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# STATUS, CAUSES AND COMBATING SUGGESTIONS OF SANDY DESERTIFICATION IN QINGHAI-TIBET PLATEAU

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**ABSTRACT**: The Qinghai-Tibet Plateau is one of the major sandy desertification regions of China. Based on the recent investigation on sandy desertification, this paper analyses the status such as the type, area, distribution and damage of sandy land desertification in the plateau. Through the analysis on the factors affecting sandy desertification in the region's natural and socio-economic systems as well as the processes and their interrelations, it can be concluded that sandy desertification in the Qinghai-Tibet Plateau resulted from the combined actions of normal natural sand drift processes, natural sandy desertification processes caused by climatic changes and man-made sandy desertification caused by improper human activities. In addition, it also predicts the possible developmental trend including the increase in desertification area and the enhancement in desertification developmental degree with the exacerbation of the complex processes, and finally puts forward some strategic suggestions to combat sandy desertification in the coming years.
**KEY WORDS**: Qinghai-Tibet Plateau; sandy desertification; desertification control

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Land desertification is one of the major issues of worldwide concern and considerable amount of research on this subject has been carried out at home and abroad (DONG and LIU, 1993a; 1993b; HOUEROU,1996; ZHA and GAO, 1996), especially the commonly known as the third pole of earth—Qinghai-Tibet Plateau has now become a focus region. Land desertification issue of the Qinghai-Tibet Plateau has attracted worldwide attention and quite a few of scholars from abroad and at home have carried out some researches in different regions of the plateau (DONG *et al*., 1991; DONG *et al*., 1993; DONG Guang-rong *et al*., 1995; DONG *et al*., 1996; HE *et al*., 1993; HUANG *et al*., 1993; JIN *et al*., 1991; JIN *et al*., 1994; LI, 1997; LI, 1998; LI *et al*., 1990; QIAN, 1986; SHAO *et al*., 1988; SUN, 1996; ZHANG and CHEN, 1998). Based on general investigation data and consulted previous research result, this paper discusses the status, causes and control measures of sandy desertification in the Qinghai-Tibet Plateau.

## 1 STATUS OF SANDY DESERTIFICATION

Sandy desertification refers to land degradation with sand drift activity as main mark in arid, semiarid and part of sub-humid areas, resulting from various factors including climatic changes and human activities (DONG Yu-xiang *et al*., 1995). Investigation of sandy desertification in 1997 showed that Qinghai-Tibet Plateau is one of serious sandy desertification regions in China. The sandy desertification of the Qinghai-Tibet Plateau has the following basic characteristics.

### 1.1 Area, Type and Distribution of Sandy Desertification

Sandy desertification land of the Qinghai-Tibet Plateau cover a total area of $31.3274\times10^6$ha (Table 1), accounting for 13.95% of the plateau's total area, or 19.50% of China's sandy desertification land area (CCICCD, 1997), of which moderate sandy desertification land occupies 55.44%, slight and serious sandy desertification land constitute 30.83% and 13.73% respectively (Table 1). On the whole, sandy desertification of the plateau is still in a rapid developmental stage.

Sandy desertification land include six types, namely mobile sand dune (sandy land), wind-eroded unaka, semi-fixed sand dune (sandy land), bare gritty land, fixed

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Table 1 Sandy desertification type and area in Qinghai-Tibet Plateau①

| Region | Serious desertification | | | | Moderate desertification | | | | Slight desertification | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mobile dune (sandy land) | | Wind-eroded unaka | | Semi-fixed dune (sandy land) | | Bare gritty land | | Fixed dune (sandy land) | | Semi-bare gritty land | |
| | Area ($\times10^3$ha) | % | Area ($\times10^3$ha) | % | Area ($\times10^3$ha) | % | Area ($\times10^3$ha) | % | Area ($\times10^3$ha) | % | Area ($\times10^3$ha) | % |
| Tibet | 336.5 | 14.92 | – | – | 968.2 | 42.42 | 10210.5 | 67.68 | 292.8 | 20.32 | 8166.4 | 99.38 |
| Qinghai | 1910.8 | 84.74 | 2045.3 | 100.00 | 1309.6 | 57.37 | 4875.6 | 32.32 | 1048.1 | 72.73 | 51.3 | 0.62 |
| West Sichuan | 5.6 | 0.25 | – | – | 4.7 | 0.21 | – | – | 99.4 | 6.90 | – | – |
| South Gansu | 1.9 | 0.09 | – | – | – | – | – | – | 0.7 | 0.05 | – | – |
| Total | 2254.8 | 100.00 | 2045.3 | 100.00 | 2282.5 | 100.00 | 1508.61 | 100.00 | 1441.0 | 100.00 | 8217.7 | 100.00 |

