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Climate Change Concerns in Mongolia

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ABSTRACT

Climate of Mongolia is a driven force on natural conditions as well as socio-economic development of the country. Due to the precariousness of climate conditions and traditional economic structure, natural disasters, specially disasters of meteorological and hydrological origin, have substantial effect upon the natural resources and socio-economic sectors of Mongolia. Mongolia's climate is characterized by high variability of weather parameters, and high frequency and magnitude of extreme climate and weather events. During the last few decades, climate of the country is changing significantly under the global warning. The annual mean air temperature for the whole territory of the country has increased by 1.56℃ during the last 60 years,. The winter temperature has increased by 3.61℃. These changes in temperature are spatially variable: winter warming is more pronounced in the high mountains and wide valleys between the mountains, and less so in the steppe and Gobi regions. There is a slight trend of increased precipitation during the last 60 years. The average precipitation rate is increased during 1940-1998 by 6%. This trend is not seasonally consistent: while summer precipitation increased by 11%, spring precipitation decreased by 17.

The climate change studies in Mongolia show that climate change will have a significant impact on natural resources such as water resources, natural rangeland, land use, snow cover, permafrost as well as major economic activities of arable farming, livestock, and society (i.e. human health, living standards, etc.) of Mongolia. Therefore, in new century, sustainable development of the country is defined by mitigating and adaptation policies of climate change.

The objective of the presentation is to contribute one's idea in the how to reflect the changes in climate system and weather extreme events in the country's sustainable development concept.

Introduction

Despite tremendous progress in science and technology, climate is still the custodian of all spheres of life on earth. This is specially true in a territory of Mongolia, a region that is very vulnerable to weather conditions and its extremes. The product outputs of the major economic sectors, such as animal husbandry, rainfed arable land farming, and the mining industry, are very sensitive to climate variability

Heavy rains, snowfalls, strong winds, sandstorms, snowstorms, hail and flooding often bring substantial damages to life and property as well as ecosystem of the country. For instance, in the two year period between 1998 and 1999, the total economic damage caused by disasters such as strong wind, blizzard, hail and thunderstorms, floods and extremely hot weather conditions was reached to 3% of GDP. Devastating weather hazards, such as dzud and droughts, are a well-known affliction of the Mongolian nomadic herder.

Dzud is the Mongolian specific term for an extraordinarily harsh winter that deprives livestock of grazing, a specific phenomena that takes its toll in the winter-spring season as high number of livestock die of starvation. This particular disaster struck twice in the cold seasons of 1999/2000 and 2000/2001, costing the livestock and livelihoods of many Mongolian herders.

Droughts in the spring and summer periods occur about every five years in the Gobi desert area, and once in every ten years over most of the parts of the country. But this weather event is occurring almost every year since 1999 in Mongolia.

During the last 40 years, Mongolia's ecosystems have clearly changed as a result of climate change and human activities. Examples include desertification, soil erosion, and water resources and bio-diversity degradation.

Since Mongolia is located at a distance of only 10o latitude from the transition zone between the Siberian taiga and the Central Asia desert, the country is very sensitive to a shift of geo-climate zones that can be caused by climate change.

Climate

Climate of Mongolia is characterized by long and cold winters, cool summers, small amounts of precipitation, high temperature fluctuations and a relatively high number of sunny days. January is the coldest month with average temperatures of -15℃ to -35℃ and an average minimum of -50℃. In December 1972, the minimum temperature was as low as -56℃ at the Uvs lake which is the coldest temperature recorded. June is the warmest month with average temperature ranging from 15℃ to 25℃. The maximum temperature can reach 35℃-43℃. July 1999 was the hottest month recorded.

Mongolia's annual mean temperature is 0.7℃ and ranges from -7.8℃ to +8.5℃. It is -4℃ in the Altai, Hangai, Hentein and Huvsgul mountainous region and -6.8℃ in the mountains and big river valleys, +2℃ in the desert-steppe, and +6℃ in the southern Gobi (Figure 1). The zero annual isotherms follow the 460N latitude which separates the mountainous area from the Gobi-desert area. The permafrost soils are distributed in areas with annual mean temperature lower than -2℃.

