NEASPEC WORKING PAPER

Combating Desertification in North-East Asia

November 2012

NEASPEC Secretariat

Table of Contents

List of Tables

List of Figures

1. *Assessment of Current Situation*

The problem of land degradation is one of the major environmental concerns of the world. Desertification, as defined by the UNCCD, means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities. At the heart of UNCCD is the commitment of the affected countries to prepare and implement action programs to prevent land degradation, mitigate the effect of drought and alleviate poverty. Human-induced desertification is one of the major physical contributing factors that increase the severity and the frequency of dust and sandstorm hazards in North-East Asia. These occur either by explosion of the top soil caused by long-term loss of vegetation, or due to the sand sources that mainly relate to geological processes of mountain erosions and sediment accumulation in the basin, which cannot be wholly eliminated.

Combating desertification refers to prevention and rehabilitation by eliminating the causative factors of desertification through policy and technical initiatives – so as to maintain or reconstruct the ecosystem functions and services for human beings, redevelop social productivity, and finally attain a sustainable socio-economic development. However, the variation of dry and windy climate, which is one of the causing factors of desertification, is related to global change and regional climate and hence is largely uncontrollable and unpredictable. Vegetation types and coverage are affected both by climate and human activities. According to existing studies, anthropogenic causes account for four-fifths of all desertification. Therefore, the current priorities of combating desertification should be concentrated on eliminating and alleviating man-made damages on vegetation and soil.

Combating desertification includes three categories, i.e. prevention, control, and sustainable utilization. Each has its own particular emphases and is interrelated into a functional relationship. Among the three categories, prevention, as the principal one, aims to prevent the occurrence and development of desertification. Control refers to working with existing lands that have been affected by desertification, while utilization means sustainable use of the natural resources with appropriate utilization indices. Here, the indices are those based on comprehensive consideration of the resilience of the ecosystem and the possible impacts of the utilization of the ecosystem. Thus, taking the policy of prevention as a priority and maintaining coordination among prevention, control and utilization is the key to a successful desertification combating activity.

1.1. China

1.1.1. The Impact of Desertification

China is one of the countries most severely affected by desertification (Kassas 1995; Liu et al. 2003). Since the early 1950s, there have been more than 70 severe dust and sandstorms causing huge economic losses, affecting the north central plain and northeast China and severely threatening the living conditions of local people. The need for large-scale programs aimed at restoring the ecosystem structure, composition and function has never been more pressing (Cairns 1999; Hobbs and Harris 2001). In China, the launch of the Three-North Forest Shelterbelt Program in 1978 marked the integration of ecological restoration into the national social and economic development plan. Since the end of 1980s, many national key ecological restoration projects have been implemented to prevent and control desertification, stabilize the sand source areas contributing to sandstorms, and alleviate wind and sand hazards in North China. With the entry into the 21 century, more integrated approaches have been undertaken and an integrated system to combat desertification was gradually established. As an outcome of these efforts, considerable improvement to the ecological conditions across the Northern China has been evidenced by the results of the national desertification monitoring systems (SFA, 2011) and through the study by assessment of the overall NPP using NDVI methodology (Bai et al. 2008).

1.1.2. Trends of desertification and policy development

Sound and effective countermeasures to desertification are always based on a better understanding of the facts on what is desertification, and where and why it happens. China's desertification control policy was focused on understanding the root causes and monitoring the overall status of desertification. Monitoring efforts included surveying the dynamic change of the severity, the extent, and the pattern of distribution. Although land use and land cover change were identified as the direct causes of land degradation, the underlying driver is mainly recognized to be human behavior. Policy measures focus on changing human behaviors either through regulatory or incentive means by the authorities at all levels. China's policies on combating desertification experienced a transition from a government-only approach to a more joint-participation approach taken by various stakeholders. This transition was accompanied by another shift, which was from strictly administrative approach to a more flexible measure-based system of laws and bylaws.

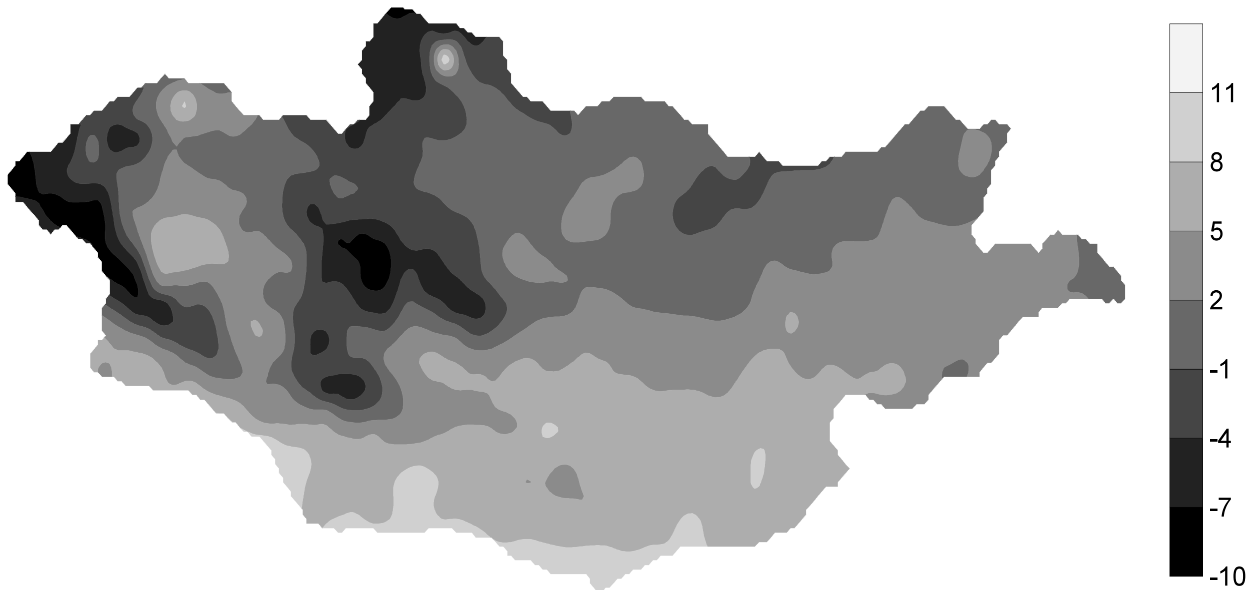
1.2. Mongolia

1.2.1. Geographic and Climatic Conditions

As one of the largest land-locked countries in the world (1,564,000 km^2), Mongolia borders with the Russian Federation in the North and China in the South, and stretches for 2,392 km from west to east and 1,259 km from north to south. Mongolia's average altitude is 1,580m above the sea level. There are four climatic zones in the country: forest steppe, steppe, semi-desert and desert. The northwest and central parts are high mountainous regions, while the eastern part is a vast steppe region. The southern part of the country is covered with semi-desert and desert areas (the Mongolian Gobi). Forests cover 7.8% of the country and mainly consist of Larch and Pine. Certain areas in the Gobi are occupied by saxaul forests.

Over decades of time, there was an increase in Mongolia's air temperature; but there were no significant increases in the level of precipitation. Such combination provided the main reason for dryness and drought in Mongolia. First, Mongolia's average air temperature on surface rose by 2.1^{0}C from 1940 to 2007. By region, this increase was 1.9-2.3^{0}C in the mountainous regions and 1.6^0 -1.7^{0}C in Gobi and the steppe regions. By season, the colder seasons had a temperature increase of 3.6^{0}C, while spring and fall seasons had temperature increase of 1.8^0-1.9^{0}C. Summer season saw temperature increase of 1.1 ^{0}C (Gomboluudev 2007).