Note: ① Estimated according to the investigation data of sandy desertification in related regions

sand dune (sandy land) and semi-bare gritty land, and they occupy 7.20%, 6.53%, 7.29%, 48.15%, 4.60%and 26.23% of the plateau's total sandy desertification land area (Table 1) respectively. Of these, gritty desertification land constitutes a high percentage of 74.38%, while sandy desertification land only occupies 25.62%. This shows that the plateau's desertification land exhibits an obviously cold and arid alpine landscape feature. Desertification process of the plateau was affected not only by the wind force of arid area and human activities but also by the factors such as mountain glaciers, periglacial freeze-thaw and running water actions. And it is characterized by strong positive development process, weak self-reversing ability and fragile ecological attribute.

Administratively the east Qinghai, Xining City, Huangnan Prefecture in Qinghai and Tianzhu in Gansu at the northeast edge of the plateau and Diqing in Yunnan and Muli in Sichuan at southeast edge of the plateau are of undesertified regions, but in about 112 counties of 15 prefectures in 4 provinces (regions), namely Tibet, Qinghai, Sichuan and Gansu around the plateau desertified lands are widespread. Sandy Desertified land in Tibet, Qinghai, Sichuan and Gansu occupies 63.76%, 35.88%, 0.35%, 0.01% of their respective total land area, however there is great difference in the distribution of different types of sandy desertified lands. Mobile sand dunes (sandy lands) almost occur in all these regions, mainly in Qinghai where the area of mobile sand dunes (sandy lands) occupies 84.74% of the region's total mobile sand dune area. Wind-eroded unaka almost entirely occurs in Qinghai, 57.37% of semi-fixed sand dunes (sandy lands) also occur in Qinghai and other 42.42% occur in Tibet. Bare gritty lands mainly occur in Tibet, accounting for about 67.68% of the region's total gritty land area. Fixed sand dunes (sandy land) occur in all these four provinces (region), 72.73% of which occur in Qinghai. Semi-bare gritty lands only occur in Tibet and Qinghai and 99.38% of which occur in Tibet.

Viewed from landform units of sandy desertification distribution, sandy desertified lands of the Qinghai-Tibet Plateau mainly occur in river valleys, lake basins and piedmont diluvial and alluvial plains, especially seriously sandy desertified lands are mainly distributed in the valleys of the Yarlung Zangbo, Pengqu, Changjiang (Yangtze) and Huanghe (Yellow) rivers and their tributary valleys, and lake shores of Qinghai Lake, Nam Lake and Bange Lake, etc. Because these landform units fall in their respective natural zones of plateau temperate belt and plateau sub-cold belt, from the southeast to northwest the natural zones of the plateau transit form warm-humid condition to dry-cold condition, as a result, sandy desertified land area gradually increases and their distribution changes from scattered patches into continuous belts and the types and developmental degrees of desertification also correspondingly change. Sandy desertified land in the humid and sub-humid forest-steppe belts of the east Tibet is limited and exhibits on evident seasonal variability, and semi-bare gritty lands mainly occur in river valleys. In the humid and sub-humid alpine cold shrub-meadow belts in West Sichuan and South Gansu, sandy desertified lands are characterized by small area and low developmental degree, with barchan dunes, parabolic dunes, coppice dunes and dune ridges scattering in degraded grasslands and river valleys. In the semi-arid steppe-meadow belt in south and east Qinghai sandy desertified lands, with mobile dunes (sandy lands) as main body, are distributed in wide river valleys and lake basins. In the semi-arid shrub-steppe belt of South Tibet there are large area and multiple types of sand dunes (sandy lands), especially barchan dunes and chains, transverse dunes, longitudinal dunes, climbing dunes, barchan dune ridges and sand sheets are distributed in river valleys, piedmont diluvial plains and lakeshore plains. Bare and semi-bare gritty lands mainly occur in piedmont diluvial plains, alluvial plains, river terraces and alluvial fans. In the alpine cold semi-arid steppe belt of north Tibet mobile sand dunes (sandy lands) and fixed sand dunes (sandy

