livestock at 111.2 million ha area of grazing land area by 2004.

The livestock sector provides livelihood to almost half of the population. The rural population constitutes over a million, most of whom are herders and their lifestyle entirely pastoral. More than three fourth land of the country is extensive grazing exploited by traditional pastoral practices. Mongolia's livestock are raised at open pasture year around. Traditionally, herders move seasonally (four times: winter-spring-summer-fall) with their livestock on the pasture and raise five types of animals as sheep, goats, cattle (including yaks), horses and camels. Sheep and goats are the most numerous among livestock numbers of a herder's household. Animals are the main if not only source of food, transport (horses and camels), cooking and heating (dried dung), and cash for the access to medical and veterinary services and education and clothing. The native breeds of animals have small body sizes and a low productivity, so their performance is substantially below that of exotic breeds.

Table 2. Changes of yield of pasture types in last 40 years

Natural zone	Pasture type	Years					
		1961-1962		1981-1982		1999-2000	
		yield	%	yield	%	yield	%
Steppe	Herb-grass	18.0	100	10.2	66.5	6.5	36.1
	Fescue-herb	8.0	100	6.5	81.2	5.1	63.7
	Feather grass-grass	11.0	100	9.3	84.5	6.7	60.4
Steppe	*Stipa mongolica*-Cleistogenes	6.0	100	3.2	53.3	2.5	41.6
	Stipa mongolica-Allium mongolica	5.0	100	2.8	56.0	2.2	44.0
Desert and desert steppe	Salsola sp.	4.5	100	3.5	72.7	3.1	68.8
	Achnatherum sp.	16.0	100	12.0	75.0	9.0	56.2
	Caragans shrub	4.0	100	3.3	82.5	3.0	75.0

According to recent research, the rate of yield has declined slightly in the desert and desert steppe regions, and significantly declined in steppe and forest steppe regions [D.Avaadorj, S. Badrakh, 2001]. The desertification process is therefore more visible in the ecotone regions, namely in steppe and forest steppe landscapes (Table 1.).

Table 3. Pasture yield change across natural zones and pasture types

Natural zone	Pasture type	Years					
		1961-1962		1981-1982		1999-2000	
		yield	%	yield	%	yield	%
Forest steppe	Herb-grass	18.0	100	10.2	66.5	6.5	36.1
	Fescue-herb	8.0	100	6.5	81.2	5.1	63.7
	Feather grass-grass	11.0	100	9.3	84.5	6.7	60.4
Steppe	*Stipa mongolica*-Cleistogenes	6.0	100	3.2	53.3	2.5	41.6
	Stipa mongolica-Allium mongolica	5.0	100	2.8	56.0	2.2	44.0
Desert, desert steppe	Salsola sp.	4.5	100	3.5	72.7	3.1	68.8
	Achnatherum sp.	16.0	100	12.0	75.0	9.0	56.2
	Caragans shrub	4.0	100	3.3	82.5	3.0	75.0

Source: GeoEcology Institute, 2001

2.2 Current state of livelihood of herders

Main factor that has contributed to pastureland degradation in recent years is the impact of climate change and global warming on Mongolian territory. Drought and heavy snow, caused by recurrent desertification in many areas of the country, have negatively impacted the lives of nomadic herders, particularly increasing the poverty level among herders who own very few animals.

Mongolian pastoral livestock sector is highly sensitive to climate change impacts. Considering the livestock based subsistence economy, and almost half of the population employed in that sector, adaptations to climate change impacts is vital in achieving sustainable development. The key risks from climate change to livestock are increased incidence of drought and *dzud* (harsh winter). More than 60 percent of the country has been identified as sensitive/vulnerable area to climate driven extremes.

Market economy newly introduced to Mongolia in the last decade also affects the herders' livelihoods. Mongolia has been exercising central market–Ulaanbaatar oriented transition while the herders-one third of population is living sparsely distributed over vast territory. Low developed infrastructure (road, communication, electricity, etc.) increases cost for social services and access to market while increased needs caused by the climatic hazards to migrate with the animals far away from the settled area seeking better pasture, is tent to increase of herders' remoteness. One-centered market, remoteness of rural population with low developed infrastructure along with frequent climatic hazards is a serious complex development issue that increases the differences between urban and rural, rich and poor and threat sustainability of entire country.