[Figure 1] Annual mean air temperature in 2006-2007, Mongolia



As for the level of precipitation, Mongolia's annual total has dropped by 7 percent - or 16 mm over the past 68 years [Table 1]. At closer look - by region, the level of precipitation dropped by 8.7-12.5 percent in the central and Gobi regions, and rose by 3.5-9.3 percent in the eastern and western regions. By season, precipitation increased by 5.2-10.7 percent in the fall and winter, and dropped by 9.1-3.0 percent in spring and summer. The annual and summer season drop in precipitation was observed mainly in the central region, eastern side of the western region, the middle of the Gobi region, and the center of the eastern region. Considering that about 70 percent of the total precipitation falls in the warmer season, the significant decrease in precipitation during the warmer season signify an overall decrease of rainfall in Mongolia over time.

[Table 1] Changes in precipitation (regional and seasonal) since 1940s in Mongolia

Classification	Regions	Percentage	Changes
Regional:	Central and Gobi regions	8.7-12.5	Reduced
	Western and eastern regions	3.5-9.3	Increased
Seasonal:	Fall and winter seasons	5.2.10.7	Increased
	Spring and summer seasons	9.1-3.0	Reduced
In 68 years:		By 7 percent	Reduced

Besides precipitation, changes occurred in the characteristics of summer time rain events: mild rains have been reduced, while thunderstorms increased from 1980s: the amount of precipitation from thunderstorms increased by 20 percent. Changes in the climate have caused changes in the total transpiration, balance in the soil humidity, and land ecosystem, thus leading to transpiration increase of 2-3 mm per annum in Mongolia. In other words, in 46 years, the transpiration, in total, has increased by 100 mm. The transpiration in Mongolia's central region has been the most accelerated, and less in western and eastern regions.

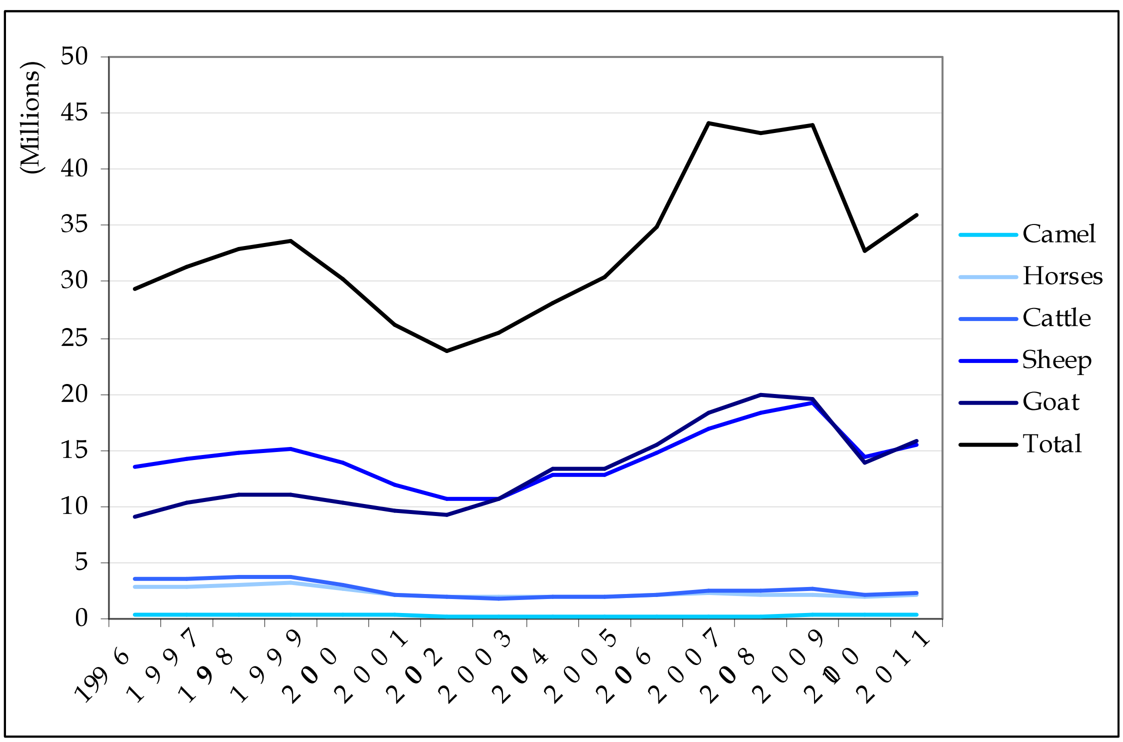
1.2.2. Economic Activities and their Influence on Land Degradation

Mongolia's main economic sectors are agriculture, coal, gold and copper mining industries. The agricultural sector in Mongolia makes up a large share in the country's economy (over 20 percent of GDP): 13 percent of the national hard currency income is generated from exports of food and agricultural products. Compared to 1990, the number of livestock has been increasing sharply and thus the pasture carrying capacity has exceeded its normal capacity. Desertification can be said to have increased due to overgrazing and soil degradation. The mining industry is also one of Mongolia's most important industries. The country's richest resources are minerals: coal, copper, fluorite, gold, iron ore, lead, molybdenum, oil, phosphates, tin, uranium, and wolfram. In the last few years, gold mining has contributed to severe land damage. Hence in Mongolia, the natures of its flourishing economic sectors are related closely to land degradation, and in turn soil degradation has become one of the biggest challenging environmental issues.

Agriculture

The Mongolian agriculture has four main discrete subsectors: (i) mechanized large-area crop production of cereals and fodder crops; (ii) small-scale farming, producing potatoes and other vegetables, with both mechanized and simple production methods; (iii) livestock, which is the traditional semi-nomadic pastoral system, where camels, horses, cattle, sheep and goats are grazed together; and (iv) small-sized intensive livestock, with housed dairy cattle, pigs and poultry. The livestock subsector dominates, contributing 84.9% of total agricultural production.

[Figure 2] Livestock population in Mongolia from 1996 to 2011



Statistics show that the number of livestock has grown overall: the total number of livestock was 23.8 million in 1990, and increased to a peak of 43.2 million in 2008
[Figure 2] (National Statistical Office of Mongolia, 2009). There are over 170 thousand herding households, producing over 80 percent of the total agricultural products. Notable is the increase in the number of goats [Table 2]. Because goats are much more voracious eaters than other livestock and consume the roots of the grass, land degradation is further aggravated by goat herding.