lands) are concentratively distributed in lakeshore plains, and river-lake depressions, furthermore there are also large area of gritty desertification land, especially bare gritty land. In the arid semi-desert belt of Ngari Plateau desertified lands are dominated by bare and semi-bare gritty lands, and mainly occur in piedmont diluvial plains and river-lake depression. Arid desert belt in Qaidam Basin is the plateau's concentrated distribution region of sandy desertified lands, where sandy desertified land has high developmental degree, with bare gritty land and wind-eroded unaka as its main body.

### 1.2 Main Damages of Sandy Desertification

The occurrence and development of sandy desertification seriously affect local production and people's livelihood and become a factor hindering the eco-environmental protection and the sustainable development of socio-economy. This is mainly manifested in the following aspects.

(1) In sandy desertification processes, sand drift damages water conservancy and hydropower projects, railways, highways, civil aviation, communication and transmission line. For example, in Tibet about 193.2km of canal are suffering from sand drift damages and about 522.3km of highway are under the threat of shifting sand encroachment (DONG, 1997).

(2) Sandy desertification directly resulted in the decrease of usable land area and the reduction of land quality and agricultural-livestock production level. For example, sandy desertified land area in Qinghai increased from $5.970\times10^6$ha in 1959 to $11.241\times10^6$ha at present, the sand dune area alone increased by $2.717\times10^6$ha, especially in the surrounding area of Qinghai Lake about $40\times10^3$ha of grassland had turned into mobile dunes, and for $47\times10^3$ha cropland reclaimed in 1958, $25\times10^3$ha have been abandoned due to sand drift damages (HE *et al*., 1993; LI *et al*., 1990). In Tibet, wind erosion resulted in an annual loss of organic matter of $20.413\times10^9$kg, total N $1.267\times10^9$kg, total P $1.149\times10^9$kg and total K $31.901\times10^9$kg. It has been estimated that N and P loss due to sandy desertification are 200 times higher than the application amount of chemical fertilizer in Tibet. Hence sandy desertification can significantly reduce the agricultural and livestock production. According to incomplete statistics, about 13.8% of croplands in Tibet decreased yields due to desertification, annual decrease in grain output reached $30.8\times10^3$t, and grass yield of natural grasslands decreased by 30%–60% (Bureau of Land Management of Xizang Autonomous Region, 1994).

(3) In sandy desertification processes sand drift activities often destroy local people's domestic facilities. According to investigations about 748 villages in Tibet are suffering from serious sand drift damages, especially the Zhongba Town has thus moved several times. As described above, desertification in Qinghai-Tibet Plateau has seriously impaired the environment and socio-economy. In Tibet, annual direct economic loss resulted from sandy desertification was about $863.037\times10^6$ yuan (RMB), annual direct and indirect economic loss in total at least reached $3.45\times10^9$ yuan (DONG, 1997).

(4) Furthermore, as an ecological source region of China, south Asia, southeast Asia or even the globe, Qinghai-Tibet Plateau is not only a source area of many rivers but also a summer monsoon pacemaker of these regions. Accordingly, sandy desertification of the plateau may cause two serious consequences in the surrounding regions. One is its influences on the flow stability of many rivers, which often causes the increase in river sediment content, seasonal water shortage and flood inundation in wet season; another is that owing to the decrease in vegetation cover the climatic model over Qinghai-Tibet Plateau changes abnormally, which may lead to the reduction of precipitation and increase of air temperature as well as the increase of dry degree, thus induce environmental degradation and the development of sandy desertification.

