G-1.2 Study on Land Use Planning Applying Preventive Technology against Desertification in China

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Abstract The purpose of this study is to develop a land use planning applying preventive technology in desertified areas of China for sustainable land use. In Horqin grassland of Inner Mongolia as a wind erosion area, we clarified the effectiveness of prevention technology for desertification on the soil properties or vegetation. Horqin Grassland was divided into five parts based on topography, soil, vegetation and desertification processes. It is possible to reduce pasture pressure with no decrease in total livestock farming through introducing and enlarging domestic livestock raising. In Sichuan and Yunnan Province as a water erosion area, we clarified that massive deforestation in the 1950's for fuel wood supply and afforestation in the 1970's. The calculated total soil losses in 1965 and 1995 were 1.7×10^2 t/ha and 5.1x10 t/ha, respectively. These values showed that reforestation had been effective. In bio-resources utilization nitrogen input mainly consisting of chemical fertilizer exceeds nitrogen output.

Key Words China, Desertification, Farm Management, Land Use Planning, Preventive Technology

1. Introduction

China suffers from severe desertification, caused mainly by excessive economic activity and natural wind and water erosion and salinization. Desertification in China has been widely developing not only in West part of China including Takla Makan Desert and Gobi Desert but also in East part of China which occupies over 90% of the food production. Therefore, it is necessary to conserve the desertified and desertifing farmland and realize sustainable land use in order to sustain the food supply for increasing population in future.

2. Research Objective

We are trying to develop a land use planning applying preventive technology in desertified areas for sustainable land use. For this purpose, a research group of National

Institute of Agro-environmental Sciences, Chiba University and University of Tsukuba is studying in Horqin Grassland, where is representative of wind erosion area. On the other hand, a research group of University of Tokyo is studying in Yuanmao of Yunnan Province and Yingting of Sichuan Province, where is representative of water erosion area. Both groups consist of researchers from natural and social sciences.

Our final goal is to demonstrate a land use planning adjusted to natural environmental and socioeconomic conditions of the region for sustainable production. We are thus quantitatively evaluating the effectiveness of desertification remedies introduced by the local government and farmers from the viewpoint of pedology and ecology. We are also studying the possibility of introducing useful technology for desertification prevention based on socio-economics.

3. Research Methods

3.1 Study in Horqin Grassland

In the case of Horqin grassland, main works are (1) remote sensing analysis for monitoring of desertified area and estimating biomass of grassland based on grazing experiment and measured data, (2) some experiments such as restoration experiments by grazing control and sand fixation measures and fertilization and irrigation experiments for evaluating the effect of the measures for grassland improvement, (3) field survey for checking land cover, land use and vegetation and edaphologic condition of grassland, and ground truth of remote sensing analysis, and (4) socioeconomic survey by statistic data and interview.

3.2 Studies in Sichuan and Yunnann Province

In Sichuan and Yunnan Province, main methods are (1) preparing land cover map based on the satellite and aerial photo image analysis, (2) analyzing the quantity of energy or nitrogen flow by statistic data and interview, (3) estimating the soil erosion ratio by Universal Soil Loss Equation (USLE), and (4) clarifying the village common such as grassland facilitates villagers' capital stock and on the other hand by a questionnaire survey.

4. Results and Discussion

4.1 Study in Horqin Grassland

4.1.1 Effectiveness of measures for preventing desertification

The neighboring sand dune without measures moved several meters. Especially, a peak moved more than 30 meters in three years. On the other hand, the experimental dune was almost fixed regardless of the plots, although deflation hollow and sand accumulation caused by wind erosion have been formed on some sites of the high-relief dune. Those results of the topographic survey suggested that all the measures applied in the experiment were quite effective to prevent sand dune remobilization.

Vegetation recovered quickly on the plots with dead plant materials such as corn stems and wheat stems, even in a high-relief dune. Especially on the plot with straw board, perennial grass was also observed. Vegetation cover on the plot of corn stems, however, decreased in the third and forth year, because corn material was gradually blown away or buried. On the other hand, on the plot with planting *A. halodendron*, few invading plants was observed, although *A. halodendron* itself grew very well, which might be caused by resource competition. Plants also invaded easily on a low-relief dune, compared with a high-relief dune.