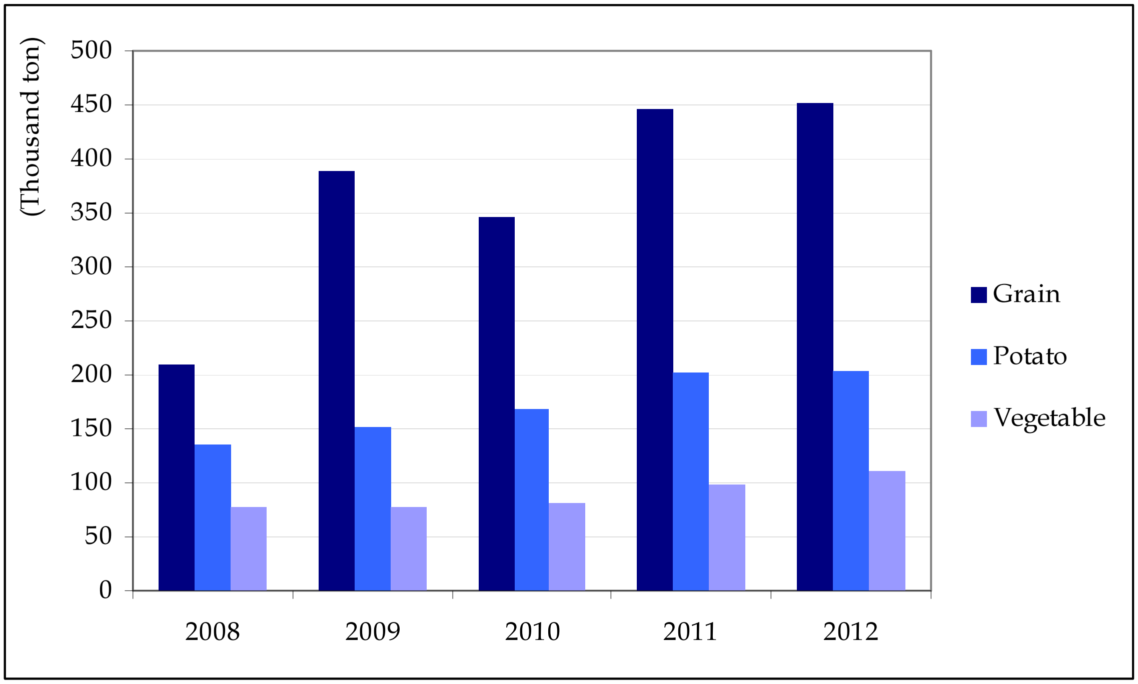
[Table 2] Number of goats and production of raw cashmere in Mongolia

	1990	1995	2000	2005	2009
Total Livestock (thousands)	25,857	28,572	30,228	30,398	41,995
Goats in Livestock (thousands)	5,126	8,521	10,270	13,267	19,465
% Goats in Livestock	20%	30%	34%	44%	46%
Raw cashmere (tons)	1,500	2,100	3,300	3,760	6,700

In addition to the trend of increasing livestock numbers, Mongolia is experiencing a significant modification of herding practices. The traditional practices of rotational grazing over the four seasons have been replaced by the herdsmen's preference to stay close to Sum[1] and Aimag[2] centers, where they can have various social services. This modification of herding practice and increased number of livestock together leads to soil degradation and desertification in Mongolia. Overall data on pastureland degradation reveals that in 2007, 12.3 ha of pastureland and lands with rich plantation have been affected, totaling to 87 percent of the total damages to the land.

The crop production subsectors have been largely characterized by the impact of privatization of large state-owned lands. Crop cultivation is limited, due to harsh continental climate (growing season is just more than 100 days long) and meager arable land. Prior to the economic transition towards market economy in the 1990s, 1.2 million ha of arable land was utilized under nationwide crop production. But the state-owned arable land was privatized during the economic transition. Privatization conceived a number of other detrimental impacts including (i) the creation of a large number of small scale producers that have introduced significant marketing complications, (ii) significant levels of conflict between the traditional users of pasture land, (iii) pasture degradation in the peri-urban area due to smaller herders stayed close to urban areas, (iv) destruction of the water points (common properties) throughout the pastoral areas, and (v) creation of an effective void for input supplies and access to technical support services. The resulting sharp fall in crop production is blamed on lack of management skills, funds, technologies, and the overall ill-implemented privatization program. As result of the decline, 690 ha of land was left as unutilized, aggravating soil degradation.

[Figure 3] Crop production in Mongolia



Mining

Mongolia is rich in natural resources, and exploitation of underground mineral resources has been increasing lately. As one of the priority sectors in Mongolian economy, the output of the mining sector has increased continuously and a large sum of foreign capital has been invested through implementing short term projects and programs.

[Table 3] Share of Mining Industry in Mongolian economy, years 2002-2007

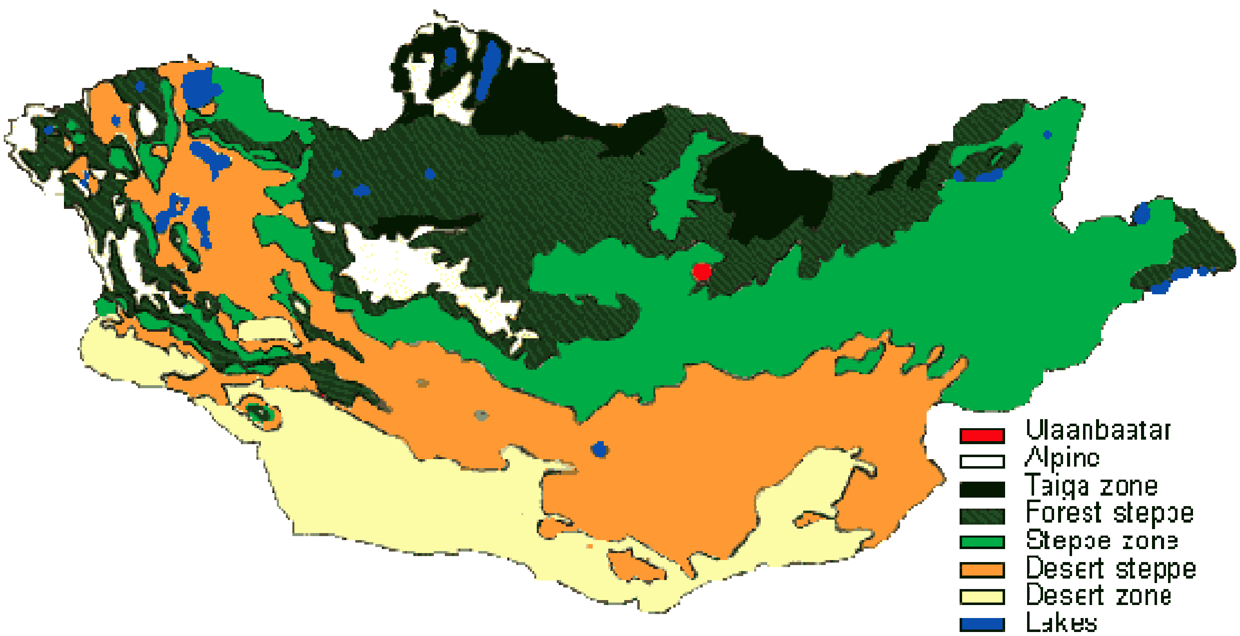
Percentage Share in,	2002	2003	2004	2005	2006	2007
Gross Domestic Products	10.1	12.7	17.3	18.0	30.0	30.0
Industrial Products	47.3	49.0	64.1	65.5	72.0	70.3
Export Products	56.1	58.9	70.8	75.8	67.9	78.4

According to 2007 indicators, geological and mining industry makes up 30% of Gross Domestic Products, 70.3% of Gross Industrial Products, and 78.4% of total exports [Table 3]. Real production volume has increased by 29-40 percents since 2003, and in parallel, world market price increase for gold and copper has raised the earnings from mineral product exportation. Among the export-oriented industries, mining industry is considered to be the priority of the Mongolian government. As a result of the government's financial and non-financial support in importing advanced technologies and equipments and in establishing favorable conditions to attract foreign investment, the output of mining industry has been increasing continually, thus its contribution to the development of the economy. However, mining activities are detrimental to land resources: strip mines and the depositions from mining activities degrade land resources[1].

1.2.3. Forest Conditions

Mongolia has relatively low forest coverage with just over 11 percent of the country covered by closed forests. The forests are mainly located in the north-central parts of the country, forming a transition zone between the Great Siberian boreal forest and the Central Asian steppe desert [Figure 4]. Due to a brief warm period, the growing season is not long enough for many plant species. Successfully replanted area represents only 5 percent of the total forest lost, mostly due to low survival rates of the seedlings. At the present, 150,000 ha of forest needs to be restored.