## 2 CAUSES AND TREND OF SANDY DESERTIFICATION

Sandy desertification is a product triggered by complex system in special regions. The cause and development trend of sandy desertification in the Qinghai-Tibet Plateau should be probed from the characteristics, variations and interrelations of regional complex system consisting of natural system and socio-economic system.

### 2.1 Characteristics and Recent Changes of Natural System

Under the influences of the plateau's relief pattern and atmospheric circulation, different regional assemblages with different temperature and water conditions were formed in the natural system of the Qinghai-Tibet Plateau. These natural regions have obvious differentiation (ZHEN, 1996). But on the whole, they exhibit the following basic characteristics: 1) Qinghai-Tibet Plateau is one of the coldest, driest and windiest regions of the same latitude in the world. Arid and semi-arid land occupies more than two thirds of the plateau's total area. Such climatic conditions as sparse precipitation and strong wind make most of the plateau have strong

wind erosion-climatic erosivity (DONG and KANG, 1994), the index of annul wind erosion-climatic factor is often more than 50, especially the corresponding index in the over half-year cold, dry and windy season may reach up to 100 days or so. Hence, the plateau is one of the strong wind erosion-climatic erosivity centers of China, which lays basic and dynamical conditions for sand drift activity in the region. 2) During the rapid uplift processes of the plateau, huge amount of loose deposits (residual slope deposits, diluvial deposits, alluvial-diluvial deposits, alluvial deposits, lacustrine deposits, etc.) were transported by rainwater, meltwater and glaciers to vast regions and soils formed by these parent materials have high sand content, for example, mean physical sand grain content of 338 soil profiles in the Nagqu region in the hinterland of Tibet reached 70.44% (Bureau of Agriculture and Animal Husbandry of Nagqu Region in Xizang Autonomous Region, 1992; Bureau of Land Management of Xizang Autonomous Region, 1992). Loose sandy soils provide a material basis for the occurrence and development of sandy desertification of the region. 3) Forest cover of the Qinghai-Tibet Plateau is extremely low, and the figures in Tibet and Qinghai are 3.49% and 0.26% respectively (Bureau of Land Management of Xizang Autonomous Region, 1992; SUN *et al*., 1988). In the arid and semi-arid regions of the plateau trees are sparse, some sparse and dwarf grasslands only have a vegetation coverage of 20%–30%, plant height generally varies between 5–20 cm and growing season is short, most of ground surface is in a bare and semi-bare state, and most of sandy surface is directly exposed to strong wind-flow and thereby is prone to deflation. These natural characteristics determine the region's strong, primary, and normal natural sand drift processes, and breed the basic factors for the occurrence and development of sandy desertification.

Climate is the most active factor, also the leading factor of the natural system of the Qinghai-Tibet Plateau, which is extremely sensitive to global changes. Under the influences of global changes, the natural region system of the plateau recently showed a change of climate toward desiccation and warming. According to ice core records (YAO *et al*., 1996), since 500 A.D. the climate of the plateau has started to become warming in a continuous cold-warm fluctuation course. Under such a background air temperature in part of the region at the east edge of the plateau commonly rose in recent years, especially the plateau's main body—Qinghai and Tibet mostly showed a large warming amplitude, with a temperature rising rate varied between 0.10–0.30℃/10a (LIN and ZHAO, 1996). For example, in the midstream areas of the Yarlung Zangbo River basin (Table 2), mean air temperature in January of the 1990s in Xigaze, Lhasa and Zetang increased by 2.1℃, 1.5℃ and 0.8℃ respectively compared to the 1960s, mean air temperate in July increased by 0.6℃, 1.3℃ and 1.1℃ respectively, and annual mean air temperature increased by 0.4℃, 1.0℃ and 0.4℃ respectively. Furthermore, since the historic period series of dry-wet alternating changes of the plateau also exhibited an increasing desiccation tendency (WU and LIN, 1981), over the 200 years since the 18th century the plateau's climate mainly tended to become arid (LIN and WU, 1986). Since the 1950s most of the plateau have received less precipitation, with a precipitation-decreasing rate varied between 10–40mm/10a (LIN and ZHAO, 1996). Especially in summer precipitation decreased significantly and climatic desiccation tended to be intensified. For example, annual precipitation in Lhasa decreased from 450mm in the 1950s to 386mm in the 1990s, and mean precipitation in 1981–1994 decreased by 38mm compared to 1961–1980.