Mongolian nomadic livestock husbandry, a typical example of a

pastoral system is and, throughout the history of Mongolia has been, the only viable economic activity. In other words, animal husbandry for a long period of time, has shaped the ways of life of Mongolian society, and has dominated the Mongolian economy. Mongolia is the third least densely populated country in the world with a population of 2.5 million people in an area of 1.5 million km^2. Livestock sector is a vital component of the Mongolian economy contributing about one third of the GDP. The rural population constitutes over a million, most of whom are herders and their lifestyle entirely pastoral. The pastoralist are vulnerable to myriad of climate induced events as *dzud*, drought, wind storm, cold rain, as the system is highly and directly dependent upon climate conditions and natural resources. They often face price volatility for livestock products due to unstable economic system.

Mongolia pastoral livestock production system has three primary components:

- natural resources, which attributes of the physical and biological environment or primary resources and climate condition;
- livestock bio-capacity of processing and converting feeds to products (i.e., milk, meat, fiber) at a rate sufficient to meet animal needs and provide a surplus for human Herders who, take management over livestock production i.e. pastoral livestock industry depends on natural resources availability that mainly governed by climate, and animal' bio-capacity to cope with environment and human element that supports and depends on livestock.

Last few years, Mongolia has faced on severe drought and harsh winter (dzud) and it might be coincident with land surface degradation due to human activity and rising of number livestock.

In recent years, wide areas of the Gobi Desert have been affected by extreme desertification and land degradation, resulting in serious changes and negative impacts on the traditional culture and livelihood of the nomads of the region. What is worse is that desertification is not limited to the Gobi region, it has recently expanded into other zones, affecting other areas of the country.

The traditional Mongolian way of life is strongly linked to the nomadic herding system or the nomadic culture of the people. For thousands of years, the Mongolian people survived harsh natural climatic conditions by herding five species of domestic animals, namely, sheep, goat, cattle, horse and camel. Mongolia's wide pasturelands served as the animals' herding ground. The animals served as the people's main source of food,

clothing, transportation and communication.

Under the old nomadic pasture system, the composition and herding of domestic animals enabled the nomads to achieve optimal results from their livelihood. During that time, Mongolian herders paid more attention to the production and productivity of domestic animals by using what is called the "migrating rotation system of land use." Under this procedure, Mongolian herders used four seasonal rotation systems for herding—coinciding with the seasons.

The traditional Mongolian herding method, practiced by people for thousands of years, ensures rational use of land resources, but is now slowly being eroded under the impact of desertification and drought.

Mongolia moved from a centrally planned economy to a market economy in the 1990s. The transition period resulted in the dispersal of thousands of herder communities and the privatization of animals.

The results of desertification have increased the number of low-income families. They have also caused a decrease in the number of young herders, as the latter continue to migrate to urban areas to look for alternative work. The traditional relationship between old herders and young generations has been altered. At its face value, desertification seems to be a natural and an ecological phenomenon, but, in fact, it is an urgent issue that has social and economic implications, one being the migration of herding populations to urban areas of Mongolia.

Mongolia is now confronting the negative consequences of desertification—in all its ecological, socio-cultural, and economic aspects. The country and its people have to face the impending overhaul of its nomadic herding system. A settlement system that held sway for thousands of years, inherited from generation to generation, is undergoing dramatic changes. The nomadic pastoral lifestyle that proved effective for centuries and an environmentally friendly herding system that suited the requirements of a unique area are facing the danger of extinction. The impacts of climate change and desertification call for a new settlement and pastoral management system that thoughtfully considers the human, geographical, social, cultural, and economic factors.

