), including Chengguan, Dazi, Linzhou Mozhugongka, Doilungdeqen, Qushui, Nyemo, Gongga, Zhanang, Qonggyai, Naidong, Sangri, Rigaze, Gyangze, Bailang, Lazi, Namling, Xietongmen. Population is concentrated. This region has high level of urbanization, and its agricultural production level also high. Social and economic development is relatively rapid. It is the capital of political, economic, transportation and cultural in Tibet.

3. Data Sources and Research Methods

3.1 Data Source

We selected 2000 and 2009 two periods Landsat TM remote sensing data as data source, the imaging time on July. Data downloaded from the U.S. Geological Survey (USGS), including 8 view images. The rail range is 137-140, 39-40. Elevation data used digital elevation model in Tibet Province. Supplementary data used 1:50000topographic maps, the ground survey data, land use in 2000 symbol library and hydrologic meteorological data.

3.2 Types of Desertified Land

The essence of the desertification is a geological and geomorphological progress that airflow (wind) acts on the sandy surface generated by the flow of sand, sand deposition, sand dunes forward, and dust blow case [1]. Referring previous studies of desertification land in Tibet, from the causes and characteristics of sand land, we divided desertification land in Tibet into 2 types (table 1): sandy type desertified land and gritty typedesertified land.

Table 1 Types and index of desertified land in YLN

Index	sandy desertified land			gritty desertified land	
	fixed sand dune	semi-fixed sand dune	moving sand dune	naked sand land	semi-naked sand land
Composition	silt ,very fine sand 90%	silt and very fine sand 75%，middle sand and fine sand 20%	fine sand 70%,very fine sand ,middle sand	very fine sand and silt 65%,a little grit	grit and very fine sand 45%,middle sand,
Surface configuration	flat sandy land, fixed dune	flat sandy land ,semi-fixed dune	flat sandy land, hill sand, barchans dune, compound dunes	flat gravel land, small brush sand	flat gravel land, small fragmentary barchans dune
Cover	>40%	25%	<2%	25-40%	<25%
Species	caraganavetsicolosand-binding grasses	sand-binding grasses stipa purea	null	stipa purea caraganavetsicolo	Artemisia younghusbandii stipa pure
Land-use type	tidal flat, sand			bare rock	

3.3 Research Methods

3.3.1 Interpretation Symbol

The pre-processing of remote data includes image composite, image enhancement, geometry rectification and radiometric correct. Based on 2000 land use symbol library in Tibet, land use types in Tibet can be divided into 9 classes. They are ice, grass, forestry, bare rock, water, cultivated land, tidal flat, sandy land and settlement place. Interpretation symbolhas been established based on

relationship between the interpretationelements, image texture, color and characteristics. Directly or indirectly identify the types of land from the TM image. Part of the interpretation marks are shown in table 2.

Table 2 Part of the Interpretation Marks in YLN

class name	forestry	cultivated land	bare rock	sandy land	tidal flat
image					
characteristic	bottom green，fluctuation with terrain	brownness，clear grain，uneven shade，having farming traces	cinerous, obvious trench，viewing strong，uneven shade，out-of-shape	yellowish white or offwhite，uneven shade，obvious trench，out-of-shape	white, fringe, having alluvial fan，located in river bank，boundary apparent

3.3.2Decision Tree Classification

Decision tree classification is a classification method using multi-source remote sensing to progressively divided image [6]. The advantage is intuition, purification and high mathematical efficiency. Its principle is progressively divided image data to get different attribute of sub-categories under some rules. Based on pre-processing of remote data, we separated ice and water from other land use types by band 7 in TM, and then distinguish between the ice and water by difference of band 3, band 4 and band 5. After that, using NDVI and band 3>band 4, we separated vegetation from others, distinguish forest and grass with NDVI and DN of band 3. Cultivated land was separated by slope and DN of band 4. Bare rock separated from sandy land by slope and DN of band 1. The specific classification method is shown in figure 1.