Surface soil properties under poplar and shrub were quite different from soil without plantation. Organic carbon content and the amount of fine particles such as clay and silt increased with the year after plantation. Subsoil properties were almost the same in every site, indicating this surface soil differences were caused by the plantation in recent years.

4.1.2 Evaluation of desertification

Desertificaion types in Horqin Grassland were classified into main 5 types with topography, soil, vegetation, and desertification processes. The desertified area expanded to the front of Da Hinngan mountain rang. Especially, it is clarified that the vegetation cover severely decreased in hilly area for recent 6 years with remote sensing analysis.

4.1.3 Biomass and soil productivity distribution

We got the following regression equation between normalized differential vegetation index (NDVI) determined by a spectral radiometer with the ground truth and dry weight (DW) of vegetation as a biomass. LogDW=4.07*NDVI+2.74 (R^2=0.66) Then, we mapped the biomass class distribution in Horqion Grassland with the Landsat data.

On the other hand, soils were classified into 5 types of the World Reference Base for Soil Resources by their morphology and physico-chemical properties: *Phaeozems*, *Chernozems*, *Calcisols and Kastanozems*, *Regosols*, *Arenosols*. We divided soil productivity into five classes using particle size, organic carbon content and CEC to construct a soil productivity map. The distribution of soil productivity type is nearly as same as the distribution of bio mass quantity.

4.1.4 Management planning for preventing desertification

In the upland areas, introduction and enlargement of intensive crops can be considered. Furthermore, in view of sustainable development of upland farming and efficient resource use, it is important to develop an agropastoral land use and farm management by involving domestic livestock. In pastoral areas, in view of Mongolia traditional culture, to promote a shift from grazing towards domestic livestock through introducing domestic livestock and then to relieve grazing pressure will be required. By using Linear Programming, we simulate the effects of involving appropriate technology and alternatives on improvement of rural economy, under the assumption of low grazing pressure and division of rangeland into individual farms.

4.2 Studies in Sichuan and Yunnann Province

4.2.1 Land use/cover changes in Yanting Province

It was found that even during the so-called "Greap Leap Forward" of the 1960s, when most forests were cut, 13.9% of Yanting County had a forest cover. The degree of recovery by reforestation since 1970s depended on the geomorphological factors.

4.2.2 Bio-resource and energy utilization in a rural village

The quantity of bio-resources production and its use in a catchment in Yanting County was found out through methods developed by us. Analysis of the bio-resources utilization showed that nitrogen input to the arable land, consisting mainly of the chemical fertilizers, was remarkably higher than the nitrogen output.

4.2.3 Land use evaluation using the USLE in a small drainage basin

The total soil losses in 1965 and 1995 were 5.9×10^3 t (1.7×10^2 t/ha) and 1.8×10^3 t (5.1×10 t/ha), respectively. It was shown that to improve the land use, proportion of forest area has to be increased by more than 5% and the forest locations are to be rearranged.

4.2.4 Characteristics and evaluation of potential for soil erosion in global scale

Results show that much of the sediment carried by the gullies consists of silt and clay, which are easily transported by runoff because of the low permeability of the topsoil layer (observed infiltration rate ranged between 10^{-4} and 10^{-7} cm/sec). From the measurement of sediment concentration in the gully and the annual precipitation data the annual sediment yield was estimated to be about 45 t/ha/year. The potential for soil erosion in the area from global scale was then evaluated with global data sets that are open to public via the Internet. The potential for soil erosion free from social factor in the global scale was defined using a relief calculated from digital elevation map and maximum monthly precipitation data. Using this method, it was suggested that the potentials of soil erosion in the area and its transportation were high at global scale.

4.2.5 Socio-economic factors affecting land degradation

Factors inducing overgrazing, which in turn cause land degradation, were identified in the study area through a quantitative analysis of the structure of farm household economy. The communal rules for preserving natural resources were also identified. Since land degradation is continuing for a long period, no clear relationship was found between the degree of rigidity of existing rules and the degree of land degradation at present.