2.3 Cropland degradation and deforestation

It is clear that desertification and land degradation are caused by both climatic factors and specific human activities (poor, unsustainable agricultural practices, overgrazing, deforestation, inadequate waste management etc).

Another direct human impact is cutting down of forests. Saxaul forest,

for example, are vital for desert ecosystems and they make up one quarter of the 8.5% land area covered by forests. Saxaul timber is used as energy source for heating and cooking. Since 1970, 125 thousand hectares of saxaul stands have been destroyed and 370 thousand hectares lost their regenerative capacity.

Loss of forests, coupled with over-grazing and inappropriate land use practices, leads to desertification and formation of barren, eroding wastelands. During the last 40 years the desert areas of Mongolia have increased by some 38,000 hectares and deserts now make up some 41% of the total land area. It has been estimated that the size of usable pastureland has decreased by 6.9 million ha during the last 30 years due to desertification; and 30% of the total pasture area in Mongolia has degraded due to misuse.

Deforestation and forest degradation in the country have national and regional concern due to their economic and ecological importance. The main causes of deforestation and forest degradation in Mongolia are forest and steppe fire followed by damage by pests and diseases, improper commercial and illegal wood logging for construction and for use as fuel, and uncontrolled grazing in forest areas and land degradation.

Forest degradation and logging result from misuse and/or mismanagement of the resource. While not conspicuous as deforestation, their impact on the environment can be very serious. According to a survey of human impact on ecosystems in Mongolia during the last 100 years, it is seen that some 40% of all forests in Mongolia have been impacted to some degree; 684,000 hectare have not regenerated after fire damage and 250,000 hectare after clear-cutting; 1,737,000 hectare of coniferous forests have been replaced by birch and poplar stands, 159,000 hectare by *steppe* and sand/stones, and 1,230,000 hectare by low quality coniferous forests. Cold-resistant *taiga* forest has been shrinking. 16% of the forest ecosystem has been replaced by non-forest ecosystems.

Abandoned croplands, mining activities and unpaved multi-track roads also directly contribute to land degradation.

In the 1950's the Government of Mongolia, following the Soviet model, had established 12 forestry state enterprises in several of the northern-central *aimags* including settlements for workers ('forestry villages'). In order to intensify forest management, mechanical harvesting operations and electronic sawmilling were introduced. These sawmills needed large timber volumes and by mid of 1980s annual cutting volume was reached up to 2 million cubic meters of timber annually.

Table 4. Crop land abundance in Mongolia

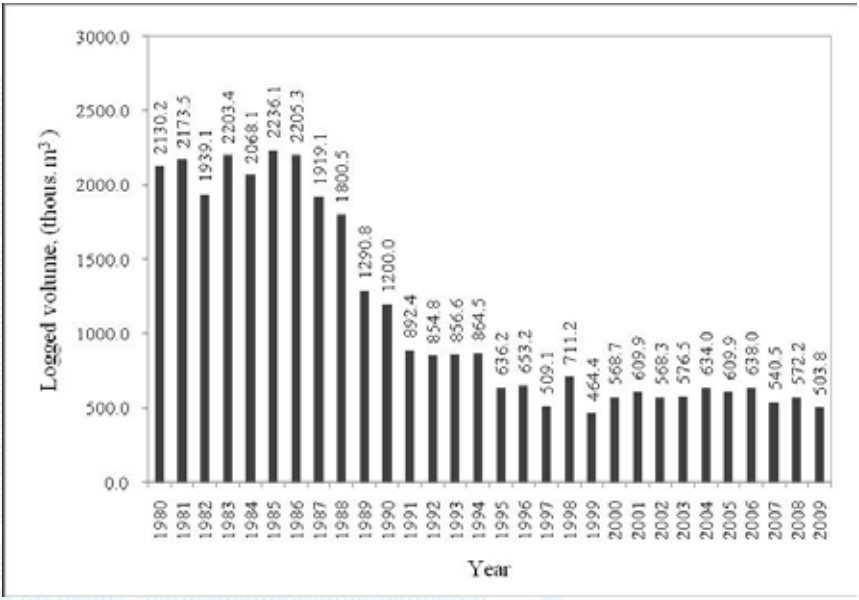
№	Names of provinces	Number of soums	Researched area (thous./h	Eroded area		Degree of erosion (thous/ha)		
				Thous.ha	Percent	Slight	Moderate	Severe
1	Arkhangai	17	69.6	39.1	56.2	13.1	18.5	7.5
2	Bayankhongor	1	3.2	2.0	62.5	1.5	0.5	-
3	Bulgan	16	126.8	45.0	35.5	28.0	10.5	6.5
4	Dornod	13	78.2	11.5	14.7	9.8	1.0	0.7
5	Zavkhan	20	81.4	14.3	17.5	8.6	2.9	2.8
6	Uvurkhangai	9	43.1	30.7	71.2	15.3	9.3	6.1
7	Tuv	24	285.8	183.9	64.7	118.8	48.5	16.6
8	Selenge	16	300.9	137.3	45.6	85.1	31.4	20.8
9	Sukhbaatar	4	30.7	28.5	92.8	10.2	11.7	6.6
10	Uvs	3	48.6	13.0	26.7	9.3	2.4	1.3