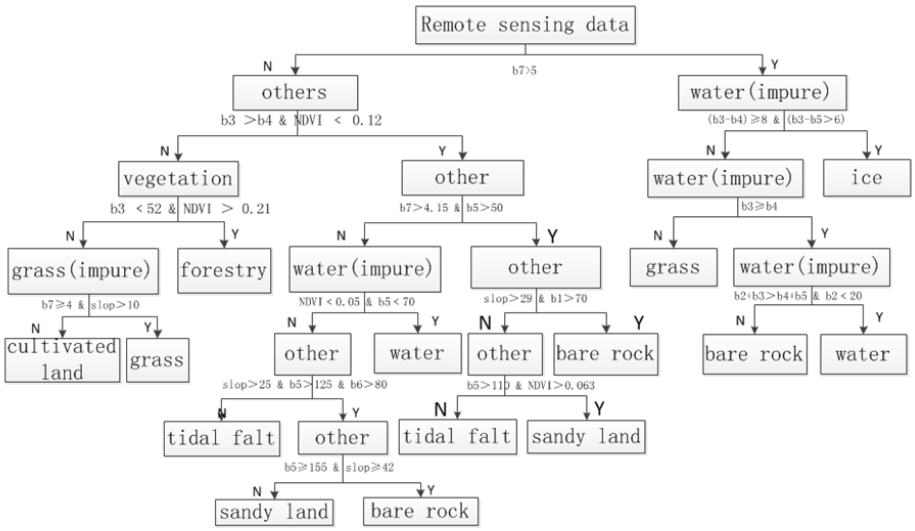

Fig. 1 Decision-tree structure

4. Consequences and Analysis

4.1 Distribution of desertified land

The total desertified land area in YLN in 2009 was 4253km^2, accounted for about 6.39% of whole area. The area of sandy land was 1388 km^2, and area of gritty land was 2864 km^2. The distribution of desertified land was extremely uneven. From the point of desertified land types, gritty desertified land accounted for about 67%, which mainly contains bare rock, distributed in the hillside, and less harm. Sandy desertified land accounted 33%, which includes moving land,

semi-shifting land, fixed land and semi-fixed land, intensive dispersal of benchland. When wind passing, dust will blowing, it seriously harm to people's life and production facilities.

From the point of geography, the study area can be divided into eastern, central and western 3 parts. Differences of desertified land distribution in 3 parts were obvious. The eastern region including Dazi, Maizhokunggar, Qonggyai, Sangri, zhanang, and Naidong. Sandy area of this region was 835km^2 accounted for 2.3% of the whole area. The area of sandy desertified land in eastern was 389 km^2, the area of gritty land was 445 km^2. The central region including Chenguan, Delongdui, Qushui, Linzhou, Nimu, Gongga. Sandy area of this region was 992 km^2 accounted for 8.31% of the whole area. The area of sandy desertified land in eastern was 559 km^2, the area of gritty land was 433 km^2. The western region including Bailang, Namulin, Jiangzi, Lazi, Rikaze. Sandy area of this region was 2426 km^2 accounted for 13.25% of the whole area. The area of sandy desertified land in eastern was 440 km^2, the area of gritty land was 1986km^2. From the above, we can saw that desertified land area in western was the most and much bigger than that in eastern and central. There was a phenomenon that gritty desertified land area in western accounted for 81.8% of western and 46.7% of study area. It was because that precipitation in western was relatively less, vegetation coverage rate was lower, and has more bare rock.

Table 3 Area and proportion of desertified land in YLN

Location	sandy desertified land		gritty desertified land		total area (km^2)
	area/km^2	proportion /%	area/km^2	proportion /%	
Eastern	389	10.3	445	46.7	835
Central	559	13.1	433	10.2	992
Eastern	440	9.2	1986	10.5	2426
Total	1388	32.6	2864	67.4	4253

4.2 Spatial evolution characteristics of sandy land in YLN

From the figure 2, we can know that desertified land in study area almost covered the entire region. The characteristics of it were wide distribution scale and relatively centralized distribution. The desertified land concentrated distributed in the wide valley basin and tributaries into the mouth area and also had the characteristics of strip, flake, and not connected. From 2000 to 2009, total area of the desertified land in study area increased 17km^2. It from 4236km^2 in 2000 increased to 4253 km^2 in 2009. The change rate of desertified land was 0.4%, average annual increasing rate was 0.44‰. These data show that trend of increasing of desertified land in study area was slowly.