The period when air temperature exceeds +10℃ and the total heat accumulation during this period is important for agriculture, because the total generated heat is necessary for vegetation growth. This period is about 90 days at altitudes of 2000 meter above sea level, 90-110 days in the forest-steppe, 110-130 days in the desert-steppe, and 150 and more days in the desert area. Accordingly, heat accumulation increases from north to south: the total effective temperature (this is the sum of the average temperatures of all days with an average temperature above 10℃) is 1500℃ in the mountains, but less than 1000℃ in areas above 2000 meter. In the arable land area of the Orhon, Selenge river basins and in the Dornod steppe the total effective temperature is as much as 1700℃. The heat accumulation reaches to 2000-2500℃ in the steppe. However, also unexpected frost occurs in this period, which limits not only the heat accumulation but also interrupts crop growth.

Precipitation varies both in time and space. The annual mean precipitation is 300-400 mm in the Hangai, Hentein and Huvsgul mountain region, 150-250 mm in the steppe, 100-150 mm in the steppe-desert and 50-100 mm in the Gobi-desert (Figure 2.). About 85-90 per cent of annual precipitation falls as rain in summer, of which 50-60% in July and August. The mountain range smoothly changes into steppe and desert from north to south. Accordingly, the heat and wind speed amounts increase whilst the precipitation and soil moisture decrease.

Fig. 1. Annual mean temperature, (℃)

Fig. 2. Annual precipitation amount, (mm)

The number of rain days is not only distributed over time, but also over space: 60-70 days in the northern part of the country, 40-60 days in the mountain valley and the Dornod steppe and 30 days in the Gobi. Most of the rain falls in a few short periods in heavy showers. For example, in the steppe the number of days with more than 5 mm rain account for only 15-30% of the total number of rain days, but they contribute to 70-80% of the total annual rainfall. Thus, the amount of annual precipitation is small, but the intensity is high. Rainfall with intensities of 50 mm/day occurs in all regions of the country.

Annual evapotranspiration is not high and almost equal to the annual precipitation. In the Hangai, Hentein, and Huvsgul mountains, where the vegetation and the soil moisture are sufficient, annual evapotranspiration is more than 300 mm. Evapotranspiration is 250-300 mm in the mountain valley and forest-steppe, 150-250 mm in the steppe, and 150 mm and less in the Gobi-desert. The potential evapotranspiration is 700, 700-800, 800-900 and 900 mm in the mountain region, the mountainous and river valley, the forest-steppe and the steppe, and the Gobi-desert, respectively.

During winter (December-March) about 10 mm of snow falls in the desert, 20-30 mm in the mountains and the Uvs lake depression and 10-20 mm in the other regions. Accordingly, the number of days with snow cover is about 150 in the mountain region, 100-150 days in the forest-steppe, 50-110 days in the Dornod steppe and the steppe zone, 50 and less in the Gobi-desert. The average depth of snow cover is not much: about 5 centimeter in mountains (the maximum is over 30), 2-5 centimeter in the steppe (the maximum is 15-20 centimeter). Winters without snow cover are very rare and have occurred only in the Gobi region.

Current Climate Change

There is not much information on historic climate records in Mongolia. The climate condition before systematic observation can only be derived from short notes about weather extremes indicated in some historic books and records, and from tree ring studies or paleo-limnology studies.

The dynamics of the air temperature and precipitation in the last 60 years (in 1936 a systematic observation started in Mongolia) have been made on the base of observed data from 25 meteorological stations that were evenly distributed over the country. The meteorological records show that the middle of 1940s, 1970s and 1980s and the end of 1950s were relatively cold and the middle of the 1940s and 1980s were relatively dry periods.

During the last 60 years the annual mean air temperature has increased 1.56℃. The winter temperature

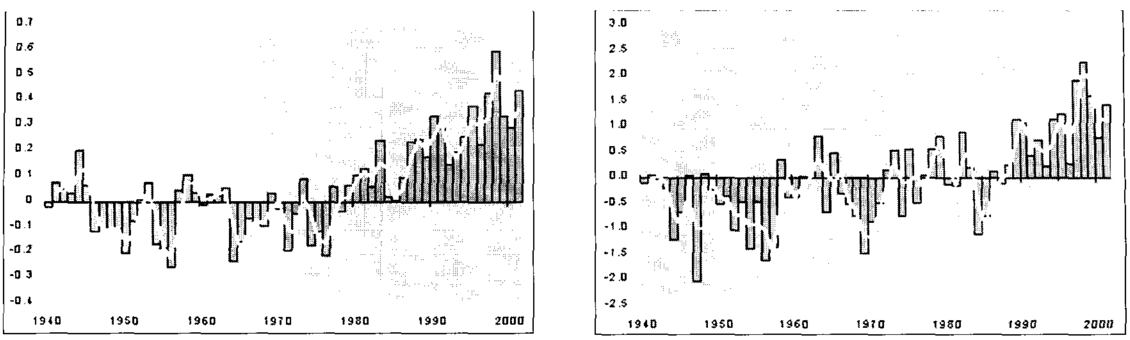

Fig. 3. Changes in global (left) and Mongolia's (right) annual mean temperature, 1940-2002