Table 2 Comparison of air temperature changes in the midstream areas of the Yarlung Zangbo River basin (℃)

| | Station | 1960s | 1970s | 1980s | 1990s | Multi-year average |
|---|---|---|---|---|---|---|
| January | Xigaze | −4.1 | −3.3 | −3.4 | −2.0 | −3.5 |
| | Lhasa | −2.5 | −2.1 | −1.6 | −1.0 | −2.1 |
| | Zetang | −0.8 | −0.9 | −0.5 | −0.0 | −0.7 |
| July | Xigaze | 13.9 | 14.1 | 13.2 | 14.5 | 14.2 |
| | Lhasa | 15.1 | 15.0 | 15.8 | 16.4 | 15.4 |
| | Zetang | 15.4 | 15.3 | 16.1 | 16.5 | 15.7 |
| Annual mean | Xigaze | 6.1 | 6.3 | 6.5 | 6.5 | 6.3 |
| | Lhasa | 7.1 | 7.6 | 7.9 | 8.1 | 7.7 |
| | Zetang | 8.1 | 8.3 | 8.7 | 8.5 | 8.4 |

With the climatic desiccation and warming, the plateau's wind erosion-climatic erosivity enhanced, surface soil resistance to wind erosion reduced, vegetation coverage and height lowered, strong wind could directly act on the sandy surface and thus exacerbating sand drift activity. As a result, natural factors that cause sand drift activity of the natural regional system of the plateau were intensified, normal natural sand drift processes were exacerbated, therefore the natural sandy desertification processes including wind erosion, blowing sand, sand dune migration, sand deposition and sand storms, etc. occurred and developed.

### 2.2 Features and Recent Changes of Socio-economic Regional System

On account of geographic environmental and historic factors, the integrated developmental level of the plateau's socio-economic regional system is relatively

low and has the following features: 1) Population density and people cultural quality are low. The population density in Qinghai and Tibet in 1998 was 7.0 person/km$^2$ and 2.1 person/km$^2$, respectively; the percentages of illiterate and semi-illiterate persons were 42.92% and 59.97% respectively. 2) Thus the plateau has not got rid of natural economic regime, resources exploitation means are single, and human existence and development directly rely on the production function of land resources. 3) Agricultural and livestock production as the main body of the region's economy is now still relying on a backward "depending on Heaven for food and depending on Heaven for livestock raising" way, agricultural and livestock production levels are low, with low input and low output. 4) People's incomes are low due to backward production ways and low economic developmental level; there still exist some poverty-stricken areas and poor families. 5) There is difference in regional economic developmental level; population and economic activity are mainly concentrated in the areas with better natural and resources conditions, such as the midstream areas of the Yarlung Zangbo River. Population density in other regions is low, with relatively low socio-economic developmental level.

The features of the socio-economic regional system determine the plateau's economic development to be dominated by extension form. This is mainly manifested in several aspects: 1) Population continue to increase, total population in Tibet and Qinghai increased from $2.93\times10^6$ people in 1952 to $7.55\times10^6$ people in 1998, and natural population growth rates in recent years ranked the country's first and second places respectively. 2) Livestock population increase rapidly. For example, total amount of livestock on hand in Tibet increased from $9.7061\times10^6$ heads in 1952 to $22.537\times10^6$ heads in 1996, with an annual increase rate of 19.3%, and the livestock increase rate in Qinghai in the same period was 18.8%. 3) Cultivated land area gradually increased. The cultivated land area in Qinghai and Tibet increased from $627.9\times10^3$ha in 1992 to $812.0\times10^3$ha in 1996, especially in the 10 years from 1952 to 1962 cultivated land area rapidly increased from $627.9\times10^3$ha to $783.0\times10^3$ha. With the increase in population and resources requirement, extension-dominated exploitation ways (increasing cropland area and livestock number, etc.) were adopted, this would inevitablely result in resources waste, vegetation and soil destruction and thereby exacerbate topsoil deflation, transport and deposition, especially in the river valleys and lake basins man-made sandy desertification developed rapidly due to high intensity of human activity. Such processes have been demonstrated by simulation experiments in wind tunnel (LIU *et al*., 1992).