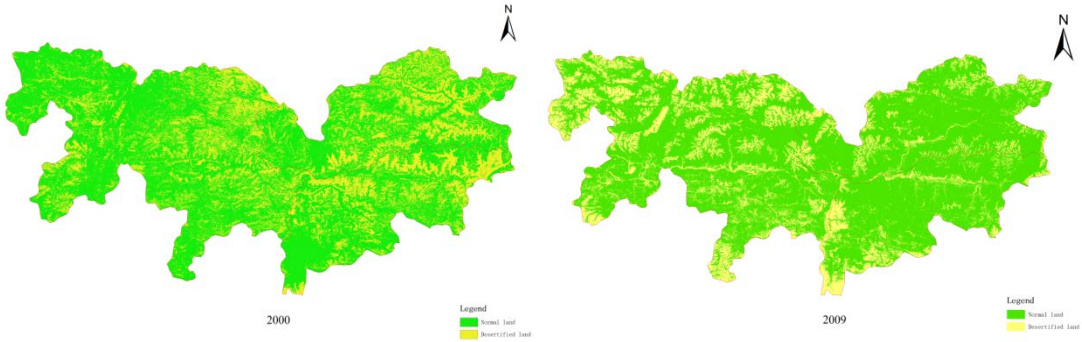

Fig. 2 Distribution of desertified land in YLN on 2000 and 2009

In the nine years, changes of different type desertified land were different. Sandy desertified land increased 11 km^2, and gritty desertified land increased 6 km^2. Increasing rate was 0.78%, 0.22% respectively. The change of desertified land area in eastern, central, and western also was different. The total area of desertified land respectively was 810 km^2 and 835 km^2 in eastern, 951 km^2 and 952 km^2 in central, and 2475 km^2 and 2426 km^2 in western. The change rate was 3.1%, 4.3%, and -2% respectively. Increasing area of eastern, central, and western was 25 km^2, 41 km^2, -49 km^2. Overall, area of desertified land in western was far bigger than that of eastern and central regions.

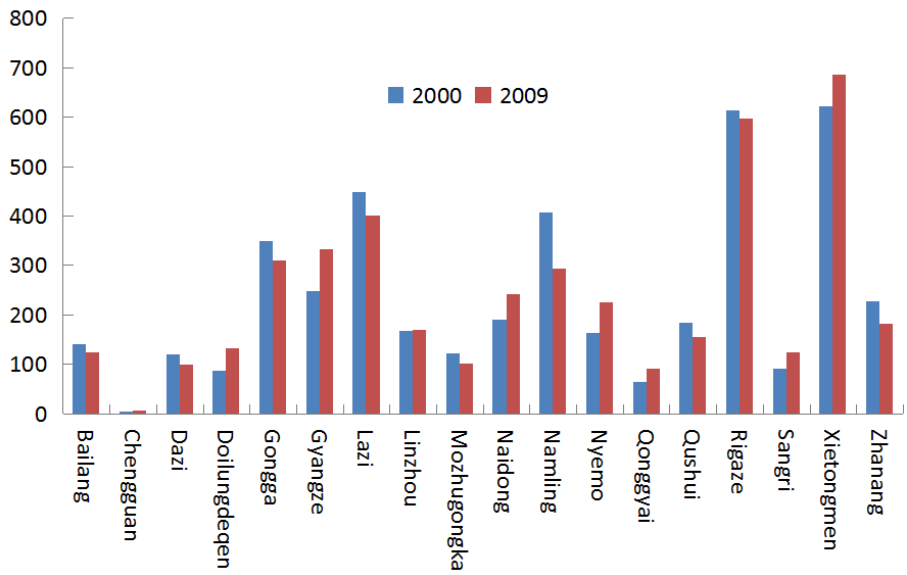

Fig. 3 Desertified land area in each country

In figure 3, the increasing area of all cities in study area was not same. The order of the desertification land area increased (from large to small) is Jiangzi, Xietongmen, Nyemo, Doilungdeqen, Sangri, Qonggyai, Linzhou, Chengguan. And the order of land decreased (from small to large) is Rigaze, Bailang, Dazi, Mozhugongka, Qushui, Gongga, Zhanang, Lazi, Namling. The top two area increased was Jiangzi and Xietongmen, increased area was 84 km^2 and 64 km^2 respectively, 34.2% and 10.3% of change rate. The top two area decreased was Namling, and Lazi, area is -114km^2 and -49km^2, -28% and -10.9% of change rate.

5. Analysis of Desertified land

5.1 Natural factors

5.1.1 Rich sandy resources

Different thickness of sediment in the fourth quarter was distributed widely in study area. It was composed by present glaciers, ancient glacier ice stains, saprolite, slope deposit, diluvium, lacustrine deposits, and aeolian deposit. Thoseloose sediment was created by the river valley and basin mountain bedrock under the influence of ice and frost, continuously produce detrital material, piled up under the action of wind and rivers. High elevation, strong solar radiation, long sunshine time, big daily range, and strongly surface physical weathering both exacerbated desertification of surface substance. Vegetation in Tibet was sparse and undersized, this lead to low surface ground coverage and poor capability on sand fixation. These natural conditions all provided rich material basis and conditions to land desertification.