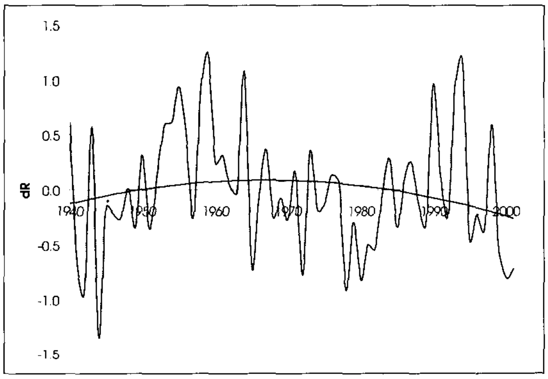

Fig. 4. Trend of normalized precipitation amount of Mongolia, 1940-2001.

has increased 3.61℃ and the spring-autumn temperature 1.4-1.5℃. In contrast, the summer temperature has decreased 0.3℃. However, this cooling tendency of summer months is ended because of hot summers of early 2000s. Particularly in March, May, September and November, the temperature has increased rapidly.

Changes in temperature are also distributed in space: winter warming is more pronounced in high mountains and in wide valleys between the mountains and less in the steppe and Gobi (Natsagdorj, 1980, Dagvadorj et al., 1998).

As can be seen from Figure 4, there is a slightly increasing trend in precipitation during the last 60 years. The country's average precipitation between 1940-1998 has increased by 6%. However, while summer precipitation increased by 11%, spring precipitation decreased by 17%. The spring dryness occurs mainly in May. There are not many changes in the precipitation in April and a little increase in the precipitation in May. The rapid increase in temperature and considerable decrease in precipitation in the spring sowing period have significant negative impacts on crop growth.

Climate Change Projections

Future climate change projections for the territory of Mongolia for the periods 2000-2039 and 2040-2069 were estimated based on the global climate change scenarios from calculations of several General Circulation Models (GCM). All GCMs predict that air temperature would increase from 2040 and even more rapidly from 2070. However, the CCCM model predicts the maximum, the CSIRO and the HADLEY2 models the minimum and the ECHAM4 and the GFDL models a medium increase in temperature respectively. It is also found that the winter warming is more pronounced than the summer warming. Warming tendency would be intensified after 2050. Some scenarios, such as the CCCM, show more warming in high mountain regions than at low altitudes.

In general, summer, winter and annual mean temperature would increase by 1.0℃-3.0℃, 1.4℃ -3.6℃ and 1.8℃ -2.8℃ in 2040, and 2.0℃ -5.0℃, 2.2℃ -5.5℃ and 2.8℃ -4.6℃ in 2070, respectively.

The modeled results of precipitation change in the 21st century cannot be summarized as easily as the temperature results, because the climate scenarios show very different results. For instance: the CCCM model indicates a precipitation decrease in the Gobi while the others indicate an increase. Changes in snow fall are not clear. Annual precipitation would increase by 20-40%. According to the GCM scenarios results, the significant increase in precipitation by 2040 will have decreased by 2070.

The changed climate with increased temperatures and precipitation in 2040 can be attractive for ecosystem conditions of the country. However, if after 2040 the temperature will continue to increase while precipitation amounts remain the same (or even decrease a little) the natural condition and socio-economic development of Mongolia will be negatively influenced.

Potential Impacts of Climate Change

Overview of the assessment of impacts of climate change on biophysical environment and economic sectors provides potential scenarios of future changes in the studied areas. In the country's specific conditions, natural zones, rangeland and water resources will experience significant changes. Economic sectors like animal husbandry and arable farming will have double impacts of these changes in basic biophysical components and direct effect of changes in global climate. In most cases these impacts would be negative. At the same time, Mongolia will have a specific concerns which relate mainly to permafrost melting and snow cover changes due to global warming. For instance, any changes in permafrost area and its intensity will have serious considerations in infrastructure and agriculture sector development strategies and planning. If snow cover will be reduced or removed in winter season, the country will have to look for alternative ways for water supply of pasture animal husbandry in spring and winter(Climate change and its impacts in Mongolia. 2000).