Source: GeoEcology Institute, 2000

In terms of age structure, Mongolia's forest is mostly mature forest that is distributed in the taiga belt with high soil erosion risks or on steep mountain slopes, which are inaccessible with the current harvesting technologies. Forest exploitation in the past has exhausted the timber resources in more accessible areas given the capacity of their equipment and transportation systems. Between 1990-2009, about 13.4 million cubic meter of timber was removed from utilization zones of forest areas in the country.

Quality of forest management continues to be inadequate, indicated by poor natural regeneration and ecological retrogression. Recorded wood production is reported to have fallen (Figure. 2), due to the reduction in the area of designated utilization forests.

Figure 2. Forest logging in Mongolia in last 20 years.



In general, clear cutting practice in the mountain forests of Mongolia is not applicable due to natural condition of these forests, because it leads to the succession change of coniferous forests by deciduous forests and to the replacement of forest ecosystems into steppe or dry meadow-steppe ecosystems; enhances surface and slope run-off, develops erosion process and reduction of the forest areas. Hence, silvicultural application and forest exploitation activities in Mongolia requires special methods and systems of timber cutting which will not be have destructive effect on protection function of the forest ecosystem and at the same time enables natural regeneration of forests.

2.3. Desertification assessment and monitoring

In NAPCD outlines the establishing integrated monitoring system and database for desertification and land degradation. The MNET initiated developing a standard methodology for desertification monitoring, which harmonizing different methodologies in Mongolia by various national and international institutions. This initiative is to serve as a nationwide fundament to deliver accurate information about desertification to decision makers by using one commonly recognized methodology instead of several differing methods and approaches. The Environmental Protection

Law and Land Law of Mongolia (article 19.2.2) calls for assessing and monitoring land erosion and desertification. According to the law, the Ministry of Nature, Environment and Tourism (MNET) provides the framework and methodology and to execute the work according to the methodological framework provided by the MNET.

Since 2010, Ministry of Nature, Environment and Tourism is developing National Monitoring System for Combating Desertification and Land degradation joining with CODEP project funded by Swiss Agency for Development and Cooperation. By Minister's order of Nature, Environment and Tourism on 2010, about 29 indicators for assessment of Desertification and Land degradation were adopted as national monitoring tool of Desertification in the country. There indicators include dryness index; ratio of deforestation; drought frequency; density of livestock; yield of grassland/pastureland; annual precipitation trend; land use change and their intensity; loss of fertile top soil; cropland expansion; change of ground water flow; demand and future trend of water resource use; abundance of biodiversity; quality of ecosystem service and others.

Starting from 2011, National Agency of Meteorology and Environmental Monitoring is developing National monitoring system for monitoring of desertification process in Mongolia. Under this action, nationwide monitoring plots of desertification and land degradation have been established. Other hand, Environmental Information Center of Ministry of Nature, Environment and Tourism joining with Geo-Ecology Institute is conducting mapping of Desertification and land Cover Change applying remote sensing technology and initiating establishment of Database of Desertification and Land Degradation of Mongolia.