**2.3 Sandy Desertification Causes**

Sandy desertification processes resulted from the combination of natural sandy desertification processes caused by natural factors of the region's natural system and man-made sandy desertification processes caused by man-made factors of the region's socio-economic system. Which one is the dominant factor of sandy desertification, man-made factor or natural factor? To further study this problem, a pure grazing region in Nagqu County of Tibet, which constitutes the main body of the Qinghai-Tibet Plateau, and a mixed agro-pastoral region in Zhanang County of the midstream area of the Yarlung Zangbo River basin in Tibet was selected to make a quantitative analysis. Principal component analytical results (Table 3) show that in the grazing region the load of man-made factor of the first principal component is highest, while in the mixed agro-pastoral region the load of climatic factor in both the first and second principal components is highest. In the mixed agro-pastoral region, whether in a vast scope or in a typical region (Zhanang County), the man-made factor of the first principal component has the highest load, and the difference in the load of climatic factor and man-made factor is small, but in the second and third principal components the climatic factor and man-made factor have the highest load respectively. This shows that climatic changes and human activities almost have equal effects on the sandy desertification to the farming area. The correlation analysis between the factors affecting desertification and sandy desertified land area shows that the correlation coefficient between deflation-prone soil area, vegetation coverage and desertified land area is highest (DONG, 1999; DONG *et al*., 1999). This suggests that the potential factors and conditions of sandy desertification lay a basis for the occurrence and development of sandy desertification of the plateau, but the natural factors play a more important role.

Sandy desertification processes of the regional complex system of the Qinghai-Tibet Plateau are based on the combination actions of natural aeolian processes resulted from natural conditions and natural sandy desertification processes made by climatic change as well as man-made sandy desertification processes made by human activities. On the whole, the climatic change under the influence of globe change is the main driving force.

**2.4 Possible Trend of Modern Sandy Desertification**

At present, the Qinghai-Tibet Plateau is in a high-tem-

Table 3 Load matrixes of principal components

| Factor | Nagqu County | | | Midstream area of the Yarlung Zangbo River basin | | | Zhanang County | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1st PC | 2nd PC | 3rd PC | 1st PC | 2nd PC | 3rd PC | 1st PC | 2nd PC | 3rd PC |
| Temperature | 0.673 | 0.207 | 0.635 | –0.535 | 0.720 | 0.267 | 0.108 | 0.730 | –0.595 |
| Precipitation | –0.116 | –0.665 | 0.623 | –0.784 | 0.031 | 0.179 | –0.622 | –0.585 | –0.113 |
| Wind velocity | 0.325 | 0.827 | 0.267 | 0.765 | –0.370 | 0.297 | 0.840 | –0.314 | –0.129 |
| Population | 0.845 | –0.349 | 0.114 | 0.560 | 0.716 | 0.342 | –0.898 | –0.142 | 0.160 |
| Cropland area | 0.701 | –0.011 | –0.396 | 0.479 | 0.521 | –0.657 | –0.412 | –0.373 | –0.758 |
| Animal-mean grassland area | –0.699 | 0.261 | 0.373 | –0.891 | –0.048 | –0.202 | –0.792 | 0.252 | 0.084 |
| Characteristic value | 2.267 | 1.359 | 1.172 | 2.823 | 1.443 | 0.781 | 2.707 | 1.199 | 0.990 |
| Contribution | 37.783 | 22.646 | 19.532 | 47.051 | 24.061 | 13.015 | 45.115 | 19.984 | 16.506 |
| Accumulated contribution | 37.783 | 60.429 | 79.961 | 47.051 | 71.112 | 84.127 | 45.115 | 65.099 | 81.605 |