5.1.2 Climate change

In natural factors, dominant factor of desertified land was climate, and the change of temperature and precipitation also played a key role. From 1950 to 2010, the annual average temperature in YLN was rise, range 0.019℃/a from 0.047℃/a. After 1980, the change rate of temperature was obvious, range 0.026℃/a from 0.065℃/a, local grew up to 0.034℃/a. The trend of annual average precipitation also gone up, range 3.60mm/a from 6.98mm/a.For example, the data from Lhasa showed that annual average temperature was significantly elevated (yellow dotted line in figure 5). And the linear regression equation showed that nearly 50 years the average annual increase in temperature was 0.036℃, calculated, especially after 1980, temperature trend was more pronounced, with an average annual increase in temperature of 0.065℃,close 1955--2009 average annual temperaturerise of 2 times.From the annual precipitation, using quadratic equation(y=0.1199x2-474.29x+469453) to simulate the average precipitation of 50 years in Lhasa station, we can know that the lowest point of annual precipitation was around 1980. Before 1980, it showed a slow downward trend and a slow upward trend after 1980.

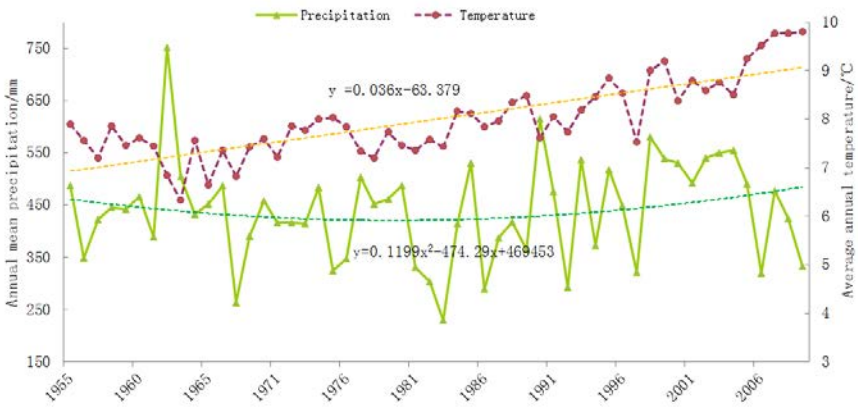

Fig. 4 the Change of annual average temperature and annual mean precipitation in Lhasa

From the above data, we can know that in recent years climate warming, rising temperature and big surface evaporationoccurred in YLN. And under the influence of wind, soil became dry and capacity of anti-erosion decrease. Although precipitation increased was good to aboveground vegetation to grow and resume, the area itself is ecologically fragile, climate positive effective on vegetation has obvious lag, sand-fixed ability is still weak. In a world, the climate change in recent years exacerbated the desertification in YLN.

5.2 Social factors

The main social factor of desertification in YLN was human activities. With the development of economic and growth in the living standard, the population in Tibet increased. And population density also increased. People has great needs on basic living material such as grain, meat, fuel and so on. In order to meet the basic material needs, solve the population pressure, people in study area not only strengthen the existing land use intensity, but continue to expand the scale and scope of land use. People developed the unfavorable or temporarily unfavorable development and utilization land, overexploitation the poor land resources, those has great influence on the appearance and development of desertification. Some bad behaviors, for example excess land reclamation, destroy the vegetation growth and soil structure, aggravated the action of corrosion, transportation, and accumulation to sand surface material, and promoted the occurrence and development of desertification. Human activity was an important factor in increasing desertification in the study region.

5.3 Analysis of driving factors

Many factors affecting the formation of land desertification, including climate, vegetation, population, livestock and other natural and social factors, but for the same area of land desertification in different periods of change, the main influence factors is climate change and human activities. Depending on the actual situation, and considering the possibility of data acquisition, we choose 10 factors (temperature, precipitation, wind speed, evaporation, wind days, population, number of livestock per unit area, agricultural GDP, arable land, effective irrigation area) which may affect the land desertification to analyze the driving factors in YLN from 2000 to 2009, and used Correlation analysis to calculate the influence degree of various factors on sandy type land, gritty type land and total desertified land. Correlation analysis results show table 5.