Estimates by the Holdridge Life Zone Classification Model showed that the forest area would be decreased and the steppe zone will move forward to the forest steppe. Also, the desert would extend its area to the north. Particularly, it has been estimated that the high mountain tundra and taiga area would decrease by 0.1-5 per cent from the current condition in period of 2020 and 4-14 per cent in 2050. Because of the warming the boundary of high mountain zone shifts up. The area of the forest steppe that is in the Khangai, Khentii, Khuvsgul, Altai mountain ranges would be decreased by 3 per cent in the first quarto and by 7 per cent in the second quarto of the 21st Century. Changes in the steppe area are not significant(0.1-3 per cent) in both periods. The desert steppe area might decrease by 7 per cent while the desert region would extend its area by 13 per cent to the Depression of the Great Lakes and desert steppe(Bayasgalan et all, 1996).

Water resources tend to be increased in the first quarto and will be a little more or at the level of current climate condition in the mid-21st Century. The pattern of river flow change in time strongly follows the pattern of climate parameters as temperature and precipitation. Thus it can be concluded that the continued climate warming leads to fall water availability of the country. According to the simulation results, almost one third of the country is defined as very vulnerable region. All rivers in this region are seasonal i.e. have flow only during rainy season. Nearly 90 per cent of the lakes have an area of less than 1 km2 and strongly depends on precipitation. The residential water demand can meet by ground water in towns, villages and settlements but the pasture water supply will be most difficult problem to solve, particularly in arid and semi-arid areas.

The research conducted to pasture productivity under climate change scenarios certainly convinces the significant negative impact. Estimates that have been drawn up on how a climate change would impact on pasture productivity warns, the carbon and nitrogen in soil organic matter will be decreased by 10 and 3 per cent and peak standing biomass will be reduced by 23.5 per cent under temperature increase of 3℃. Simulation results on soil organic C and N, peak biomass and plant protein changes in different geographical zones suggested that the most vulnerable regions in the country are the desert steppe and desert.

Potential evapotranspiration will be increased by 7-10 times than the increase of precipitation. This negative balance of moisture capacity undoubtfully limits the both growing season and pasture productivity in future. Obviously natural zones shift has direct effects on rangeland production and plant communities and indirect influence on livestock production and ultimately the economy.

Climate change will effect significantly on re-growth and productivity of forests. The forest area would be decreased due to expansion of the steppe and desert zones under future climate change scenarios. The high mountain tundra and taiga area would decrease by 0.1-5 per cent from the current condition in period of 2020 and 4-14 per cent in 2050. The area of the forest steppe would be decreased by 3 per cent in the first quarto and by 7 per cent in the second quarto of the 21st Century. At the same time, the species composition and productivity of specific forested sites will have significant changes.

The estimates of study on global warming predict the reduction of area with snow cover till 33.4% and 22.6% in the first quarto and middle of 21st century respectively. Moreover the number of days with stable snow cover is going to be less. Particularly, in 2050 periods, there can be water shortage for animal watering in the Dornod steppe or western part of the country, Orkhon, Selenge river basin, and Lakes basin during wintertime.

Late formation and earlier melting of snow cover would lead to decrease soil moisture capacity that can result adversely in crop yield. Therefore, it is certainly requires to take explicit measure in crop technology and water supply in pasture to over come the climate change adverse impacts.

There is a clear change in permafrost under climate change in Mongolia. According to the results of impact assessment, the area of permafrost will be limited from 24 to 28 percent of the entire country's land by 2020 and 16-25 per cent by 2050. Proceeding from this, conclusion can be made that the area of permafrost of Mongolia shall decrease 8.8 to 24.7 percent and occupy only 17.3 per cent (at present it is about 63 per cent) of the territory and noticeable changes will take place in the surface water balance, soil moisture and the temperature regime, vegetation cover and socio-economic consequences.

Frequency of wind storms, including sand/dust storms is increasing significantly during the last decades because of soil degradation and desertification in Mongolia, specially in the Gobi desert area.