[Figure 4] Forest map of Mongolia

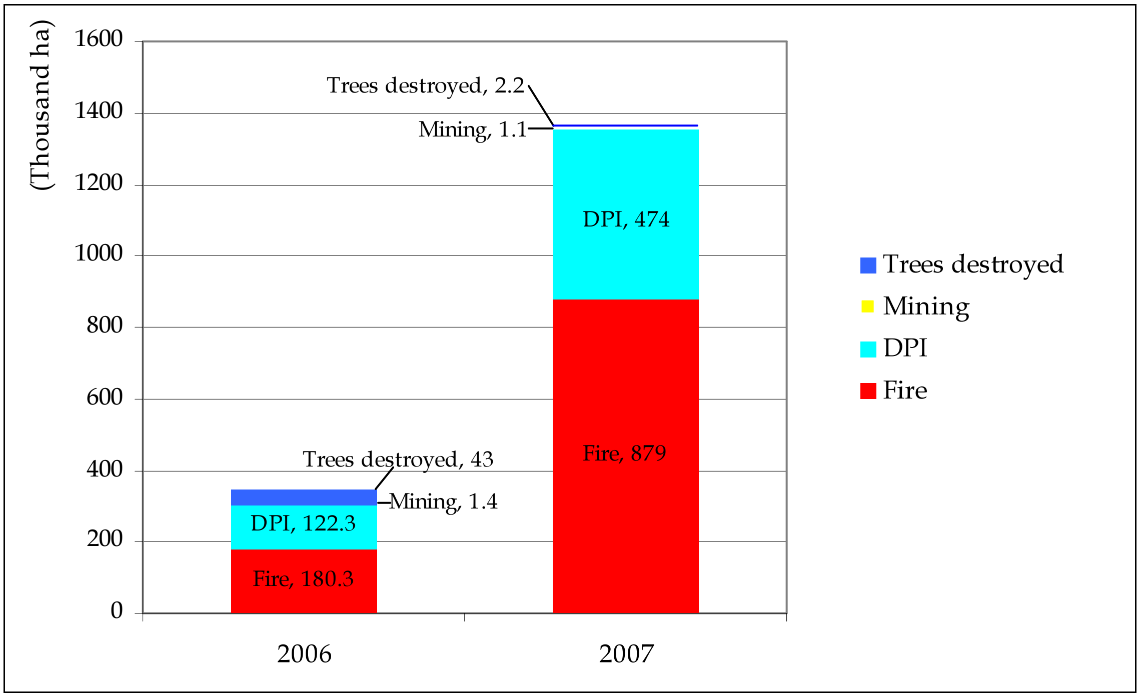


The major causes for deforestation and forest degradation are forest fire, overgrazing, mining, improper management, poor enforcement of forest legislation, damage by pests and diseases and the ever increasing climate change impacts. Mongolia's forest reserves are greatly affected by forest fires, diseases and pests, mining activities, illegal cutting of forest, which causes imbalances in the ecological balance. Wildfires constitute a major factor that determines spatial and temporal dynamics of forest ecosystems. About 4 million ha are disturbed to a varying degree, either by fire (95 percent) or by logging (5 percent). On average, 50 to 60 large forest fires and 80 to 100 large state fires occur annually. The recent increase in the number of fires is related to human activities. In comparison to the 2006 data on damages to the forest reserve, in 2007 the forest area affected by fires, diseases, pests and insects has increased by 3.9 times. However, the forest

[1] Batjargal, Z., 1997. Desertification in Mongolia. In: Agricultural Research Institute of Iceland (ed.), RALA Report No. 200. Keldnaholt, Iceland, pp. 107–113.

reserves, affected by the mining exploitation and forest with destroyed trees, bushes and scrubs have been reduced [Figure 5].

[Figure 5] Damages to the Mongolian forest reserves by affliction type



*DPI = Disease, Pests, and Insects

2. *Policy Mechanisms*

2.1. China

2.1.1. Legal Mechanisms and Institutional Arrangements

Combating desertification for sustainable development has been incorporated into the National Socio-economic Development Plan. Legislation has been enacted in accordance with the Plan, and a series of programs, such as in-situ monitoring, legal guarantee and training systems, have been set up with all levels of the government. Also, the Three-North Forest Shelterbelt Program, which aimed to change the status of wind-sand damage and soil and water erosion rates in Northwest, North and Northeast China, covered 551 counties with 42.4% of China's total land area. The law on combating desertification attaches the responsibility for programming and implementing activities on combating desertification to governments at various levels above county. To enhance the execution of the law, by-laws on the system of responsibilities of the government officials were established. Delegated by the State Forestry Administration, the central government signed pledges with provincial governments on targets of combating desertification. The governors of the provinces who fails to achieve the targets were penalized with lower scores in their official term evaluation compared to their successful peers. The governors who did not take action for desertification control during their official term are to be further penalized.

The institutional arrangements for combating desertification center around economic and social development plan by governments at all levels. Central government provides primary financial support for national programs while local governments provide co-financing for the national programs implemented in their administrative areas. The level of co-financing varies according to financial situation in each province.

[Table 4] Schematic arrangement of NCB to combat desertification in China

	State Forestry Administration (SFA)
National Frameworks	China National Coordinating Group to Combat Desertification (CCGCD)
	China National Committee for the Implementation of the UN Convention to Combat Desertification (CCICCD)
	National Bureau to Combat Desertification (NBCD)
18 Group Members	Ministry of Foreign Affairs (MFA)
	National Development and Reform Commission (NDRC)
	Ministry of Science and Technology (MOST)
	Ministry of Civil Affairs (MOCA)
	Ministry of Finance (MOF)
	Ministry of Land and Resources (MLR)
	Ministry of Railways (MOR)
	Ministry of Communications (MOC)
	Ministry of Water Resources (MWR)
	Ministry of Agriculture (MOA)
	Ministry of Commerce (MOC)
	People's Bank of China (PBC)
	State Administration of Taxation (SAT)
	Ministry of Environmental Protection (MEP)
	Chinese Academy of Sciences (CAS)
	China Meteorological Administration (CMA)
	Office of National Agricultural Comprehensive Development (ONACD)
	Leading Group Office of Poverty Alleviation and Development (LGOPAD) of the State Council
8 Institutions	National Research and Development Centre for Combating Desertification (RDCCD)
	National Training Centre for Combating Desertification (NTCCD)
	National Desertification Monitoring Centre (DMCCD)
	Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI, CAS),
	Xinjiang Institute of Ecology and Geography (XIEG, CAS)
	State Key Laboratory of Quantitative Vegetation Ecology (SKLQV, CAS)
	Institute of Applied Ecology (IAE, CAS)
	Institute of Soil and Water Conservation (ISWC, CAS)

National framework to combat desertification includes CCGCD and CCICCD under the leadership of the SFA and features eighteen other group members [Table 4]. National Bureau to Combat Desertification (NBCD) is the administrative body for combating desertification at central government level, whose role and function is mainly focused on administrating and organizing the implementation of all the actions relating to desertification control across the country. The Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI) is a national institution specialized in desert research and jointly directed by both the Chinese Academy of Sciences and the State Forestry Administration. The Institute was established in the late 1950's and has more than ten research and experimental stations in arid, semi-arid and dry sub-humid areas. Xinjiang Institute of Ecology and Geography (XIEG) has 8 research divisions and five research and experimental stations on desert ecosystems in Xinjiang, while the State Key Laboratory of Quantitative Vegetation Ecology (SKLQV) has several sandy grassland ecosystem research stations in Inner Mongolia. The Institute of Applied Ecology (IAE) has 10 departments on the thematic topics related to desertification and its combating, and the Institute of Soil and Water Conservation (ISWC) has several field stations in Shaanxi for conducting the research and development projects to control soil and water erosions, particularly on the Loess Plateau in Northwestern China.