Table 5. Indicators for Monitoring of Desertification and Land Degradation (DLD).

Supporting process	Indicators	Affecting scale		
		Local	Regional	National
Climatic	Precipitation			
	Air humidity			
	Drought frequency			
Pastoral	Pasture carrying capacity			
	Pasture yield			
	Pasture plant composition			
Soil-vegetation	Sheet erosion			
	Slope erosion			
	Wind erosion			

National monitoring system for land degradation and desertification (including mapping of appropriate conservation measures) is in place and involved institutions are able to update it regularly and it is used as a basis for decision making.

In 2004, researchers from the Center of Desertification Studies, as part of basic research entitled "Desertification dynamics and its future trend in Mongolia", developed a new set of indicators (Table 6.).

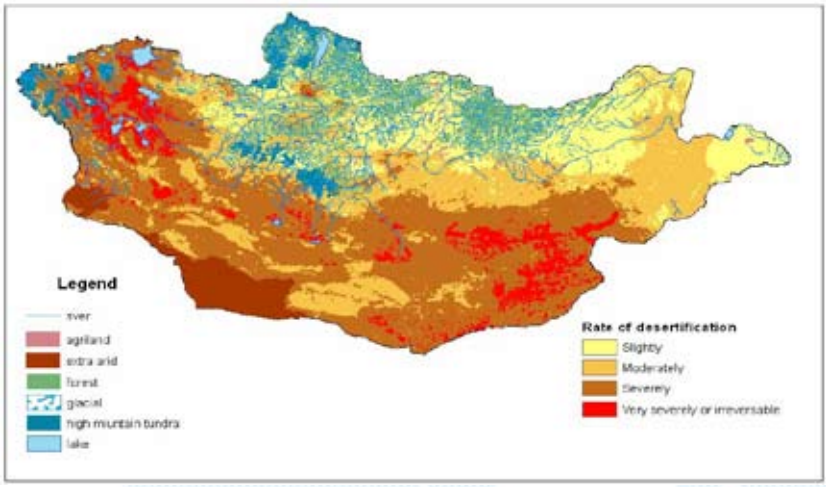
According to results of comparative assessment it is visible that with joint influence of climate change and human interaction the resilience of dryland ecosystem is worsen. Unfortunately, the land degradation caused by inappropriate practice of natural resource use is become a largest threat facing the vast steppe region of Mongolia. Thus, the most attention is should paid to prevent the encroachment of land degradation in such fragile and naturally unique ecosystems of steppes and forest steppe [Mandakh, Dash, 2006].

Table 6. Indicators for assessing desertification

Influencing processes	Indicator	Spatial extent			Useful data
		Local	Regional	National	
Climate change	Amount of effective rainfall				Meteorological observations
	Air relative humidity				
	Frequency of drought				NOAA, MODIS data
	Drought index				Meteorological observations, and NOAA, MODIS data
Overgrazing	Pasture carrying capacity				Field survey
	Pasture yield				Field survey for small scales and Remote Sensing data for nation-wide assessment
	Vegetation cover/ composition change				Field data
Soil erosion	Sheet erosion				
	Slope erosion				
	Wind erosion				
Land use	Changes in agricultural land				Ground truth data and some RS
	Agricultural soil condition				Ground truth data
	Land use management plan				Regional development plans

Source: Mandakh N., Dash D. (2006): The state of the desertification in Mongolia and its mapping. Research report, Ulaanbaatar, Mongolia (in press)