Note: PC is the abbreviation of principal component

perature and low-humidity period. Inferred from the past temperature-humidity alternating regimes (WU and LIN, 1981; YAO *et al*., 1996), high-temperature and low-humidity period is often followed by a high-temperature and high-humidity period. Accordingly, the present high-temperature and low-humidity period is most likely to be followed by a relative high-temperature and high-humidity period, with slightly higher temperature and precipitation than present level. In addition, the present climatic elements of the plateau exhibited a two-year quasi-pulse and inferred from the 11-year, 22-year and Brueckner periodicities (TCIG-CAS, 1984), the plateau's driest period is over, it will be followed by a relative humid period, and the plateau's precipitation in the early 21st century is most likely to reach the mean value or even slightly higher than the mean value. Because the plateau has quite sensitive response to rising temperature, the temperature rise caused by green house gas $CO_2$ will significantly affect the plateau's climate in the future. Although different predicted results are obtained, it is generally accepted that the plateau's climate will inevitably become warm and humid in the future 50 years due to greenhouse effect (LI and GONG, 1996; LI and CHEN, 1999; ZHANG, 1996; ZHANG, 1993; ZHAO, 1996). It is predicted that by 2010, 2020 and 2040 the plateau's air temperature may rise by 0.2℃, 0.3℃ and 0.5℃ and its precipitation may increase by 0.0%, 1.0% and 4.0%, respectively. Therefore, the beginning of the 21st century may be a relatively warm and humid period of the plateau as compared to present climatic regime, but their variation amplitude is limited. Furthermore, with the rise in temperature, the evaporation rate will increase and the desiccation degree of part of the region will further increase. As a result, the natural factors affecting the plateau's sandy desertification processes will go on existing, or even to be strengthened in part of the region.

Population pressure is a root of overuse of land resources in the plateau. At present, the plateau's population is in a continuously increasing period, and in the coming years its population birth rate and natural growth rate will continuously keep a higher level. Such regimes as rapid increase in population and resources requirement, low education level of farmers and herdsmen, and backward production techniques are impossible to be changed in a short time, hence overuse of land resources will continue and ground surface disturbance will increasingly exacerbate.

It should be pointed out that the factors resulted in natural sandy desertification and man-made sandy desertification and their processes are not isolated, instead they are linked with each other, feed-backed to each other, and intensified to each other. Therefore, if there are no effective control measures to be adopted in the coming years, the plateau's sandy desertification will inevitably spread and aggravate due to combined effects of above two processes.

## 3 SUGGESTIONS TO COMBAT SANDY DESERTIFICATION

It is urgent to combat sandy desertification and establish sandy desertification control engineering in the Qinghai-Tibet Plateau, the suggestions to combat sandy desertification are as follows.

(1) The plateau's sandy desertification has become an issue of common concern in China, South Asia, Southeast Asia and even the globe. The plateau's sandy desertification control will benefit not only China but also many other countries in the world. Therefore the plateau's sandy desertification control should be received enough attention. Governments should more concern this problem and provide financial, technical

and manpower supports to combat the plateau's sandy desertification and speed up the plateau's eco-environmental construction engineering.

(2) The sandy desertification control of the plateau should place emphasis on ecological protection, in combination with rehabilitation and proper exploitation. Sandy desertification control priorities are different in different regions. In areas with dense population and better natural and economic conditions, for example, in river valleys and lake basins, proper exploitation can be carried out on condition that some protective measures are being adopted. Other regions should be dominated by environmental protection and ecological restoration.

(3) The priority to combat sandy desertification of the plateau at present is to eliminate the man-made factors and man-made accelerating processes due to irrational human economic activities. Combined with active rehabilitation, the sandy desertification of the plateau may finally be reversed.

(4) To eliminate the man-made factors and man-made accelerating processes, strict population control should be viewed as a precondition and great efforts should be made to readjust industrial structure and land-use structure, develop favorable industries in the light of local resources and environment conditions, protect eco-environment and improve people's living standard. Sandy desertification control is a long-term, arduous and complex system work, the implementation of this task should follow the following principles: attach high importance to scientific desertification control techniques, under unified the leadership of related organization formulate an overall planning, complete various projects step by step and put easy one before hard one, give priority to key areas, and gradually push ahead various works through experiment and demonstration.

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