At local governmental level, the coordinating groups or leading groups have also been set up to be in charge of management, organization and execution of combating desertification in different areas. For example, the Desert Control and Reforestation Division at the Forestry Department of Inner Mongolia Autonomous Region, China is the implementing and managing agency responsible for desertification control at the provincial government level; it serves also as a coordinating agency for the sublevel institutions at the county level. The corresponding agencies at the county level are the Desert Control and Reforestation Offices.

2.1.2.Policies

Government budget is mobilized through the Ministry of Finance to provide grants for projects such as the *National Desertification Monitoring Systems*. The National Desertification Monitoring System has been established with funds for scientific research, technical application and extension, and financing of the national ecological improvement programs. The national-scale monitoring consists of drought and sandstorm monitoring, on-site monitoring of sensitive regions, and monitoring of implemented projects. Ministry of Science and Technology and Chinese Academy of Sciences also allocate budget for basic and applied research for combating desertification.

Several innovative policies and projects have been implemented, including preferential tax policies, discounted loans, and rights to use state-owned land, which are provided as incentives to those who contribute towards combating desertification. Because collective action is crucial, participation of local stakeholders (e.g. farmers, local government etc.) is of key importance in the development and implementation of possible solutions to combat desertification. One example in subsidizing a participating individual or a household is the cash or food subsidies for those who convert croplands to forests and grasslands. The program titled Cropland Conversion to Forests Program (initiated in 1999) consists of three parts: grain, cash and seedling. The standard for annual grain subsidy was 150 kg per mu (one mu = 667 m^2) in the Yangtze River drainage basin, and 100 kg per mu in the Yellow River drainage basin. Since 2005, the grain subsidy has been transformed into cash equivalent. The standard for annual cash subsidy was 20 CNY per mu for seed and 50 CNY per mu for seedling. Thanks to such policies, a significant amount of degraded and marginalized farmland has been converted to tree planting and grass growing areas. Living and labor conditions of farmers have been enhanced as result of such initiatives, leading to more secure livelihoods in rural areas. The structure of local industries has been optimized due to results of increased and diversified employment opportunities, and increased income, thus, speeding up the poverty alleviation process.

2.1.3. Prohibiting Illegal and Excessive Logging, Overgrazing and Farmland Reclamation

In order to address overgrazing, herders are offered a number of options to contribute towards combating overgrazing. For one, they are provided with plots of land to culture and harvest, while being encouraged to cut down the size of their flocks by 40 percent. Alternatively, the herders can relocate their flocks to a different location for some period of time to stall-feed their animals by the means of certain compensations from the state government. For the overgrazed area, wire-fencing is utilized to protect overgrazed places.

The reconstruction of ecosystems is implemented through protection, rehabilitation and restoration of vegetation. By virtue of laws and ordinances, the local governments designate certain natural reserves and parks as a preventive measure for effectively prohibiting activities that exploit the natural assets [Figure 6]. For instance, in order to forbid excessive farmland reclamation and excessive logging – the West Ordos National Nature Reserve, Egina Euphrates Poplar Forests National Nature Reserve, and Egina Euphrates Poplar National Forest Park have been created in Inner Mongolia. Such natural reserves and parks also prevent overhunting and forest fires. Local governments also designate places for limited tillage, grazing, and wood chopping. As part of rehabilitation and restoration, terraces on slopes steeper than 25 degrees are planted with grasses, bushes and trees. Also huge tracts of farmlands are converted back to wetlands, pastures, forests and lakes.

[Figure 6] National Natural Reserve Parks of desert ecosystem in west Inner Mongolia, China

2.1.4. Ecological Benefits

The government has put in place a mechanism to encourage people to participate in combating desertification, by providing rewards for those who contribute to creating ecological benefits. For example, the government encourages the planting of drought-resistant trees in erosion-prone areas. In some places farmers are paid to plant trees rather than raise crops. Also, for those who are willing to collect and use rainwater, the government subsidizes necessary technology. On another note, those who gain specific profit from an ecological project are taxed accordingly. The central government itself also uses its revenues to invest in key national ecological improvement programs for provision of benefits for the public. Via such participatory programs for creating ecological benefits, the government promotes the linkage between public ecological benefits and raising population's environmental awareness and sense of responsibility.

In a reverse case, those who utilize the lands that have been restored must pay a certain fee. Those who destroy ecological balance of a given land are not only fined but are also held responsible for restoring the ecological value of the land. Any fine that is collected must be used in projects for restoring and improving the damaged areas. A notable example is in Xinjiang Uyghur Autonomous Region (Sun and Chen, 2002). Xinjiang, located in the dry Northwestern China with large deserts, has a fragile ecological environment with a poor 1.87% forest coverage rate. In 1997, a provincial Forest Ecological Benefit Compensation Scheme was established. Funds have been collected from monthly salaries of employees in government departments, institutions and enterprises that have located in the region. Additional funds have been collected from revenues from crude oil, nonferrous minerals, scenic zones and forest parks.

2.2. *Mongolia*

2.2.1. Legal

The existing *Land Law* provides the legal framework for better management of pasture and water resources. Article 52 of Land Law provides rights for the local governments to allocate winter and spring pastures to groups of herders under certain conditions. Via signed contracts, preventing land degradation and restoration are agreed upon as the main purpose of such pastures. Article 29 and 53 of the Law provides the property rights and certificates for winter and spring camp shelters, vegetable plots and hayfields for herders. However, it is being evaluated that such important Articles in the Law have not been implemented effectively. Currently, the *Law on Pasture* and the revised *Land Law* have been submitted to the Parliament for approval. The most effective method to use the pasture land is the traditional rotational grazing and resting. Otherwise, an also useful but more expensive method is to fence certain parts of the pasture area.

2.2.2. Livestock

With regards to the livestock sector, the government's policy intends to improve capacity in order to protect livestock from natural disaster's risk. Consequently, aid and loan assistance is provided with great efforts to attract foreign investors and donors. In the recent years, policies to support rural population's cooperation have increased. As a means to promote such participation, the government is assisting intensified farming that is based on new technologies for improving livestock production and herding methods.

In the mining sector, the government of Mongolia gives high importance to sustainability of the environment by utilizing strategically important deposits and decreasing tax burdens in this sector. The *Minerals Law*, which was ratified in 2007, has been enforced and renewed. The Government Action Plan is currently being implemented.

2.2.3.Forest

As for forest management, all forests and land in Mongolia are state-owned. Since 1990, the institutional and legal framework of the forestry sector has changed several times. According to the Mongolian Law on Forest, forests are functionally classified as strictly protected forests (8.4 million ha), protected forests (7.9 million ha) and utilization forests (1.2 million ha). The extent of utilization forests has been progressively reducing during the recent years (i.e. since 1992) by transferring areas to the category of strictly protected and protected forests. In addition, the National Forest Agency was formed in 2005 with the responsibilities such as seedling, planting and reforestation. Through such efforts on forest management, the Mongolian government strives to reduce various afflictions including frequent fires.

2.2.4.Internet access to the traditional technologies and approaches (MONCAT)

With the assistance of international projects, an online database for traditional and modern conservation approaches and technologies has been created. This online information database is called as "MONCAT"-Mongolia's Conservation Approaches and Technologies. The traditional online information database is available on the website www.moncat.mn. Currently, most of the information for conservation and technologies is collected from Khovd, Omnogobi, Dundgobi, Gobi-Altai and Darkhan-Uul aimags. The Institute of Geo-ecology has responsibility to enrich the online information database for conservation approaches and technologies.