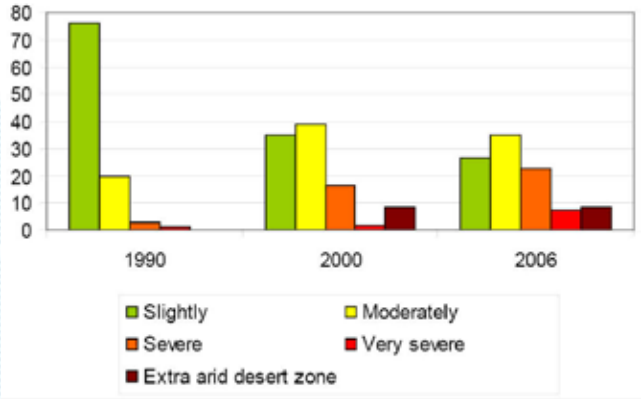
Figure 3. Desertification map, 2006



Source: GeoEcology Institute, Mongolian academy of Sciences.

Comparison between the second and third nation-wide desertification assessments shows that the total extent of desertification has not increased. However, the amount of land in the severe category has increased. For instance the region belonging to the central part of Dornogobi aimag was considered as slightly desertified in the 1990 assessment, while in 2000, D.Dash et al (2005) assessed the region as moderately desertified. In 2006, land condition was considered even worse with irreversible degradation having occurred.

Figure 4. Desertification trend in 1990, 2000 and 2006



2.4 Regional impact of Desertification

Dust and sand storms originated from desertification and land degradation involves strong winds that blow a large quantity of dust and fine sand particles away from the ground and carry them over the long distance with severe environmental impacts along the way. It often has severe impacts across the countries in the North East Asia region. The major dust and sand storms originating source areas in the region are the deserts and semi-desert areas of Mongolia and China.

Some statistics indicate that average occurrence of dust and sand storms were 5 times a year of 1950s, 8 times 1960s, 14 times 1970s, and 23 times in 1990s. the region experienced 32 dust and sand storms in 2001 and the most severe dust and sand storms for decades in 2002.

Mongolian scientists derived the number of dusty days per year from the sum of the number of days with the dust storms and drifting dust obtained from number of meteorological stations in Mongolia from 1960s. The trend is upward in the period since 2000, perhaps as result of prolonged drought and the increased grazing pressure on semiarid grazing land.

Large scale dust and sand storms has significant environmental effects that cause enormous economic losses, present serous public health concerns over a wide geographic area.

Stepping up dust and sand storms prevention and control is justified, given the enormous damage costs by dust and sand storms, and the urgent need to reduce the frequency and severity of dust and sand storm. The benefits of anti-dust and sand storm efforts include the reduction in

economic losses and the restoration of damaged ecosystems.

Transboundary environmental problems such as dust and sand storms originated from desertification and land degradation can be most effectively be solved through the international cooperation. The various initiatives of the governments and, non-government organizations and volunteers from the dust and sand storms affected countries have been actively undertaking cross-border activities to mitigate dust and sand storms events.

Trend in Mongolian Climate in the recent decades and its implication

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Abstract

The linear trends of precipitation in Mongolia and associated atmospheric water balance and circulation fields are investigated in the recent three decades (1979-2008). It has been found that precipitation in all summer months (July to September) shows a significant decreasing trend, particularly in northeast part of Mongolia (Fig. 1). The trends in atmospheric water balance shows, however, somewhat different features from month to month; in July the decrease in moisture convergence is primarily responsible for that in precipitation, in August the decrease in evapo-transpiration in addition to moisture convergence is likely to be responsible for the decrease in precipitation, in September the decrease in evapo-transipiration is a major player for the decrease in precipitation as shown in Fig. 2.

This intra-seasonal change in trends of the atmospheric water balance may be related to the land-atmosphere interaction through precipitation, vegetation and evapotransipiration as suggested by Miyazaki et al.(2004). It is also interesting to note that the atmospheric circulation change over and around Mongolia show somewhat similar pattern, i.e., intensified anti-cyclonic circulation anomaly over there in July through September.

These results suggest that the recent decreasing trend of precipitation in late summer (August and September) may be attributed to decrease of evapo-transpiration. We need further discussion whether these changes are at least partly relevant to anthropogenic impact (of land cover change) or larger scale climate change associated with the global-scale warming or no (e.g., Batima et al. 2005).