In many cases, any changes in a selected environmental components or economic sectors caused by global climate change will effect others. Therefore, integrated impact assessment is necessary to provide more or less systematic framework to structure present knowledge and review the issues that can facilitate more systematic searching for possible responses, which can be most important and practical. There are given some considerations on more subjected in qualitative analysis applying to the "Cross Impact Analysis". Interaction matrix representing the relationship between natural resources and agriculture of Mongolia shows that the climate change has influence to natural zones, water resources, permafrost, snow cover, rangeland, livestock, arable land, pasture water supply, and wild animals.

Generalizing all these considerations, it should be perceived that the effects of past human activities are large and expecting more. According to the results of all sectors, the steppe and desert-steppe are much vulnerable to small changes of climate variables than other regions. The impacts in these areas would be water resources decline → pasture degradation → land use change → animal husbandry → economy → society. Thus more attention should be paid in conservation and restoration of natural resources and balance management in various human activities taking into account the expected changes of climate.

Adaptation to Climate Change

In order to overcome the adverse impacts of climate change and to provide sustainability of future life or simply to survive, policies and strategies to adapt to changes in global climate are essential for natural and biological resources as well as human beings. There are, however, substantial uncertainties in potential impacts of global climate change on ecosystem and socio-economic sphere. The outputs and findings from impacts and vulnerability assessment indicate both negative and positive impacts in different sectors of nature and economy. Anyhow, the countries have to be ready to any possible risks related to climate change.

Article 4.1(b) of the UN Framework Convention on Climate Change (UNFCCC) states: "All Parties ... shall ... formulate, implements, publish and regularly update national and, regional programmes containing measures to mitigate climate change .. and measures to facilitate adequate adaptation to climate change".

The IPCC concluded that, although there are substantial uncertainties, global warming could have important detrimental effects on agriculture, forestry, natural ecosystems, water resources, human settlements, and coastal protection. The priority aim of adaptation policy must be to reduce the uncertainties about the impacts of climate change so that the necessary adaptation measures can be properly targeted.

National climate change action programme(NAPCC, 2000) approved by the Government of Mongolia in 2001 includes a framework of climate change adaptation policies and strategies as well as recommendable adaptation measures to overcome the adverse impacts of climate change at the national level.

Reference

Bayasgalan Sh, B.Bolortsetseg, D.Dagvadorj and L. Natsagdorj. 1996, The Impact of Climate Change on Spring Wheat Yield in Mongolia and Its Adaptability. Adapting to Climate Change: Assessment and Issues. (eds: Joel B.Smith et al) Springer, pp. 164-173.

Gomboluudev P. Climate Change Projection in Mongolia. 2002, Proceedings of the Symposium on Climate Change and Arable Farming. October 2002, Darkhan city., Ulaanbaatar, 2002, pp. 60-68.

Climate change and its impacts in Mongolia. 2000, (Eds: Batima P. and Dagvadorj D.) -UB, JEMR publishing, Mongolia, 2000, 199p.

Climate Change: Rangeland and Animal Husbandry. 2003, ADMON Printing, Ulaanbaatar, pp. 120.

Dagvadorj D., Mijiddorj R. and Natsagdorj L. 1994. Climate Change and Variability Studies in Mongolia. 1998, In: Papers in Meteorology. Annual Scientific Journal of Hydrometeo Res., Ins. No.17. Ulaanbaatar, p. 3-10.

Dagvadorj D. and Z.Batjargal, Response Actions to Address Climate Change Problems, 1999. Papers in Meteorology and Hydrology. Vol. 21/2, Ulaanbaatar, pp. 3-16.

IPCC, 2001. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the IPCC (eds: Hougthon J.T et al), Cambridge University Press, pp. 881.

IPCC, 2001. Climate Change 2001: Synthesis Report. Contribution of Working Groups Ⅰ, Ⅱ and Ⅲ to the Third Assessment Report of the IPCC(eds:

Robert T. Watson and Core Writing Team), Cambridge University Press, pp. 397.

Natsagdorj L. Latest Variations of Climate in Mongolia, 1980, Papers in Meteorology and Hydrology. Vol. 5, 1980, Ulaanbaatar, pp. 54-63.

National Action Programme on Climate Change(NAPCC). 2000, Ulaanbaatar, pp. 166.

Vulnerability and Adaptation Assessment in Mongolia. Vulnerability and Adaptation to Climate Change. 1996. Interim Results from the USCSP. Environmental Science and Technology Library. Volume 8, 1996. Kluwer Academic Publishers. pp. 183-206.