3. Technical Measures

3.1. Prevention and Rehabilitation

Science-based desertification prevention and rehabilitation techniques include, among others: i) construction of integrated ecosystems for protection, rehabilitation and restoration of vegetation in line with the ecological characteristics; ii) setting up of natural reserves according to laws to forbid excessive farmland reclamation, illegal and excessive logging, overgrazing and overhunting, and to prevent bush and forest fires; and iii) reforestation and revegetation of shelterbelts to protect the farmland and pastures, including windbreaks as the sand desert control ecosystems and planting forests for purposes of the soil erosion control.

3.1.1.Sand Barriers to Stabilize Shifting Sand Dunes

The first stage consists of installation of sand barriers made of local materials such as willow branches or wheat straw to act as a windbreak. Stalks stand approximately 10-15 cm above the dune surface. This creates sufficient windbreak to slow down the surface sand movement and preserves intact for 4-5 years, so the plants can establish themselves in the protected regions [Figure 7].

[Figure 7] The sand barriers of straw checkerboards

3.1.2. Artificially and Naturally Restored Desert System

Aerial and artificial reforestation is used to restore vegetation and gradually construct a complex multilayer and multifunction ecological system. Based on the technique of straw checkerboards, China has made progress with slowing down sand dune movement by revegetating plants inside straw checkerboards. The checkerboards protect the plants long enough for them to take hold permanently while stabilizing the dunes and stopping sand from migrating. The rain-fed sand-binding vegetation for stabilizing the migrating desert dunes in the Shapotou area at the southeastern edge of the Tengger Desert use shrubs consisting predominantly of *Caragana korshinskii*, *Hedysarum scoparium* and *Artemisia ordosica*. The vegetation has established a desert shrub ecosystem with a dwarf-shrub and biological soil crusts cover on the stabilized sand dunes. Since 1956 the success of this effort has not only ensured the smooth operation of the Baotou-Lanzhou railway in the sand dune section, but it has also played an important role in the restoration of the local eco-environment. Therefore, the Shapotou project is viewed as a successful model for desertification control and ecological restoration along the transport line in the arid desert region of China[Figure 8]. The eco-environmental characteristics have changed gradually in the stabilized sand dune areas compared to those of the migrating sand dune. The biological soil crusts and sub-soil layer thickness in artificially vegetated ecosystem increased gradually, as more time elapsed since the stabilization. The maximum thickness reached 5 cm, and the average thickness for different stabilized sites constituted 3.8 cm. The volumetric soil moisture content at the depth of 0-15 cm has also increased, which is advantageous to perennial grasses and annual forbs. The number of plant species increased significantly compared to that of the migrating sand dune areas, from the initial five native species to more than ten. The stabilization of the migrating desert dunes increased the volumetric soil moisture content within the profile of 0-15 cm from 2.0% to 3.3%. The annual forbs species including *Pugionium calcaratum*, and *Stilpnolepis centiflora* that formerly grew sporadically in migrating desert dunes disappeared completely, and *Agriophyllum squarrosum* and *Corispermum patelliforme* died away gradually. However, other annual forbs including *Bassia dasyphylla* and *Eragrostis poaeoides* took advantage of the stabilized dune surface conditions and propagated and established abundantly. The artificial shrub ecosystems have become complex, and feedback mechanisms have been set up between the community components (e.g., plant species) and environmental factors (e.g., soil water and nutrients), attaining a dynamic balance.

[Figure 8] The revegetation stabilized desert ecosystems

3.2. *Integrated Sustainable Management*

3.2.1.Revegetation

Revegetation entails construction of integrated ecosystems of protecting, rehabilitating and restoring vegetation. Apart from establishing sand control shelterbelts to block the migrating sand, the natural vegetation must be protected properly. This can be achieved through establishing National Natural Reserve Parks (Fig. 1). In what has been described as the world's most ambitious reforestation project, the Chinese are planting a line of trees and shrubs, parallel to the Great Wall of China, to protect farmland in northern China from Gobi Desert sand blown by the fierce Mongolian winds. Stretching from Xinjiang to Heilongjiang, this "Green Wall" covers a strip of land 4,000 miles in length (named as Three-North Forest Shelter Belter).

3.2.2.Water Resource Allocation and Management System

This includes setting up a proper water resources supply and demand management system by restructuring water use, reducing agricultural use and returning more water for ecosystem services, appropriate allocation of water rights, establishing caps on water use for cities along the river, assigning water quotas for each industry and household. It is important to have water quotas exchanged through marketing and strengthen agricultural irrigation quotas and water user rights trading. For example, the Heihe River Basin Authority of the Yellow River Conservation Commission of China is responsible for the water resources allocation and management between the upper, middle and lower reaches of Heihe River, to simultaneously guarantee the water requirements for farmland and riparian desert areas.

4. Projects and Practical Lessons

4.1. Case Studies

4.1.1.China

Sand Prevention and Control in Jarud Banner

The Jarud Banner government launched this project in 2010, for the duration of ten years. The groundwater level of Jarud Banner has been lowered significantly while the water quality has worsened due to population increase, agricultural and industrial development. In addition, river water has also been significantly reduced in volume as result of various climate factors. The short term objectives of the project are forestry construction on 2.5 million mu, grassland desertification prevention on 12 million mu, and soil preservation and control on 1.35 million mu.

Based on the principle of coexistence of conservation and exploitation, the project intends to cultivate grains using intercropping and work with private sector entities to enter the market economy and develop the sand industry. There are 1.2 million mu of *Caragana* shrub forest, 600,000 mu of aspen forest, 3.8 million mu of apricot forest, 23,000 mu of fruit tree economic forest, 36,000 mu *Sapindaceae* energy forest and 5,000 mu of sand land herbs in Jarud Banner. These would make a significant contribution to sand prevention and control as well as to the living standards of the communities. In the long-term, the implementing agency strives to recover 2.3 million mu of land that has been exposed to desertification. The strategy is to create two small towns, affecting roughly more than 1,500 peasants and herdsmen.

The methods and approaches used in this project include the following:

- Formulating and implementing a series of conservation policies and systems such as welfare forest management, prohibition on grazing, strengthening of forest law enforcement, and cracking down on illegal behaviors;
- Strengthening water management by intercepting water through water conservancy projects that include agricultural water conservation and plantation of sandy soil plants;
- Enforcing accurate assessment of environmental impacts from development projects;
- Assigning responsibilities of each level of government for sand prevention and control (the government of Jarud Banner has to report annual progress to the Jarud Banner National People's Congress); and
- Setting up legal system for construction projects, supervision system for construction progress as well as reimbursement system for capital management.

Different types of sample demonstration zones have been established. Artificial firewood collection, over-cultivation, over-grazing and cultivation on steep slope cause problems such as degradation of arable land, soil erosion, and desertification. In response, the project transformed the farmlands to forests and pasturelands to grasslands in order to strengthened resilience to sandstorms. In order to prevent and control grassland desertification, the project implemented policies and activities such as putting up fences, promoting rotational grazing, planting artificial grass, aerial seeding, and improving pasture. At the same time, grass vegetation efforts have been put in place by transforming pastureland to grassland, controlling pest, and artificially planting grass. As success factors, the project points to strong leadership, increased technology usage, fortified legal system, implementation of early warning system, and strong scientific basis in policy-making. As existing problems, the project observes low awareness of the public, limited funding, outdated management skills, and inadequate legal mechanisms.