Table 5 Desertification of land change and the influence factors of correlation analysis

Driving factors		Desertification land area variation			Desertification land area rate		
		Sandy type	Gritty type	summation	Sandy type	Gritty type	Summation
Natural	temperature	-0.1504	0.2532	0.2667	-0.6187	0.3402	0.0192
	precipitation	0.2089	-0.2503	0.1928	0.2804	0.0994	0.2320
	Wind speed	0.2531	-0.0943	-0.5504	-0.1562	-0.8366	-0.5228
	evaporation	-0.3146	0.4434	-0.5853	-0.4302	-0.1649	-0.3273
	Windy days	0.1450	0.0431	0.2781	0.0663	-0.0037	0.2503
Social	livestock	-0.4019	0.1433	-0.2648	-0.3624	0.3441	-0.2411
	population	-0.0162	0.0041	0.2043	0.0627	-0.4452	0.3569
	agricultural GDP	0.1477	0.0386	0.1182	-0.0808	-0.0701	-0.2175
	arable land	-0.0903	0.1538	-0.5045	0.2086	-0.1088	0.1175
	effective irrigation area	-0.1434	-0.2994	-0.0454	-0.0796	0.5039	-0.4408

According to the analysis, we can concluded that the related coefficient value (absolute value) of wind speed and evaporation capacity was the biggest among the natural factors that influenced land desertification changes during 2000 to 2009 in the YLN Region of Tibet. The related coefficient value between the amount of general area changes in desertified lands and evaporation capacity was the biggest with -0.5853 while the related coefficient value between changing rate and wind speed is the highest with -0.5228. In contrast, in sandy type desertified land, the related coefficient value between the amount of general area changes in desertified lands and evaporation capacity was the biggest with -0.3146 while the related coefficient value between changing rate and air temperature was the highest with -0.6187; in gritty type desertified land, the most related with the amount of general area changes in desertified lands was evaporation capacity with the value 0.4434, while the most related with changing rate was wind speed with the value 0.8366. The data showed that among the natural factors, wind speed and the degree of drought were of the important influence on the land desertification changes during 2000 to 2009, at the same time, air temperature was another key factor. Among social factors, the most related with the amount of general area changes in desertified lands was cultivated land area with the value -0.5045, while the most related with the rate of general area changes in desertified lands was effected irrigation cultivated land area with the value -0.4408; In sandy type desertified land, the related coefficient value of both the changing amount and rate of desertified land area between the social factors was livestock amount with the value of -0.4019 and -0.3624; In gravel type desertified land, the related coefficient value of both the changing amount and rate of desertified land area between the social factors was effected irrigation cultivated land area with the value of-0.2994 and 0.5039. All the above illustrated that among social factors, the amount changes of cultivated land and livestock were the relatively important factors which influenced land desertification changes during 2000 to 2009, and the population was the determinative factors.

Among all the correlation coefficient, there are 7 influence factors which correlation coefficient absolute value above 0.5, five of them in natural, others in social.Through rank correlation coefficient, the highest correlation coefficient (-0.8366) was the wind speed and area change rate of gritty land. Therefore, the main driving factors of desertified land in YLN region from 2000 to2009 was natural and human behaviors, the role of natural factors a little heavy.In all 60 correlation coefficient, the absolute value of only 7 above 0.5, shows that the influence and strength of various factors on change of desertification land has a certain degree difference, but more a common type of the influence and function. So, we can think that desertified land in YLN region from 2000 to 2009 was the result of many factors work together.

6. Summary

Studied the present situation of desertification, the change of time and space and analyzed the driving factors, we could draw the following conclusions:

(1) The desertified land area in YLN was 4236 km^2 in 2000 and 4253 km^2 in 2009. The area was on the rise, but growth rate was slow. From 2000 to 2009, desertified land increased 17 km^2, average annual growth rate was 0.44‰. Meanwhile, sandy desertified land area increased 11 km2 and gritty desertified land area increased 6 km^2.increased rate is respectively 0.78% and 0.22%

(2)From 2000 to 2009, the change of desertified area in eastern, central and western in YLN is not same.

Area increased 25 km^2 in eastern, 41 km^2 in central and -49 km^2 in western, and rate change percentage was 3.1%, 4.3% and -2% respectively.

(3) Influence factors of desertified land in YLN included natural factors and social factors. In natural environment, wind speed and evaporation have the most impact, temperature also is an important factor. In social, the dominant factor is population growth which lead to resource shortage and increased the number of agricultural acreage and livestock.

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