Stabilization of active sand dunes, and wind and sand prevention and control in Xinjiang, China

Karamay City, Korla City and Hotan City, Xinjiang Uyghur autonomous region have worked to implement scientific research and demonstration projects from June 2006 to December 2010. The Research Institute of Forestry of the Chinese Academy of Forestry is the implementing agency, with funding provided by the National Science and Technology Pillar Program in the Eleventh Five-Year Plan. The long term goal of the projects is developing a multilateral and integrated conservation system, and providing a sand prevention and control model for other drought areas. The projects aimed to construct 30,000 mu research demonstration areas for implementing a sand stabilization and wind prevention system. Another objective was to increase the vegetation coverage of the demonstration areas by 15-25 percent and conserving water by 10-20 percent. In order to achieve such objectives, the methods used were the following: ribbon aloe vera sand stabilization technology, forest conservation, *Populus euphratica* forest restoration, haloxylon seeding with *Cistanche tubulosa*, and forest-grass compound approach. In addition, good-quality sand stabilization plants, drip irrigation, and brackish water drip irrigation were utilized.

A wide variety of stakeholders were included in the project. For Karamay City, Xinjiang Ecology and Geography Research Institute, Xinjiang Agricultural University, Shihezi University and Western Xinjiang Oasis Ecology Development Co., Ltd. Were involved, while the Xinjiang Academy of Forestry was involved in the project of Korla and Hotan City.

Thirteen types of fine sand binder plants were selected, including haloxylon, mangrove, anabasis aphylla, tamarix, gray poplar, populous, transit yang, rong hu 1, rong hu 2, prunus serrulata, elaeagnus angustifolia, and pointed elaeagnus angustifolia. An index system for drought-tolerant and salt-tolerant plants was established. 31,500 mu of demonstration area was set up with quicksand and oasis sand fixing system. Researchers, local forestry officers and scientific and technical personnel collaborated on this task. Because the demonstration zone is characterized by harsh conditions and desert vegetation has a long cycle, the current techniques require a long-term watch.

Wastewater Treatment Plant, Erenhot, Inner Mongolia, China

Like many other areas of Inner Mongolia Autonomous Region of China, Erenhot experiences an acute deficit of drinking and irrigational water. Available resources of groundwater are mostly used for drinking purposes. In order to implement the city's ambitious plan of combating desertification and greening its downtown and surrounding areas, the city authorities put in place an ambitious plan to construct a modern wastewater treatment. The plant was completed in 2010 with a total treatment capacity of 15,000 m^3 per day. The Erenhot wastewater treatment plant is located about 1km northeast of the downtown, running 35 kilometers of wastewater pipeline network to provide 87 percent of the water for urban greening. In the long run, the plant is expected to increase its capacity to 25,000 m^3 per day, to cover a total area of 4.62 hectares by 2020. The current budget for this project is about 70 million CNY.

The plant utilizes a modern bacterial treatment technology based on the advanced German design - BIOLAK multistage wastewater treatment process to produce sufficient amount of water to irrigate more than 100,000 trees planted in the Erenhot area. Moreover, a part of the treated water is diverted to an artificially created wetland, which provides recreational and ecological services for the area. Erenhot, located only 8 km away from the neighboring Mongolian city of Zamyn-Uud, can serve as a good model for combating desertification for the adjacent Mongolian territories in East Gobi region. Collaboration between Erenhot and Zamyn-Uud already includes annual donations of tree seedlings by the Chinese authorities to their neighbors in Mongolia. Protecting environmental sustainability of this cross-border region is important not only for the well-being of the local population. Because this area serves as the main trade corridor between the two countries, ensuring the protection of existing road and railway infrastructure is another significant reason for the collaborated efforts.

[Figure 9] Modern wastewater treatment plant and artificial wetland in Erenhot

4.1.2.Mongolia

Multilateral Projects in Mongolia

Presently, there are several ongoing and completed projects, co-implemented through international organizations (UNDP, SDC, ADB) as well as through bilateral cooperation with countries including the Netherlands, Republic of Korea and Japan. The projects worked on pasture management system improvement, local income generation, small production of fuel for herders, and vegetable and fruit tree growing. The projects implemented activities to test the good practice models for local communities; for instance, the “Sustainable Grassland Management” project helped to establish 72 herders cooperatives, of which, 51% are registered as formal herder institutions, 23 as NGOs and 14 as simple cooperatives. This project has made a significant contribution to this impact, as appropriate mechanisms to improve pasture productivity were put in place in 12 targeted *soums* (districts) of 3 *aimags* (provinces): Bogd, Jinst, Erdenetsogt and Galuut soums of Bayankhongor aimag; Tugrug, Sant, Khujirt and Khairkhandulaan soums of Uvurkhangai aimag; Bayangol, Javkhlant, Mandal and Eroo soums of Selenge aimag. The projects include forming herder groups in order to implement efficient pasture management measures such as pasture rotation and resting, improving pasture and hayfields, training for carrying-capacity assessment and monitoring, and establishing a sustainable financing mechanisms. The projects have positive impacts on the well-being of the herder population as the herders benefit from increased productivity of their pasture, directly impacting the condition of their livestock and products. At the same time, the development of herder groups' own microcredit and diversification of their revenue sources (processing livestock products, vegetable gardening, and ecotourism) allow them to accrue significant economic profit and diversify their food supply.

The common and long-term goal of these projects is to increase the welfare of herding families through the sustainable management of Mongolian grasslands. Socio-economic and ecological goals are inextricably linked. On the one hand, improved herder welfare (higher herder incomes, reduced poverty, reduced vulnerability to risks, increased social cohesion, and improved quality of life) requires more sustainable natural resource, especially in grassland management. On the other hand, grassland use will not be sustainable unless herder welfare is improved and poverty is reduced: poor herders are often by force engaged in unsustainable herding practices because the range of management options is reduced without the capacity to improve their own livestock and pasture management standards.

Coping with Desertification Program, SDC

This 7-year project was implemented by Swiss agency for Development Cooperation (SDC) as part of ODA activities of Switzerland. The SDC mainly focuses on bilateral or multilateral cooperation, humanitarian aid and cooperation with Eastern Europe. As part of bilateral cooperation, the SDC is operating in 12 priority countries including Mongolia and it started its operation in Mongolia in 2001. The SDC office in Mongolia believes that although grazing plays an important role in maintaining the local economy, it accelerates desertification of the Mongolian grasslands. According to SDC, there are three management areas that need to be strengthened to prevent further desertification: (1) grassland, (2) water resources, and (3) stock-farming. SDC identifies planting as a key strategy against desertification and pilot projects are underway to test effectiveness. The pilot plantation project was implemented in 2007 during the first phase of Coping with Desertification Program. The primary purpose of this pilot project was to devise an effective model of plantation in order to successfully combat desertification. The plantation project planted about 4,000 trees on both sides of the main road to the Khovd Airport in 2008. The total of 7-hectare land was previously exposed to severe sandstorms and land degradation. The planted trees included Caragana (Caragana arborescens), Siberian Elm(Ulmus pumila), Salicaceae (Salix.L), and common sea-buckthorn (Hippophae rhamnoides). About ten local people were hired to plant trees, in addition to students drawn from Khovd Agricultural University. The drip-irrigation system was installed, allowing regular irrigation of twice a week. A sample survey found that 95% of trees planted survived. It can be said that the pilot plantation project contributes to knowledge on best practices and indigenous technologies for coping with desertification. The SDC project is based on active and direct participation of the local community, and it aims to raise awareness and generate additional income for them. In order to promote active participation of the local community, SDC facilitated the formation of community organizations for fighting poverty, decreasing water level of the Buyant River, planting windbreaks and preventing desertification.

Greening Mongolia Project, Rotary Korea

This plantation project has been implemented by the Rotary Korea from 2005 to 2009. The budget for this project was funded by Rotary Korea and Rotary International as one of the matching-fund projects. The Institute of Geoecology, Mongolian Academy of Sciences supported the project with technical advice and design for the project sites. Projects were launched in 2005, 2006, and 2007 under different themes: 2005 on planting windbreaks, 2006 on planting fruit trees for income generation for the local community, and 2007 on protecting rare varieties for the establishment of an ecological park. With three years as the duration for all projects, the local governments had agreed to take over at the end of the three years.

Among the seven plantation projects that started in 2005, city of Dalanzadgad in South Gobi Aimag can be regarded as an exemplary case. In Dalanzadgad, typical wind speed is around 10 to 15 metres per second and desertification is occurring at a fast pace. To mitigate the damage of sandstorm on the local community, windbreaks were planted in Ikh Govin Tugul Plantation Nursery, located in the entrance to the city. Area size of the plantation was 10 hectares, with one water well and one water tank installed for irrigation. The trees were irrigated once or twice a week through a hose or a ditch that was dug during the time of plantation. The species of trees that were planted included Siberian Elm (Ulmus pumila), Poplar (Pupulus spp.) and Tamarix chinensis. The 2008 sample survey found that 91% of Siberian Elm and 73.3% of Poplar survived. As of 2008, the plantation site management was transferred to the local government, who in turn delegated a private company 'Great Gobi Grove' to manage the plantation. Key factors for success included well-established watering system and good maintenance by the private company, which contributed to high survival rate of the trees. Also, the aimag government was highly interested and actively involved, even after the completion of the project. Despite the success, there is a concern that the plantation may not be maintained in the long term due to limited funding and decreasing rainfall in the region.

4.2. Recommendations

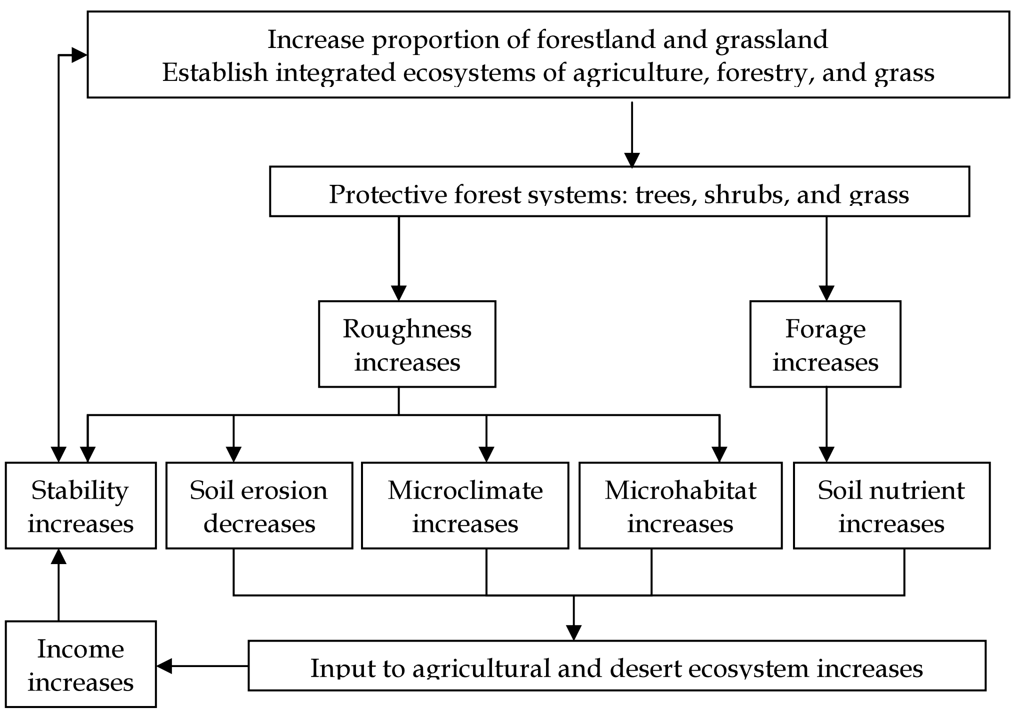
The arid areas of China share similar natural conditions and land use types with those in Mongolia; thus, the Chinese experience in desertification and dust and sandstorm control may provide lessons for Mongolia. Recommendations from the lessons learned are as follows:

- Consider the natural environment (including ecological benefits and the ecological dynamic equilibrium of the Gobi Desert ecosystems), development of the local economies and social communities (including population management and poverty alleviation) together in an integrated strategy;
- Apply sound ecological principles to rehabilitate the Gobi Desert ecosystems and evaluate the effects of its revegetation on the microclimate and microhabitat;
- Motivate all stakeholders by employing measures that would contribute to income growth of local farmers and herders to complement the ecological benefits of key national programs;
- Integrate ecological restoration with mechanical and engineering approaches - e.g., on the southeastern edge of the Tengger Desert;
- Strengthen research activities on the climate variation and adaptive responses in vegetation management; and
- Explore appropriate irrigation methods such as micro-irrigation system [Figure 10].

[Figure 10] Advanced dripping irrigation system for reclamation of desert land

[Figure 11] can serve as a model for desertification and dust and sandstorm control. The key idea is to increase income by improving the quality of the environments.

[Figure 11] Sustainable desertification combating system



If Mongolia chooses to increase the proportion of forestland and grassland to establish an integrated ecosystem of farmlands and pastures, one can expect as result a more stable ground surface, increase in surface roughness, ameliorated microclimate, and enhanced microhabitat. This in turn would reduce soil erosion and consequently reduce the occurrence of dust and sandstorms, while increasing the reliability of local resident income and welfare.

There are four immediate objectives to reach the desired achievements and outputs in sustainable managing the grasslands:

1. Strengthen existing customary forms of co-operation among herders within and between local communities of land users;
2. Facilitate formation of new herder communities and percolate to wider governance structures, engaging the *bagh* (subdistricts) and the soum;
3. Build the capacity of herder community associations to negotiate with third party providers for inputs and services; and
4. Strengthen the ability of central government to create and manage an appropriate legal and economic environment for sustainable herder and grassland development..

Self-financing and Fund Allocation Mechanisms

Due to the limited financing resources from the central State fund, self-financing and fund allocation mechanisms for small cooperatives and entities, as well as for private people, are crucial. After completion of most of the projects in rural areas, small funds or self-financing mechanisms are needed in order to sustain the project activities. However, currently there aren't any proper self-financing and fund-allocation mechanisms to maintain and expand the irrigation system and wind-and-sand breaks in Mongolia. While several international projects designed self-financing systems, most failed due to the lack of effective funding source. Local administrations also were not successful in sustaining their assistance to the cooperatives. Meanwhile, the participants themselves did not have enough experience to continue the project activities.

The self-financing mechanism for an irrigation system and wind-and-sand breaks depends on how well the self-financing model is designed. And a self-financing mechanism is very closely related to crop rotation and intercropping, which are vital for continued support through out the year. In order for the local cooperatives to maintain effective irrigation and wind-and-sand breaks on a self-sufficient basis, they must be able to create profit from the fruits and vegetables they produce. The members of local cooperatives must have training on how to sell their products in the local markets.

Raise awareness for the local community

Since inappropriate land tenure policies regarding pasture land have led to land degradation and disputes among pastoralists, it is essential to increase the awareness of all soum herders on basic pasture management issues. The herders must recognize the importance of rotational grazing, fencing, and resting of the pasture land. A major outcome of the herders' capacity development through the project is their newfound *confidence in their own capacity to improve their livelihood and the condition of their pasture*. The herders that participated in the second phase of "Sustainable grassland management" project have agreed with above notion. This recognition is probably the most important outcome of "Sustainable Grassland Management" project.